Appendix 10-4:

Water Quality Survey Report prepared by YCDC-WSD

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

WATER QUALITY SURVEY REPORT FOR HLAING RIVER BASIN

FINAL VERSION

JANUARY 2018

PREPARED BY:

ENGINEERING DEPARTMENT (WATER AND SANITATION)

YANGON CITY DEVELOPMENT COMMITTEE (YCDC)

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DISI	Directorate of Industrial Supervision and Inspection
DO	Dissolved Oxygen
EC	Electrical Conductivity
ECD	Environmental Conservation Department
EIA	Environment Impact Assessment
IZ	Industrial Zone
JICA	Japan International Cooperation Agency
MOH	Ministry of Health
ORP	Oxidation Reduction Potential
TDS	Total Dissolved Solid
N/P	Nitrogen/Phosphorus
T-N	Total Nitrogen
T-P	Total Phosphorus
TSS	Total Suspended Solid
PCCD	Pollution Control and Cleansing Department
YCDC	Yangon City Development Committee
EDWS	Engineering Department (Water and Sanitation)
WHO	World Health Organization

EXECUTIVE SUMMARY

i) Background and Purpose

The main objectives of the water quality survey are set to confirm the pollution statuses in the target river basin and to examine the impacts of industrial wastewaters or other pollution sources on Hlaing River in Yangon. The water quality survey was composed of total five times surveys: in February 2016, June 2016, January - February 2017, September 2017 and February 2018 in order to cover the dry season and rain season from 2016 to early 2018. This water quality survey report presents the results from 3rd survey and 4thsurveys focusing to check the suitability of possible intake points for future water supply.

ii) Findings

The findings from 3rd and 4th water quality surveys at Kokkowa in the Hlaing River basin and 4th water quality survey in Wataya are summarized as follows.

(1) Basic parameters of two sampling points are acceptable for water supply as new water sources. However, turbidity was more than 200 times of WHO standards. Therefore sedimentation treatment should be applied.

(2) Moderate level of organic substances at Kokkowa was indicated by COD. It was not an elevated level, but slightly higher than desirable level for water supply source in the dry season. It needs to be noted for the water supply plan and water treatment plant design.

(3) Pesticides values from both sampling points fall under the acceptable limit by comparing with Japanese and Vietnamese standards. However pesticides should be monitored by season because there is agricultural land along the river.

iii) Conclusions and Recommendations

The water quality monitoring results at Kokkowa and Wataya were analyzed. Overall, water quality in the Kokkowa River, which will be used as the water supply source, is likely to be suitable for water supply purposes. However, the pesticides, BOD and COD parameters etc. should be monitored seasonally. Wataya point requires more surveys and examination to confirm check the suitability as a drinking water source.

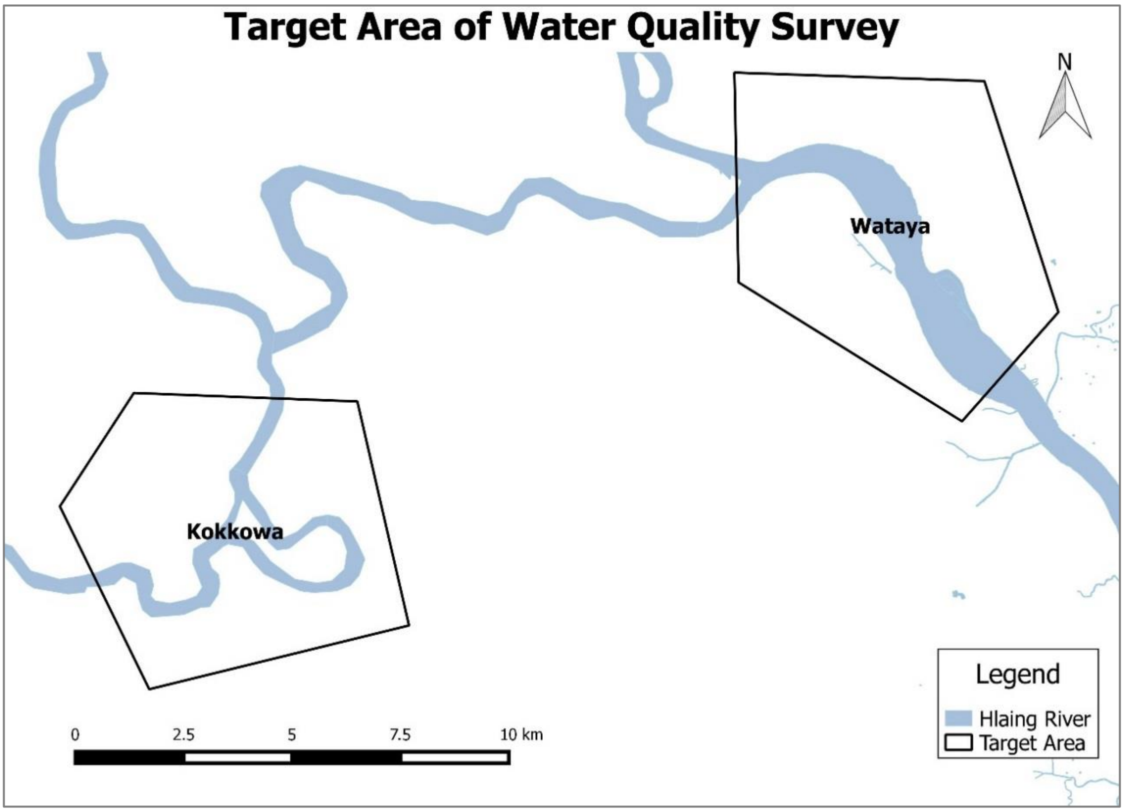
1 INTRODUCTION AND OBJECTIVES

1.1 Background

JICA Expert Team, ECD Yangon and YCDC (WSD and PCCD) conducted water quality surveys of the Hlaing River basin from February 2016 to February 2018. The primary purpose of this study was to collect and analyze data to be used in the assessment on the condition of surface water in the Hlaing River. In detail, Kokkowa is proposed for intake point of Kokkowa Water treatment plant by YCDC. Wataya is considered to be potential intake point for water supply to Hlawga Reservoir. The water quality of Kokkowa and Wataya analysis are very important for future water supply in Yangon (see the target area in Figure 1.1-1).

The Project for Capacity Development in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar, has been implemented cooperated with Environmental Conservation Department (ECD), Pollution Control and Cleansing Department (PCCD) and Engineering Department Water and Sanitation (EDWS) of Yangon City Development Committee (YCDC), and JICA Expert Team. This project aims to get the knowledge and information on the water quality survey for the current status of the Hlaing River Basin through the on-site measurement and laboratory analysis.

The water quality survey was conducted for a total five times: in February 2016, June 2016, January - February 2017, September 2017 and February 2018.



Source: EDWS, YCDC

Figure 1.1-1 Target Area of Water Quality Survey

1.2 Objectives

The water quality data in Kokkowa and Wataya is collected and analyzed, focusing on physical, biological and chemical contamination. Considering the design of Kokkowa Treatment Plant and other water supply plan, the objectives of water quality survey for target area are developed as follows,

(1) To investigate the seasonal changes of water quality in Kokkowa and Wataya which are the upper parts of Hlaing River.

(2) To confirm water quality whether it is suitable for domestic water supply.

1.3 Legal basis of water quality survey

YCDC was initially established as a city municipal organization since Myanmar was under the British to carry out municipal works, and its name was changed in history as Ran-goon City Municipal Corporation in 1922, as Rangoon City Municipal Committee in 1972, as Rangoon City Development Board in 1977, as Rangoon City Development Committee in 1985 (YCDC, 2014a).

According to the provisions of Yangon City Development Law (14 May 1990), YCDC bestowed wide powers and authority, for instance, YCDC was authorized to implement its own project by using its own funding resources. However, at present, YCDC needs to apply permissions of projects to the national government, and the funding sources of YCDC are incorporated into the national budget by the new policy. YCDC set up as a ministerial level and comprises with 20 departments and one committee office, to create a modern city with the features and characteristics of city while preserving its greenery and the intrinsic beauty for its citizens by the guidance of the national government. YCDC is directly responsible for the development and maintenance of Yangon City in all aspects.

According to Yangon City Development Law, YCDC must organize with minimum seven members to maximum 15 members; the Chairman, Vice-Chairman (Vice-Mayor), Secretary, Joint Secretary, and the other are Committee Members. Mayor of Yangon City is responsible not only the Chairman of YCDC but also the minister of Development Affairs of Yangon Region.

Engineering Department (Water & Sanitation) (EDWS) is one of the 20 departments under YCDC, which is responsible to supply of clean and potable water to the citizens of Yangon City and to serve sewerage and sanitation facilities of the city.

Department of engineering (Water& Sanitation) is trying to implement the duties & responsibilities of department by doing the following five objectives activities-

1. To distribute daily clean and fresh drinking water to the people who are living in Yangon.
2. To collect the water tariff fully.
3. To protect the non-revenue water.
4. To develop and manage the water distribution and the system of sewage with the help of modern technology.

The Organization of Engineering Department (Water & Sanitation) has one Head of Department as chief engineer and three Deputy Head of Department for three deputy chief engineers. There are reservoir division, supporting division, water supply division, electrical and mechanical division, pipe plant division, administration finance division, and sanitation division in Engineering Department (Water and Sanitation). Water quality monitoring section is one of the sections under supporting division. Responsibility of water quality monitoring section is water quality analyzing and monitoring of reservoir, tube well and water distribution pipeline which supply by YCDC. Furthermore it monitors the Kokkowa River, new water source, for water supply. EDWS laboratory can monitor 26 parameters which is physical, chemical and bacteriological analysis. Water Quality Monitoring Section have to change of the existing monitoring methods to the standardize methods which are recommended in Myanmar National Drinking Water Quality Standard.

2 SURVEY METHODS

2.1 Role and responsibility of survey team

Following tables show role and responsibility of 3rd and 4th survey team.

Table 2.1-1 Role and Responsibility of 3rd survey team

Organization	Responsibility
JICA Expert Team	Supervisor of water quality survey
Environ Myanmar Co.,Ltd	Surveyors - Water quality sampling and onsite measurement - Send water samples to Lab. - Outsource the water quality analysis.
ECD (Yangon), YCDC (EDWS , PCCD)	Counterparts - Analyze water sample in EDWS Lab. - Water quality sampling and onsite measurement

Source: EDWS, YCDC

Table 2.1-2 Role and Responsibility of 4th survey team

Organization	Responsibility
JICA Expert Team	Supervisor of water quality survey - Outsource the water quality analysis to Japanese lab
Social & Environmental Associates-Myanmar	Surveyors - Water quality sampling and onsite measurement - Send water samples to Lab. - Outsource the water quality analysis to Myanmar lab
ECD (Yangon), YCDC (EDWS , PCCD)	Counterparts - Analyze water sample in EDWS Lab. - Water quality sampling and onsite measurement

Source: EDWS, YCDC

2.2 Sampling schedule

The sampling schedule for 3rd water quality survey in Hlaing River Basin is listed below.

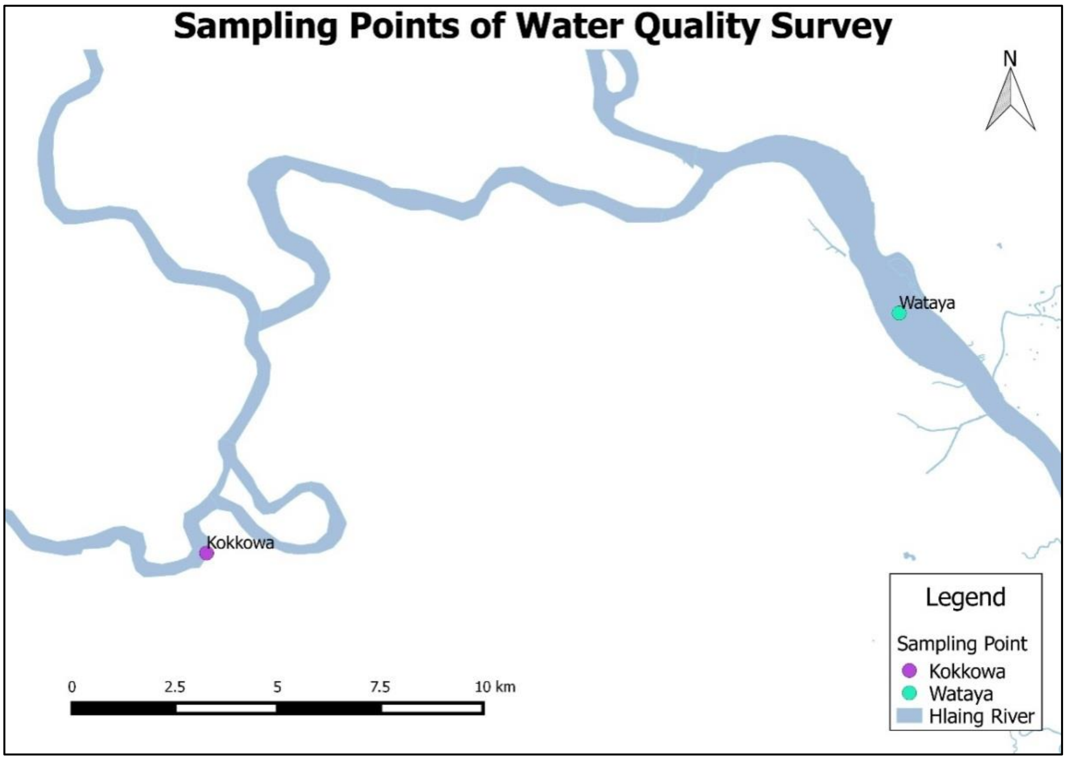
- 8:00 – 16:30, 30 January 2017: Sampling in the Hlaing River and Shwe Pyi Thar IZ
- 8:00 – 16:30, 31 January 2017: Sampling in the Hlaing River and Pan Hlaing River
- 8:00 – 14:00, 1 February 2017: Sampling in Kokkowa

The sampling schedule for 4th Water quality survey in the Hlaing River Basin is listed below.

- 8:00 – 16:30, 18 September 2017: Sampling in the Hlaing River and Pan Hlaing River
- 8:00 – 16:30,19 September 2017: Sampling in the Hlaing River, Pan Hlaing River and Shwe Pyi Thar IZ
- 8:00 – 14:00, 20 September 2017: Sampling in Kokkowa

2.3 Sampling points

The surface water samples were taken from 10 points in the Hlaing River basin. Among them, in the report, two points, namely, Kokkowa and Wataya were selected to evaluate the results because YCDC has a plan or preliminary idea to take raw water for water treatment plant from these points. See these two main sampling points in Figure 2.3-1.



Source: EDWS, YCDC

Figure 2.3-1 Sampling Points of Water Quality Survey

2.4 Survey parameter

2.4.1 Measurement parameter

Following parameters are analyzed for each water sample.

1) Onsite measurement parameters -

Air temperature, pH, EC, salinity, turbidity, water temperature, ORP, DO, TDS

2) Laboratory Analysis parameters -

Total coliform, TSS, BOD, COD, cyanide, oil and grease, phenols, total phosphorus, total nitrogen, zinc (Zn), total chromium (T-Cr), chromium (hexavalent), arsenic (As), copper (Cu), total mercury (Hg), cadmium (Cd), lead (Pb), pesticides and PCBs

This report will focus on eight parameters, i.e., BOD, COD, pesticides, turbidity, pH, salinity, total phosphorus and total nitrogen of Kokkowa and Watayar sample. Among them, seasonal changes between dry and wet season are examined for total phosphorus and total nitrogen data of Kokkowa sampling point.

2.4.2 Guideline levels

In Myanmar, there is Environmental Quality (Emission) Guidelines (NEQG) (MOECAF, 2015) to be applied for wastewater, storm water runoff, effluent and sanitary discharges and Myanmar National Drinking Water Quality Standards by MOH. Moreover, EDWS central laboratory use drinking water quality guideline values of WHO and Myanmar National Drinking Water Quality Standards by MOH for domestic water supply. At the present, there has no river water quality standards in Myanmar. Therefore, Japanese Environment Standard. (Environment Agency Notification No. 59) and Vietnamese environmental standard (QCVN08:2015) are also introduced for reference. To evaluate surface water quality in this surveys, Vietnamese environmental standard was selected to be referred because Myanmar and Vietnam are neighboring countries and water quality characteristic is similar.

Table 2.4-1 Water Quality Standards Guidelines

No	Parameter	Unit	Japanese Environment Standard	Vietnamese Environmental Standard (A1)	Drinking water quality guideline used in EDWS mainly based on WHO guideline	Drinking water quality Standard of MOH
1	BOD	mg/l	≤ 1 – 10 mg/l (for rivers)	4	≤ 2	-
2	COD	mg/l	-	10	-	-
3	Pesticides	mg/l	-	See Table 3.1-1	See Table 3.1-1	See Table 3.1-1
4	Turbidity	NTU	-	-	5	5
5	pH	mg/l	6.0 – 8.5 (Class D: Water for agricultural use in rivers)	6.0 – 8.5	6.0 – 8.5	6.5 – 8.5
6	Salinity	ppt	-	-	0.5	
7	Total phosphorus (T-P)	mg/l	< 0.1 (Class V: Fishery class for marine products and agricultural use in lakes)	-	-	-
8	Total nitrogen (T-N)	mg/l	< 1 (Class V: Fishery class for marine products and agricultural use in lakes)	-	-	-

Source: Environment Agency Notification No. 59 (Ministry of Environment in Japan, last amended in 2016), Vietnamese national technical regulations on surface water quality (A1 Class: for domestic water supply) (QCVN 08-MT 2015/BTNMT), Draft national drinking water quality standards (MOH superseded by MOHS, 2014), Guidelines for drinking-water quality (fourth edition, WHO, 2011)

2.5 Sampling and Measurement

2.5.1 Sampling method

The water samples were taken from a boat or bridge. Firstly, a plastic bucket was rinsed three times directly with sample water. Sample water was taken and mixed to be homogeneous water in the bucket. Each sample bottle was rinsed three times with the homogeneous water and then filled by the sample water for laboratory analysis. After samples were collected, they were kept in an ice-box and transported to laboratories.

Source: JICA Expert Team

Figure 2.5-1 Photos of Water Sampling

2.5.2 On-site measurement method

The pH, EC, DO and some other measurement parameters were analyzed by an on-site water quality meter.

Source: JICA Expert Team

Figure 2.5-2 Photos of On-site Measurement at Kokkowa

The following Table shows a list of equipment used for on-site measurement.

Table 2.5-1 Field Measurement Equipment

No.	Manufacture	Model Name	Parameter
1	Horiba	U52G Multiparameter Water Quality Meter	pH, DO, conductivity (EC), salinity, TDS, water temperature, turbidity, ORP

Source: JICA Expert Team

2.5.3 Laboratory analysis method

The following Tables show laboratory analysis methods of 3rd and 4th water quality survey.

Table 2.5-3 Analysis Method of 3rd Water Quality Survey

No.	Parameter	Method	Name of laboratory
1	BOD	In-house method based on Standard methods for the examination of water and wastewater (APHA, AWWA, and WEF) 22nd Edition, 2012, 5210 B	CLT(Thailand)
2	COD Cr	In-house method based on Standard methods for the examination of water and wastewater (APHA, AWWA, and WEF) 22nd Edition, 2012, 5220 C	CLT(Thailand)
3	Total organic chlorine pesticides	In-house method based on EPA Method 508 by GC/μ-ECD	CLT(Thailand)
4	Total organic phosphorus pesticides	In-house method based on EPA Method 507 by GC/FPD	CLT(Thailand)
5	Total nitrogen (T-N)	In-house method based onStandard methods for the examination of water and wastewater (APHA, AWWA, and WEF) 22nd Edition, 2012, 4500-N C	CLT(Thailand)
5	Total phosphorus (T-P)	In-house method based on Standard methods for the examination of water and wastewater (APHA, AWWA, and WEF) 22nd Edition, 2012, 4500-P J	CLT(Thailand)

Source: JICA Expert Team

Table 2.5-4 Analysis Method of 4th Water Quality Survey

No.	Parameter	Method	Name of laboratory
1	BOD	Respirometric method (HACH Method 10099)	DOWA Eco-system–Myanmar Co., Ltd. for survey in Hlaing River basin
2	COD Cr	JIS K0102 (2016) 20.1	OSUMI CO., Ltd.
3	Pesticides	See below	OSUMI CO., Ltd.
4	Total nitrogen (T-N)	JIS K0102(2016) 45.2	OSUMI CO., Ltd.
5	Total phosphorus (T-P)	JIS K0102(2016) 46.3.1	OSUMI CO., Ltd.

Source: JICA Expert Team

3 RESULTS AND DISCUSSION

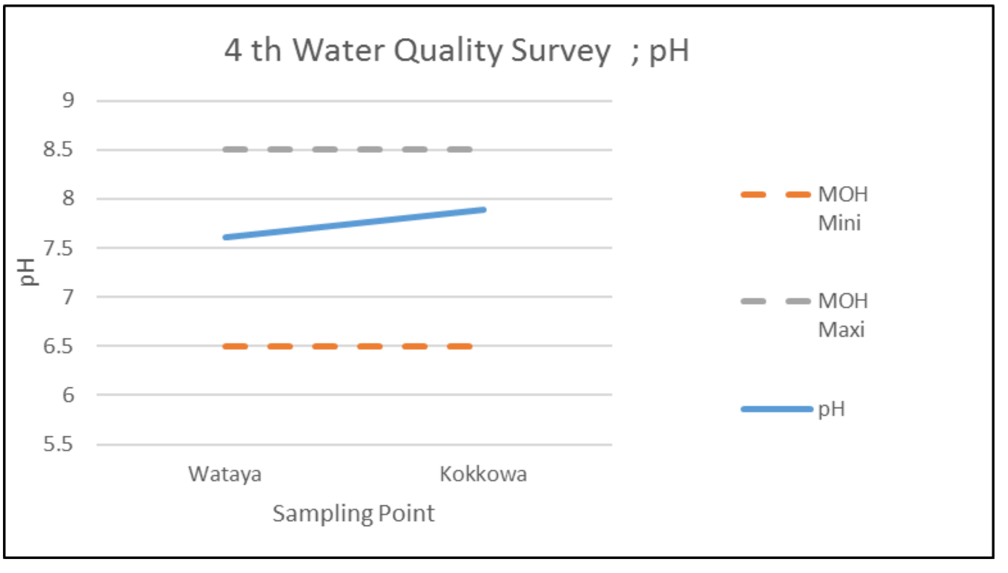
3.1 Water quality results

Overall, pH value as well as the concentration of salinity and BOD were acceptable for raw water in the proposed area of water treatment plant for Kokkowa River water. The Wataya point showed higher pollution level compared with Kokkowa with regard to turbidity, COD, total phosphorus and total nitrogen.

3.1.1 Basic parameters

(i) pH

The figure illustrates the range of pH value at Kokkowa and Wataya water sampling point. The pH range of the drinking water quality standard of MOH is 6.5 to 8.5. The values of Kokkowa point and Wataya point in the 4^{th} survey are 7.8 and 7.61 respectively. Compared with Drinking Water Quality Standard of MOH, these sampling results of pH value is acceptable for raw water of proposed water treatment plant.

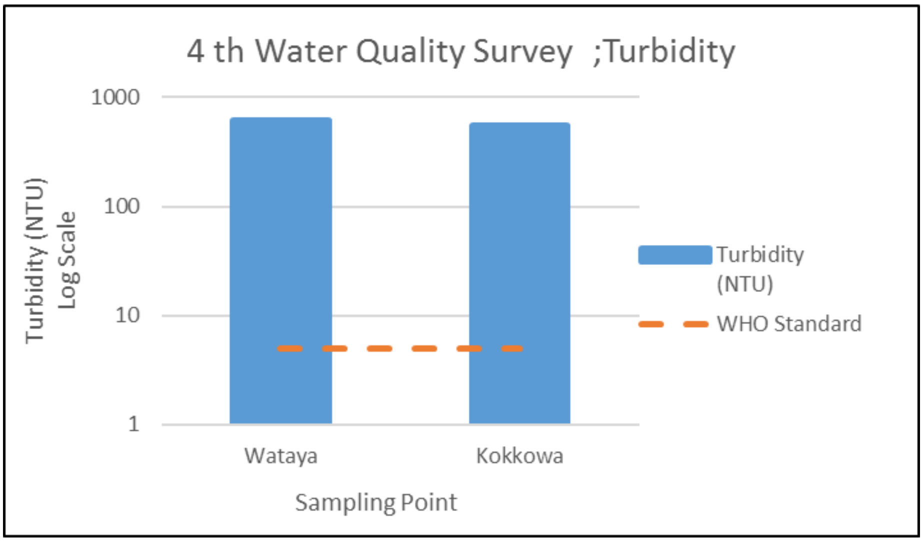


Note: MOH line shows the acceptable range of draft national drinking water quality guideline value (MOH, 2014)
Source: EDWS, YCDC

Figure 3.1-1 pH Level of Kokkowa and Wataya

(ii) Turbidity

Figure 3.1-2 shows the turbidity of Wataya and Kokkowa sampling point. As the river water character, turbidity is quite high in both points compared with the WHO guideline and MOH standards.

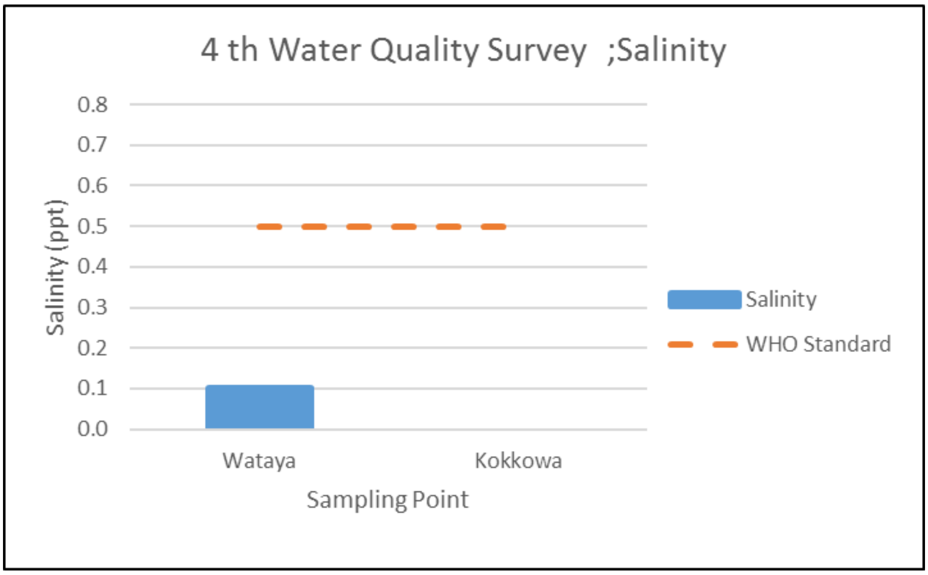


Note: 5 NTU is suggested by WHO Standard: Guidelines for drinking-water quality (fourth edition, WHO, 2011) as a requirement for small and rural water supplie
Source: EDWS, YCDC

Figure 3.1-2 Turbidity level of Kokkowa and Wataya

(iii) Salinity

Figure 3.1-3 provides the salinity of Wataya and Kokkowa sampling points. The salinity level of both points at Wataya and Kokkowa are under the value of drinking water guideline applied in EDWS.



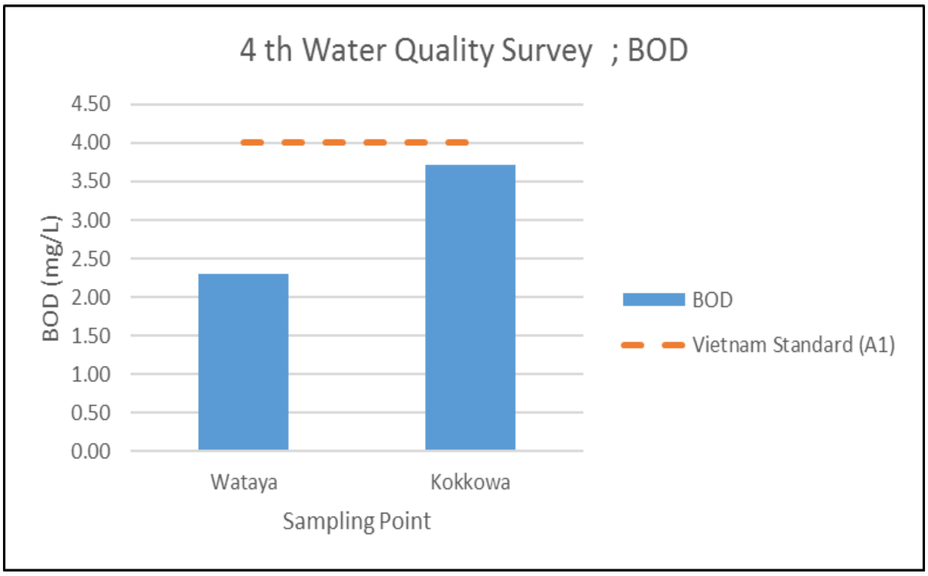
Source: EDWS, YCDC

Figure 3.1-3 Salinity Level of Kokkowa and Wataya

3.1.2 Organic substances

(i) BOD

Figure 3.1-4 shows the BOD levels obtained from Wataya and Kokkowa. The amount of BOD in Wataya and Kokkowa are 2.3 and 3.72 respectively while the Vietnamese environment standard of BOD is 4 mg/l. BOD levels in Wataya and Kokkowa points are lower than Vietnamese standard.

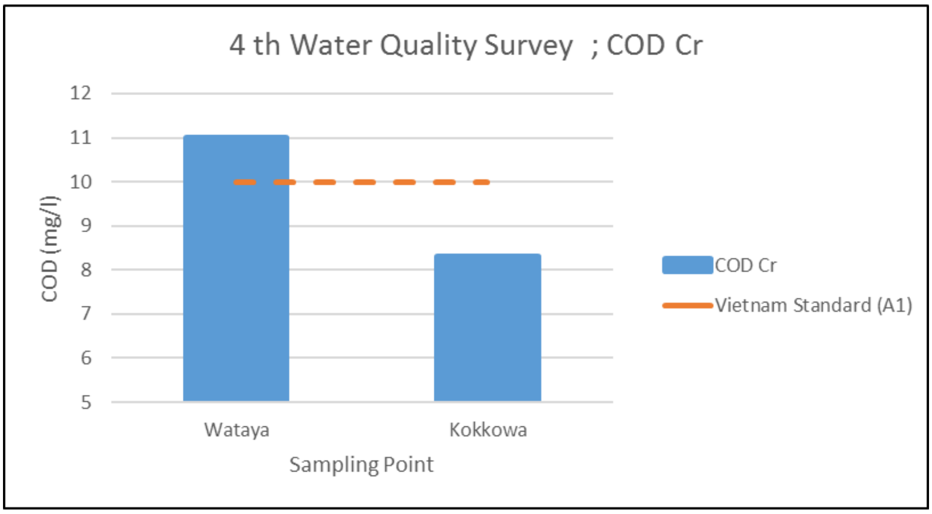


Vietnam Standard (A1): Vietnamese national technical regulations on surface water quality (A1 Class: for domestic water supply) (QCVN 08-MT 2015/BTNMT)
Source: EDWS, YCDC

Figure 3.1-4 BOD level of Kokkowa and Wataya

(ii) COD

Figure 3.1-5 shows the COD levels obtained from Wataya and Kokkowa. The Vietnamese environment standard of COD is 10 mg/L (A1 Class for domestic water supply). The amount of COD in Wataya and Kokkowa are 11 and 8.3 respectively. Wataya point shows slightly higher COD than reference Vietnamese environment standard. The Kokkowa point's valude is lower than the Vietnamese standard.



Vietnam Standard (A1): Vietnamese national technical regulations on surface water quality (A1 Class: for domestic water supply) (QCVN 08-MT 2015/BTNMT)
Source: EDWS, YCDC

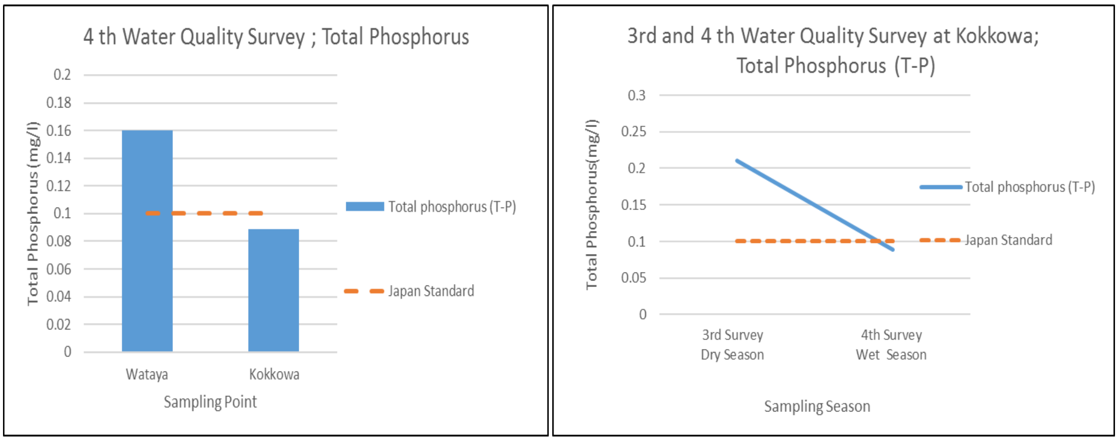
Figure 3.1-5 COD Level of Kokkowa and Wataya

3.1.3 Nutrients

(i) Total phosphorus (T-P)

Total phosphorus concentrations were recorded during dry season by the 4th survey and wet season by the 3rd survey for the Kokkowa sampling point as well as during the dry season by the 4th quality survey for Wataya. Total phosphorus results of Wataya and Kokkowa in the dry season exceeded the reference Japan Environment Standard. i.e., 0.1 mg/L for lakes, while it is less than 0.1 mg/l of standard in the wet season.

The total phosphorus to be applied to the river water quality is not included in the reference standard shown in Table 2.4-1. It is know that the high phosphorus values may trigger the significant algae bloom in the enclosed water body and in general not much considered for conservation of flowing river water. Although the possible adverse impact by phosphorus in rivers could be limited, such moderate level of phosphate in the dry season indicates the pollution impact from domestic wastewater, agricultural wastewater and others.



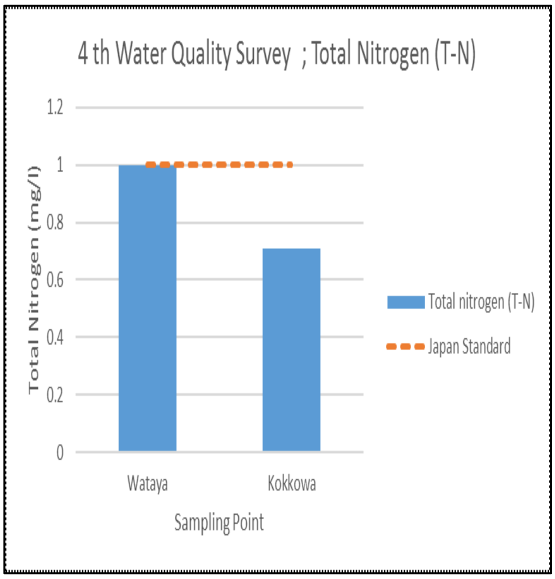
Note: "Japan Standard" shows Class V, fishery class for marine products and agricultural use in lakes, Environment Agency Notification No. 59 (Ministry of Environment in Japan, last amended in 2016), Source: EDWS, YCDC

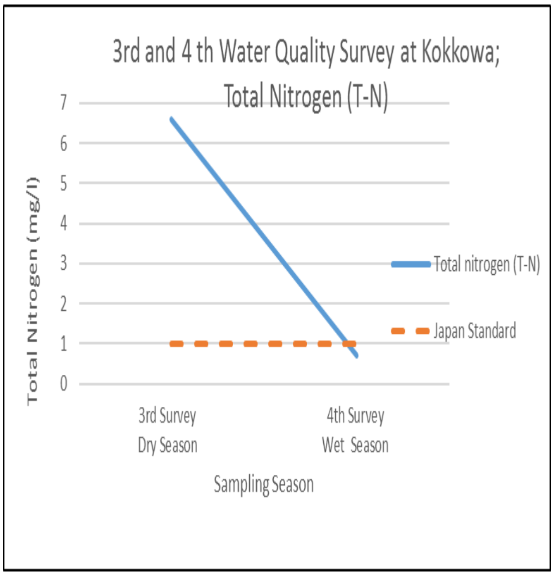
Figure 3.1-6 T-P Results

(ii) Total Nitrogen (T-N)

The figure 3.1.7 illustrates T- N level of Kokkowa between the dry and wet season. The T-N concentration of dry season (6.58 mg/l) was sharply decreased in the wet season (1.1 mg/l). In the 4th quality survey of Wataya, T –N concentration is slightly higher than the reference standard; Japanese Environment Standard for lakes (1.1 mg/L).

As mentioned above for T-P, T-N is also not included in the reference standard shown in Table 2.4-1. In general, ammonia, nitrite and nitrate, not total nitrogen are specified in the surface water quality standard for rivers. At this time such individual nitrogen forms were not investigated because of unavailability of reliable laboratories. The laboratories that can analyze a slight level of phosphorus with good precision in water environment were not found local area and it was difficult to assure good preservation conditions to transport phosphorus samples to overseas countries. In order to evaluate the nitrogen-related water quality status, each chemical form of nitrogen needs to be checked.





Note: "Japan Standard" shows Class V, fishery class for marine products and agricultural use in lakes, Environment Agency Notification No. 59 (Ministry of Environment in Japan, last amended in 2016)
Source: EDWS, YCDC

Figure 3.1-7 T- N Results

3.1.4 Pesticides

The following table shows the concentration of pesticides at two sampling points. According to results, any pesticides were not detected under this survey conditions. It was good in terms of usage for water supply. However, the monitoring must be closely linked to periods of pesticide use. In the excessive rainfall time or irrigation period, the water containing pollutants flushes out from the land to the river. Therefore, pesticides and other residues including nitrates and phosphates can be quickly transported and contaminate ground water and fresh water over a large geographical area. The individual pesticides have unique properties and many variable factors that determine the specific risk in terms of water pollution. Thus more monitoring data targeting on the pesticides use period and flood season will be necessary.

Table 3.1-1 Pesticides monitoring results of Wataya and Kokkowa

No.	No	Unit	No.1	No.10	Reference Standard or Guideline	
	Location name		Wataya	Kokkowa	Surface Water	Drinking Water
					Vietnam	Myanmar
	Left/Center/Right		Center	Center	Env.Std (QCVNO8:2015)	MOH Draft National Drinking Water Quality Std (2014)
	Sampling Date		19/9/2017	20/9/2017	A2	
	Sampling Time		11:16	9:46	For Domestic water supply with treatment	
1	Aldrin	mg/L	< 0.0005	< 0.0005	0.1	<0.00003 (Aldrin+Dieldrin)
2	Atrazine	mg/L	< 0.0005	< 0.0005	-	0.1
3	4,4'-DDD	mg/L	< 0.0005	< 0.0005	-	-
4	4,4'-DDE	mg/L	< 0.0005	< 0.0005	-	-
5	4,4'-DDT	mg/L	< 0.0005	< 0.0005	0.001(DDT)	0.01(DDT)
6	Endosulfan	mg/L	< 0.0005	< 0.0005	-	0.03
7	Endosulfan sulfate	mg/L	< 0.0005	< 0.0005	-	-
8	Endrin	mg/L	< 0.0005	< 0.0005	-	0.0006
9	HCH-alpha (benzene hexachloride-alpha) (alpha-BHC)	mg/L	< 0.0005	< 0.0005	0.00002 (BHC)	-
10	HCH-beta(beta-BHC)	mg/L	< 0.0005	< 0.0005		-
11	HCH-delta(delta-BHC)	mg/L	< 0.0005	< 0.0005		-
12	HCH-gamma(Lindane) (ganma-BHC)	mg/L	< 0.0005	< 0.0005		-
13	Alachlor	mg/L	< 0.0005	< 0.0005	-	0.02
14	Diazinon	mg/L	< 0.0005	< 0.0005	-	-
15	Chlorpyrifos	mg/L	< 0.0005	< 0.0005	-	0.03
16	Dimethoate	mg/L	< 0.0005	< 0.0005	-	0.006
17	Imidacloprid	mg/L	< 0.0005	< 0.0005	-	0.01

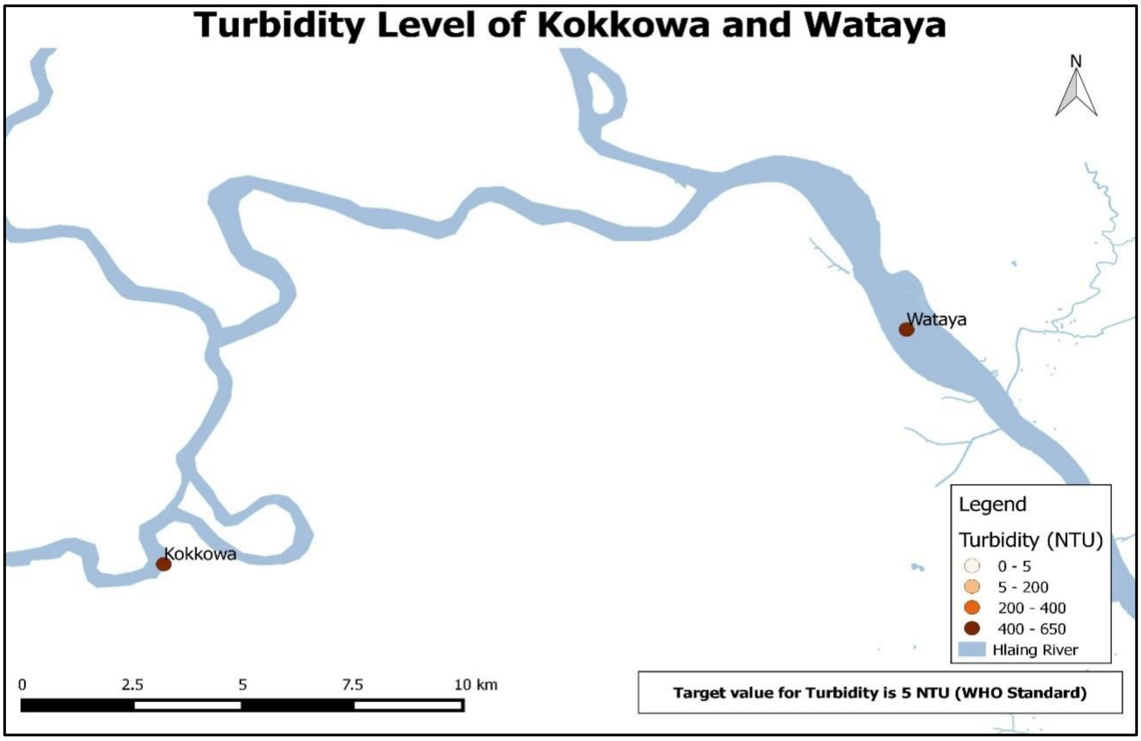
Source: EDWS, YCDC

3.2 Discussion

3.2.1 Discussion of basic parameters results

(i) **pH** is an important parameter for evaluating toxicity of an aquatic system. High acidity (a low pH) can convert insoluble metal sulfides to soluble forms, which increases the bioavailability. A high pH can also cause ammonia toxicity. The surface measurements from the two sampling points showed the pH level fell in the acceptable limit of drinking water quality standard of MOH. Therefore the pH level of these sampling points are suitable for water supply.

(ii) **Turbidity** is the cloudiness of the water, which is related to the shape, size and concentration of particles suspended in the water. Turbidity typically increases during high flow events (e.g. heavy rain, snowmelt, etc.) as soil particles are washed off from city streets, parking lots and agricultural fields. Resuspension of river sediments under high flow conditions can also contribute to higher turbidity levels. In the Hlaing river basin, turbidity is higher than twenty times of WHO standards. As a result, if they are applied for water supply, sedimentation treatment will be required.



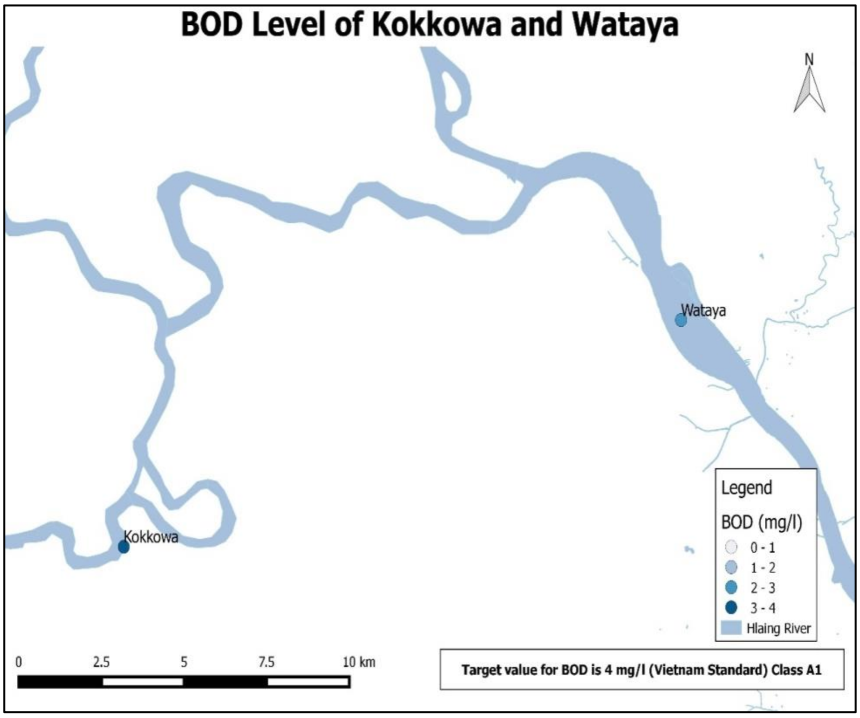
Source: EDWS, YCDC

Figure 3.2-1 Turbidity level of Kokkowa and Wataya sampling points

(i) **Salinity** of the river water is the concentration of total salts dissolved in the water. Rain falling over the river will add freshwater back to the surface and decrease the salinity, although the salinity can increase in the blackish water or sea water depending on the tidal effect. Salinity is typically expressed in units of “parts per thousand” (ppt). Regarding samples taken in the raining season, salinity values were under the guideline of WHO standards. Thus these sampling points were suitable for water supply at the survey time. However, especially in Wataya, which is closer to the sea, the change in salinity and behavior of saltwater intrusion should be checked.

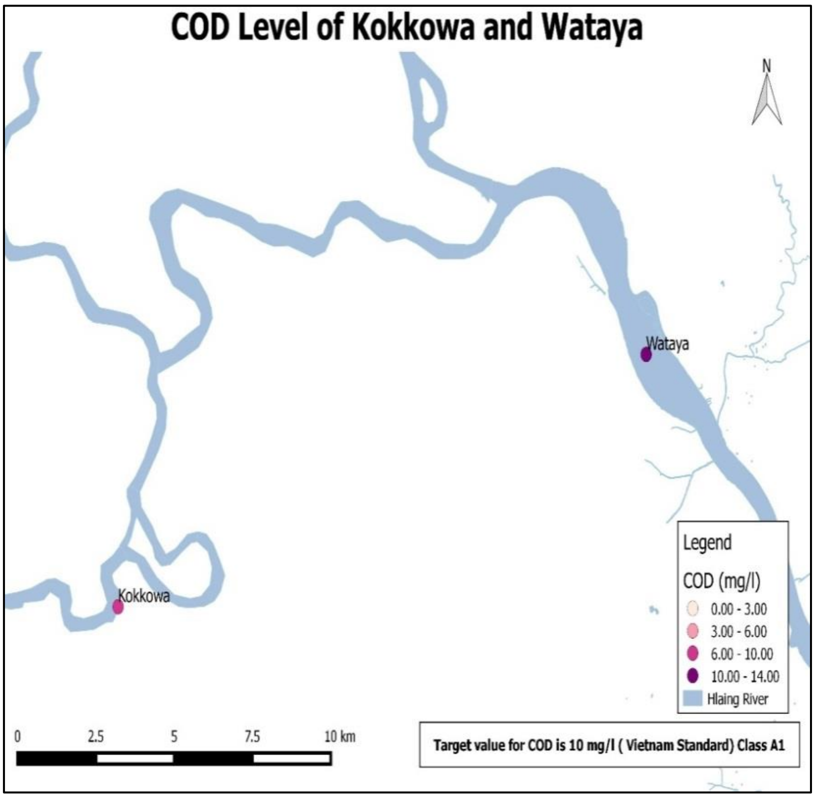
3.2.2 Discussion of organic substances results

(i) **Biochemical oxygen demand** (**BOD**, also called **biological oxygen demand**) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 C. It is often used as an indicator of organic pollution level in the water. BOD is similar in function to chemical oxygen demand (COD) and to be measured for estimating the amount of organic compounds in water. The survey found that BOD value of two sampling points is less than target value of Vietnamese standards. On the other hand, COD value of Wataya point is slightly higher than Standards value. In consequence, there are slight concerns on potential health risk that might be caused by organic material in water treatment plant. If chlorine disinfection process is applied in the treatment system, chlorine reacts with natural organic matter in raw water, resulting in formation of undesirable byproduct: trihalomethanes (THMS), haloacetic acids (HAAs), haloacetonitriles (HANs) and other chemical compounds. Total Organic Carbon (TOC) will be an important parameter for that concern. Moreover, Wataya sampling point needs to be further investigated to monitor seasonal water quality to consider future water supply.



Source: EDWS, YCDC

Figure 3.2-2 BOD level of Kokkowa and Wataya Sampling Points



Source: EDWS, YCDC

Figure 3.2-3 COD Level of Kokkowa and Wataya Sampling Points

3.2.3 Discussion of nutrients

(i) **Total Nitrogen** is a sum of measurement amount of all forms of nitrogen (organic and inorganic). The importance of nitrogen in the aquatic environment varies depending on the forms of nitrogen, which can be present as ammonia, nitrite, nitrate and organic nitrogen. Analytically, total nitrogen can be determined by firstly digesting the sample followed by colorimetric measurement. Total nitrogen is reported as mg/l N. According to 4th water survey result, total nitrogen level at target sampling points are under 0.1 mg/L, the Japanese environmental standard for lakes (Class V, for fishery class for marine products and agricultural use in lakes). However, the dry season of Kokkowa results was higher than that reference value. Although the water quality standard for lakes are not totally suitable to be referred for water quality, this result implies the more pollution impact of nitrogen in the dry season. The nitrogen level for each chemical form needs to be analyzed and monitored seasonally to consider the future water supply.

(ii) **Total Phosphorus** express both inorganic and organic forms of phosphorus. Due to the longer residence time in lakes, total phosphorus rather than just orthophosphate is considered to be the most critical nutrient in most cases of lake environment. Analytically, it is normally determined by prior digestion of the sample followed by colorimetric measurement. The total phosphorus is typically reported as mg/l. T-P level at Kokkowa was more than 0.1 mg/L in the dry season, but decreased in the wet season. On the other hand, the Wataya sampling point showed more than 0.1 mg/L of T-P even in the wet season. Water quality at Wataya sampling point needs to monitored over time to examine the possibility of future water supply.

3.2.4 Discussion of other

(i) **Pesticides** are largely used in agricultural settings, and to a lesser extent, in urban areas. They can be transported into water bodies where they pose a risk to aquatic life and human health. In Wataya and Kokkowa sampling point, no pesticides pollution was confirmed within the scope of survey. However, water quality of these sampling points need to be analyzed and monitored by season because there is a wider area of agricultural land in upstream of the river.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

According to the water quality results, the following conclusions are came out,

1.) As for basic parameters, pH values obtained from the Kokkowa River sampling point and Wataya sampling point are ranged in the acceptable limit and not too much different each other. Turbidity and salinity values from these two sampling points have almost the same value. However, the turbidity values are higher than the guideline value suggested by WHO although salinity values are acceptable. As a result, if such high-turbid water is applied for water supply, sedimentation treatment will be required.

2.) Compared with the Vietnamese surface water quality standard, the value of BOD obtained from Kokkowa and Wataya are in the acceptable limit but BOD at Kokkowa is around 1mg/l higher than Wataya value. In COD results, the value of COD from Wataya is much higher than the Kokkowa results and does not meet with the Vietnamese standard. The BOD and COD concentration is not specifically considered to judge the suitability for water supply and water treatment plant design. However, in order to consider the effect of organic carbon, which may be a health problem risk when chlorine disinfection is applied, Total Organic Carbon (TOC) will also need to be checked.

3.) The total phosphate value of Wataya point is 0.2 mg/l higher than the Kokkowa result in the dry season. Compared the water quality of Kokkowa between the wet season and dry season, it was found that its T-P value in the dry season is higher than one in the wet season, while results of two sampling time exceeded the reference standard value for lakes. For total nitrogen value, T-N shows that the value of Wataya is slightly higher than the Kokkowa value. The nutrient level for specific nitrogen forms at these two sampling points needs to be analyzed and monitored by season to consider future water supply.

4.) Pesticides values from both sampling points was under the acceptable limit compared with Japanese and Vietnamese standards. However pesticides should be monitor seasonally because there are a wide area of agricultural land beside and upstream of the river.

4.2 Recommendation

Overall, water quality in the Kokkowa River, which will be used as water supply source, is likely to be suitable for water supply purposes. However, the pesticides, BOD and COD parameters etc. should be monitored seasonally. Wataya point requires more surveys and examination to confirm the suitability as a drinking water source.

Appendices

Appendix 1 Photo Gallery

	
Haling River	Pan Hlaing River
	
Creek in ShwePhy Thar IZ in Yangon (Shwe-5)	Sub-stream of Hlaing River (Shwe-1)

Source: JICA Expert Team

Appendix 2 List of Data

A2.1 Analysis Results of 4th Water Quality Survey

Table A.2.1-1 Results of Wataya and Kokkowa Sampling point (Osumi (Jp Lab))

No	Location name	Unit	Wataya	Kokkowa
	Left/Center/Right		Center	Center
	Sampling Date		19/9/2017	20/9/2017
	Sampling Time		11:16	9:46
On-site measurement				
1	Air Temperature	° C	33.20	31.00
2	Water Temperature	° C	28.80	28.49
3	pH	-	7.61	7.89
4	ORP	mv	320	190
5	Conductivity	ms/cm	0.125	0.099
6	Turbidity	NTU	618	545
7	DO	mg/L	6.67	6.68
8	TDS	mg/L	81	66
9	Salinity	ppt	0.1	0.0
Laboratory analysis				
1	BOD	mg/L	2.30	3.72
2	Total Coliform	MPN/100ml	35000	4600
3	Total Suspended Solids (TSS)	mg/L	420	120
4	COD Cr	mg/L	11	8.3
5	Cyanide(total)	mg/L	< 0.1	< 0.1
6	Oil and grease	mg/L	< 1	< 1
7	Phenols	mg/L	< 0.005	< 0.005
8	Total phosphorus (T-P)	mg/L	0.16	0.089
9	Total nitrogen (T-N)	mg/L	1.0	0.71
10	Zinc (Zn)	mg/L	0.054	0.029
11	Total chromium (T-Cr)	mg/L	0.048	0.019
12	Chromium (Hexavalent)	mg/L	< 0.005	< 0.005
13	Arsenic (As)	mg/L	0.0026	0.0016
14	Copper (Cu)	mg/L	0.017	0.010
15	Total Mercury (Hg)	mg/L	< 0.0005	< 0.0005

16	Cadmium (Cd)	mg/L	< 0.001	< 0.001
17	Lead (Pb)	mg/L	0.0097	< 0.005
18	Pesticides	mg/L	See Table 3.3-1	See on Table 3.3-1
19	PCBs	mg/L	< 0.0005	-
BOD/COD ratio			0.21	0.45
N/P ratio			6.3	8.0

Table A.2.1-1 Results of Wataya and Kokkowa Sampling point (YCDC Lab)

No	Location name	Unit	Wataya	Kokkowa
	Left/Center/Right		Center	Center
	Sampling Date		19/9/2017	20/9/2017
	Sampling Time		11:16	9:46
Analysis result by Engineering Department (Water and Sanitation)- YCDC				
1	pH	-	7.33	7.38
2	EC	mS/cm	0.116	0.103
3	Turbidity (NTU)	NTU	346	198
4	TDS	mg/L	58	52
5	Salinity	ppt	0.06	0.05
7	Chloride	mg/L	10	12
6	Total Nitrogen	mg/L	3	6
8	Nitrite nitrogen (NO2-N)	mg/L	0.006	0.001
9	Nitrate nitrogen (NO3-N)	mg/L	0	0
10	Ammonia nitrogen (NH3-N)	mg/L	0.23	0.21
11	Phosphate	mg/L	0.54	0.28
12	Sulphate	mg/L	5	2
Analysis result by WWTP lab- YCDC				
1	pH	-	8.6	7.8
2	Turbidity	NTU	314	231
3	DO	mg/L	0.53	0.61
4	TDS	mg/L	60.2	91.3
5	BOD	mg/L	15.9	3.7
6	Total Suspended Solids (TSS)	mg/L	228	33.5
7	COD Cr	mg/L	40	0.2
BOD/COD ratio			0.40	18.50

Appendix 10-5:

Water Quality Survey Report prepared by ECD Mandalay

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

WATER QUALITY SURVEY REPORT FOR TAUNGTHAMAN LAKE

APRIL, 2018

PREPARED BY:

ENVIRONMENTAL CONSERVATION DEPARTMENT (MANDALAY)

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
ECD	Environmental Conservation Department
EIA	Environment Impact Assessment
EU	European Union
IZ	Industrial Zone
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
MCDC	Mandalay City Development Committee
MONREC	Ministry of Natural Resources and Environmental Conservation
TSS	Total Suspended Solid
USEPA	United States Environmental Protection Agency
TP	Total Phosphorus
TN	Total Nitrogen
WQS	Water Quality Survey
PTM	Paw Taw Mu
PYTC	Pa Yan Taw
TT	Tagon Taing
UST	U Shwe Taung
N-TTML	Northern Taungtaman Lake
S-TTML	Southern Taungthaman Lake

EXECUTIVE SUMMARY

i) Purpose

The Project for Capacity Development in Basic Water Environment Management and EIA System in Myanmar has been implemented as a bilateral technical cooperation between Ministry of Natural Resource and Environmental Conservation (MONREC) and Japan International Cooperation Agency (JICA) which is three-year project starting from June 2015 to June 2018. The implemented project areas are the Hlaing River Basin in Yangon and the Doke Hta Waddy River Basin in Mandalay. The project output (2) is to enhance the Capacity for implementing water quality survey in order to obtain reliable information. Five times water quality survey had been conducted during the project period; two times in the raining season and three times in the dry season.

This report has been developed by the representative group of Environmental Conservation Department (Mandalay). The target area of the report is Taungthaman Lake which is located in the Doke Hta Waddy River Basin of Mandalay. The reason to choose this area is that Taungthaman Lake has been surrounded by the Mandalay Industrial Zone, household, agricultural and livestock lands. Therefore, there have many concerns about the influent wastewater from those potential pollution source into the lake.

This report is aiming to access the water quality changes in Taungthaman Lake which are affected by the pollution sources nearby based on third and fourth water quality survey results of the project. The concerned pollution sources are the Mandalay Industrial Zone, squatting area, restaurants, domestic household, plantations and duck farms.

ii) Findings

The 4th WQS Results represent the rainy season and 3rd WQS Results represent the dry season. The TSS, BOD and COD levels are much higher at the Pan Yan Taw Creek and diluted at Taungthaman Lake. Total coliform level is high at both Pa Yan Taw and Taungthaman lake. Total nitrogen (T-N) and total phosphorus (T-P) levels are high at Taungthaman Lake. The lead (Pb) at the U Shwe Taung Bridge is high for ambient water quality.

The TSS, BOD and COD are higher in dry season than in the rainy season. Total coliform is higher in the rainy season than in the dry season. The flood washes out the impurities of the squatting area into the water bodies. Thus the concentration of total coliform in the rainy season is higher than the dry season. And T-N and T-P are higher in the dry season than rainy season, which might be affected by the restaurants, domestic household, plantations and duck farms on the lake.

The water quality of the Pa Yan Taw Creek is not suitable for the irrigation purpose. And the water quality of the Taungthaman Lake is not suitable for the domestic use of water. However, it is suitable for agricultural use. The water quality of the north Taungthaman Lake is worse than the southern Thaungthaman Lake.

iii) Conclusions and Recommendations

The water quality of the Taungthaman Lake is changed due to the effect of pollution sources nearby and seasonally. Therefore, the wastewater from the Mandalay Industrial Zone, squatting area, restaurants, domestic household, plantations and duck farms can be the main factors that will impact the water quality of Taungthaman Lake.

The awareness programs for the notification for the priority nine industries to implement the EMP should be conducted in the Mandalay Industrial Zone Area. The water quality monitoring and inventory of biodiversity index should be conducted to build the database system and to ensure the environmental status. The awareness programs on the collected information and knowledge of the environmental status of Taungthaman Lake should be conducted with the stakeholders of the Lake to share the knowledge and to get the suggestion for environmental quality promoting processes. The water quality of Taungthaman Lake should be maintained or improved to be suitable for the agricultural use.

1 INTRODUCTION AND OBJECTIVES

1.1 Background

The Project for Capacity Development in Basic Water Environment Management and EIA System in Myanmar has been implemented as a bilateral technical cooperation between Ministry of Natural Resource and Environmental Conservation (MONREC) and Japan International Cooperation Agency (JICA). This is three-year project starting from June 2015 to June 2018. There are six outputs of the project according to the work plan; four outputs for Water Environment Management component and two outputs for EIA System component. The implemented project areas are the Hlaing River Basin in Yangon and the Doke Hta Waddy River Basin in Mandalay. One of the achievements of the project is output (2) Enhancement of the Capacity for implementing water quality survey to obtain reliable information. Five times water quality survey had been conducted during the project period; two times in raining season and three times in dry season.

This report has been developed by the representative group of Environmental Conservation Department (Mandalay). There have four members for this group who are Khin Myo Sat Aye (Staff Officer of ECD- Nay Pyi Taw), Pyae Pyoe Kyaw (Staff Officer of ECD- Shan State), Aye Moe Kyaw (Deputy Staff Officer of ECD- Mandalay) and Khaing Thandar Kyaw (Deputy Staff Officer of ECD- Mandalay).

The target area of the report is Taungthaman Lake which is located in the Doke Hta Waddy River Basin of Mandalay. The reason of the choosing this area is due to a lot of fish dying in 2015. Besides, Taungthaman Lake has been surrounded by the Mandalay Industrial Zone, household, agricultural and livestock lands. Therefore, there have many concerns of influent wastewater from them into the lake. Furthermore, Taungthaman Lake and U Pein Bridge are the historic place of Myanmar and it is famous among Myanmar people and the tourists. Moreover, almost 2000 locals from the thirteen villages depend on the Taungthaman Lake for a living. Target area is shown in Figure 1.1-1.

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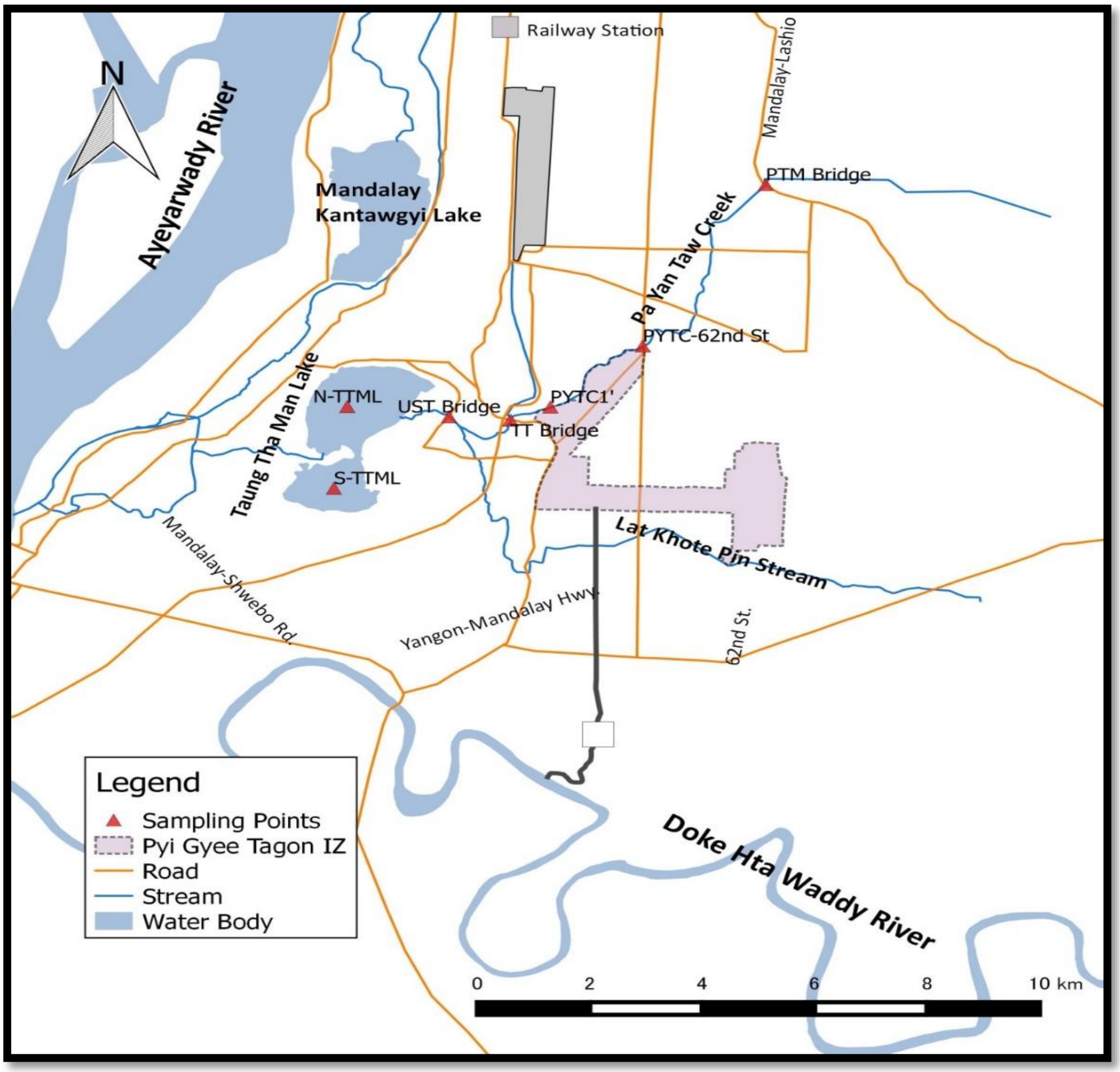


Source: ECD Mandalay

Figure 1.1-1 Target Area

1.2 Objective of water quality survey report

According to the Environmental Conservation Law (2012), Ministry of Natural Resources and Environmental Conservation may has a responsibility for laying down, carrying out and monitoring programmes for conservation and enchancement of the environment, and for conservation, control and abatement not to cause environmental pollution. Moreover, this Ministry may have to fullfill the related rules and regulations to maintain and promote the Environmental Quality. Environmental Quality Standards, one of the most important regulations, have not developed yet in Myanmar. It is not only the Ministry's reponsibility but also the key of the enforcement of the law. Therefore, the Ministry may need to investigate the actual status of the environment and may have to take an action for the safety of people by stipulating the related regualtion or plan.

Therefore, this report is aiming to access the water quality changes in Taungthaman Lake which are affected by the pollution sources nearby based on third and fourth water quality survey results of the project.

1.3 Survey Area

1.3.1 Water inlets of the Taungthaman Lake

The water inlets of the Taungthaman Lake are Pa Yan Taw Creek and Lat Khote Pin Stream. The Pa Yan Taw Creek passes the agricultural land, Mandalay Industrial Zone and residential area. There is a branch of Pa Yan Taw Creek, Kolumbo Channel which crosses the domestic quarter. The Lat Khote Pin Stream passes the agricultural and residential areas.

1.3.2 Water Usage of the Taungthaman Lake

Some villagers near the Taungthaman Lake do fishing for their living and use the lake for washing and bathing. Moreover, the lake has been used for fishery from the past. Both seasonal cultivation and duck farms have been established round and on the lake. It is also used for the recreation for enjoying view of the lake and U Pein Bridge as well as riding the sampan in the lake. Therefore, the water of the lake is used for agriculture, livestock, recreation and livelihood.

1.3.3 Information of Taungthaman Lake

Taungthaman Lake is situated in Amarapura Township of the Mandalay within the Doke Hta Waddy River Basin. Its area was 2500 acre hundred years ago and then it became about 800 to 1000 acre in normal rainfall. Sometimes it is around 1800 acre during the heavy rainfall and it has raised 9 fts to 15 fts depth. The water level of the lake drops from November to May and the rainy season is started from June to the beginning of October. Almost five million species of flora and fauna occur in the lake. The water of the lake flows into the Shwe Sar Yan Creek and then enters into the Ayeyarwaddy River.

1.3.4 Target Area

This report focuses on the water quality changes of Taungthaman Lake which would be affected by inlets. Pa Yan Taw Creek is concerned to the variety of pollution sources including Mandalay Industrial Zone and it is combined with the Lat Khote Pin Stream near the lake. Therefore, the target survey areas of the report are northern and southern parts of Taungthaman Lake as well as Pan Yan Taw Creek.

1.4 Pollution Source near the Target Area

There are seven townships in Mandalay District; Amarapura, Aungmyaetharzen, Chanayetharzan, Mahaaungmyay, Patheingyi, Pyigitagon. Taungthaman Lake is geologically connected with the Pyigyitagon Township which is located at the eastern part of the Taungthaman Lake. The inlets of the lake pass through the Pyigyitagon Township and the lake is located in Amarapura Township.

1.4.1 Mandalay Industrial Zone

Mandalay Industrial Zone has been established since 1990, located in Pyi Gyi Tagon township of Mandalay, and has 3530 plots on the 1820 acre. This Industrial Zone has involved 1292 industries in total; 392 in large, 304 in medium and 596 in small including distillery, sugar factory, textile industry, wood processing, plastic goods, battery, detergent, pharmaceutical, fertilizer, metal smelting, metal casting, tannery, paper mill and so on. Central Wastewater Treatment System for Mandalay Industrial Zone is under construction stage. Therefore, most of the industries directly discharge the wastewater into the water resources nearby and 10 inches pipeline. There have only 93 wastewater discharging industries in the industrial zone; 10 industries are discharging into 10 inches pipeline, 18 industries are discharging into Pan Yan Taw creek, 65 industries are discharging into No. 6 Irrigation water discharged channel respectively. There are 27 industries along the Pa Yan Taw Creek; the industrial type and number of these 27 industries are six distilleries, one candy factory, ten sugar factory, one textile industry, five tanneries, one paper ,ill and three cardboard factory.

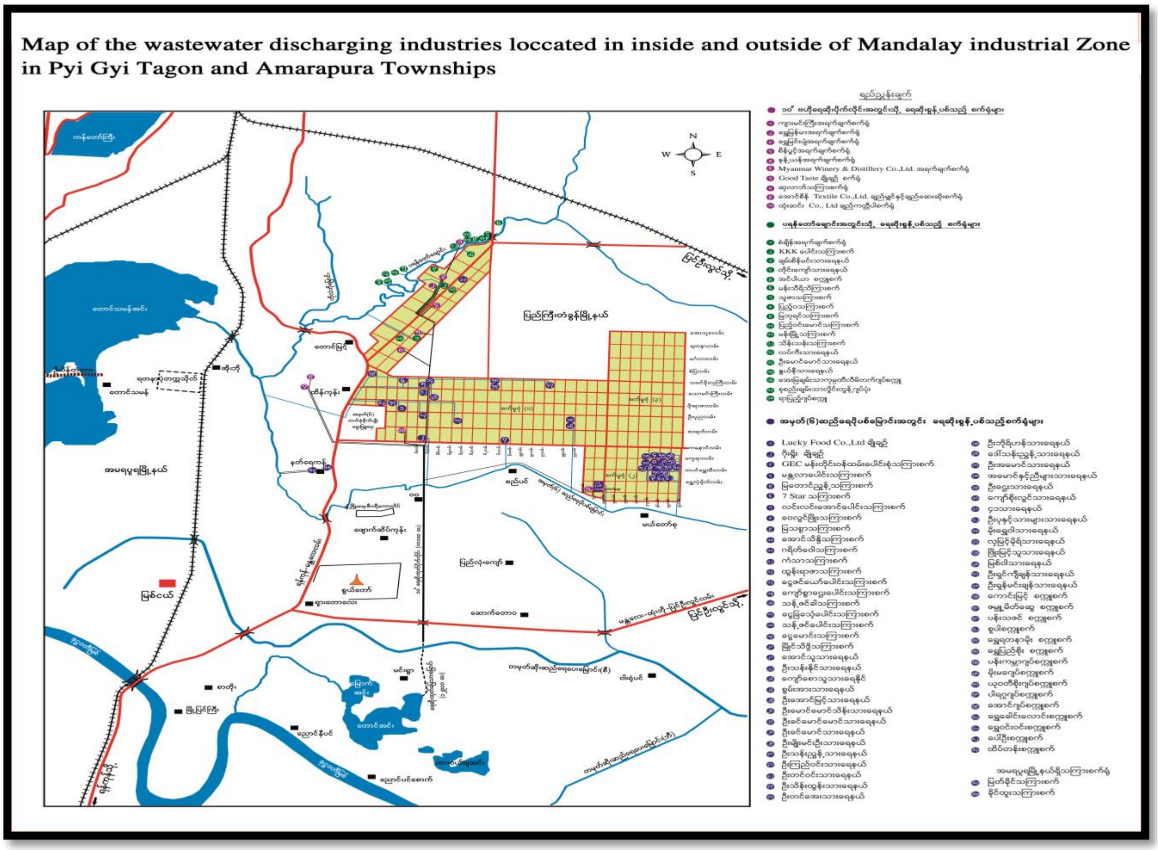
The list of industries along the Pa Yan Taw Creek and the plot map of Mandalay Industrial Zone are descried in Table 1.4-1and Figure 1.4-1.

Table 1.4-1 List of industries along Pa Yan Taw Creek

No.	Name of the Industry	Remark
1.	Kyar Min Gyi Distillery	
2.	Shwe Myanmar Distillery	
3.	Shwe Myin Pyan Distillery	
4.	Sein Pwint Distillery	Stopped
5.	Nant Yan Distillery	
6.	Good Taste Candy Factory	
7.	Su Lat sugar factory	
8.	Aung Sein Textile	
9.	San Chain Distillery	Stopped
10.	KKK Sugar Factory	
11.	Chan Sein Min Thar Tannery	
12.	Tyne Kyaw Tannery	
13.	Emperor Paper Mill	
14.	Man Thiri Sugar Factory	
15.	Thuzar Sugar Factory	
16.	Pyaewa Sugar Factory	
17.	Mya Bayin Sugar Factory	
18.	Pyae Win Maung Sugar Factory	
19.	Man Myoe Sugar Factory	

No.	Name of the Industry	Remark
20.	Thein Than Sugar Factory	
21.	Lucky Tannery	
22.	U Mg Mg Than Tannery	
23.	Nweni Tannery	Stopped
24.	Aye Mya Chanthar Cardboard Factory	
25.	Susee Chanthar Wave Cardboard Factory	
26.	Ya Pyae Cardboard Factory	
27.	Great Wall Sugar Factory	

Source: Mandalay City Development Committee



Source: MCDC

Figure 1.4-1 Plot map of Mandalay Industrial Zone

According to the aforementioned Figure 1.4-1, sugar factories seem to be the biggest pollution source in this area, followed by the distillery and tannery. But sugar factories are operated only between October and April of a year. Moreover, Ministry of Home Affairs announced to stop the operation of distilleries without wastewater treatment system on August 15th, 2017.

Regarding those industry types, i.e., distillery, candy factory, sugar factory, textile, tannery and paper mill and cardboard factory, the Emission Guideline was referred from the annex (1) of the National Environmental Quality (Emission) Guidelines (EQEG) (2015) as shown in Table 1.4-2. Based on these references, Table 1.4-3 was prepared to show the possible water pollutants discharged from these industries along the Pa Yan Taw Creek.

Table 1.4-2 Key Industries in Mandalay Industrial Zone and References to the Emission Guidelines

No.	Industry	Reference of Emission Guidelines in NEQG
1	Distillery	2.3.1.8 Breweries and Distilleries
2	Candy Factory	
3	Sugar Factory	2.3.1.7 Sugar Manufacturing
4	Textile	2.3.2.1 Textile Manufacturing
5	Tannery	2.3.2.2 Tanning Leather Finishing Manufacturing
6	Paper Mill	2.3.3.3 Pulp and Paper Mills
7	Cardboard Factory	

Source: Annex (1), Myanmar National Environmental Quality (Emission) Guidelines (NEQG) (2015)

Table 1.4-3 List of Parameters related to Suspected Pollutants from Industries along Pa Yan Taw Creek

No.	Parameters	Remark
1	5-day Biochemical oxygen demand	
2	Active ingredients / Antibiotics	
3	Adsorbable organic halogens	
4	Ammonia	
5	Biocides	
6	Cadmium	
7	Chemical oxygen demand	
8	Chloride	
9	Chromium (hexavalent)	
10	Chromium (total)	
11	Cobalt	
12	Color	
13	Copper	
14	Nickel	
15	Oil and grease	
16	Pesticides	
17	pH	
18	Phenol	
19	Sulfate	
20	Sulfide	
21	Temperature increase	
22	Total coliform bacteria	
23	Total nitrogen	
24	Total phosphorus	
25	Total suspended solids	
26	Zinc	

Source: Myanmar National Environmental Quality (Emission) Guidelines (EQEG) (2015)

1.4.2 Residential Quarter

Pyi Gyi Tagon Township has 28.5 km^2 in area, 8343/km^2 in density and its population is about 234,698. Pyi Gyi Tagon combines both the industrial and urban nature. Amarapura Township has 237,618 in population, 205 km^2 in area and 1160/km^2 in density. Most of the area of Amarapura Township is the rural communities and they depend on the Taungthaman Lake for their living. The villages near the Taungthaman Lake are Taungthaman Village, Da None

Village, Nat Yaae Kan Village, Hin Thar Bone Oe Village, Kan Peit Village,Let Pan Zin Village, Tha Gyi Yar Village and so on.

Yadanarbon University is situated at the eastern part of the lake in Amarapura. Therefore, there has a lot of hostels and restaurants to support the university students. Furthermore, area occupied by squatters or illegal tenants has been situated between northern-east of the lake and the Mandalay Industrial Zone which has no sanitary latrine system. The heavy rain causes floods around the Taungthaman Lake every year and the water has remained in the squatting area and it is dried in summer season.

Furthermore, there have around 73 restaurants near the edges of the U Pein Bridge situated between north and south of the Taungthaman Lake. These restaurants discharge the wastewater directly into the lake. Besides, there have around 45 small boats as the recreational facilities.

Therefore, Section 2.6.4 “Tourism and Hospitality Development” in EQEG’s Annex (1), is referred for the possible effluent parameter of the residential area. The general pollutants in the wastewater from the residential area are described in the following Table 1.4-4.

Table 1.4-4 List of General Pollutants from the Residential Area

No.	Parameters
1	Biological Oxygen Demand (BOD)
2	Chemical Oxygen Demand (COD)
3	Oil and Grease
4	pH
5	Total Coliform Bacteria
6	Total Nitrogen
7	Total Phosphorus
8	Total Suspended Solids

Source: Myanmar National Environmental Quality (Emission) Guidelines (EQEG) (2015)

1.4.3 Agriculture and Livestock

During the dry season starting from November to May of the year, the water level of the lake is dropped. Meanwhile, the bed of the lake appears and the cultivation on the lake starts. Seasonal crops including bean, corn, paddy, onion are planted on and around the lake. Besides, the duck farms are built on the brink of the lake all year round. The ducks swim near the strand of the lake and eat the pests of the cultivated vegetable. Therefore, EQEG’s Annex (1), 2.2.2 Annual Crop Production and 2.2.4 Poultry Production are referred for the potential effluent parameter from those agricultural activities. The general pollutants in the wastewater discharged from the seasonal crops plantation and duck farms, are described in the following Table 1.4-5.

Table 1.4-5 List of General Pollutant for the Seasonal Crops Plantation and Duck Farms

No.	Parameters
1	5-day Biochemical oxygen demand
2	Active ingredients / Antibiotics
3	Arsenic
4	Biological oxygen demand
5	Cadmium
6	Chemical oxygen demand
7	Heavy metals (total)
8	Lead
9	Mercury
10	Oil and grease
11	pH
12	Temperature increase
13	Total coliform bacteria
14	Total nitrogen
15	Total organochlorine pesticides
16	Total phosphorus
17	Total suspended solids

Source: Myanmar National Environmental Quality (Emission) Guidelines (EQEG) (2015)

1.5 Legal basis of water quality survey

1.5.1 Related Legislations for Water Environment Management

(1) Constitution of the Republic of the Union of Myanmar

The Constitution of the Republic of the Union of Myanmar was stipulated in 2008, expresses that the Union shall protect and conserve natural environment and every citizen has the duty to assist the Union in carrying out environmental conservation.

(2) Myanmar Environmental Conservation Law, Rules and regulations

Myanmar Environmental Conservation Law was enacted on 30th March, 2012 and expresses that Ministry may have a responsibility to carry out the activities regarding the conservation and the enchancement of the environment to protect and solve the pollution problem developing the related plans and regulations. Articles 10 and 11 express as the Ministry may formulate and modify Environmental Quality Standard (EQS) including surface water, groundwater, costal and marine, atmospheric, emission, effluent, noise, vibration and others with the approval of the Union Government and Committee. Article (13) describes the Ministry shall implement the the comprehensive monitoring system on the performance of waste disposal and possible pollution by itself or in co-ordination with relevent organizations. Besides, Articles 14 and 15 are related with installation of wastewater treatment plant.

Environmental Conservation Rules was adopted on 5th June, 2014 and Rules 26 (A) expresses the Department may have a responsibility to carry out the collection and compiling of data for the conservation and enhancement of the environment, doing research and conducting training program. Rule 38 expresses the amendment of EQS that may be necessary, for the interest of the public according to the time and location. Projects and business, identified by the Ministry in accordance with the Article 21 of the EC Law and EC Rules 62, are required to undertake IEE or EIA or to develop an EMP, and to obtain an ECC in accordance with the Article 21 of the EC Law and EC Rules 52, 53 and 55. The Rules 69 (A) expresses that any person shall not emit, ask to emit, dispose, ask to dispose, pile and ask to pile, by any means, hazardous waste or hazardous substances stipulated by notification according to any rules in this rules at any place which may affect the public directly or indirectly.

Environmental Impact Assessment Procedure (EIA Procedure) and National Environmental Quality (Emission) Guidelines (EQEG) were issued on 29 December 2015. No.108 of the EIA Procedure describes the project proponent shall submit monitoring reports to the Ministry not less frequently than every six months, as provided in a schedule in the EMP, or periodically as prescribed by the Ministry. No. 6 of the EQEG expresses that provision of the Guidelines shall be reflected in EMP and ECC as commitment of the project.

(3) Law for Conservation of Water Resources and Rivers and its rules

The Law for Conservation of Water Resources and Rivers was enacted in 2006 and the Rules were stipulated in 2013. This law intends to conserve and protect the water resources and rivers system, to smooth and safety waterways navigation along rivers and to protect the environmental impact. Its Rules 9 describes that if the Department repairs for the protection of water pollution and conservation of environment, the polluter who caused water pollution and environmental impact in the rivers will be fined the adequate amount of money for expense of repair.

(4) Myanmar National Water Policy

Myanmar National Water Policy was formulated in 2015 and its objectives are to disseminate knowledge and create awareness, develop responsible behaviors and create enabling environment for sustainable water use as well as to enhance water information, knowledge, know-how, technology, cooperation, consultation and partnerships. This policy describes that the present scenario of water resources and their management in Myanmar has given rise to several concerns, one of the important amongst them is “Water Quality Standards” should be set by relevant Ministries under the direction of the NWRC for the purpose of both “domestic and industrial” and “economical use and their discharges” to prevent surface, ground and marine water.

(5) Standing Order No.3 of Ministry of Industry (1), Water and Air Pollution Control Plan (1995)

This standing order was adopted by the Ministry of Industry aiming to develop the Cleaner Production in the industries under the Ministry of Industry (1) and to prevent the pollution caused by industries. It expresses about the water pollution control, specific factories for reporting monitoring results of wastewater, setting time frame for wastewater treatment facilities.

1.5.2 Water Quality Standards

Water Quality Standards (WQS) have not been developed yet in Myanmar, although the development of ambient Water Quality Standards is ongoing under MONREC with the assistance of Asian Development Bank (ADB) and Myanmar National Drinking Water Quality Standards has been already drafted in 2014. Therefore, in this report, other countries' WQS, namely, Vietnamese WQS, Japanese WQS and Ireland EPA Surface Water Quality Standards will be used in this report to evaluate the Water Quality Status of the Taungthaman Lake.

1.6 Survey objectives

The objective of the water quality survey for Taungthaman Lake and Pa Yan Taw Creek are as follows:

1) To access water quality changes and confirm the current water quality of the Taungthaman Lake from 3rd and 4th WQ survey results
2) To train the staffs of counterpart organizations on water quality survey

2 Survey Methods

2.1 Role and responsibility of survey team

The survey works were conducted by a local environmental consultant company under the management of JICA Expert Team. The staff of ECD (Mandalay) and MCDC participated the sampling activities to supervise the survey works and to get the experience during the project period.

2.1.1 3rd Water Quality Survey Sampling Team Members

The 3rd water quality survey sampling team members of the Doke Hta Waddy River Basin of Mandalay are shown in Table 2.1-1.

Table 2.1-1 Survey Team Members in 3rd Water Quality Survey

No	Members	Organization	Note
1.	Ms. Tomoe Takeda	JICA Expert Team	to supervise the survey activities
2.	Mr. Salai Thura Zaw	JICA Expert Team	Ditto
3.	Ms. Thet Su Su Hnin	JICA Expert Team	Ditto
4.	Mr. Josiah Bowles	ENVIRON Myanmar Co., Ltd	to conduct the survey activities
5.	Supporting surveyors	ENVIRON Myanmar Co., Ltd	to conduct the survey activities
6.	Mr. Pyae Pyo Kyaw	Environmental Conservation Department (Mandalay)	to supervise the survey works and to get the experience
7.	Staffs	Mandalay City Development Committee	to supervise the survey works and to get the experience

Source: JICA Expert Team

2.1.2 4th Water Quality Survey Sampling Team Members

The 4th water quality survey sampling team members of the Doke Hta Waddy River Basin of Mandalay are shown in Table 2.1-2.

Table 2.1-2 Survey team members in 4th Water Quality Survey

No	Members	Organization	Note
1.	Ms. Tomoe Takeda	JICA Expert Team	to supervise the survey activities
2.	Ms. Thet Su Su Hnin	JICA Expert Team	Ditto
3.	Ms. May Thinzar Kyaw	JICA Expert Team	Ditto
4.	Mr. Josiah Bowles	Social & Environmental Association-Myanmar	to conduct the survey activities
5.	Supporting surveyors	Social & Environmental Association-Myanmar	to conduct the survey activities
6.	Staffs	Environmental Conservation Department (Mandalay)	to supervise the survey works and to get the experience
7.	Staffs	Mandalay City Development Committee	to supervise the survey works and to get the experience

Source: JICA Expert Team

2.2 Sampling schedule

2.2.1 3rd Water Quality Survey Sampling schedule

The 3rd water quality sampling was undertaken from 8:00 AM to 16:30 PM of 23rd and 24th October 2017 in the Doke Hta Waddy River Basin of Mandalay.

2.2.2 4th Water Quality Survey Sampling schedule

The 4th water quality sampling was undertaken from 8:00 AM to 16:30 PM of 25th and 26th September 2017 in the Doke Hta Waddy River Basin of Mandalay.

2.3 Sampling points

The 3rd and 4th water sampling activities were conducted in the Doke Hta Waddy River Basin at the following sampling points.

2.3.1 3rd Water Quality Survey Sampling points

During the 3rd water quality survey, sampling activities were conducted in 15 different sampling points. Along the Doke Hta Waddy River, there have four sampling points; upstream and downstream of discharge point, discharge point and Myint Nge Bridge. There has only six sampling points regarding the Taungthaman Lake and Pa Yan Taw Creek, these points are considered for this report to access the water quality changes from upstream of water inlet and the lake. The three sampling points of Pa Yan Taw Creek are PTM Bridge, PYTC1' and TT Bridge. The point at the UST Bridge is situated under the junction of Pan Yan Taw Creek and Lat Khote Pin Stream. These sampling points of the creek show the behavior of pollution sources nearby. There has only two sampling points at the centers of the northern and southern parts of Taungthaman Lake, namely N-TTML and S-TTML which can indicate the actual water quality level of the lake. The 3rd water quality survey sampling points and time of Taungthaman Lake and Pa Yan Taw creek are shown in Table 2.3-1.

Table 2.3-1 3rd Water Quality Survey Sampling Points and Time of Taungthaman Lake and Pa Yan Taw Creek

Location Name	Sampling Date	Sampling Time	Location	
			Latitude	Longitude
PTM Bridge (Paw Taw Mu Bridge)	23-1-2017	9:29	21.9457	96.1311

Location Name	Sampling Date	Sampling Time	Location	
			Latitude	Longitude
PTYC-1' (Pa Yan Taw Creek [Myo Ma Aung Myin Street])	23-1-2017	12:59	21.9015	96.094
TT Bridge (Tagon Taing Bridge)	23-1-2017	12:13	21.8989	96.0871
UST Bridge (U Shwe Taung Bridge)	23-1-2017	15:36	21.8996	96.0766
N-TTML (Northern Taungthaman Lake)	24-1-2017	10:35	21.9016	96.0591
S-TTML (Southern Taungthaman Lake)	24-1-2017	10:35	21.8854	96.0568

Source: JICA Expert Team

2.3.2 4th Water Quality Survey Sampling points

During the 4th water quality survey, water samples were collected from the 15 different sampling points. There has seven sampling points regarding the Taungthaman Lake and Pa Yan Taw Creek, these points are taken into account for this report to access the water quality changes of the lake due to the water inlet. The four sampling points of Pa Yan Taw Creek are PTM Bridge, PYTC-62nd St, PYTC1' and TT Bridge to access the water quality affected by the pollution sources nearby. The point at the UST Bridge is situated under the junction of Pan Yan Taw Creek and Lat Khote Pin Stream. There has two sampling points at the centers of the northern and southern part of the Taungthaman Lake to investigate the actual water quality levels of the lake. The 4th water quality survey sampling points and time of Taungthaman Lake and Pa Yan Taw are shown in Table 2.3-2.

Table 2.3-2 Sampling Points and Time of Taungthaman Lake and Pa Yan Taw creek in 4th Survey

Location Name	Sampling Date	Sampling Time	Location	
			Latitude	Longitude
PTM Bridge (Paw Taw Mu Bridge)	2-10-2017	10:48	21.9457	96.1311
PTYC-62nd Str. (Pa Yan Taw Creek [on 62nd street, upstream from Pyi Gyi Tagon IZ])	2-10-2017	11:50	21.9137	96.1099

Location Name	Sampling Date	Sampling Time	Location	
			Latitude	Longitude
PTYC-1’ (Pa Yan Taw Creek [Myo Ma Aung Myin Street])	2-10-2017	15:30	21.9015	96.094
TT Bridge (Tagon Taing Bridge)	2-10-2017	14:36	21.8989	96.0871
UST Bridge (U Shwe Taung Bridge)	2-10-2017	16:50	21.8996	96.0766
N-TTML (Northern Taungthaman Lake)	3-10-2017	16:11	21.9016	96.0591
S-TTML (Southern Taungthaman Lake)	3-10-2017	16:40	21.8854	96.0568

Source: JICA Expert Team

2.4 Survey parameter

2.4.1 Measurement parameter

The water quality survey team undertakes on-site measurement and sampling collection during the survey time. During the 3rd water quality survey, nine parameters for on-site measurement and twenty-eight parameters for laboratory analysis were analyzed. For the 4th water quality survey, nine parameters for on-site measurement and nineteen parameters for laboratory analysis were analyzed.

There are a number of factories such as distilleries, paper mill, textile and tannery as well as residential area which are situated at the upstream of the Pa Yan Taw Creek and water catchment of the Taungthaman Lake. Moreover, residential area, agricultural and livestock area are located on and around the Taungthaman Lake. Therefore, the potential pollutant; Total Suspended Solid (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD Cr), total coliforms, Total Phosphorus (T-P), Total Nitrogen (T-N), lead (Pb) and arsenic (As), totally eight parameters will be focused in this report.

TSS is selected to access inorganic and organic particles in the water, which would be affected by the discharge of industry and residential area. BOD and COD are selected to estimate the organic pollution of the water and they are also the important indicators of overall water quality. Total coliforms represent fecal and other bacteria which are the indicators of possible presence of pathogenic micro-organisms. T-P and T-N are the nutrient parameters and they are selected to estimate the eutrophication status of the water. Pb and As are the heavy metals to access the health risk to aquatic life of the lake and residents.

2.4.2 The Levels of Water Quality Standards

Surface Water Quality Standards of Myanmar have not been developed yet. Therefore, reference standards of foreign countries such as Japan Water Quality Standards, Vietnam Water Quality Standards and Ireland Environmental Protection Agency will be used as references. Table 2.4-1 shows the reference standards for surface water quality to make the comparison with the results of surveys.

Table 2.4-1 Referenced Surface Water Quality Standards

No.	Parameter	Unit	Japan WQS[1]					Vietnam WQS[2]	Ireland EPA[3]
			Human Health	River (D)	River (E)	lake (B)	Lake (V)	B1	A3 waters
1	BOD	mg/l	-	≤8	≤10	-	-	15	7
2	Total Coliform	MPN/100 ml	-	-	-	-	-	7500	100,000
3	TSS	mg/l	-	≤100	-	≤15	-	50	-
4	COD Cr	mg/l	-	-	-	≤5 (Mn)	-	30	40
5	T-P	mg/l	-	-	-	-	≤0.1	-	-
6	T-N	mg/l	-	-	-	-	≤1	-	20
7	Pb	mg/l	≤0.01	-	-	-	-	0.05	0.05
8	As	mg/l	≤0.01	-	-	-	-	0.05	0.10

Source: 1- Japan Water Quality Standards; River (D): Water for agricultural use, River (E): Does not have bad odor, Lake (B): Fishery of Carp etc. and water for agricultural use, Lake (V): Fishery class for marine products such as carp and agricultural water etc., CAL: For conservation of aquatic life, 2- Vietnam Water Quality Standards; B1: For Irrigation, 3- Parameters of Water Quality, Interpretation and Standards, Ireland Environmental Protection Agency; A3: for Surface Water

2.5 Sampling and measurement

2.5.1 Sampling method

A water quality survey team conducted on-site measurement and sampling collection during the survey times. During the 3rd water quality survey, twenty-eight parameters for laboratory analysis were collected and sent to the laboratory in Thailand. For the 4th water quality survey, seventeen parameters for laboratory analysis were analyzed in Japanese laboratory while the other two parameters that requires immediate analysis were analyzed in Myanmar laboratory. The sampling activities were conducted in accordance with the Standards Operation Procedure for surface water sampling of the project. Some parameters were analyzed at the MCDC's water laboratory. The collected samples were preserved referring to the Japanese Industrial Standards (JIS) and other official procedures summarized in Table 2.5-1. Figure 2.5-1 shows the picture of on-site sampling in the 4th survey.

Table 2.5-1 Sample Preservation Methods

No.	Parameter	Water Sample Bottle	Example of required water sample volume (ml)	Methods
1	BOD	P, G	1000	Store it in a cool, dark place at between 0˚C and 10˚C. Testing should be carried out as soon as possible.
2	Total Coliform	P (sterile)	250	Cool<10˚C, 0.08% Na2S2O3 (0.1 ml 10%Na2S2O3/125 ml)& 15%EDTA
3	TSS	P, G (B)	500	Quickly filter, separate and measure. TDS and TR increase if stored in a soft glass bottle. When iron or manganese is included, close the lid tightly to avoid any exposure to the air, and store it in a dark place at 10˚C or lower (but without freezing).
4	COD Cr	P, G	100	Store it in a cool, dark place at between 0˚C and 10˚C. Measurements should be carried out as soon as possible.
5	T-P	G (A)	100	These can preserve by adding sulfuric or nitric acid until the pH around 2.
6	T-N	P	500	25%H2SO4 to pH <2, Cool ≤6˚C, 0.008% Na2S2O3 to de-chlorinate
7	Pb	P	500	1+1 HNO3 to pH <2
8	As	P	500	1+1 HNO3 to pH <2

G: Glass bottles, P: Poly bottles

(A): washed with acid, (B): borosilicate glass, (S): washed with organic solvent for the parameters sensitive to photochemical reactions, samples should be kept in amber-colored glass bottles or covered with black boxes.

Source: JICA Expert Team

Source: JICA Expert Team

Figure 2.5-1 Photo of on-site sampling

2.5.2 Laboratory analysis method

The water sample analysis in laboratories was conducted both in Myanmar and in Japan. The following Table 2.5-2 shows the method and the name of laboratory for the target parameters at the 4th survey in this report.

Table 2.5-2 Laboratory Analysis Methods for samples (4th water quality survey)

No.	Parameter	Method	Name of laboratory
Laboratory analysis in Myanmar			
1	BOD	Respirometric method (HACH Method 10099)	DOWA Eco-system–Myanmar Co., Ltd. for survey in Hlaing River basin
		Membrane electrode method (SM 2012:5210 B and 4500-O G)	REM-UAE Laboratory and Consultant Co., Ltd. for survey in Doke Hta Waddy River basin
2	Total Coliform	Standard total coliform fermentation method (APHA 9221 B)	DOWA Eco-system–Myanmar Co., Ltd. for survey in Hlaing River basin
		Multiple tube fermentation technique (SM 2012:9221 B)	REM-UAE Laboratory and Consultant Co., Ltd. for survey in Doke Hta Waddy River basin
Laboratory analysis in Japan			
1	Total Suspended Solids (TSS)	Environment Agency Notification No. 59, 1971, Appendix, Table 9	OSUMI CO., Ltd.

2	COD Cr	JIS K0102 (2016) 20.1	OSUMI CO., Ltd.
3	Total phosphorus (T-P)	JIS K0102(2016) 46.3.1	OSUMI CO., Ltd.
4	Total nitrogen (T-N)	JIS K0102(2016) 45.2	OSUMI CO., Ltd.
5	Lead (Pb)	JIS K0102(2016) 54.4	OSUMI CO., Ltd.
6	Arsenic (As)	JIS K0102(2016) 61.4	OSUMI CO., Ltd.

Source: JICA Expert Team

3 Results and Discussion

3.1 Water Quality Results

The 3rd WQS results are used as background data comparing with the 4th WQS results to access the water quality changes of the lake. The 3rd WQS was conducted in January 2017 and the results represent for the dry season. The 4th WQS represents the rainy season data.

3.1.1 Water quality results

The following Table 3.1-1 expresses the water quality results of the target sampling point of 3rd WQS in Pa Yan Taw Creek and Taungthaman Lake.

Table 3.1-1 3rd Water Quality Results of Target Points

No	Parameters	PTM Bridge	PYTC-62nd St	PYTC1'	TT Bridge	UST Bridge	N-TTML	S-TTML
1	BOD (mg/l)	7.92	23.67	337.50	482.50	206.25	67	15.25
2	Total Coliform (MPN/100ml)	1,300	-	33,000	-	79,000	28,000	33
3	TSS (mg/l)	80	-	208	25	210	47	50
4	COD Cr (mg/l)	14.22	44.70	883.92	1056.64	215.39	103.63	62.99
5	T-P (mg/l)	0.20	0.52	-	-	3.65	2.63	0.44
6	T-N (mg/l)	0.45	2.63	-	-	<0.05	19.22	0.83
7	Pb (mg/l)	-	-	-	-	0.1914	<0.0005	0.0016
8	As (mg/l)	-	-	-	-	0.0081	0.0044	0.0022

Note: T-P and T-N in lakes are compared with Japanese environmental standard for lakes (V Class: for fishery for smelt etc., industrial water, agricultural water, and conservation of the environment). The other parameters are compared with Vietnamese surface water quality standard (B1 class for irrigation).

Source: ECD-Mandalay based on the data from JICA Expert Team

The following Table 3.1-2 presents the water quality results of the target sampling point of 4th WQS in Pa Yan Taw Creek and Taungthaman Lake.

Table 3.1-2 4th Water Quality Results of Target Points

No	Parameters	PTM Bridge	PYTC-62nd St	PYTC1'	TT Bridge	UST Bridge	N-TTML	S-TTML
1	BOD (mg/l)	6.6	2.3	5.1	4.8	5.6	6.0	5.4
2	Total Coliform (MPN/100ml)	-	-	> 160,000	-	> 160,000	17,000	24,000
3	TSS (mg/l)	44	68	36	28	22	15	14
4	COD Cr (mg/l)	14	23	32	34	31	28	28

5	T-P (mg/l)	0.063	0.28	0.31	0.39	0.31	0.38	0.36
6	T-N (mg/l)	0.63	2.1	2.1	3.0	2.0	2.0	1.7
7	Pb (mg/l)	-	<0.005	<0.005	<0.005	0.0051	<0.005	<0.005
8	As (mg/l)	-	0.0032	0.0035	0.0034	0.0041	0.0037	0.0042

Note: T-P and T-N in lakes are compared with Japanese environmental standard for lakes (V Class: for fishery for smelt etc., industrial water, agricultural water, and conservation of the environment). The other parameters are compared with Vietnamese surface water quality standard (B1 class for irrigation).

Source: ECD-Mandalay based on the data from JICA Expert Team

In Table 3.1-1 and Table 3.1-2, pink color fillings represent the maximum point of each parameter and the values in red show the results that are above the reference standards.

3.1.2 Basic parameters

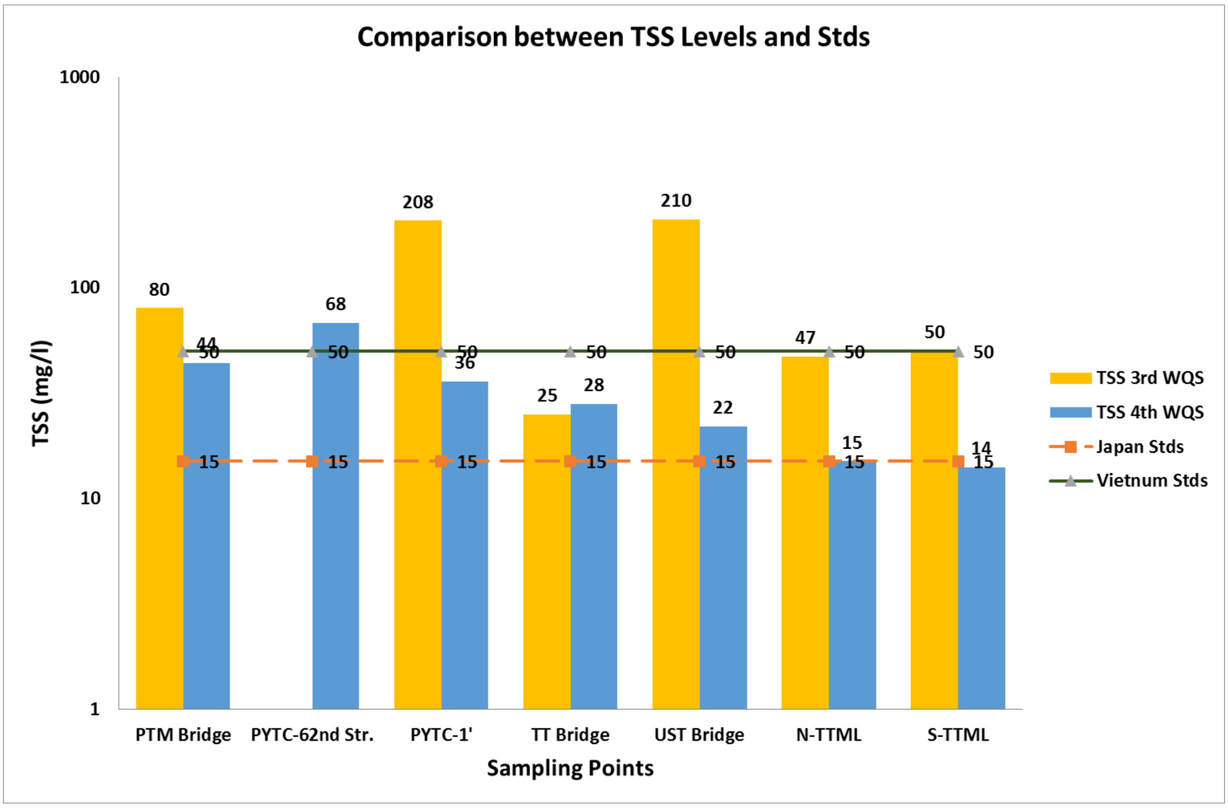
(1) Total Suspended Solids (TSS)

TSS is investigated to estimate the conditions of the water quality. TSS is a physical parameter which is used to describe the inorganic and organic particles of the water body. And the most common pollutant in the world is the dirt in the form of TSS. The high concentration of TSS will cover the aquatic life and interfere with the sufficient oxygen transfer. Besides, it will reduce the light penetration in the surface water. It can seriously damage fishery water and affect the fish life. It will give the rise to septic and offensive conditions and may indicate the presence of unsatisfactory sewage effluent discharge.

Figure 3.1-1 shows comparison of TSS levels with reference standards for 3rd and 4th WQS. The level of TSS of 3rd WQS results differs from the point to point and the level of 4th is slightly decreased from upstream to downstream in the flow direction. However, the TSS level of the 3rd survey is much higher than one of the 4th survey. Compared with the Vietnamese Surface Water Quality Standards for irrigation for reference, the TSS level of 3rd survey exceed the reference standard at PTM Bridge, PYTC-1' and UST Bridge. Especially the results at PYTC-1' and UST Bridge were more than four-times higher than the reference standard. On the other hand in the 4th survey, only PYTC-62nd St was around 1.4 times higher than reference standard. The point of PYTC-62nd St was not analyzed in 3rd WQS.

Compared with Japanese lake water quality standards for agricultural use to access the water quality of Taungthaman Lake, the 3rd WQS result is 3.1 times higher than the Japanese standard at N-TTML and 3.3 times higher at S-TTML. The TSS value of 4th WQS in the lake met with the standards.

The 3rd WQS samples were taken in the dry season. Thus it is likely that the water level is low and the concentration of TSS become higher. The 4th WQS represents the rainy season and the concentration is lower due to dilution effect by large water volume.



Source: ECD-Mandalay based on the data from JICA Expert Team

Note: The sample of PYTC-62nd St was not analyzed in 3rd WQS

Figure 3.1-1 Comparison between TSS Levels and Standards

3.1.3 Organic substances

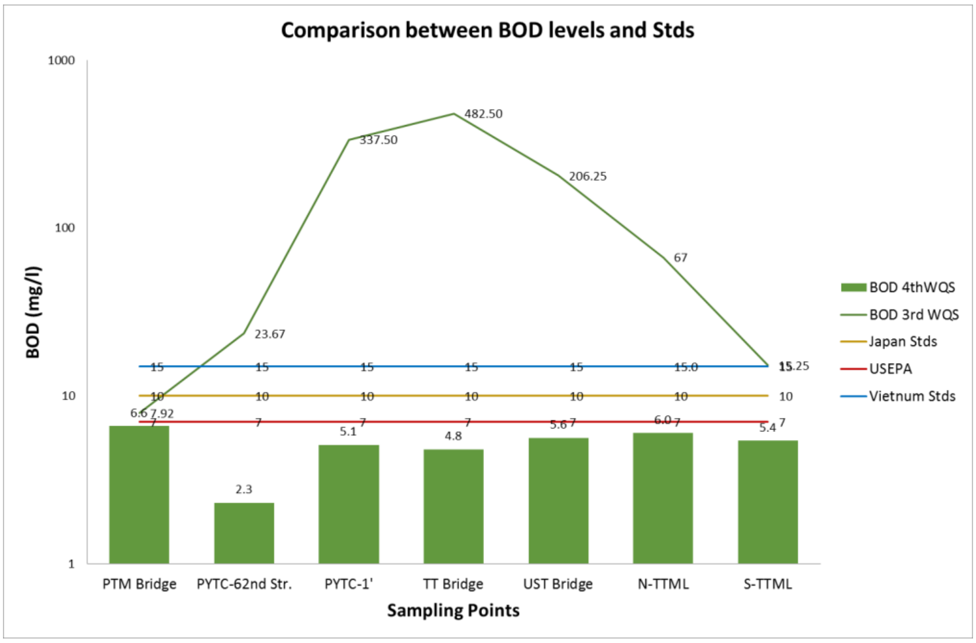
In consideration for the organic pollutants from the pollution sources in the Pa Yan Taw Creek and Taungthaman Lake, BOD and COD are investigated to estimate the pollution status in these water bodies. BOD is measured as the amount of oxygen consumed by microorganisms during decomposition of organic matter and it can indicate biodegradable organic compound of water. COD is the amount of oxygen required for degradation of the organic compounds of wastewater to occur. The bigger COD value the wastewater has, the more oxygen it consumes in the water bodies.

(1) Biochemical Oxygen Demand (BOD)

Figure 3.1-2 shows comparison of BOD levels with reference standards for 3rd and 4th surveys. The levels of BOD in the 3rd WQS were extremely high and lower in the 4th WQS. The level of 3rd WQS is higher than the 4th WQS. Compared with the Vietnamese Surface Water Quality Standards for irrigation, the 3rd WQS results are 1.6 times higher at PYTC-62nd St, 23 times higher at PYTC-1', 32 times at TT Bridge and 14 times higher at UST Bridge. On the other hand, Japanese surface water quality standard for Class E is stricter than the Vietnamese standard for irrigation water.

Compared with Vietnamese Surface Water Quality Standards for irrigation to access the water quality of Taungthaman Lake, the result is 4.5 times higher than the standard at N-TTML in the 3rd WQS. And the water quality at S-TTML in the 3rd WQS meets almost with the Vietnam standard. The water quality results of 4th WQS meet with the Standards. On the other hand, there is no BOD level for lake water quality in the Japan Standard.

The 3rd WQS is for dry season so the water level is low and the concentration of BOD is high. The 4th WQS represents for the rainy season so the concentration is lower due to the high water volume.



Source: ECD-Mandalay based on the data from JICA Expert Team

Figure 3.1-2 Comparison between BOD Levels and Standards

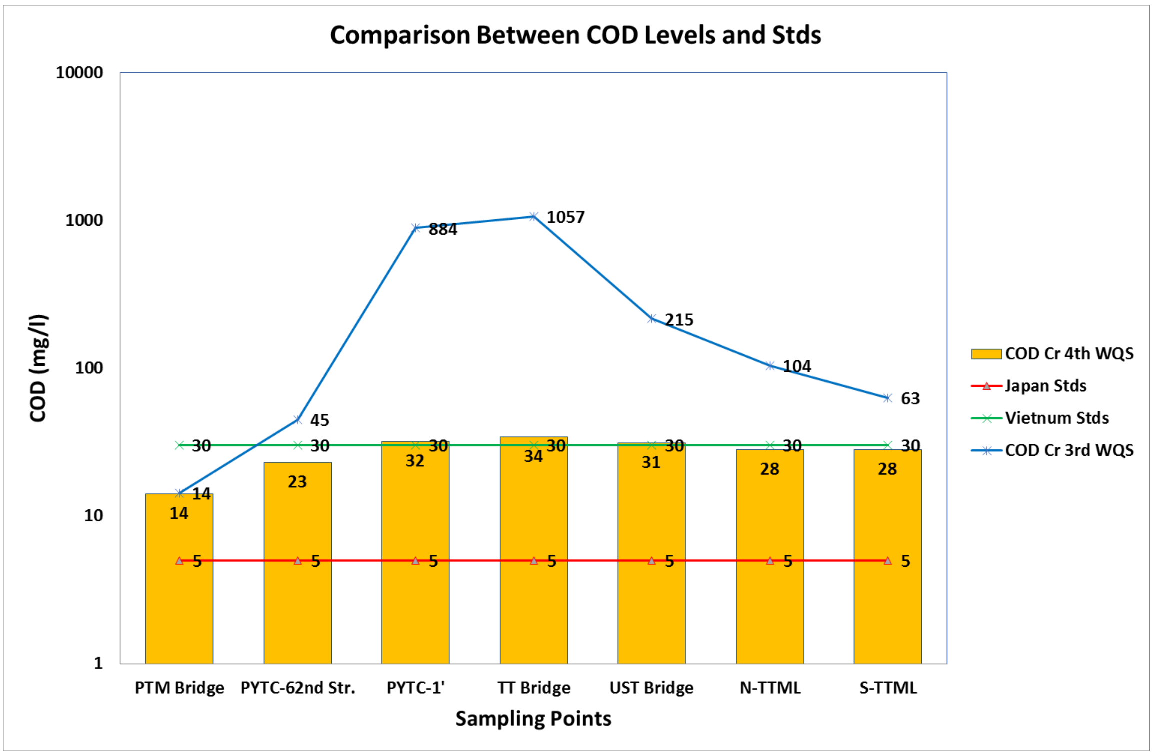
(2) Chemical Oxygen Demand (COD)

Figure 3.1-3 shows comparison of COD levels with standards for 3rd and 4th surveys. The levels of COD in the 3rd WQS were extremely high in large part and lower in the 4th WQS. The level of 3rd WQS is mostly much higher than that of the 4thWQS. Compared between the

WQS results and the Vietnam Surface Water Quality Standards for irrigation, the result in 3rd WQS is 1.5 times higher than the standard at PYTC-62nd St, 29 times higher PYTC-1', 35 times at TT Bridge and 7.2 times higher at UST Bridge. On the other hand, there is no COD-Cr level for river water quality in the Japanese standard.

Referred to Vietnamese Surface Water Quality Standards for irrigation to access the water quality of Taungthaman Lake, the result is 3.5 times higher in the 3rd WQS. And the result of S-TTML in the 3rd WQS is closer to but still slightly higher than the Vietnamese standard. The COD-Mn level of lake water quality standard for Class E in Japan is stricter than the Vietnamese standard for irrigation water even though COD-Mn result is lower than COD-Cr result due to the difference in the analytical method. The COD of Japanese standard for lakes is specified for COD-Mn that is analyzed by Manganese catalyst process. The COD results of the lake in the 4th WQS meet with the Standards.

The 3rd WQS is conducted in the dry season so the water level is low and the concentration of COD could be high. The 4th WQS represents the rainy season so the concentration is low with the high water volume.



Source: ECD-Mandalay based on the data from JICA Expert Team

Figure 3.1-3 Comparison between COD Levels and Standards

3.1.4 Bacteria

According to the wastewater pollutants from the pollution sources of Pa Yan Taw Creek and Taungthaman Lake, total coliform is investigated to estimate the possible conditions of the water quality in terms of bacteria. Total coliform indicates the degree of pollution and sanitary of water.

(1) Total coliform

Table 3.1-3 shows total coliform levels in the 3rd and 4th surveys and Vietnamese standard. Figure 3.1-4 shows a comparison of total coliform levels with the standards for the 3rd and 4th surveys. The levels of total coliform in some points of 3rd WQS and 4th WQS are extremely high. The level of total coliform in the 4th WQS is much higher than that in the 3rd survey. Compared with the Vietnamese Surface Water Quality Standards for irrigation, the WQS results are 4.4 times higher than the standards at PYTC-1' and 10 times at UST Bridge in the 3rd WQS as well as it is more than 20 times higher at PYTC-1' and UST Bridge in the 4th WQS. The water for the point of PYTC-62nd St and TT Bridge were not analyzed in the 3rd WQS. It was same to PTM Bridge, PYTC-62nd St and TT Bridge in the 4th WQS.

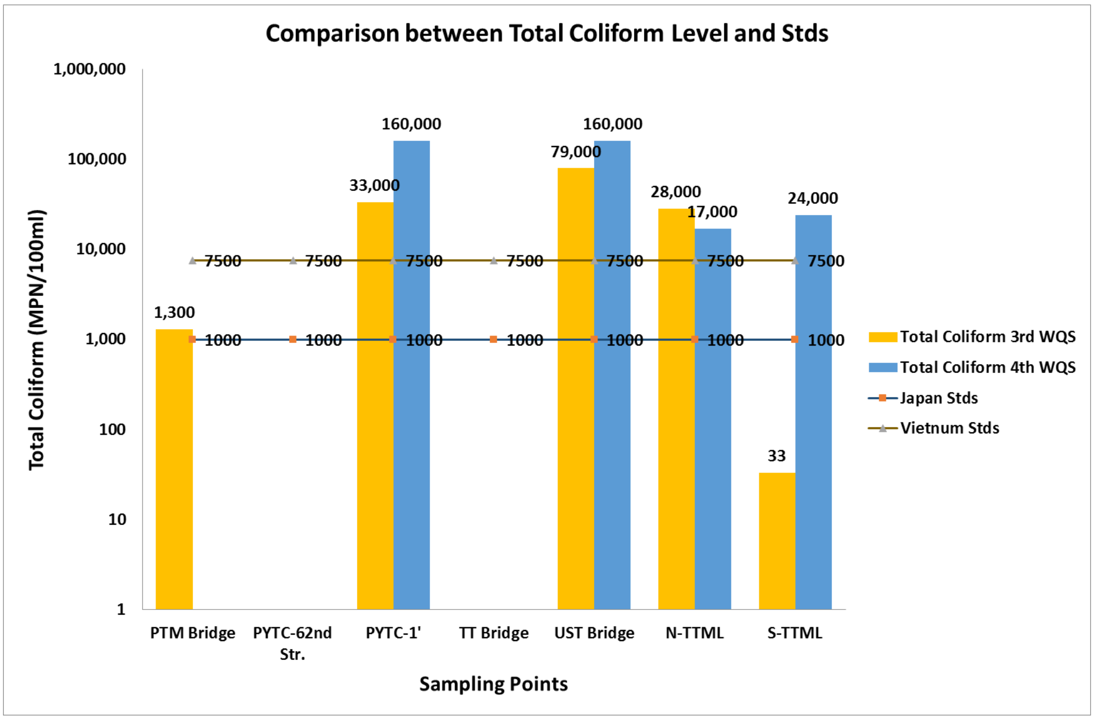
Referred to Vietnamese Surface Water Quality Standards for irrigation to access the water quality of Taungthaman Lake, the result is 3.7 times higher at N-TTML in the 3rd WQS and 3.2 times higher at S-TTML in the 4th WQS.

The 3rd WQS is for dry season and the 4th WQS represents for the rainy season. According to the flooding behavior of this area, the impurities of the squatting area are washed out into the water bodies. Therefore, it is likely that the concentration of total coliform in the rainy season is higher than the dry season at most points.

Table 3.1-3 Total Coliform Levels in 3rd and 4th surveys and Vietnamese Standard

No	WQ/Standard	PTM Bridge	PYTC-62nd St	PYTC1'	TT Bridge	UST Bridge	N-TTML	S-TTML
1	3rd WQS	1300	-	33000	-	79000	28000	33
2	4th WQS	-	-	>160,000	-	>160,000	17000	24000
3	Vietnamese Standard	7500	7500	7500	7500	7500	7500	7500

Source: ECD-Mandalay based on data from JICA Expert Team



Note: PYTC-62nd St and TT Bridge in the 3rd WQS as well as PTM Bridge, PYTC-62nd St and TT Bridge in the 4th WQS were not surveyed for total coliforms.

Source: ECD-Mandalay based on the data from JICA Expert Team

Figure 3.1-4 Comparison between Total Coliform levels and standards

3.1.5 Nutrients

According to the wastewater pollutants from the pollution sources of Pa Yan Taw Creek and Taungthaman Lake, T-N and T-P are investigated to estimate the possible conditions of the water quality in terms of nutrients. T-N is the nutrient parameter and the main sources of nitrogen compounds in water are fertilizers and domestic wastewater. It may lead to the eutrophication. T-P is the nutrient parameter and the main sources of nitrogen compounds in water are human and animal waste, soil erosion, detergents, septic system and runoff from farmland or fertilized lawns. It may lead to the eutrophication.

(1) Total nitrogen (TN)

Table 3.1-4 shows T-N levels in the 3rd and 4th surveys and reference standards, and Figure 3.1-5 shows comparison between T-N levels in the 3rd and 4th surveys and the standards. The levels of T-N at all points of Pa Yan Taw Creek and Taungthaman Lake in the 3rd WQS and 4th WQS are in line with the Ireland EPA for surface water

Referred to Japanese Lake Water Quality Standards for agricultural water to access the water quality of Taungthaman Lake, the T-N level in the 3rd WQS is 19 times higher than the standard at N-TTML but less than the standard at S-TTML. On the other hand, in the 4th WQS, the T-N level in the 4th survey is less than the standard at S-TTML but 1. 7 times higher than the standard at S-TTM. There is no T-N level in the Vietnamese Standards.

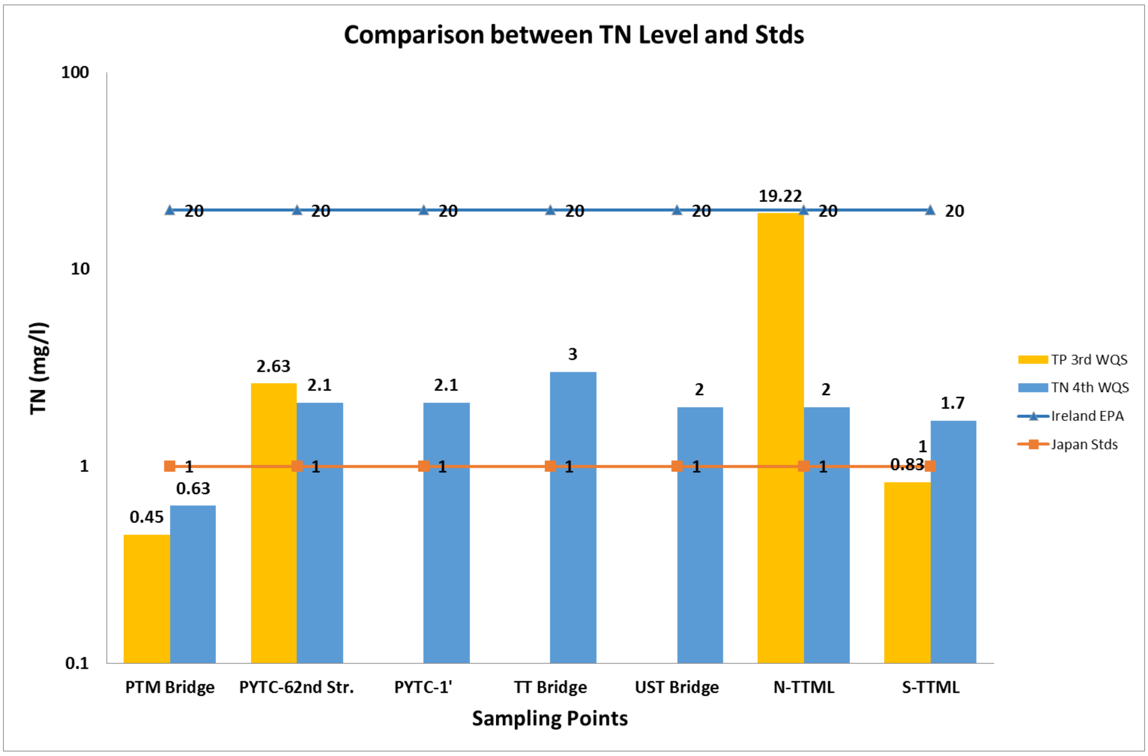
The 3rd WQS is conducted in the dry season and the 4th WQS represents the rainy season. T-N concentration of N-TTML in 3rd WQS is much higher than that in the 4th survey.

Table 3.1-4 T-N Levels in 3rd and 4th surveys and Standards

No	WQ	PTM Bridge	PYTC-62nd St	PYTC1'	TT Bridge	UST Bridge	N-TTML	S-TTML
1	3rd WQS	0.45	2.63	-	-	<0.05	19.22	0.83
2	4th WQS	0.63	2.1	2.1	3	2	2	1.7
3	Japan Stds	1	1	1	1	1	1	1
4	Ireland EPA	3	3	3	3	3	3	3

Note: The T-N for the points PYTC1' and TT Bridge were not analyzed in the 3rd WQS.

Source: ECD-Mandalay based on the data from JICA Expert Team



Note: The T-N for the points PYTC1' and TT Bridge were not analyzed in the 3rd WQS.

Source: ECD-Mandalay based on the data from JICA Expert Team

Figure 3.1-5 Comparison between T-N levels and standards

(2) Total phosphorus (TP)

Table 3.1-5 shows T-P levels in the 3rd and 4th surveys and reference standards. Figure 3.1-6 shows comparison between T-P levels in 3rd and 4th surveys and the standards. Referred to Japanese Lake Water Quality Standards for agricultural water to access the water quality of Taungthaman Lake, the T-P levels of 3rd WQS are 26.3 times higher than the standard at N-TTML and 3.4 times higher at S-TTML., and the 4th WQS results are 3.8 times higher at N-TTML and 3.6 times higher at S-TTML. There is no TN level for Vietnam Standards and Standards for the Creek.

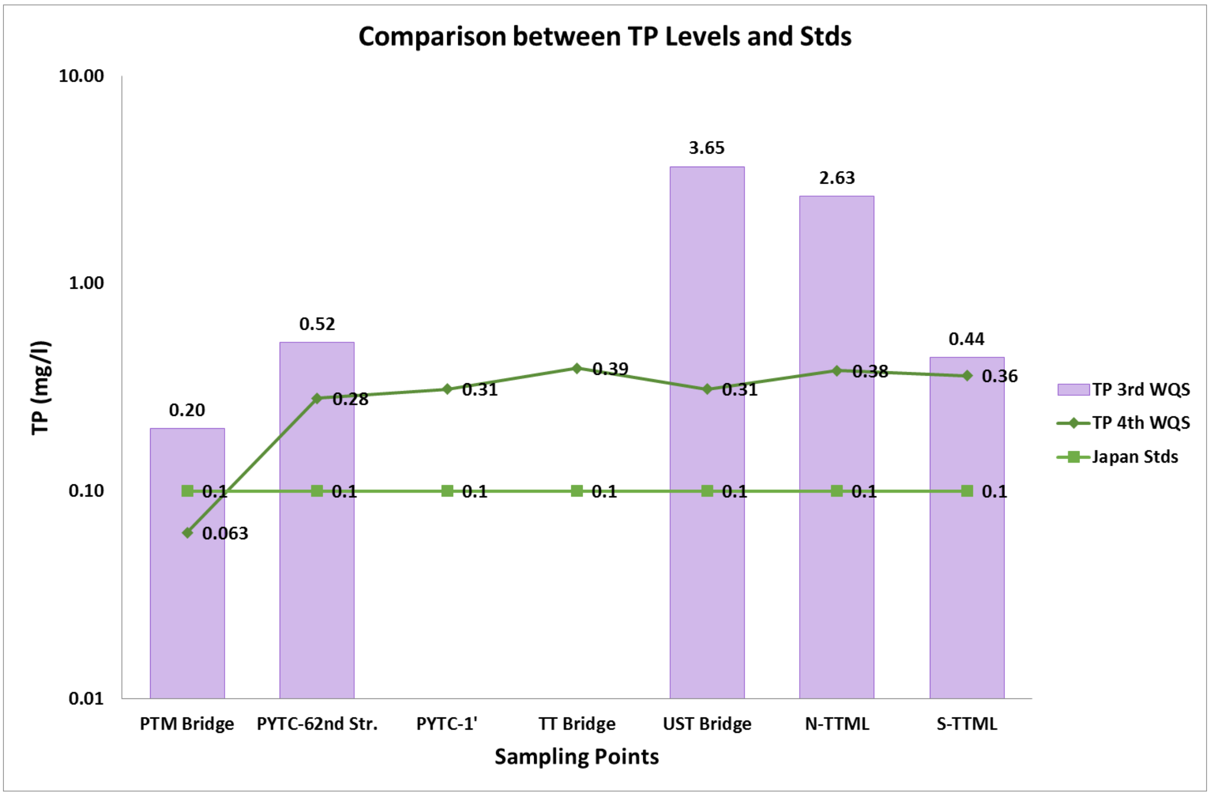
The 3rd WQS is for dry season and the 4th WQS represents the rainy season. T-P concentration of N-TTML in the 3rd WQS is much higher than the 4th survey because most of the restaurants, domestic household and duck farms are located in this area. All points of the lake show high TP level and thus it can lead to the eutrophication process.

Table 3.1-5 Comparison between T-P and Standards

No	WQ	PTM Bridge	PYTC-62nd St	PYTC1’	TT Bridge	UST Bridge	N-TTML	S-TTML
1	3rd WQS	0.20	0.52	-	-	3.65	2.63	0.44
2	4th WQS	0.63	0.28	0.31	0.39	0.31	0.38	0.36
3	Japan Stds	-	-	-	-	-	0.1	0.1

Note: The T-N for the points PYTC1’ and TT Bridge were not analyzed in the 3rd WQS.

Source: ECD-Mandalay based on the data from JICA Expert Team



Note: The T-N for the points PYTC1' and TT Bridge were not analyzed in the 3rd WQS.

Source: ECD-Mandalay based on the data from JICA Expert Team

Figure 3.1-6 Comparison between T-P levels in 3rd and 4th surveys and with standards

3.1.6 Heavy metals

In consideration of the wastewater pollutants from the pollution sources of Pa Yan Taw Creek and Taungthaman Lake, lead (Pb) and arsenic (As) are considered to estimate the possible conditions of the water quality.

Pb is a heavy metal and it is found in coal ash, industrial waste, paint, pipes and naturally occurring. The exposure of lead (over 15 ppb) can affect the nervous and reproductive systems, cause muscle and joint pain, and damage the brain.

As it is a heavy metal and it is mainly intake via the food and drinking water. The long term exposure of arsenic in drinking water tends to be the risk of skin cancer.

(1) Lead (Pb)

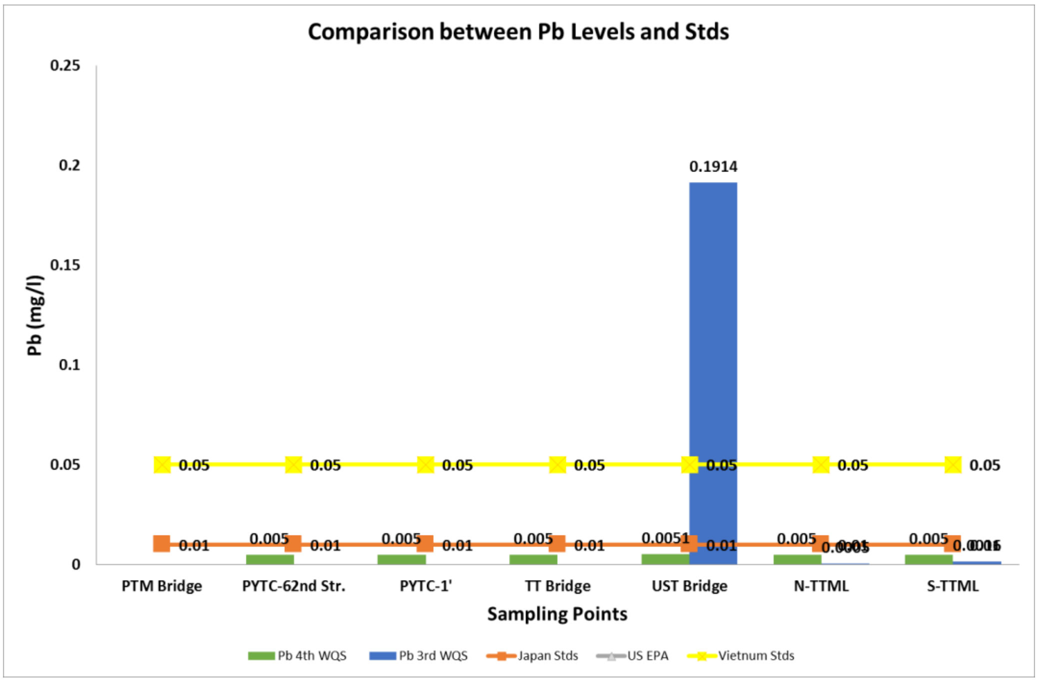
Table 3.1-6 shows Pb levels in the 3rd and 4th surveys and reference standards. Figure 3.1-7 shows a comparison between Pb levels and the standards. The Pb levels of 3rd and 4th WQS in most points are in line with the all reference surface water quality standards and only the point of UST Bridge in 3rd WQS is higher than the Japanese standards. Compared with the Vietnamese Surface Water Quality Standards for irrigation, the 3rd WQS results is 3.83 times higher than the standard at UST Bridge. The other points meet with the standards. Japanese water quality standard for human health is stricter than the Vietnam standard for irrigation water.

The point of UST Bridge is located in Mandalay Industrial Zone. Therefore, it can be affected by the wastewater of the industries nearby. But the level of Pb in the 4th WQS is much lower than the 3rd WQS. Therefore it is thoughtful for the seasonal condition and the behavior of industrial process.

Table 3.1-6 Pb Levels in 3rd and 4th surveys and Standards

No	WQ	PTM Bridge	PYTC-62nd St	PYTC1'	TT Bridge	UST Bridge	N-TTML	S-TTML
1	3rd WQS	-	-	-	-	0.1914	0.0005	0.0016
2	4th WQS	-	<0.005	<0.005	<0.005	0.0051	<0.005	<0.005
3	Japan Stds	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01
4	Vietnam	0.05	0.05	0.05	0.05	0.05	0.05	0.05
5	Ireland EPA	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Source: ECD-Mandalay based on the data from JICA Expert Team



Source: ECD-Mandalay based on the data from JICA Expert Team

Figure 3.1-7 Comparison between Pb levels in 3rd and 4th surveys with standards

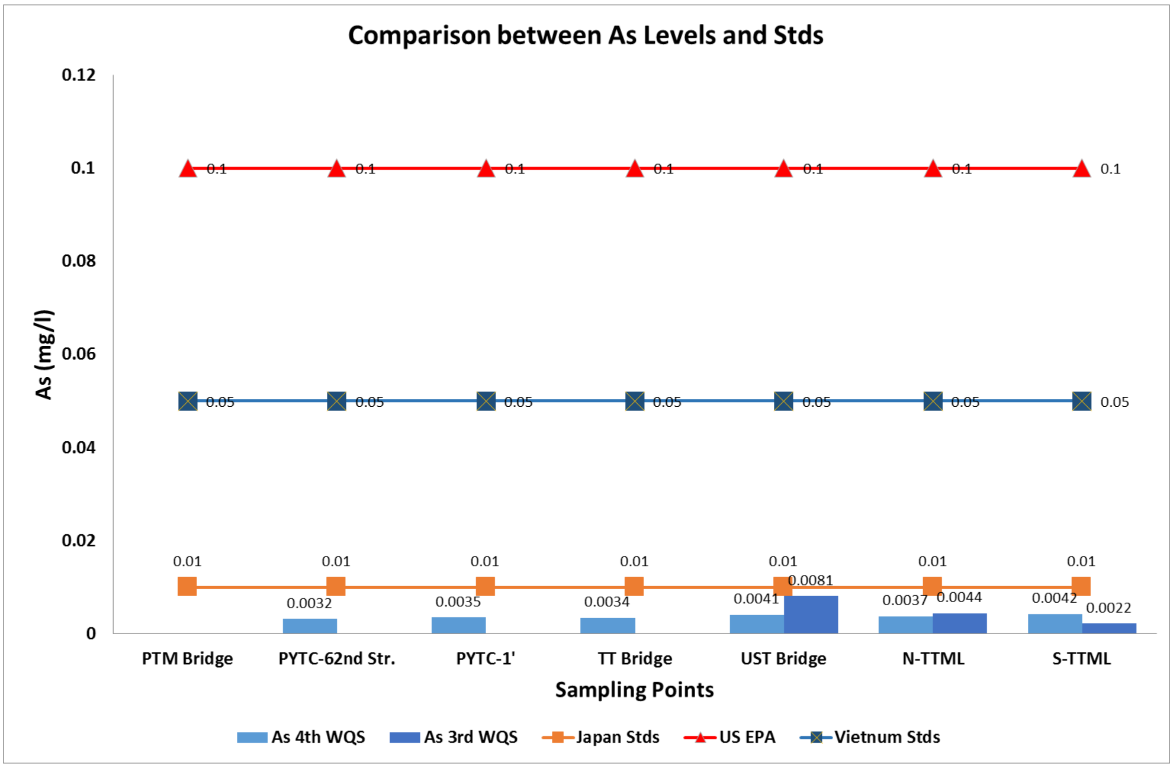
(2) Arsenic (As)

Table 3.1-7 shows As levels in the 3rd and 4th surveys and standards. Figure 3.1-8 shows a comparison between As levels in 3rd and 4th surveys with standards. The levels of As in 3rd WQS and 4th WQS are under the all reference standards at all points. The level of As at UST Bridge in 3rd WQS is a little bit higher than other points. The point of UST Bridge is located in Mandalay Industrial Zone. Therefore, there would have a potential pollution source discharging the wastewater containing arsenic from the industries nearby.

Table 3.1-7 As Levels in 3rd and 4th surveys and Standards

No	WQ	PTM Bridge	PYTC-62nd St	PYTC1'	TT Bridge	UST Bridge	N-TTML	S-TTML
1	3rd WQS					0.0081	0.0044	0.0022
2	4th WQS		0.0032	0.0035	0.0034	0.0041	0.0037	0.0042
3	Japan Stds	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01	≤0.01
4	Vietnam	0.05	0.05	0.05	0.05	0.05	0.05	0.05
5	Ireland EPA	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Source: ECD-Mandalay based on the data from JICA Expert Team



Source: ECD-Mandalay based on the data from JICA Expert Team

Figure 3.1-8 Comparison between As levels in 3rd and 4th surveys with standards

3.2 Discussion

3.2.1 Findings about the Pollutant Levels

The 4th WQS results represent the rainy season and 3rd WQS results represents the dry season. According to the abovementioned data, the results of TSS at PTM Bridge, PYTC-1' and UST Bridge in the 3rd WQS and at PYTC-62nd St in the 4th WQS are higher than others. The point of PYTC-62nd St was not analyzed in the 3rd WQS. The TSS levels of N-TTML and S-TTML in the 3rd WQS are higher than 4th WQS.

The levels of BOD at PYTC-62nd St, PYTC-1', TT Bridge, UST Bridge and N-TTML in the 3rd WQS are higher than the reference standards of Vietnam. The BOD results of 4th WQS meet with the standards. The results of COD at PYTC-62nd St, PYTC-1', TT Bridge, UST Bridge N-TTML and S-TTML in the 3rd WQS are much higher than the standards. The COD results of 4th WQS meet with the standards. As a whole, TSS, BOD and COD are much higher at the Pan Yan Taw Creek and diluted at the Lake. TSS, BOD and COD are higher in dry season than rainy season. The high water volume can dilute the concentration of TSS, BOD and COD in the rainy season. TSS, BOD and COD are high at the Industrial Zone area.

Meanwhile, the level of total coliform at PYTC-1', UST Bridge and N-TTML in the 3rd WQS as well as at PYTC-1', UST Bridge, N-TTML and S-TTML in the 4th WQS are higher than the standards. The results of 4th WQS are much higher than that of 3rd WQS in large part. Therefore, total coliform is high at both Pa Yan Taw and Taungthaman lake. Total coliform is higher in the rainy season than dry season. This might be because that flood washes out the impurities of the squatting area into the water bodies so the concentration of total coliform in the rainy season is higher than the dry season. Total coliform is affected by the Industries, squatting area, restaurants, domestic household, plantations and duck farms.

For T-N and T-P, the levels of T-N at N-TTML in 3rd WQS and at N-TTML and S-TTML in 4th WQS are higher than the standards. The levels of T-P at N-TTML and S-TTML in both 3rd WQS and in 4th WQS are higher than the standards. Therefore, T-N and T-P are high in Taungthaman Lake. It was found that T-N and T-P are higher in dry season than rainy season. It might be affected by effluent from the restaurants, domestic household, plantations and duck farms at the NTTML. Therefore, it can lead to the eutrophication process at NTTML.

For heavy metals, the levels of Pb in all points of the 4th WQS are in line with the surface water quality standards and only the point of UST Bridge in the 3rd WQS is higher than the standards. The results of As of 3rd WQS and 4th WQS are under the standards in all points.

The level of As of 3rd WQS in UST Bridge is a little bit higher than other points. Therefore, Pb and As are high at the UST Bridge. It might be affected by the wastewater of the industries nearby.

3.2.2 Finding about the Pollution Sources

It is affected by the wastewater discharging from the industries on the Pan Yan Taw Creek. The flood in the rainy season has seriously affected on the sanity of water quality. It is affected by the restaurants, domestic household and duck farms on the lake.

3.2.3 Finding about the Water Quality Status

The water quality of the Pa Yan Taw Creek is not suitable for the irrigation purpose. And the water quality of the Taungthaman Lake is not suitable for the domestic use of water. But it is still suitable for agricultural use. The water quality of the northern part of Taungthaman Lake is worse than the southern part of the Lake.

3.2.4 Finding about the Water Quality Changes

The water quality has been changed in accordance with the water allocation as there have usually found organic pollutants and nutrients. But the flooding behavior causes deterioration on sanity of water. Therefore, the levels of organic pollutants and nutrients are decreased in rainy season, while the level of total coliform is increased. On the other hand, the levels of organic pollutant and nutrients are high in dry season.

4 Conclusions and Recommendations

4.1 Conclusions

The water quality of the Taungthaman Lake is changed due to the effect of pollution sources nearby and seasonally. Therefore, the wastewater from the Mandalay Industrial Zone, squatting area, restaurants, domestic household and duck farms totally affect the water quality of Taungthaman Lake. But it is needed to clarify with more specific information and to conduct regular water quality monitoring to investigate the actual status.

4.2 Recommendations

The central wastewater treatment plant for the Mandalay Industrial Zone is now under construction stage. And the notification for the priority nine industries to implement the EMP during one year was developed in January 2018. Besides, awareness programs for the notification for the priority nine industries to implement the EMP should be conducted in the Mandalay Industrial Zone Area. After the awareness period, the warning period and notice letter should be undertaken for the enforcement. It is the very final step to take action on the non-compliance industries cooperating with the relevant Ministry.

It is important to ensure the knowledge of the environmental status of the water bodies; state of water quality and state of ecosystem health. Therefore, regular water quality monitoring and inventory of biodiversity index should be conducted to build the database system and to ensure the environmental status cooperating with the academic field; Yadanabon University which located near Taungthaman lake. The awareness programs on the collected information and knowledge of the environmental status of Taungthaman Lake should be conducted with the stakeholders of the Lake to share the knowledge and to get the suggestion for environmental quality promoting processes.

The water of Taungthaman Lake should be the agricultural use. And it is not suitable for the domestic use of water. To improve the water quality of the lake, abovementioned activities should be undertaken definitely.

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14. *Water Quality Survey Manual (Draft Version), JICA Expert Team*

Appendices

Appendix 1 Photographs

	
Taungthaman Lake	Taungthaman Lake
	
TT Bridge	PYT Creek
	
Columbo Stream	Taungthaman Lake

Source: JICA Expert Team

Appendix 2 List of Data

A2.1 Analysis Results of 3rd Water Quality Survey

Table A.2.1-1 3rd survey results of specified parameters in target area for this report

Quantities of Water Quality Sampling and Analysis									
3rd water quality sampling and analysis in Mandalay									
No.	Parameter	Date	23/01/17	23/01/17	23/01/17	23/01/7	23/01/17	24/01/17	24/01/17
		ampling tim	9:29	11:32	12:59	12:13	15:36	9:47	10:35
		No	1	2	3	4	5	6	7
		breviated na	PTM Bridge	Upstream of PYTC2	PYTC1	TT Bridge	UST Bridge	N-TTML	S-TTML
		ocation nam	Paw Taw Muu Bridge (Upstream of PYTC3	Upstream of PYTC, before confluence	Pa Yan Taw Creek 1	Tagon Taing Bridge	U shwe Taung Bridge	Northern Thaung Tha Man Lake	Southern Thaung Tha Man Lake
		Left/Center/ Right	Center	Center	Center	Center	Center	-	-
		Depth	Surface	Surface	Surface	Surface	Surface	Surface	Surface
On-site measurement									
1	pH		8.13	8.32	6.88	7.13	7.22	7.98	8.92
2	pH	mv	-74	-84	-6	-20	-25	-66	-118
3	Conductivity	mS/cm	0.741	1.4	1.64	1.62	1.64	1.31	0.446
4	Salinity	ppt	0.4	0.7	0.8	0.8	0.8	0.7	0.2
5	Turbidity	NTU	103	151	114	86.9	91.1	78.2	83.2
6	TDS	g/L	0.475	0.896	1.05	1.04	1.05	0.839	0.29
7	Water Temperature	Degree C	20.54	22.46	27.37	25.19	27.23	24.61	26.17
8	ORP	mv	225	206	-247	-216	-234	119	99
9	DO	mg/L	11.33	4.81	0.81	1.01	8.82	4.4	5.2
10	Ambient air temperature	Degree C	29.3	32.5	33.9	33.6	31.7	28.7	30.4
Laboratory analysis									
1	Total Suspended Solids (TSS)	mg/L	80.00		208.00	25.00	210.00	47.00	50.00
2	BOD	mg/L	7.92	23.67	337.50	482.50	206.25	67.00	15.25
3	COD Cr	mg/L	14.22	44.70	883.92	1056.64	215.39	103.63	62.99
4	Total phosphorus (T-P)	mg/L	0.20	0.52			3.65	2.63	0.44
5	Phosphate (PO4-)	mg/L	0.02				1.89	0.3	0.21
6	Total nitrogen (T-N)	mg/L	0.45	2.63			<0.05	19.22	0.83
7	Zinc (Zn)	mg/L					0.0090	<0.0015	<0.0015
8	Arsenic (As)	mg/L					0.0081	0.0044	0.0022
9	Lead (Pb)	mg/L					0.1914	<0.0005	0.0016
10	Total Coliform	MPN/100ml	1,300		33,000		79,000	28,000	33

A2.2 Analysis Results of 4th Water Quality Survey

Table A.2.2-1 4th survey results of specified parameters in target area for this report

No	No	Unit	13	8	9	7	6	11	12	Lab. Name
	Location name		PTM Bridge	PYTC-62nd Str.	PYTC-1'	TT Bridge	UST Bridge	N-TTML	S-TTML	
			Paw Taw Muu Bridge (Upstream in PYTC, after confluence)	Pa Yan Taw Creek (on 62nd street, upstream from Pyi Gyi Tagon IZ)	Pa Yan Taw Creek 1 (Myo Ma Aung Myin Street)	Tagon Taing Bridge	U shwe Taung Bridge	Northern Thaung Tha Man Lake	Southern Thaung Tha Man Lake	
	Left/Center/Right		Center	Center	Center	Center	Center	Center	Center	
	Sampling Date		2/10/2017	2/10/2017	2/10/2017	2/10/2017	2/10/2017	3/10/2017	3/10/2017	
	Sampling Time		10:48	11:50	15:30	14:36	16:50	16:11	16:40	
On-site measurement										
1	Air Temperature	° C	33.8	31.90	34.50	35.77	34.33	32	32.39	-
2	Water	° C	30.46	30.65	31.71	31.60	33.06	31.63	31.23	-
3	pH	-	7.56	7.86	7.82	7.46	7.77	8.18	8.56	-
4	ORP	mv	196	147	95	-78	123	118	132	-
5	Conductivity	ms/cm	0.339	0.424	0.447	0.504	0.435	0.424	0.409	-
6	Turbidity	NTU	74	97.10	72.1	73.5	52.2	34	35.5	-
7	DO	mg/L	7.38	6.31	8.89	5.11	6.70	5.12	6.43	-
8	TDS	mg/L	227	275	310	323	283	275	266	-
9	Salinity	ppt	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-
Laboratory analysis										
1	BOD	mg/L	6.6	2.3	5.1	4.8	5.6	6.0	5.4	REM-UAE
2	Total Coliform	MPN/ 100m	-	-	> 160,000	-	> 160,000	17,000	24,000	REM-UAE
3	Total Suspended Solids (TSS)	mg/L	44	68	36	28	22	15	14	Osumi (Jp Lab)
4	COD Cr	mg/L	14	23	32	34	31	28	28	Osumi (Jp Lab)
5	Total phosphorus (T-P)	mg/L	0.063	0.28	0.31	0.39	0.31	0.38	0.36	Osumi (Jp Lab)
6	Total nitrogen (T-N)	mg/L	0.63	2.1	2.1	3.0	2.0	2.0	1.7	Osumi (Jp Lab)
7	Zinc (Zn)	mg/L	-	0.014	0.011	0.0096	0.016	0.0074	0.0050	Osumi (Jp Lab)
8	Arsenic (As)	mg/L	-	0.0032	0.0035	0.0034	0.0041	0.0037	0.0042	Osumi (Jp Lab)
9	Lead (Pb)	mg/L	-	< 0.005	< 0.005	< 0.005	0.0051	< 0.005	< 0.005	Osumi (Jp Lab)

Appendix 10-6:

Water Quality Survey Report prepared by MCDC-WSD

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

WATER QUALITY SURVEY REPORT FOR DOKE HTA WADDY RIVER BASIN

FINAL VERSION

APRIL2018

PREPARED BY:

WATER AND SANITATION DEPARTMENT

MANDALAY CITY DEVELOPMENT COMMITTEE

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Appendices

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LST OF ABBREVIATIONS

ADB	Asian Development Bank
BOD	Biochemical Oxygen Demand
C/P	Counterpart
COD	Chemical Oxygen Demand
DISI	Directorate of Industrial Supervision and Inspection
DO	Dissolved Oxygen
EC	Electrical Conductivity
ECD	Environmental Conservation Department
EIA	Environment Impact Assessment
EU	European Union
GIS	Geographic Information System
GOM	Government of Myanmar
GPS	Global Positioning System
GLV	Guideline Value
IZ	Industrial Zone
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
MCDC	Mandalay City Development Committee
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOE	Ministry of Education
MOECAF	Ministry of Environmental Conservation and Forestry
MOH	Ministry of Health
MOI	Ministry of Industry
MONREC	Ministry of Natural Resources and Environmental Conservation
MOST	Ministry of Science and Technology
MOT	Ministry of Transport
SS	Suspended Solid
USEPA	United States Environmental Protection Agency
YCDC	Yangon City Development Committee

EXECUTIVE SUMMARY

i) Background and Purpose

As one of activities under the Project for Capacity Development in Basic Water Environment Management and EIA System in Myanmar, the water quality survey were implemented to build the capacity of the government staff from Environmental Conservation Department (ECD) under the Ministry of Natural Resources and Environmental Conservation (MONREC), Yangon City Development Committee (YCDC) and Mandalay City Development Committee (MCDC). The report is written by a team from Water and Sanitation Department (WSD), MCDC as a part of the requirement to enhance the report writing skill relating with water quality surveying.

Water quality surveys were implemented in total of five times. Based on the acquired water quality results from 3rd and 4th survey among them, the report aims to assess the impact on the water quality of Doke Hta Waddy River Basin by the direct industrial wastewater disposal. To assist the future water supply project for Pyi Gyi Tagon township which will be utilized as the water source form Doke Hta Waddy River, the water quality of necessary parameters are examined as an preliminary study.

ii) Findings

The following facts were discovered when evaluating the water quality data.

(1) Pollution impact on the Doke Hta Waddy River by the industrial wastewater disposal
- The level of orgnaic pollution in the Doke Hta Waddy River is still limited due to a large water dilution capacity even if the industrial wastewater from Shwe Pyi Thar IZ contains high concentration of nutrition such as nitrogen and phosphorus and discharges to the river.
- The oil and grease, phenol and chromium hexavalent were also detected at the discharge point but the adverse effect to the river still could be negligible level at the time of survey.
- The quality of wastewater from the 10 inches pipeline did not wholly comply with the guideline values applied to wastewater (general application, Environmental Quality (Emission) Guideline, 2015).

(2) Potentiality of Doke Hta Waddy River to use as a source for water supply
- The parameters compared in the report such as pH, DO, TSS, BOD and COD satisfied the desirable water quality level for domestic supply with suitable treatment system according to the reference standard (A2 category, Vietnamese

National Technical Regulations on Surface Water, QCVN 08: 2015/BTNMT) except for the total coliform during wet season.

- No severe level of toxic chemical or heavy metals was detected in the surveys.

iii) Conclusions and Recommendations

The water quality survey results are concluded as follows.

- The significant adverse effect to the water quality of Doke Hta Waddy River by the pollutants from the direct discharging of the industrial wastewater was not overserved, apparently due to the result of large dilution effect of river water.
- The water from the river can be utilized for water distribution by applying suitable treatment system.

The recommendations are remarked as follow.

- To acknowledge the long-term effect by the industrial wastewater as well as seasonal and temporal changes on the Doke Hta Waddy River, the continuous monitoring such as implementation of biweekly water quality survey is vital.
- Based on the results from the two times surveys, the river water quality is good enough to use as a source of water supply. However the investigation on the maximum and minimum available quantity of water especially in the hot season also must be considered due to the Ye Ywar Dam which is located at the upstream of the proposed water intake point.

1 Introduction and Objectives

1.1 Background

The Project for Capacity Development in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar was started in June 2015 by Japan International Cooperation Agency (JICA) to support and enhance capacities of Ministry of Natural Resources and Environmental Conservation (hereinafter referred to as "MONREC"), formerly known as Ministry of Environmental Conservation and Forestry (MOECAF) and other associated organizations such as MCDC and YCDC to manage water environment and to implement EIA reviews. The overall project will be finalized in June 2018.

1.1.1 Targets of the Project

There are two main components in project activities, namely (i) the water environment management component and (ii) the EIA component. Under the water management component and the EIA component, a total of six outputs are included. Table 1.1-1 below describes the overall goal, project purpose and outputs of the project.

Table 1.1-1 Overall Goal, Project Purpose and Outputs of the Project

Item	Contents		Components
Overall Goal	Impact of industrial effluents from industrial zones on river water quality is alleviated, and advanced EIA approach for complicated issues are taken into account.		
Project Purpose	Capacity for developing basic water pollution control measures based on obtained and interpreted information is enhanced and the institutional framework of the EIA review works is established.		
Outputs	Output 1	Inspection procedure is standardized.	Water environment management
	Output 2	Capacity for implementing water quality survey to obtain reliable information is enhanced.	Water environment management
	Output 3	Database of water pollution sources and river water quality is developed.	Water environment management
	Output 4	Capacity of interpreting the information for water pollution control measures is enhanced.	Water environment

			management
	Output 5	Necessary technical manuals and forms for the EIA review are developed.	EIA
	Output 6	Capacity of MONREC and the EIA Report Review Body on the EIA review is enhanced.	EIA

Source: JICA Expert Team

1.1.2 Brief information on report and focus areas

The output 2 focuses on the water quality surveys, which were planned in total of five times. The report writing trainings were implemented to develop the capacity of the government staff and assigned them to write own reports based on the acquired 3rd and 4th water quality survey results. The official from YCDC, MCDC and ECD (Mandalay) were involved in developing individual reports. This report is mainly written by the staff from Water and Sanitation Department (WSD), MCDC.

The main water body which will be covered in this report is called the Doke Hta Waddy River. It is also known as Myit Nge River that originates from the northern Shan State where it is known as Namtu River, flourishing westwards along the mountainous terrain to meet with the Irrawaddy River at the heart of Myanmar as a tributary. The Doke Hta Waddy River has been serving for agriculture as a water source along its way. At 52 kilometers southeast of Mandalay City, Ye Ywa Dam is located on the Doke Hta Waddy River. The Ye Ywa Dam is the site of a 790-Megawatt hydroelectric power plant which is the largest dam in Myanmar.

The water quality survey targeting the Doke Hta Waddy River Basin is carried out to identify and monitor the impacts on the river water by the direct discharging of the industrial wastewater from 10 inches pipeline. The pipeline comes from the Industrial Zone (IZ) which has been established since 1990 in Pyi Gyi Tagon township. With the growth of industries in Pyi Gyi Tagon township from time by time, concerns about the industrial wastewater disposal system was arisen as taking into account for wastewater treatment system and acknowledgements to environmental pollution were evoked. Thus, six waste stabilization ponds were constructed in Taung Myint Ward in 1998. Thereafter, the effluent was discharged by 3 miles long, 8 inches pipeline which ended up in an open drainage channel leading to Taung Inn creek and Myaut Inn creek and afterwards, finally flowed into Doke Hta Waddy River. In 2008, many complaints and protests were occurred near the stabilization ponds due to the raising of nuisance smell. Therefore, the stabilization ponds were terminated and a sedimentation pond was constructed at No. (La La – 22), near No. (6) irrigation over water stream. It has 50,000 gallons of capacity and the wastewater were pumped into a pipe with a length of 2 miles and a diameter of 10 inches with the flow rate capacity of 500,000 gal/day. In 2015, the pipeline was joined to discharge the industrial wastewater from 50 industrials directly into the Doke Hta Wadddy River. Presently, a centralized industrial wastewater treatment plant is being constructed by Hydrotek Supreme Company Limited.

Source: MCDC

Figure 1.1-1 Industrial Wastewater Directly Discharging into Doke Hta Waddy River

On the other hand, in the near future, there will be a project to distribute water utilizing the source of Doke Hta Waddy River. Therefore, an investigation on the river water quality status is also performed in this report as a purpose of preliminary study to supply water to the dwellers from Pyi Gyi Tagon township. Water quality results from different labs is also be compared to assess the quality control and assurance measures in the MCDC lab. This report encapsulates the survey methodology from the actual activities as well as the water quality data acquired from the on-site measurement and laboratory analysis.

1.1.3 Outline of water quality surveys

The water quality survey is composed of five-time surveys totally: in February 2016, June 2016, January 2017, October 2017 and February 2018. In Mandalay, a comparative analysis program was carried out in December 2016 as a supplement of the survey to check the accuracy of chemical analysis.

Source: MCDC

Figure 1.1-2 Water Sampling in the Doke Hta Waddy River

1.2 Legal basis of water quality survey

According to the Article 45 of the Constitution of the Union of Myanmar (2008), there is an expression that the Union shall protect and conserve natural environment. Therefore, the Environmental Conservation Law (Law No.9, 2012) and the Environmental Conservation Rules (2013) were enacted as a basic environmental law and rules. To specify precise authorization of Ministry of Natural Resources and Environmental Conservation (MONREC) in planning, implementing and monitoring of environmental conservation programs, there is a description about it in the Article 7 of the Environmental Conservation Law. Article 13 of the Environmental Conservation Law specifies that MONREC shall maintain a comprehensive monitoring system and implementation of necessary matters by MONREC itself or in coordination with relevant parties, relating to environmental pollution. Apart from that, Environmental Conservation Rules (Notification No.50, 2014) remarks that the required special inspections and investigations at necessary time and place to enable to stipulate environmental quality standards may be conducted by the Environmental Conservation Department (ECD), though environmental quality standards are under development. Thus, MONREC has the authority to monitor the water quality for conservation, pollution and establish the environmental quality standards.

For pronouncing effective administration decisions, it is vital to monitor the water quality of public water bodies and obtain spatial and historical data. However, there are no laws or rules that stipulate the specific mandate or responsibilities of water quality monitoring in the public water bodies yet, and a nation-wide or region-wide water quality monitoring has not been conducted by national or local governments with regard to water environment conservation and management. The detailed measures of water quality survey have not yet specified as well.

In general, a surface water quality survey in Myanmar is conducted by an organization that has a special interest in the water body. Such surveys include drinking water monitoring by Ministry of Health and Sports or local governments from the view point of public health: river water monitoring by a managing ministry or organization of specific river section, such as Ministry of Transportation and Communications and Ministry of Agriculture and Irrigation: water environmental survey for specific projects, such as an EIA study for checking the basic water quality status: and other on-demand water quality survey, as shown in Table 1.2-1. Each organization conducts the survey based on internationally recognized or their own method considering the purpose of the survey.

Mandalay City Development Committee, a city administrative body under the regional government, has authority to manage water environment around Mandalay city boundary. In 1992, Mandalay City Development Committee Law was enacted. The law was amended in 2014 and again in 2016 by the Mandalay Region Hluttaw. The law mentions in Section 69 that MCDC has responsibility to manage the water for consuming, wasted polluted water and liquid of excrement in accord with the standards of WHO or concerned ministry as prescribed by time to time. Therefore, MCDC and MONREC cooperate in this project to monitor water quality in Doke Hta Waddy river basin concerning with wastewater disposal.

Table 1.2-1 Types of Water Quality Survey in Myanmar

No	Implementer	Example Cases
1	Government/public institution	[Periodical survey] - MOTC periodically conducts the water quality monitoring in the Ayeyarwady River. - A department in charge of water supply in the local government such as WSD/MCDC checks the water quality of the supplied water every week. - In addition, WSD/MCDC conducts the every-week water quality monitoring in Doke Hta Waddy River as well as Taung Tha Man Lake and channels flowing into/out from Taung Tha Man Lake. [Demand-based survey] - A joint inspection team composed of representatives from relevant ministries and organizations checked the water quality to investigate the water pollution status in Taung Tha Man Lake and other areas in 2015.
2	Project proponent of EIA	- A water quality survey is generally conducted in a basic

No	Implementer	Example Cases
		environmental survey of EIA/IEE in surrounding of project area or project-affected area based on the requirement of EIA Procedure (2015) and the result is evaluated according to National Environmental Quality (Emission) Guidelines (2015). - As one of example, an EIA study for a central wastewater treatment plant to be constructed nearby the Doke Hta Waddy River investigated the water quality in Doke Hta Waddy River in early 2016.
3	Others (NGO, researchers etc.)	- A research team from Yadanabon University conducted the water quality survey mainly in Ayeyarwaddy River and once in Thaung Tha Man Lake for their research about water resource.

Source: JICA Expert Team

1.3 Survey objectives

The objectives of the survey are set up as follow.

i. To identify the impact on Doke Hta Waddy River water quality due to direct industrial wastewater disposal
ii. To investigate the water quality status of Doke Hta Waddy River for domestic water supply

2 Outlines of the survey

2.1 Data source

Most of the analyzed water quality data are acquired from the 3rd and 4th water quality survey conducted by ECD, MCDC and JET. The final validated and analyzed water quality data results used in the official report by JET are applied in the report. Data utilized from the relevant governmental department are also mentioned at the bottom of the respective figure or table.

2.2 Role and responsibility of survey team

The sampling works for both 3rd and 4th surveys were done by the local environmental consultant company under the management of JICA Expert Team (JET). The 3rd survey was done by Environ-Myanmar Co., Ltd and the 4th survey was done by Social and Environmental Associates Myanmar (SEAM). Relevant government staff from WSD (MCDC) and ECD (Mandalay) joined the survey to learn the water sampling techniques and to support the sampling work during the survey.

Source: MCDC

Figure 2.2-1 Water Sampling by the Local Consultant Company

The members from JICA Expert Team (JET) provided assistance and supervision on overall water sampling. The local consultant company mainly has done most of the water sampling job.

2.3 Sampling schedule

The sampling times were adjusted according to season variations in order to obtain the seasonal impacts to the water bodies by conducting the surveys once in the wet season and once in the dry season per year. The water sampling works from 1st to 5th water quality survey for the Doke Hta Waddy River Basin were carried out according to the following schedule.

Table 2.3-1 Overall Sampling Schedule

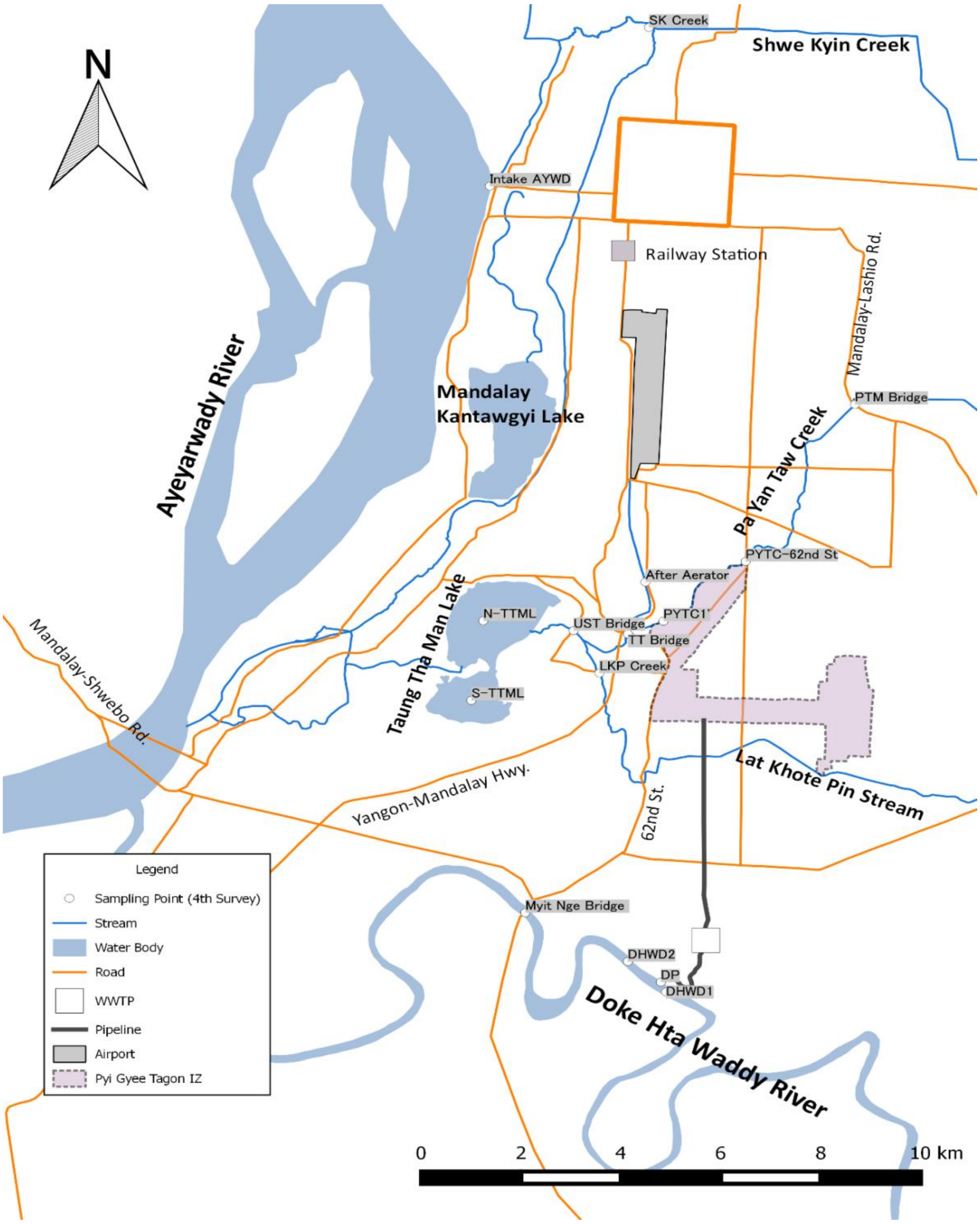
Title	Survey	Remark
1st water quality survey	17, 18 and 25 (re-sampling) February 2016	Since the survey team found out that the sample volumes were not enough to analyze, re-taking of water samples took place in 25th February
2nd water quality survey	27 and 28 June 2016	The samples of the Doke Hta Waddy River were taken at night time.
Comparative analysis program	17 December 2016	Supplemental survey to check the accuracy of chemical analysis
3rd water quality survey	23 and 24 January 2017	-
4th water quality survey	3 October 2017	Wastewater discharging pipe was under the Doke Hta Waddy River.
5th water quality survey	26 and 27 February 2018	-

Source: JICA Expert Team

2.4 Sampling points

During the 3rd water quality survey, 14 sampling points were taken for environmental analysis. In the 4th water quality survey, the sampling points were slightly changed. In order to gain the water quality status of the Ayeyarwady River at the intake source point of Booster Pumping Station – No.8, an additional sampling point was chosen and there were a total of 15 sampling points in that survey. One unknown sample (duplicate sample) was also taken in both 3rd and 4th water quality survey to compare the results for analytical quality assurance.

In this report, only four sampling points from the 4th survey: industrial wastewater discharging point (DP), upstream of discharge point (DHWD – 1) and downstream of discharge points (DHWD- 2 and Myint Nge Bridge) will be utilized to identify the impact by industrial wastewater disposal. In addition, the 3rd survey results will be referred to make a comparison for seasonal changes. The sampling points in the 4th water quality survey are shown in the following figure.



Source: JICA Expert Team

Figure 2.4-1 Sampling Points in 4th Water Quality Survey

2.5 Survey parameter

2.5.1 Measurement parameter

Different parameters were selected to examine based on the sampling point locations and other criterions and agreed in the meetings and discussions with the relevant stakeholders from time to time. Some parameters were measured on-site using a multi-parameter water quality meter and the other parameters were measured at the respective laboratories.

The parameters assessed in this report are pH, BOD, COD, TSS and Total coliforms. The following table described the number of parameter measured in 3^{rd} and 4^{th} water quality survey (analyzed in the field and laboratories in Myanmar, Thailand and Japan).

Table 2.5-1 Measured Parameters

No.	Tested Parameter	Total analyzed quantity (Unit = Sample)	
		3^{rd} survey	4^{th} survey
1.	Air Temperature	14	15
2.	Water Temperature	14	15
3.	pH	14	15
4.	Oxidation-Reduction Potential (ORP)	14	15
5.	Conductivity	14	15
6.	Turbidity	14	15
7.	Dissolved Oxygen (DO)	14	15
8.	Total Dissolved Solids (TDS)	14	15
9.	Salinity	14	15
1.	Total Suspended Solids (TSS)	13	16
2.	BOD	15	16
3.	COD Cr	15	16
4.	Cyanide(total)	7	13
5.	Oil and grease	9	13
6.	Phenol~~s~~	7	13
7.	Total phosphorus (T-P)	10	15
8.	Phosphate (PO4-)	8	-
9.	Total nitrogen (T-N)	10	15
10.	Ammonia nitrogen(NH3-N)	8	-
11.	Nitrite nitrogen(NO2-N)	8	-
12.	Nitrate nitrogen(NO3-N)	8	-
13.	Zinc (Zn)	7	13
14.	Total chromium (T-Cr)	9	13
15.	Chromium (Hexavalent)	9	13
16.	Arsenic (As)	7	13

No.	Tested Parameter	Total analyzed quantity (Unit = Sample)	
		3rd survey	4th survey
17.	Copper (Cu)	7	13
18.	Total Mercury (Hg)	9	13
19.	Cadmium (Cd)	7	13
20.	Lead (Pb)	7	13
21.	Total Coliform	10	11
22.	Total organic chlorine pesticides	2	-
23.	Total organic phosphorus pesticides	2	-
24.	PCB*	1	1
25.	Pesticides	See Appendix -2 Table A 2.2-3	See Appendix -2 Table A 2.2-3

* PCBs for the 3rd survey is "Aroclor 1254".

Source: JICA Expert Team

2.5.2 Guideline levels

The values in the table below are the guideline levels which will be utilized in the report.

Table 2.5-2 Guideline Levels to be Referred

No	**Parameter**	**Unit**	**Vietnam**	**Myanmar**
			(QCVN 08:2015)	**NEQG (2015), for wastewater, storm water runoff, effluent and sanitary discharges application)**
			A2	
1	pH	value	6-8.5	6-9
2	Dissolved Oxygen	mg/l	≥5	-
3	BOD_5 20 C	mg/l	6	50
4	Coliform	MPN/100 ml	5000	400
5	Total Suspended Solid	mg/l	30	50
6	COD Cr	mg/l	15	250
7	Cyanide	mg/l	0.05	1
8	Oil and Grease	mg/l	0.5	10

No	Parameter	Unit	Vietnam (QCVN 08:2015)	Myanmar
			A2	NEQG (2015), for wastewater, storm water runoff, effluent and sanitary discharges application)
9	Phenols	mg/l	0.005	0.5
10	Total Phosphorus (T-P)	mg/l	-	2
11	Total Nitrogen (T-N)	mg/l	-	-
12	Zinc	mg/l	1.0	2
13	Total Chromium (T-Cr)	mg/l	0.1	0.5
14	Chromium (Hexavalent)	mg/l	0.02	0.1
15	Arsenic	mg/l	0.02	0.1
16	Copper (Cu)	mg/l	0.2	0.5
17	Total Mercury (Hg)	mg/l	0.001	0.01
18	Cadmium (Cd)	mg/l	0.005	0.1
19	Lead (Pb)	mg/l	0.02	0.1

Source: JICA Expert Team

2.6 Sampling and measurement

To obtain the accurate results, water sampling and measurement were done according to the operation procedures recommended by the JET.

Source: MCDC

Figure 2.6-1 Photos of Water Sampling

2.6.1 Sampling method

The surface water was taken with a sampling bottle directly or with a sampling plastic bucket before filling into the sampling bottle pre-cautiously. The water collected each time into the sampling bucket was assured to be well homogenized as described in detail in Section 2.6.5. In the 4th water quality survey, most measurement parameters except for BOD and total coliform were analyzed in Japan and it required two or three days transportation period. Thus, sample preservation with chemicals for different measured parameters was also performed by the supervision of JET.

2.6.2 On-site measurement method

For on-site measurement, Horiba multi-parameter water quality meter was used for the measurement of the parameters as mentioned in the table below.

Table 2.6-1 Equipment for On-site Measurement

No.	Parameter	Model Name	Parameter
1	Horiba	U52G Multi-parameter Water Quality Meter	pH, DO, conductivity (EC), salinity, TDS, water temperature, turbidity, ORP

Source: JICA Expert Team

Source: MCDC

Figure 2.6-2 Photo of On-site Measurement

2.6.3 Water flow measurement method

The same equipment was used in the both 3rd and 4th survey according to the water quality survey manual developed by the JET to measure the water velocity as described in the following table.

Table 2.6-2 Equipment for Water Flow Measurement

No.	Parameter	Model Name	Parameter
1.	Tamaya	Digital current meter UC-200v	Water velocity
2.	Global Water	Global water flow probe FP111	Water velocity

Source: JICA Expert Team

2.6.4 Laboratory analysis method

The laboratory analysis methods will be shown in Appendix 2. The water samples were also analyzed by MCDC WSD laboratory. The below table shows the MCDC laboratory analysis method.

Table 2.6-3 Measurement Method in MCDC Lab

No.	Parameter	Measurement Method / Equipment
1.	TP, TN, CN, Cu, Zn, Color, As, SO_4, NO_3, Cr^{6+}, NH_3-N	Using DR-3900-Spectrophotometer
2.	Ca, Mg, Hardness, Total Alkalinity, Chloride	Titration Method
3.	BOD	Winkler's Method

4.	COD	Digestion Method
5.	DO	Membrane Electrode Method (senION 378)
6.	TDS, Salinity, EC	Membrane Electrode Method (senION 156)
7.	TSS	Using DR-3900-Spectrophotometer
8.	Total Coliform	Fermentation Method

Source: MCDC

2.6.5 Quality control method (On-site measurement)

The on-site measuring equipment, Horiba U52G was calibrated in accordance with its manual before taking into the field. For the analyzed results accuracy, the instrument was used in the shady place as measuring in the direct sunlight could intervene the results. Since water samples were collected from the source directly by taking with a plastic bucket for a couple of times to fill into the larger plastic bucket until the require amount of water is obtained, substantially mixing of the sample water was executed when two water bodies (e.g. creek, stream and river) confluence just before the sampling point. The larger plastic bucket was rinsed carefully every time with the sample source before placing the water into it.

3 Results and Discussion

3.1 Hydrological conditions

The Doke Hta Waddy River is a branch of Ayeyarwady River which sources from the Northern Shan State flowing west direction, meeting the Ayeyarwady River at Ava. Therefore, it has an enormous basin. It is also difficult to delineate the exact boundary of the basin around Mandalay because the land is quite flat and there are artificial channels as well as the 10-inch pipeline that drains the wastewater from Pyi Gyi Ta Gon IZ to Doke Hta Waddy River. Table 3.1-1 and Table 3.1-2 describe monthly mean temperature and monthly rainfall in Mandalay from 2005 to 2014.

Table 3.1-1 Monthly Mean Temperature in Mandalay District (Average), Years 2005-2014

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Temp; (°C)	22.4	25	29.2	32.3	31.9	31.2	31.1	30.4	29.8	28.9	26.4	22.6

Source: 2015 Myanmar Statistical Yearbook, Central Statistical Organization, Ministry of National Planning and Economic Development

Table 3.1-2 Monthly Rainfall in Mandalay District (Average), Years 2005-2014

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (Millimeters)	2	2	8	36	152	99	56	158	199	178	22	12

Source: 2015 Myanmar Statistical Yearbook, Central Statistical Organization, Ministry of National Planning and Economic Development

The river water level which is collected from Department of Metrology and Hydrology under Ministry of Transport and Communication is summarized in the Appendix 2.

3.2 Applied water quality standards

The following water quality standards, which also mentioned wholly in Section "2.5.2 Guideline levels" will be utilized in this report.

(1) QCVN 08:2015/BTNMT (National Technical Regulations on Surface Water, Vietnam)

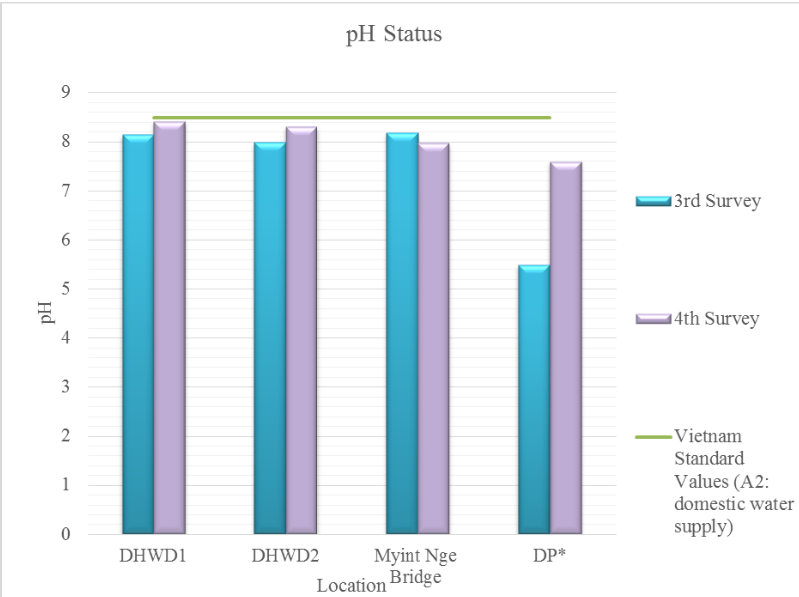
(2) Wastewater, Storm Water Runoff, Effluent and Sanitary Discharges (General Application), National Emission Quality Guideline (NEQG) (2015), Myanmar

The water quality from the points; DHWD1, DHWD2 and Myint Nge Bridge, will be compared with the above-mentioned Vietnamese quality standard while the quality from DP will be compared with the NEQG.

3.3 Water quality results

3.3.1 Basic parameters

(1) pH



Source: MCDC and JICA Expert Team

Figure 3.3-1 pH Status in 3rd and 4th Water Quality Survey

The pH values in the both 3rd and 4th water quality survey fall within the Vietnam Standard Guideline Values (A:2 – Domestic Water Supply) ; between 6 and 8.5 except at DP in the 3rd survey, which shows pH 5.49. The pH value from the 3rd survey at DP of 5.49 also did not comply with NEQG (2015). Therefore, it may affect the ecological conditions and aquatic life in the river near DP. In the 4th water quality survey, the 10 inches pipeline was submerged in the river and was unable to acquire sample water directly. Thus, pH value at DP in the 4th water quality survey was not significantly different with those of river water.

(2) Turbidity

Due to season dissimilarity in the survey period, turbidity in the sample water of 3rd water quality survey (conducted in hot season) was far less than for the 4th water quality survey (conducted in wet season). The considerable difference of turbidity value was observed at DP and it was likely caused because the wastewater from pipeline was diluted with the river water when sampling.

Table 3.3-2 Turbidity Status in 3rd and 4th Survey

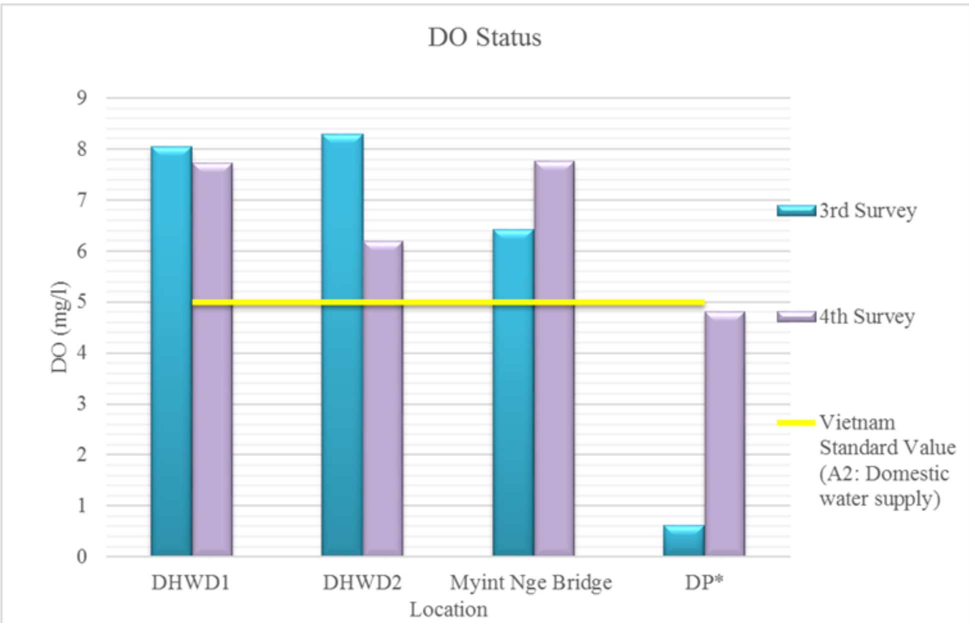
Location	DHWD1	DHWD2	Myint Nge Bridge	DP
3rd survey	0.4	1.9	4.3	>1000
4th survey	39.5	32	34	90.2

Unit: NTU

Source: MCDC and JICA Expert Team

(3) DO

With the exception of DP, all points satisfied the DO limit of reference standard (≥ 5 mg/L) in the both surveys.



Source: MCDC and JICA Expert Team

Figure 3.3-2 DO Status in 3rd and 4th Water Quality Survey

(4) TSS

Total suspended solids (TSS) values in the Doke Hta Waddy River met the Vietnamese standard (A:2 – Domestic Water Supply) in the both seasons even if the direct discharging of the industrial wastewater was flowing to the water body of the Doke Hta Waddy River.

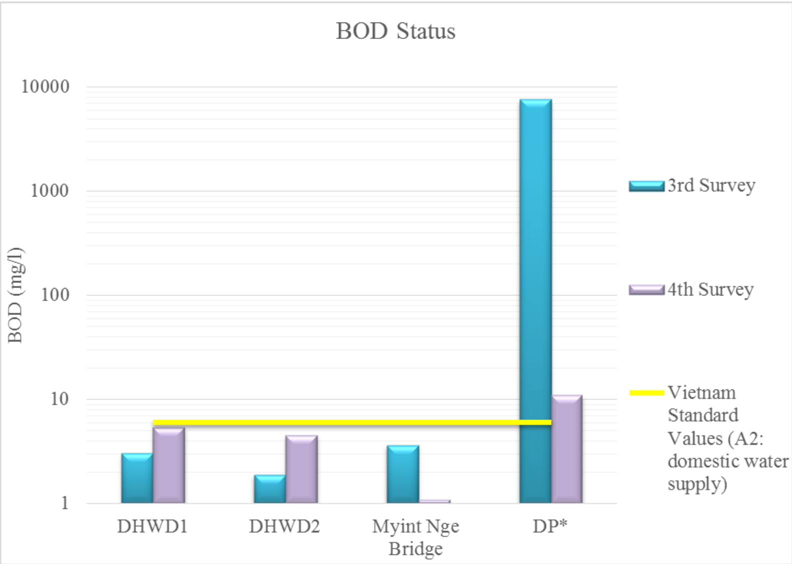
Table 3.3-1 TSS Status in 3rd and 4th Survey

Location	DHWD1	DHWD2	Myint Nge Bridge	DP	Vietnam Standard value (A:2 – Domestic Water Supply)
3rd survey	0.5	0.5	6.0	5160	**30**
4th survey	14	16	22	86	**30**

Source: MCDC and JICA Expert Team

3.3.2 Organic substances

(1) BOD

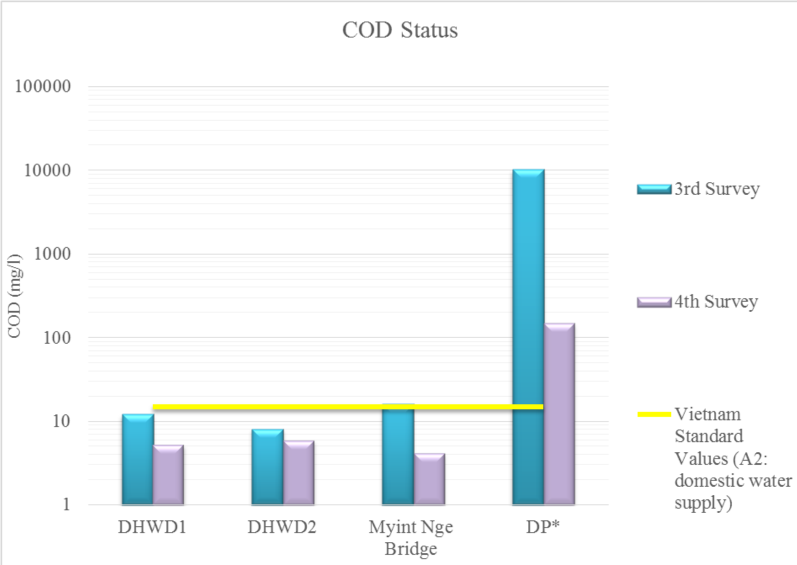


Source: MCDC and JICA Expert Team

Figure 3.3-3 BOD Status in 3rd and 4th Water Quality Survey

The BOD values were within the acceptable range of Vietnamese standard value (A:2 – Domestic Water Supply) of 6 mg/l apart from at the DP. The significant reduction in BOD at DP during the 4th quality survey was encountered due to the 10 inches pipeline submerging the river and could not access to take sample without diluting with the river water.

(2) COD



Source: MCDC and JICA Expert Team

Figure 3.3-4 COD Status in 3rd and 4th Water Quality Survey

COD values complied with the A2 category (domestic water supply with treatment) of the Vietnamese surface water standard besides at the Myint Nge Bridge in the 3rd water quality survey which was a little higher than the standard value.

3.3.3 Bacteria

(1) Total coliform

In the wet season, the total coliform numbers in all sampling points were exceedingly more than the reference standard value likely due to the runoffs from precipitation which conveys organic pollutants. At DHWD1 and Myint Nge Bridge points, less number of coliform (below the standard value) was detected in the dry season. DHWD2 was neglected to examine the total coliform since the Myint Nge Bridge point is also the downstream of the DP. The red-colored values in the blow table represent the ones which are higher than the standard value.

Table 3.3-2 Coliform Status in 3rd and 4th survey

Location	DHWD1	Myint Nge Bridge	DP	Vietnamese Standard value (A:2 – Domestic Water Supply)
3rd survey	79	25	16,000,000	**5,000**

4th survey	92,000	160,000	> 160,000	**5,000**

Source: MCDC and JICA Expert Team

3.3.4 Nutrients

Total nitrogen and total phosphate levels were high at the DP in both survey. At the Myint Nge Bridge, the levels were stabilized to nearly the original condition as in DHWD1 (see Appendix 2).

3.3.5 Heavy metals and other pollutants

Based on the surveys, no heavy metal was detected above the standard value aside from DP. The high level of phenols, oil and grease and chromium hexavalent were also observed at the DP (see Appendix 2).

3.4 Discussion

3.4.1 Impact on the Doke Hta Waddy River by industrial wastewater

From the water quality analysis results, it can be discovered that the impact by the industrial wastewater is still limited due to the large effect of dilution by river water. As the water level of the Doke Hta Waddy River is linked to the Ye Ywa Dam which is situated at the upstream, continuous monitoring is necessary by collaborating with the relevant stake holders. Arising of the nuisance smell around the discharge point was also found out. Any toxic chemicals and heavy metals were not detected at the moment in the River apart from DP. Due to fluctuation of the rate of industrial wastewater disposing from the pipeline, a long-term monitoring is required to assess its quality in the broader spectrum.

3.4.2 Potentiality for source of water distribution

In terms of water quality, the Doke Hta Waddy River has the acceptable range in most of the parameters, comparing with Vietnamese surface water standard values. From the water quality results of 3rd and 4th survey, advanced water treatment system to remove toxic matters would not necessary and ordinary water treatment will be enough to use the Doke Hta Waddy River as a source. But, in order to ensure that the water quality of this River is suitable enough for domestic water supply and distribution over the time, it is essential to investigate more details of water quality considering the external factors such as seasonal impacts, nonpoint pollution sources and geographical conditions. In terms of quantity, water discharge rate from the Ye Ywa Dam should be accounted before initializing of the water supply project. See more detailed discussions in the Water Quality Status Report prepared by JICA Expert Team for output 4 of the Project. Overall, it is considered that the Doke Hta Waddy River has a huge potential as a source for water provision.

4 Conclusion and Recommendations

4.1 Conclusions

Based on the survey evaluation, the following significant points were discovered.

- The impact by the industrial wastewater to the Doke Hta Waddy River is still limited due to large water dilution capacity despite the fact that the industrial wastewater contains oil and grease, chromium hexavalent, phenols and high concentration of nutrients such as nitrogen and phosphorus.
- The wastewater discharged from the 10 inches pipeline does not comply with the the guideline values applied to wastewater (general application, Environmental Quality (Emission) Guideline, 2015) for most parameters.
- In the Doke Hta Waddy River, except for the number of total coliform analyzed in the 4^{th} survey (wet season), other water parameters tested in the both survey satisfied the A2 category of Vietnamese National Technical Regulations on Surface Water (for domestic water supply with treatment and conservation of aquatic lives, QCVN 08:2015 /BTNMT)
- With the application of suitable water treatment system, the water from the Doke Hta Waddy River has an enormous potential to use as a source for water distribution.

4.2 Recommendations

Overall recommendations are listed as below.

- To acknowledge the long-term effect by the industrial wastewater and seasonal and temporal changes on the Doke Hta Waddy River, continuous monitoring such as implementation of biweekly water quality survey is vital.
- Based on the results from the two surveys, the river water quality is good enough to use as a source to supply but investigation on the maximum and minimum available quantity of water especially in the hot season must be considered, since the river water quality would be significantly affected by operation of the Ye Ywa Dam which is located at the upstream of the proposed water intake point.

REFERENCES

- Draft Water Quality Survey Report, JICA Expert Team, March 2017
- National Technical Regulations on Surface Water, QCVN 08:2015/BTNMT (Vietnam)
- National Emission Quality Guideline (2015), Myanmar
- PowerPoint presentation on 4^{th} water quality survey result, JICA Expert Team, November 2017
- PowerPoint presentation on Water Quality Status Report No.2 in Mandalay, JICA Expert Team, March 2018

Appendices

Appendix 1 Photographs

	
Doke Hta Waddy River	Water Sampling in Doke Hta Waddy River
	
Water Sampling in Doke Hta Waddy River	Water Sampling at Discharge Point
	
Water from Discharge Point	Doke Hta Waddy River Basin

Source: JICA Expert Team

Appendix 2 List of Data

A2.1 Analysis Results of 3^{th} Water Quality Survey

Table A.2.1-1 Results of 3^{rd} Water Quality Survey – (1)

No.	Parameter	Date	24/01/17	24/01/17	24/01/17	24/01/17	23/01/17	23/01/17	23/01/7	23/01/17	23/01/17	24/01/17	24/01/17	23/01/17	23/01/17	23/01/17	Unknown	Total Q'ty
		Sampling time	13:10	14:26	16:01	15:15	16:13	15:36	12:13	12:59	13:59	9:47	10:35	10:42	11:32	9:29		
		No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Abbreviated name	DHWD1	DHWD2	Myint Nge Bridge (DHWD 4)	DP	LKP Stream	UST Bridge	TT Bridge	PYTC1	After-aeration 2	N-TTML	S-TTML	TPK Bridge	Upstream of PYTC2	PTM Bridge	UK-M	
		Left/Center/Right	Center	Center	Center	-	Center	Center	Center	Center	Center	-	-	Center	Center	Center	-	
		Depth	Surface	Surface	Surface	-	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	-	
On-site measurement																		
(1)	pH	-	-	7.98	8.17/8.15	5.49	8.52	7.22	7.13	6.88	7.74	7.98	8.92	8.16	8.32	8.13	-	15
(2)	pH	mv	-75	-66	-77	71	-96	-25	-20	-6	-53	-66	-118	-75	-84	-74	-	15
(3)	Conductivity	mS/cm	0.443	0.435	0.434/0.449	5.36	1.81	1.64	1.62	1.64	1.29	1.31	0.446	0.54	1.4	0.741	-	15
(4)	Salinity	ppt	0.2	0.2	0.2/0.2	2.9	0.9	0.8	0.8	0.8	0.6	0.7	0.2	0.3	0.7	0.4	-	15
(5)	Turbidity	NTU	0.4	1.9	1.2/4.3	>1000	210	91.1	86.9	114	34.8	78.2	83.2	139	151	103	-	15
(6)	TDS	g/L	0.288	0.287	1.27/0.292	3.37	1.16	1.05	1.04	1.05	0.824	0.839	0.29	0.346	0.896	0.475	-	15
(7)	Water Temperature	Degree C	24.2	23.7	29.64/24.53	31.62	27.42	27.23	25.19	27.37	26.32	24.61	26.17	21.23	22.46	20.54	-	15
(8)	ORP	mv	126	147	59/86	-255	42	-234	-216	-247	-248	119	99	197	206	225	-	15
(9)	DO	mg/L	8.04	8.29	4.78/6.43	0.62	5.27	8.82	1.01	0.81	8.97	4.4	5.2	7.4	4.81	11.33	-	15
(10)	Ambient air temperature	Degree C	32.1	31.6	29.8	30.4	30.5	31.7	33.6	33.9	32.8	28.7	30.4	30.1	32.5	29.3	-	15
Laboratory analysis																		
(1)	Total Suspended Solids (TSS)	mg/L	<0.50	<0.50	6.00	5160.00	154.00	210.00	25.00	208.00	8.00	47.00	50.00	-	-	80.00	2.00	13
(2)	BOD	mg/L	3.05	1.88	3.60	7600.00	29.00	206.25	482.50	337.50	20.67	67.00	15.25	15.33	23.67	7.92	<1.00	15
(3)	COD Cr	mg/L	12.19	8.13	16.26	10295.47	71.12	215.39	1056.64	883.92	34.54	103.63	62.99	22.35	44.70	14.22	8.13	15
(4)	Cyanide~~(total)~~	mg/L	<0.05	-	<0.05	0.14	-	0.09	-	-	-	<0.05	<0.05	-	-	-	<0.05	7
(5)	Oil and grease	mg/L	13.12	-	1.88	72.81	-	31.61	-	-	-	22.67	25.63	3.74	-	8.22	25.71	9
(6)	Phenols	mg/L	<0.001	-	<0.001	1.26	-	<0.001	-	-	-	<0.001	<0.001	-	-	-	<0.001	7
(7)	Total phosphorus	mg/L	<0.10	-	<0.10	77.85	-	3.65	-	-	-	2.63	0.44	0.31	0.52	0.20	<0.1	10

	(T-P)																
(8)	Phosphate (PO4-)	mg/L	0.00	-	0.01	7.47	-	1.89	-	-	-	0.3	0.21	-	-	0.02	N.D	8
(9)	Total nitrogen (T-N)	mg/L	<0.05	-	<0.05	10.06	-	<0.05	-	-	-	19.22	0.83	2.07	2.63	0.45	<0.05	10
(10)	Ammonia nitrogen(NH3-N)	mg/L	0.54	-	0.38	98.11	-	12.26	-	-	-	28.36	1.61	-	-	0.46	0.54	8
(11)	Nitrite nitrogen(NO2-N)	mg/L	<0.02	-	<0.02	0.21	-	<0.20	-	-	-	<0.20	<0.2	-	-	0.22	<0.02	8
(12)	Nitrate nitrogen(NO3-N)	mg/L	<0.50	-	<0.50	<0.05	-	<0.05	-	-	-	<0.50	<0.05	-	-	<0.50	<0.50	8
(13)	Zinc (Zn)	mg/L	0.0026	-	<0.0015	0.1292	-	0.0090	-	-	-	<0.0015	<0.0015	-	-	-	0.0017	7
(14)	Total chromium (T-Cr)	mg/L	<0.0015	-	<0.0005	0.0135	0.0017	0.0025	-	0.0023	-	<0.0015	<0.0005	-	-	-	<0.0005	9
(15)	Chromium (Hexavalent)	mg/L	<0.0025	-	<0.025	<0.05	<0.025	<0025	-	<0.0025	-	<0.025	<0.025	-	-	-	<0.025	9
(16)	Arsenic (As)	mg/L	0.0020	-	0.0035	0.0049	-	0.0081	-		-	0.0044	0.0022	-	-	-	0.0020	7
(17)	Copper (Cu)	mg/L	0.0005	-	<0.0005	0.0248	-	0.0029	-		-	<0.0015	<0.0015	-	-	-	<0.0005	7
(18)	Total Mercury (Hg)	mg/L	<0.0002	-	0.0011	0.0018	0.0013	0.0014	-	0.0012	-	0.0013	0.0011	-	-	-	0.0010	9
(19)	Cadmium (Cd)	mg/L	<0.0005	-	<0.0015	<0.0005	-	<0.0015	-		-	<0.0005	<0.0005	-	-	-	<0.0005	7
(20)	Lead (Pb)	mg/L	<0.0005	-	<0.0005	0.0041	-	0.1914	-		-	<0.0005	0.0016	-	-	-	<0.0005	7
(21)	Iron (Fe)	mg/L	-	-	-	-	-	-	-		-			-	-	-	-	0
(22)	Manganese(Mn)	mg/L	-	-	-	-	-	-	-		-			-	-	-	-	0
(23)	Total Coliform	MPN/100mL	79	-	25	16,000,000	490	79,000	-	33,000	-	28,000	33	-	-	1,300	49	10
(24)	Total organic chlorine pesticides	mg/L	-	-	<0.001	-	-	-	-	-	-	0.001	-	-	-	-	-	2
(25)	Total organic phosphorus pesticides	mg/L	-	-	<0.005	-	-	-	-	-	-	<0.005	-	-	-	-	-	2
(26)	PCB (Aroclor 1254)	mg/L	-	-	<0.01	-	-	-	-	-	-		-	-	-	-	-	1

Source: JICA Expert Team

A2.2 Analysis Results of 4th Water Quality Survey

Table A.2.2-1 Results of 4th Water Quality Survey – (1)

No	No	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Location name		DHWD1	DHWD2	Myint Nge Bridge	DP*	LKP Stream	UST Bridge	TT Bridge	PYTC-62nd Str.	PYTC-1'	After-aeration	N-TTML	S-TTML	PTM Bridge	SK Creek	Intake AYWD	UK-M
	Left/Center/Right		Center	Center	Center	-	Center	Center	Center	Center	Center	Center	Center	Center	Center	Center	Left	-
	Sampling Date		3/10/2017	3/10/2017	3/10/2017	3/10/2017	2/10/2017	2/10/2017	2/10/2017	2/10/2017	2/10/2017	2/10/2017	3/10/2017	3/10/2017	2/10/2017	2/10/2017	2/10/2017	-
	Sampling Time		10:20	11:30	14:11	12:01	16:10	16:50	14:36	11:50	15:30	12:55	16:11	16:40	10:48	9:53	8:45	-
On-site measurement																		
1	Air Temperature	° C	39.22	38.55	38.60	29.27	35.67	34.33	35.77	31.90	34.50	35.94	32	32.39	33.8	34	32	-
2	Water Temperature	° C	28.50	29.00	29.43	38	33.47	33.06	31.60	30.65	31.71	31.59	31.63	31.23	30.46	29.88	31	-
3	pH	-	8.40	8.30	7.96	7.59	8.03	7.77	7.46	7.86	7.82	7.93	8.18	8.56	7.56	8.02	7.88	-
4	ORP	mv	140	145	185	69.00	135	123	-78	147	95	-232	118	132	196	160	206	-
5	Conductivity	ms/cm	0.235	0.293	0.289	0.348	0.363	0.435	0.504	0.424	0.447	1.10	0.424	0.409	0.339	0.306	0.199	-
6	Turbidity	NTU	39.5	32	34	90.20	32.3	52.2	73.5	97.10	72.1	104	34	35.5	74	96.6	74.1	-
7	DO	mg/L	7.73	6.21	7.78	4.82	6.57	6.70	5.11	6.31	8.89	5.36	5.12	6.43	7.38	8.52	7.68	-
8	TDS	mg/L	160	190	191	234	242	283	323	275	310	701	275	266	227	202	133	-
9	Salinity	ppt	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.2	0.2	0.2	0.1	0.1	-
Laboratory analysis																		
1	BOD	mg/L	5.4	4.5	1.1	11.0	2.7	5.6	4.8	2.3	5.1	3.9	6.0	5.4	6.6	1.6	5.4	4.2
2	Total Coliform	MPN/100ml	92,000	-	160,000	> 160,000	35,000	> 160,000	-	-	> 160,000	160,000	17,000	24,000	-	-	92,000	54,000
3	Total Suspended Solids (TSS)	mg/L	14	16	22	86	7.8	22	28	68	36	28	15	14	44	62	45	17
4	COD Cr	mg/L	5.3	6.0	4.2	150	17	31	34	23	32	70	28	28	14	15	11	4.6
5	Cyanide(total)	mg/L	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-	-	< 0.1	< 0.1
6	Oil and grease	mg/L	< 1	-	< 1	9.1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	-	< 1	< 1
7	Phenols	mg/L	< 0.005	-	< 0.005	0.012	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0086	< 0.005	< 0.005	-	-	< 0.005	< 0.005
8	Total phosphorus (T-P)	mg/L	< 0.06	-	< 0.06	0.32	0.10	0.31	0.39	0.28	0.31	2.7	0.38	0.36	0.063	0.20	0.077	< 0.06
9	Total nitrogen (T-N)	mg/L	0.30	-	0.34	2.8	0.60	2.0	3.0	2.1	2.1	18	2.0	1.7	0.63	1.2	0.51	0.27
10	Zinc (Zn)	mg/L	0.0081	-	0.0098	0.014	0.010	0.016	0.0096	0.014	0.011	0.018	0.0074	0.0050	-	-	0.0087	0.0094
11	Total chromium (T-Cr)	mg/L	0.0058	-	< 0.005	0.0050	< 0.005	0.011	< 0.005	0.0054	0.0054	0.0050	< 0.005	< 0.005	-	-	0.0056	0.0050

No	No	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Location name		DHWD1	DHWD2	Myint Nge Bridge	DP*	LKP Stream	UST Bridge	TT Bridge	PYTC-62nd Str.	PYTC-1'	After-aeration	N-TTML	S-TTML	PTM Bridge	SK Creek	Intake AYWD	UK-M
	Left/Center/Right		Center	Center	Center	-	Center	Center	Center	Center	Center	Center	Center	Center	Center	Center	Left	-
	Sampling Date		3/10/2017	3/10/2017	3/10/2017	3/10/2017	2/10/2017	2/10/2017	2/10/2017	2/10/2017	2/10/2017	2/10/2017	3/10/2017	3/10/2017	2/10/2017	2/10/2017	2/10/2017	-
	Sampling Time		10:20	11:30	14:11	12:01	16:10	16:50	14:36	11:50	15:30	12:55	16:11	16:40	10:48	9:53	8:45	-
12	Chromium (Hexavalent)	mg/L	< 0.005	-	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-	-	< 0.005	< 0.005
13	Arsenic (As)	mg/L	0.0016	-	0.0019	0.0033	0.0040	0.0041	0.0034	0.0032	0.0035	0.0041	0.0037	0.0042	-	-	0.0017	0.0019
14	Copper (Cu)	mg/L	< 0.005	-	< 0.005	0.016	< 0.005	0.0097	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-	-	< 0.005	< 0.005
15	Total Mercury (Hg)	mg/L	< 0.0005	-	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	-	-	< 0.0005	< 0.0005
16	Cadmium (Cd)	mg/L	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-	< 0.001	< 0.001
17	Lead (Pb)	mg/L	< 0.005	-	< 0.005	0.0056	< 0.005	0.0051	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-	-	< 0.005	< 0.005
18	Pesticides	mg/L	See Table A 2.2-3	-	-	-	-	-	-	-	-	-	-	-	-	-	See Table A 2.2-3	-
19	PCBs	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	< 0.0005	-

Source: JICA Expert Team

Table A.2.2-2 Results of 4th Water Quality Survey (MCDC)

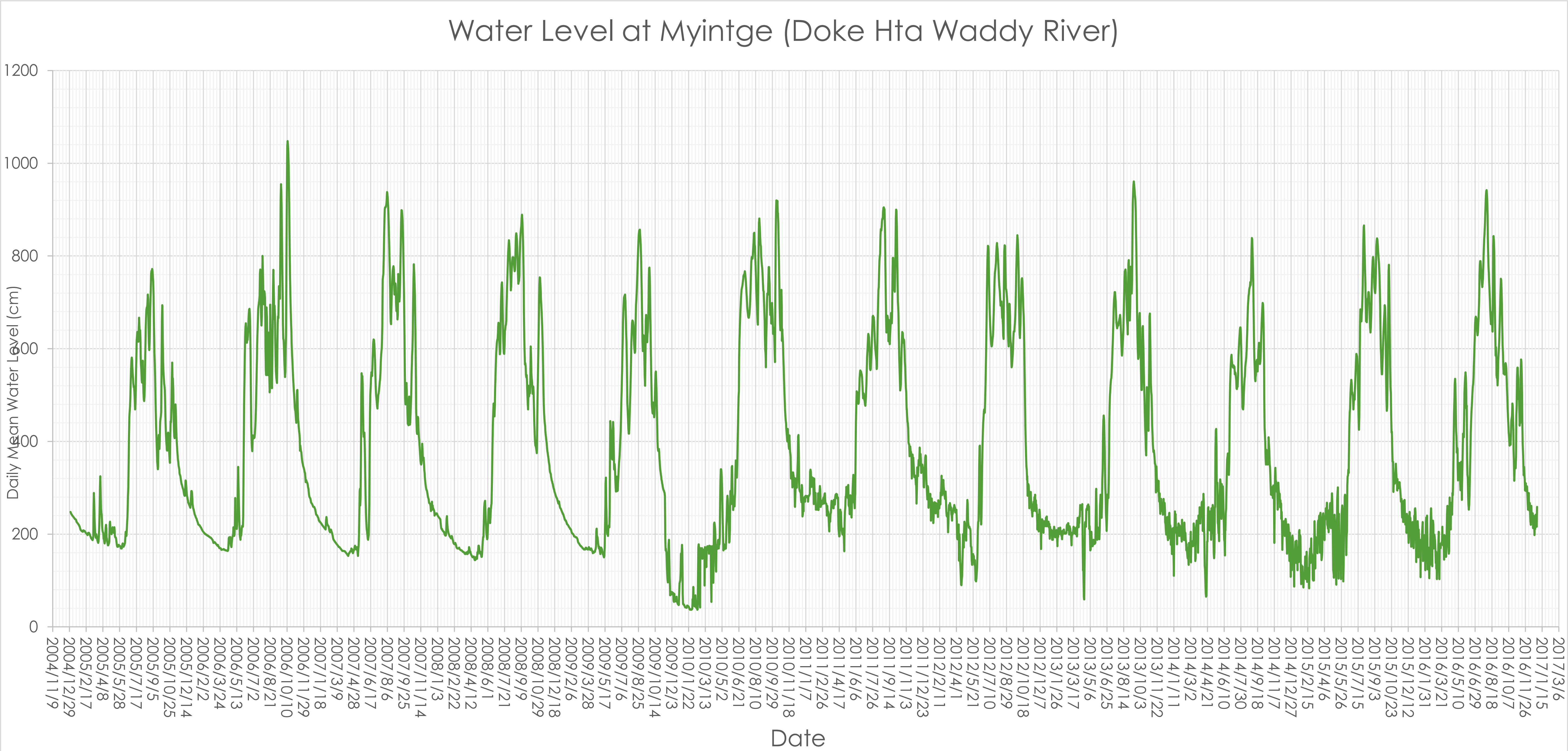
	Date	3.10.2017	3.10.2017	3.10.2017	3.10.2017	2.10.2017	2.10.2017	2.10.2017	2.10.2017	2.10.2017	2.10.2017	3.10.2017	3.10.2017	2.10.2017	2.10.2017	2.10.2017	3.10.2017
	Location Name	DHWD-1	DHWD-2	Myint Nge Bridge	DP	LKP stream	UST Bridge	TT Bridge	PYTC-62 Str	PYTC-1	After-aeration 2	N-TTML	S-TTML	PTM Bridge	SK Creek	Intake AYWD	UK-M
	Time	10:20am	11:30am	2:11pm	12:00	4:10pm	4:50pm	2:36pm	11:50am	3:30pm	12:55pm	4:11pm	4:40pm	10:48am	09:53am	8:45am	10:20am
	Latitude	21˚49'35.2"	21˚49'54.6"	_	_	21˚53'28.1"	21˚53'59"	21˚53'56.1"	21˚54'49.1"	21˚54'5.5"	21˚54'34.1"	21˚54'56"	21˚59'7.9"	21˚56'44.4"	22˚01'20.6"	21˚59'24.4"	21˚49'35.2"
	Longitude	96˚05'40.6"	96˚05'14.3"	_	_	96˚04'53.9"	96˚04'36.1"	96˚05'13.7"	96˚06'36.3"	96˚05'38.4"	96˚05'25.6"	96˚03'32.7"	96˚03'23.6"	96˚07'51.9"	96˚05'28.3"	96˚03'37.3"	96˚05'40.6"
On Site measurement																	
1	Air Temperature (°C)	39.2	38.55	38.61	_	35.67	34.33	35.77	31.9	34.5	35.94	32	32.39	33.77	_	_	39.2
2	Temperature (°C)	28.5	29	29.43	29.27	33.42	33.06	31.6	30.65	31.71	31.59	31.63	31.23	30.46	29.88	31	28.5
3	pH	8.4	8.3	7.96	7.59	8.03	7.77	7.46	7.86	7.82	7.93	8.18	8.56	7.56	8.02	7.88	8.4
4	pHmV	-86	-80	-60	-38	-65	-49	-30	-54	-52	-59	-74	-97	-36	-64	-56	-86
5	ORPmV	140	145	185	69	135	123	-78	147	95	-232	118	132	196	160	206	140
6	EC (mS/cm)	0.235	0.293	0.289	0.348	0.363	0.435	0.504	0.424	0.477	1.1	0.424	0.409	0.339	0.306	0.199	0.235
7	Turbidity (NTU)	39.5	32.3	34	90.2	32.3	52.2	73.5	97.1	72.1	104	34	35.5	74	96.6	74.1	39.5
8	DO (mg/l)	7.73	6.21	7.78	4.82	6.57	6.7	5.11	6.31	8.89	5.36	5.12	6.43	7.38	8.52	7.68	7.73
9	TDS (g/l)	0.16	0.19	0.191	0.234	0.242	0.283	0.323	0.275	0.31	0.701	0.275	0.266	0.227	0.202	0.133	0.16
10	Salinity (ppt)	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.2	0.2	0.2	0.1	0.1	0.1
Lab Analysis																	
1	Total Suspended Solid	13	12	15	73	14	24	40	37	38	71	17	17	33	24	41	13
2	DO (mg/l)	6.8	5.93	5.82	5.46	5	2.77	0.93	3.92	2.66	0.35	5.79	6.3	5.43	5.38	5.91	6.08
3	BOD(mg/l)	4.5	4.4	4.6	9.5	21	28	45	38	42	58	28	26	35	4.8	3.9	4.6
4	$COD_{cr\ (mg/l)}$	11.25	11	11.5	23.75	52.5	70	112.5	95	105	145	70	65	87.5	12	9.75	11.5
5	cyanide (total) (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
6	Total phosphorus (T-P)(mg/l)	0.898	3.95	2.97	5.63	2.62	3.82	8.39	9.29	4.84	18.1	5.69	6.45	3.04	7.62	1.26	1.25
7	Total Nitrogen (T-N)(mg/l)	0.067	0.532	0.433	0.544	0.573	1.17	1.07	0.258	1.06	7.64	1.32	1.34	0.293	0.33	0.238	0.035
8	Zinc (Zn)(mg/l)	0.13		0.21	0.18	0.04	0.05	0	0.15	0	0	0.06	0.17			0.44	0.12
9	Copper (Cu)(mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Source: MCDC

Table A 2.2-3 Results of 4th Water Quality Survey (Pesticide)

No.	No	Unit	No.1	No.15
	Location name		DHWD1	Intake AYWD
	Location Description		Upstream of the wastewater-discharging point	Intake point of Ayeyarwaddy River
	Left/Center/Right		Center	Left
	Sampling Date		3/10/2017	2/10/2017
	Sampling Time		10:20	8:45
1	Aldrin	mg/L	< 0.0005	< 0.0005
2	Atrazine	mg/L	< 0.0005	< 0.0005
3	4,4'-DDD	mg/L	< 0.0005	< 0.0005
4	4,4'-DDE	mg/L	< 0.0005	< 0.0005
5	4,4'-DDT	mg/L	< 0.0005	< 0.0005
6	Endosulfan	mg/L	< 0.0005	< 0.0005
7	Endosulfan sulfate	mg/L	< 0.0005	< 0.0005
8	Endrin	mg/L	< 0.0005	< 0.0005
9	HCH-alpha (benzene hexachloride-alpha)(alpha-BHC)	mg/L	< 0.0005	< 0.0005
10	HCH-beta(beta-BHC)	mg/L	< 0.0005	< 0.0005
11	HCH-delta(delta-BHC)	mg/L	< 0.0005	< 0.0005
12	HCH-gamma(Lindane)(ganma-BHC)	mg/L	< 0.0005	< 0.0005
13	Alachlor	mg/L	< 0.0005	< 0.0005
14	Diazinon	mg/L	< 0.0005	< 0.0005
15	Chlorpyrifos	mg/L	< 0.0005	< 0.0005
16	Dimethoate	mg/L	< 0.0005	< 0.0005
17	Imidacloprid	mg/L	< 0.0005	< 0.0005

Source: MCDC



Source: DMH

Figure A.2.3 Water Level at Doke Hta Waddy River

Table A.2.3-2 Analysis Method of 4th Water Quality Survey (Japan Lab) –(1)

No.	Parameter	Method	Name of laboratory
Laboratory analysis in Myanmar			
1	BOD	Respirometric method (HACH Method 10099)	DOWA Eco-system–Myanmar Co., Ltd. for survey in Hlaing River basin
		Membrane electrode method (SM 2012:5210 B and 4500-O G)	REM-UAE Laboratory and Consultant Co., Ltd. for survey in Doke Hta Waddy River basin
2	Total Coliform	Standard total coliform fermentation method (APHA 9221 B)	DOWA Eco-system–Myanmar Co., Ltd. for survey in Hlaing River basin
		Multiple tube fermentation technique (SM 2012:9221 B)	REM-UAE Laboratory and Consultant Co., Ltd. for survey in Doke Hta Waddy River basin
Laboratory analysis in Japan			
3	Total Suspended Solids (TSS)	Environment Agency Notification No. 59, 1971, Appendix, Table 9	OSUMI CO., Ltd.
4	COD Cr	JIS K0102 (2016) 20.1	OSUMI CO., Ltd.
5	Cyanide(total)	JIS K0102 (2016) 38.1.2 and 38.3	OSUMI CO., Ltd.
6	Oil and grease	Standard Method 5520 B	OSUMI CO., Ltd.
7	Phenols	JIS K0102(2016) 28.1.1 and 28.1.2	OSUMI CO., Ltd.
8	Total phosphorus (T-P)	JIS K0102(2016) 46.3.1	OSUMI CO., Ltd.
9	Total nitrogen (T-N)	JIS K0102(2016) 45.2	OSUMI CO., Ltd.
10	Zinc (Zn)	JIS K0102(2016) 53.3	OSUMI CO., Ltd.
11	Total chromium (T-Cr)	JIS K0102(2016) 65.1.4	OSUMI CO., Ltd.
12	Chromium (Hexavalent)	JIS K0102(2016) 65.2.1	OSUMI CO., Ltd.
13	Arsenic (As)	JIS K0102(2016) 61.4	OSUMI CO., Ltd.
14	Copper (Cu)	JIS K0102(2016) 52.4	OSUMI CO., Ltd.
15	Total Mercury (Hg)	Environment Agency Notification No.59, 1971, Appendix, table 1	OSUMI CO., Ltd.

Table A.2.3-2 Analysis Method of 4th Water Quality Survey (Japan Lab) –(2)

No.	Parameter	Method	Name of laboratory
16	Cadmium (Cd)	JIS K0102(2016) 55.4	OSUMI CO., Ltd.
17	Lead (Pb)	JIS K0102(2016) 54.4	OSUMI CO., Ltd.
18	Pesticides	See below	OSUMI CO., Ltd.
19	PCBs	Environment Agency Notification No.59, 1971, Appendix, table 3	OSUMI CO., Ltd.
Laboratory analysis in Japan (pesticides)			
1	Aldrin	GC-MS *	Nihon Ecotech Co., Ltd.
2	Atrazine	GC-MS *	Nihon Ecotech Co., Ltd.
3	4,4'-DDD	GC-MS *	Nihon Ecotech Co., Ltd.
4	4,4'-DDE	GC-MS *	Nihon Ecotech Co., Ltd.
5	4,4'-DDT	GC-MS *	Nihon Ecotech Co., Ltd.
6	Endosulfan	GC-MS *	Nihon Ecotech Co., Ltd.
7	Endosulfan sulfate	GC-MS *	Nihon Ecotech Co., Ltd.
8	Endrin	GC-MS *	Nihon Ecotech Co., Ltd.
9	HCH-alpha (benzene hexachloride-alpha)(alpha-BHC)	GC-MS *	Nihon Ecotech Co., Ltd.
10	HCH-beta(beta-BHC)	GC-MS *	Nihon Ecotech Co., Ltd.
11	HCH-delta(delta-BHC)	GC-MS *	Nihon Ecotech Co., Ltd.
12	HCH-gamma(Lindane)(ganma-BHC)	GC-MS *	Nihon Ecotech Co., Ltd.
13	Alachlor	GC-MS *	Nihon Ecotech Co., Ltd.
14	Diazinon	GC-MS *	Nihon Ecotech Co., Ltd.
15	Chlorpyrifos	GC-MS *	Nihon Ecotech Co., Ltd.
16	Dimethoate	LC-MS/MS *	Nihon Ecotech Co., Ltd.
17	Imidacloprid	GC-MS *	Nihon Ecotech Co., Ltd.

*Analyze based on "Notice by the Director General of the Environment Management Bureau No.170391 of March 9, 2017"

Appendix 11:

Manual for Operation and Maintenance of Databases

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

MANUAL

FOR

OPERATION AND MAINTENANCE OF DATABASES

VERSION 4.0

December 2017

PREPARED BY:

JICA EXPERT TEAM

PREFACE

This manual for database operation and maintenance was developed as part of the outputs of the bilateral technical cooperation project between Myanmar and Japan entitled “Project for Capacity Development in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar (hereinafter referred to as “the Project”). The project has the aim to support and enhance capacities of Ministry of Natural Resources and Environmental Conservation (MONREC) and other organizations concerned to manage water environment and to implement EIA reviews. Among the six outputs of the project, this manual was produced to fulfill the goal of Output 3 “database of water pollution sources and river water quality is developed”. We sincerely hope that this manual helps each organization develop and maintain databases of water pollution sources and surface water quality for good management of water environment.

JICA Expert Team

Flow Chart for Database Development

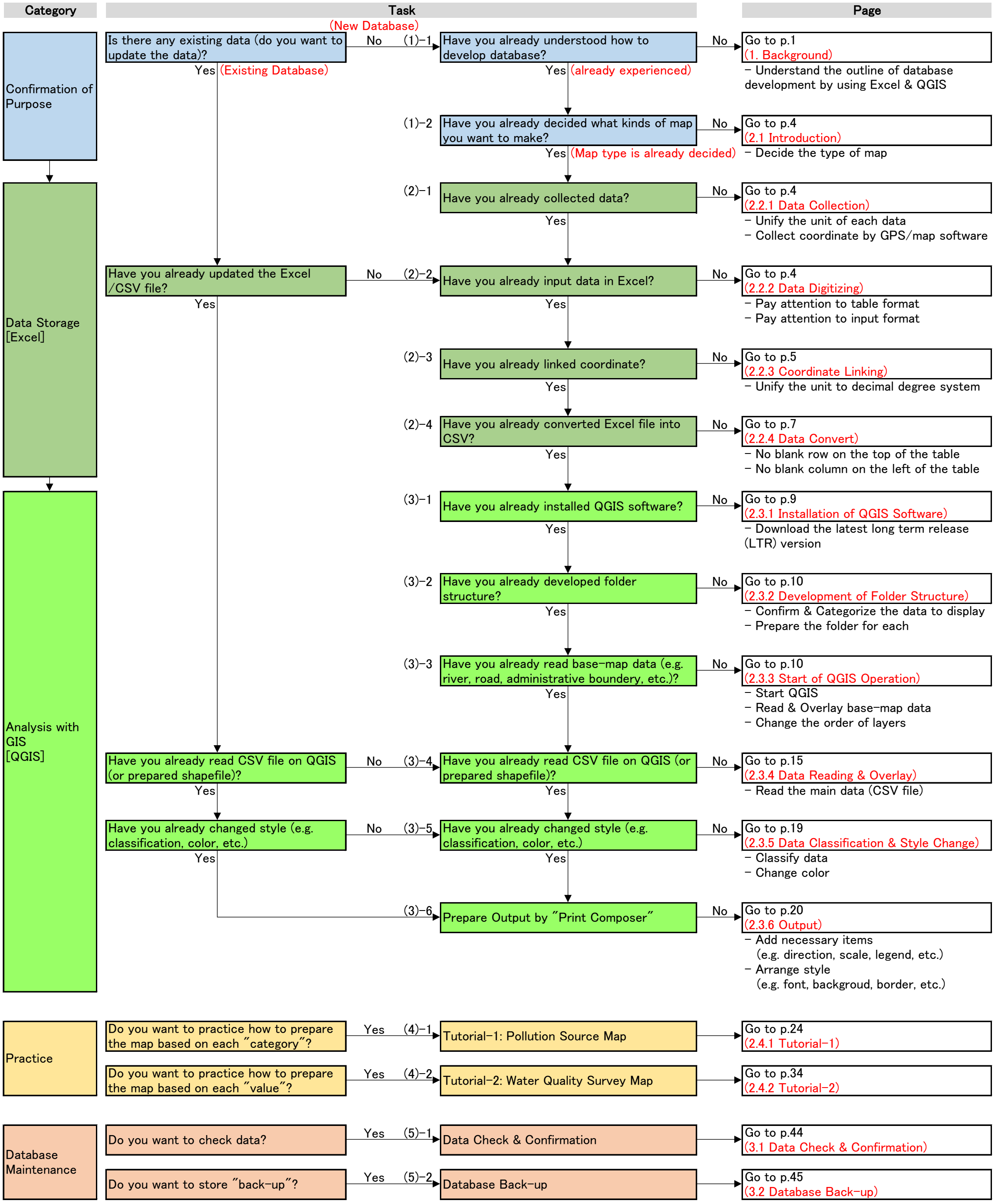


Table of Contents

1 BACKGROUND

1.1 BACKGROUND

In order to manage the water environment of rivers and lakes, it is necessary to consider both pollution sources and water quality of water bodies in each river basin, and for this purpose, related information on pollution sources and water bodies should be collected, stored and analyzed. With the recent increase in industrial activities and their impact to water environment in Myanmar, the demand for databases for managing such information is increasing rapidly. In order to demonstrate how such databases may be developed, this project constructed databases of pollution sources and databases of surface water quality in the target areas, namely Hlaing River basin in Yangon and Doke Hta Waddy River basin in Mandalay.

This manual shows how to operate and maintain these databases for water environment management.

1.2 OBJECTIVES

This manual was developed to support officers and staff members of ECD, YCDC and MCDC in managing environmental information by developing and using databases. The objective of the manual is:

- To provide officers and staff with a tutorial document about the databases developed in this project, so that they can self-teach and/or train others how to operate, add new data and maintain theses databases for water environment management.

1.3 TARGET AND USE OF MANUAL

1.3.1 Target

The main target of the manual is officers and staff members of ECD, YCDC and MCDC who are in charge of database development, operation and maintenance.

1.3.2 Use of Manual

This manual contains the following two hands-on tutorial modules in Section 2.4:

- [Let’s Try (1)] To make the location map of Sector (Pollution Source)
- [Let’s Try (2)] To make the BOD map (Surface Water Quality)

These modules are the core of this manual, and you are strongly encouraged to try these modules. However, to go through these tutorials, you will need some basic knowledge in GIS.

To help you gain such knowledge quickly, more basic explanations about the structure of the database and GIS software are given in other sections of the manual.

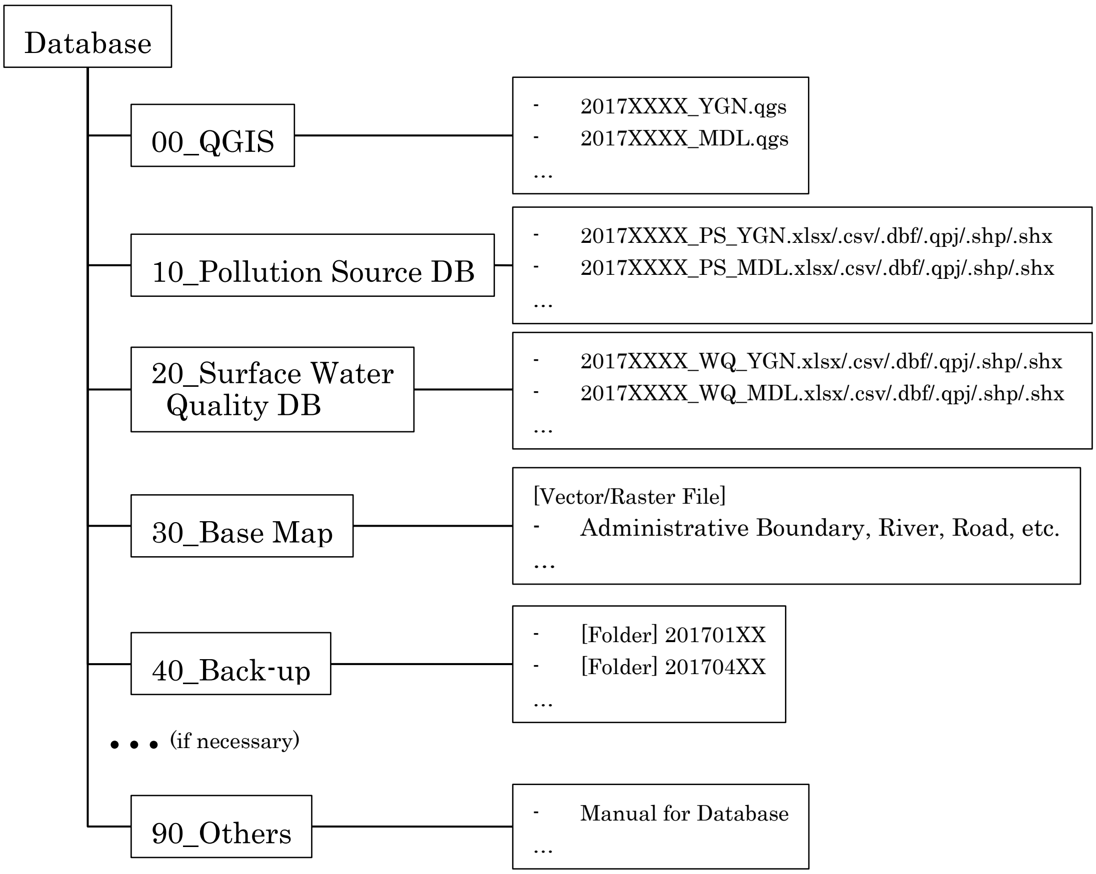
1.4 STRUCTURE AND FLOW

1.4.1 Database Structure

Two types of databases are explained in this manual, namely "Pollution Source Database" and "Surface Water Quality Database".

- Pollution Source Database: To store many kinds of information of pollution source
- Surface Water Quality Database: To store analysis results of water quality of target rivers/lakes

Figure 1-1 shows the database structure. "DB" means Database, "PS" means Pollution Source and "WQ" means Surface Water Quality of public water bodies, such as rivers and lakes.

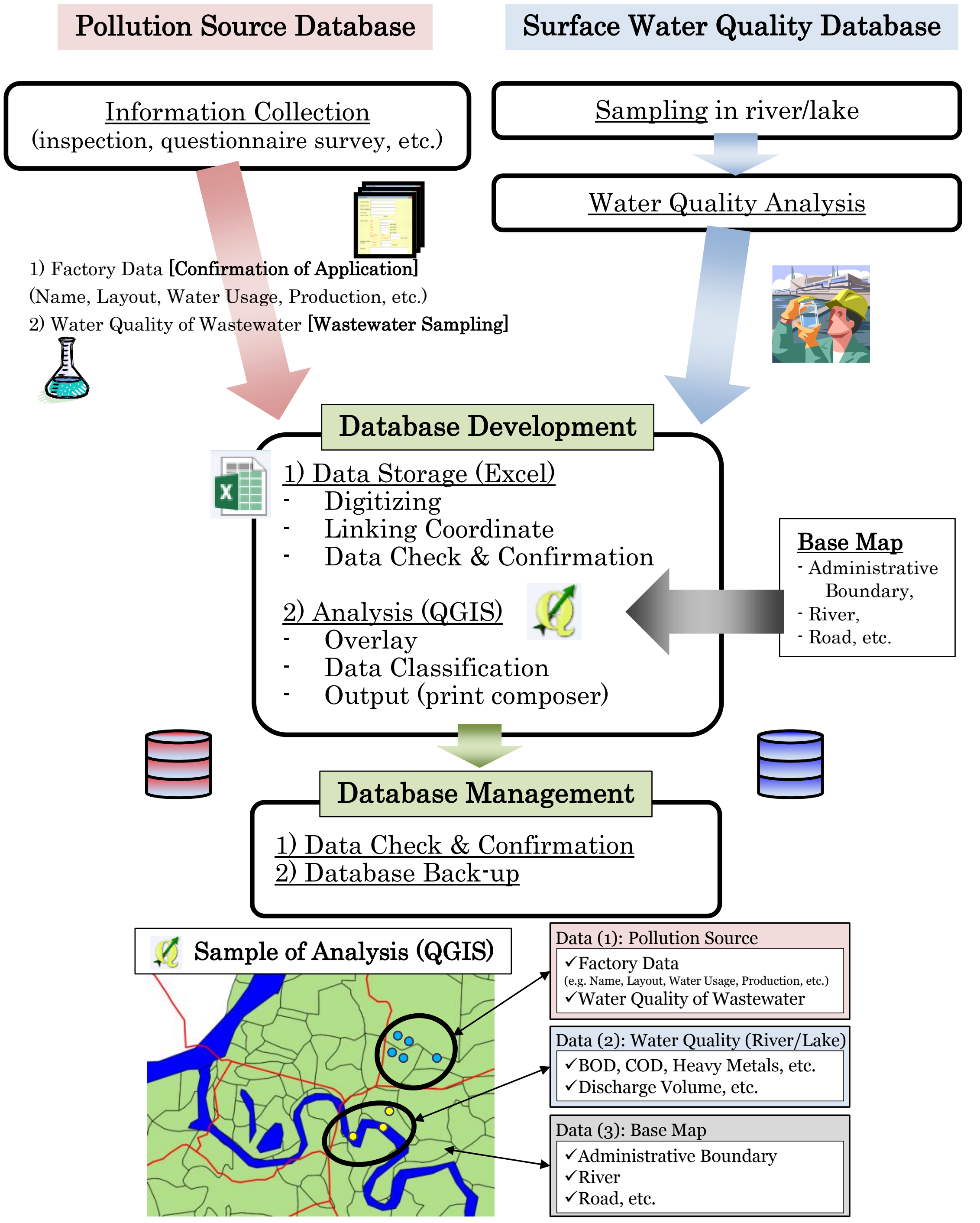


Source: JICA Expert Team

Figure 1-1 Database Structure

1.4.2 Data Flow

Figure 1-2 shows the data flow for the Pollution Source Database and the Surface Water Quality Database.



Source: JICA Expert Team

Figure 1-2 Data Flow

2 DATABASE OPERATION

2.1 INTRODUCTION

In this chapter, procedures of database operation (usage), including data storage by using Excel and analysis by using QGIS, are shown. Then, two tutorial modules are presented in Section 2.4 to give users hands-on experiences in using the databases developed in this project.

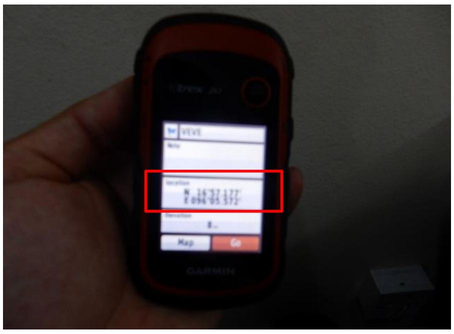
2.2 DATA STORAGE

2.2.1 Data Collection

When you start preparing maps by using QGIS, it is necessary to collect the coordinate of each point. The main ways to collect coordinate are as follows.

(1) *GPS Device*

Coordinate can be collected easily by using GPS device which has the function to record the coordinate of a lot of points (e.g. “Waypoint Manager”, etc.). The below photo shows the sample of GPS device. In addition, some kinds of mobile phone have functions to collect coordinate recently.



(2) *Map Software*

If you cannot collect coordinate by GPS device, it is one option to find coordinate by map software, some of which is available free of charge.

2.2.2 Data Digitizing

Data in a database should be readily accessible to users, and the data in the databases developed in this project were first stored in Excel spreadsheet files. In this way user can always access and analyze data without specialized software. However, to see the data in GIS software, QGIS, it is necessary to convert the data to CSV (comma-separated value) format. Thus, in this section, the user will learn how to enter data into Excel, and then convert the file to CSV format. Table below shows an example of an Excel data set of surface water quality.

Column Name (Title)

No.	Name	Sampling Date	Latitude	Longitude	Laboraory	BOD (ppm)	COD (ppm)	pH	DO (mg/l)	TSS (ppm)
1	Pan Hlaing 1	21-Jun-16	16.86042	96.03381	Wastewater Treatment Lab	17	32	7.4	2.67	392
2	Pan Hlaing 2	21-Jun-16	16.82722	96.10306	Wastewater Treatment Lab	20	15	7.6	2.16	260
3	Hlaing 1	21-Jun-16	16.94967	96.05700	Wastewater Treatment Lab	14	9	7.6	3.58	151
4	Hlaing 3	21-Jun-16	16.87228	96.09142	Wastewater Treatment Lab	10	10	7.7	3.93	187
5	Hlaing 5	21-Jun-16	16.80572	96.11861	Wastewater Treatment Lab	11	11	7.6	3.38	182
6	HTIZ 1	22-Jun-16	16.83939	96.07566	Wastewater Treatment Lab	224	325	6.6	1.23	26
7	HTIZ 2	22-Jun-16	16.84475	96.06835	Wastewater Treatment Lab	118	248	6.8	1.22	53
8	Shwe 1	22-Jun-16	16.93066	96.07438	Wastewater Treatment Lab	359	173	6.1	1.2	135
9	Shwe 3	22-Jun-16	16.93947	96.08693	Wastewater Treatment Lab	546	85	6.2	1.73	229
10	Shwe 5	22-Jun-16	16.94655	96.09228	Wastewater Treatment Lab	152	261	6.5	1.26	150

Rows

In Excel data entry, the first row contains the column names (title) and definition for the data type in each column. Data analysis with Excel is beyond the scope of this manual, but users can carry out most data analysis using Excel.

If you need to create a data table from scratch, follow the following guidelines for organizing your data.

- The data should be **organized in rows and columns**, with each row containing information about one record, such as a sample ID, or factory type.
- In the first row of the list, each column should contain a short, descriptive and **unique heading**.
-

Column Name (Title)

No.	Name	Sampling Date	Latitude	Longitude	Laboraory	BOD (ppm)	COD (ppm)	pH	DO (mg/l)	TSS (ppm)

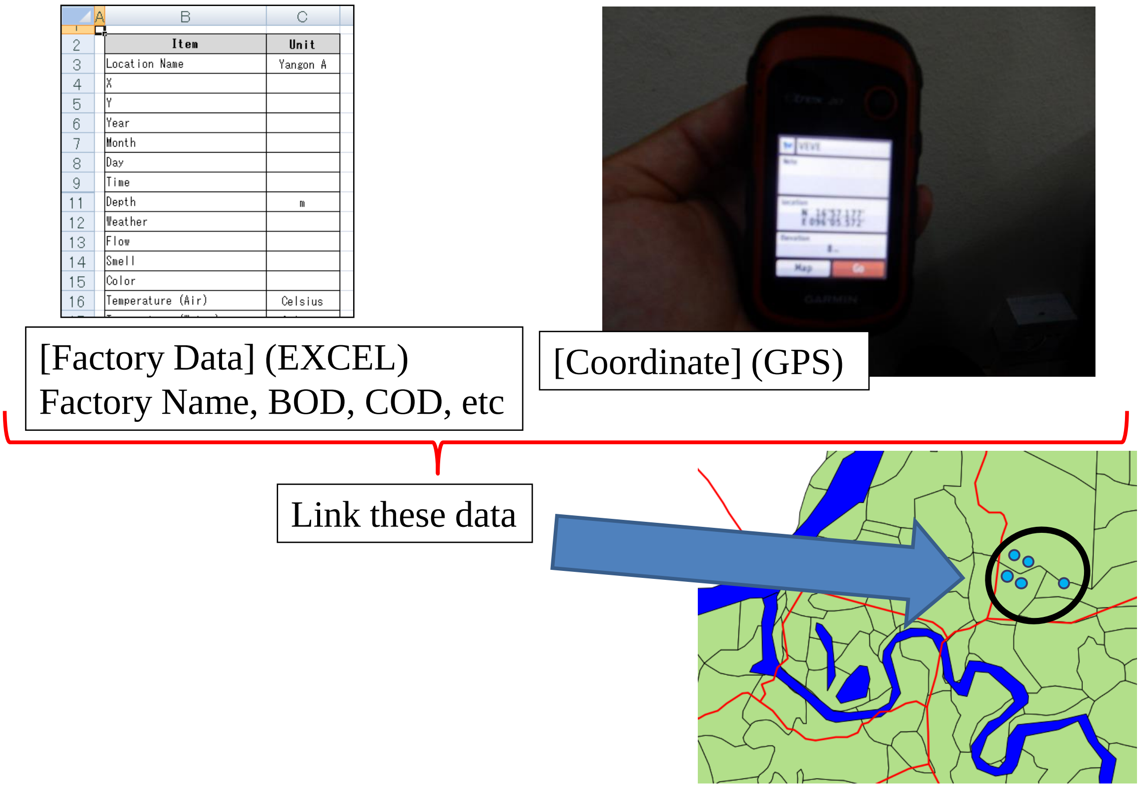
- Each column in the list should contain **one type of data**, such as dates, currency, or text.

Good		Bad	
(Only Number)	10	(Number & Text)	10 ppm
(Only Text)	Factory		

- Each row in the list should contain the **details for one record**, such as a factory type order. If possible, include a unique identifier for each row, such as an order number.
- The list should have **no blank rows** within it, and no completely blank columns.
- The list should be **separated from any other data** on the worksheet, with at least one blank row and one blank column between the list and the other data.

2.2.3 Coordinate Linking

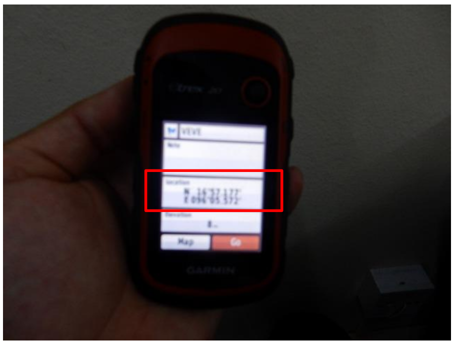
Before creating the CSV file, you need to make sure to enter geographical coordinate data (longitude and latitude) of the location of interest so that the GIS software can recognize the geographical location of the data in the system as explained in the following figure.



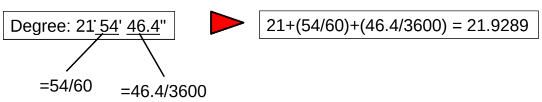
Source: JICA Expert Team

Figure 2-1 Image of Linking Coordinate

The coordinate data can be obtained using a GPS device. The way to see and input coordinate is shown below.



Waypoint Manager



In this example, the coordinate data in degree-minute-second system (21°54’46.4”) is converted to decimal degree system (21.9289°) so that Excel can readily recognize the numerals. Enter both longitude and latitude data in decimal degree unit into the Excel file.

2.2.4 Data Convert

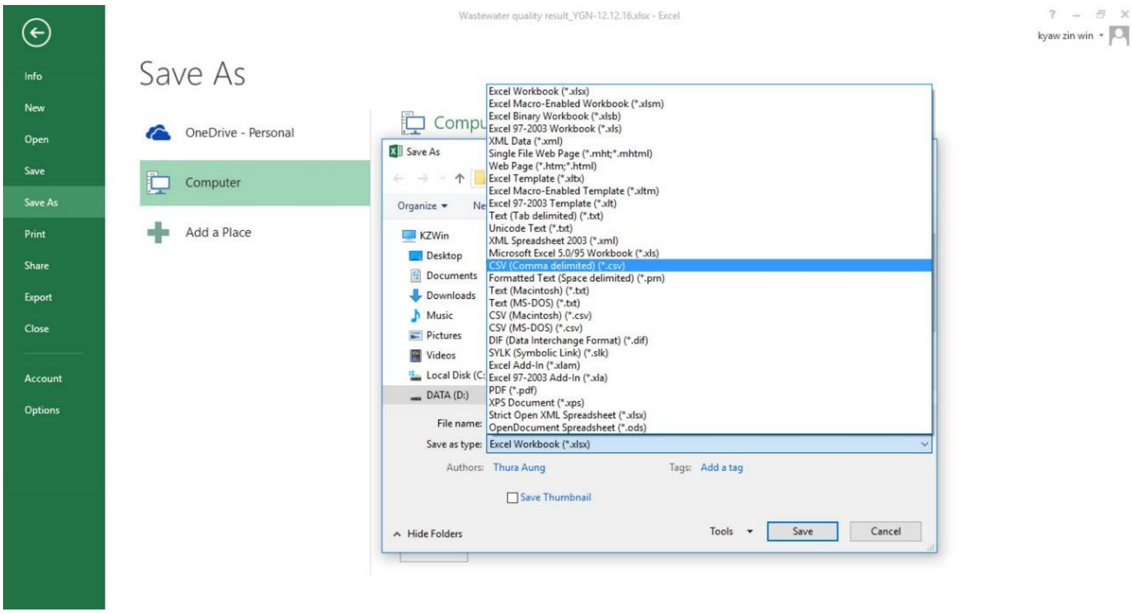
After the data digitizing and linking coordinate, the Excel data should be converted into CSV format. The necessary steps are as follows:

File → Save as → Computer → <your data folder>

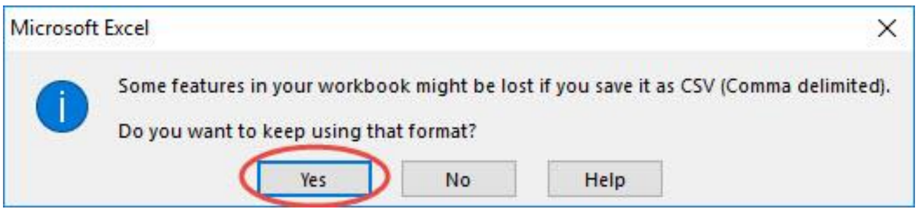
Select the location where you want to save your file. (e.g. “Database/10_Pollution Source DB” folder)

Next, in “Save As” box, select “**Save as type**” in “**CSV (Comma delimited) (*.csv)**”.

Then type your file name in “File name” box and press “**Save**”.



After you click Save, Excel will display the following message saying: Some features in your workbook might be lost if you save it as CSV (Comma delimited).



This info-notification can be ignored. Thus, you can click Yes to get your current worksheet saved in the CSV format. The original workbook (the .xls/.xlsx file) will be closed and you will notice that the name of your current sheet will change.

To check the CSV file, which you recently saved in your database folder, you could use Notepad that comes with Windows or other text editor such as notepad++. Figure below shows an example of a CSV file opened with text editor.

```
No.,Sampling Site,Location Name,Survey,Latitude,Longitude,Sampling date,Sampling time,
1,H1,Hlaing 1-C,1st,16.94967,96.05700,2016/2/23,11:40,,,7.93,27.71,0.423,0.2,911,178,2
2,H2,Hlaing 2-C,1st,16.90917,96.08272,2016/2/22,13:41,,,7.99,27.92,0.361,0.2,>1000,71,
3,H3,Hlaing 3-C,1st,16.87228,96.09142,2016/2/22,15:14,,,8.00,27.37,1.100,0.5,1000,91,7
4,H4,Hlaing 4-C,1st,16.83036,96.11228,2016/2/22,12:23,,,7.99,27.29,1.430,0.7,>1000,122
5,H5L,Hlaing 5-L,1st,16.80606,96.11956,2016/2/22,9:58,,,7.76,26.87,3.700,1.9,813,123,2
6,H5C,Hlaing 5-C,1st,16.80572,96.11861,2016/2/22,11:00,,,7.78,27.81,2.260,1.2,690,130,
7,H5R,Hlaing 5-R,1st,16.80747,96.11692,2016/2/22,10:30,,,7.86,27.13,2.830,1.5,808,107,
8,PH1,Pan Hlaing 1-C,1st,16.86042,96.03381,2016/2/22,17:15,,,7.99,27.29,1.430,0.7,>100
9,PH2,Pan Hlaing 2-C,1st,16.82722,96.10306,2016/2/22,15:43,,,7.98,28.11,2.830,1.5,>100
10,Shwe1,Shwe 1-C,1st,16.93066,96.07438,2016/2/23,12:35,,,5.87,30.87,85.500,0.4,329,14
11,H1,Hlaing 1-C,2nd,16.94967,96.05700,2016/6/20,15:55,,,7.74,28.79,0.546,0.3,477,192,
12,H3,Hlaing 3-C,2nd,16.87228,96.09142,2016/6/20,14:57,,,7.74,29.21,0.567,0.3,470,191,
13,H5C,Hlaing 5-C,2nd,16.80572,96.11861,2016/6/20,12:15,,,7.73,29.15,0.608,0.3,507,197
14,PH1,Pan Hlaing 1-C,2nd,16.86042,96.03381,2016/6/20,9:55,,,7.40,29.89,2.680,1.4,991,
15,PH2,Pan Hlaing 2-C,2nd,16.82722,96.10306,2016/6/20,10:55,,,7.38,29.98,1.420,0.7,624
16,Shwe1,Shwe 1-C,2nd,16.93066,96.07438,2016/6/21,11:14,,,6.12,30.58,2.490,1.3,418,-20
17,Shwe3,Shwe 3-C,2nd,16.93931,96.08710,2016/6/21,10:30,,,5.11,31.23,1.440,0.7,163,-22
18,Shwe5,Shwe 5-C,2nd,16.94651,96.09220,2016/6/21,9:23,,,7.23,34.89,2.450,1.2,33.9,-60
19,HTYIZ1,Hlaing Thar Yar Industrial Zone 1-C,2nd,16.83939,96.07566,2016/6/21,12:20,,,
20,HTYIZ2,Hlaing Thar Yar Industrial Zone 2-C,2nd,16.84475,96.06835,2016/6/21,13:10,,,
21,H1,Hlaing 1-C,3rd,16.94967,96.05700,2017/1/30,9:30,,,7.79,25.89,11.362,0.2,288,170,
22,H3,Hlaing 3-C,3rd,16.87228,96.09142,2017/1/30,10:25,,,7.74,26.19,1.270,0.6,1000,118
```

If you open the same file by using Excel, you can see the data as follows.

A1 | fx | No.

	A	B	C	D	E	F	G	H	I	J	K	L
1	No.	Sampling S	Location N	Survey	Latitude	Longitude	Sampling date	Sampling ti	Weather	Air Temper	pH	Water Te
2	1	H1	Hlaing 1-C	1st	16.94967	96.057	2016/2/23	11:40			7.93	27.7
3	2	H2	Hlaing 2-C	1st	16.90917	96.08272	2016/2/22	13:41			7.99	27.9
4	3	H3	Hlaing 3-C	1st	16.87228	96.09142	2016/2/22	15:14			8	27.3
5	4	H4	Hlaing 4-C	1st	16.83036	96.11228	2016/2/22	12:23			7.99	27.2
6	5	H5L	Hlaing 5-L	1st	16.80606	96.11956	2016/2/22	9:58			7.76	26.8
7	6	H5C	Hlaing 5-C	1st	16.80572	96.11861	2016/2/22	11:00			7.78	27.8
8	7	H5R	Hlaing 5-R	1st	16.80747	96.11692	2016/2/22	10:30			7.86	27.1
9	8	PH1	Pan Hlaing	1st	16.86042	96.03381	2016/2/22	17:15			7.99	27.2
10	9	PH2	Pan Hlaing	1st	16.82722	96.10306	2016/2/22	15:43			7.98	28.1
11	10	Shwe1	Shwe 1-C	1st	16.93066	96.07438	2016/2/23	12:35			5.87	30.8
12	11	H1	Hlaing 1-C	2nd	16.94967	96.057	2016/6/20	15:55			7.74	28.7
13	12	H3	Hlaing 3-C	2nd	16.87228	96.09142	2016/6/20	14:57			7.74	29.2
14	13	H5C	Hlaing 5-C	2nd	16.80572	96.11861	2016/6/20	12:15			7.73	29.1
15	14	PH1	Pan Hlaing	2nd	16.86042	96.03381	2016/6/20	9:55			7.4	29.8
16	15	PH2	Pan Hlaing	2nd	16.82722	96.10306	2016/6/20	10:55			7.38	29.9
17	16	Shwe1	Shwe 1-C	2nd	16.93066	96.07438	2016/6/21	11:14			6.12	30.5

A CSV data is simply a table with column breaks that are identified by a comma. The column names and definitions are enclosed in quotes and are separated by commas.

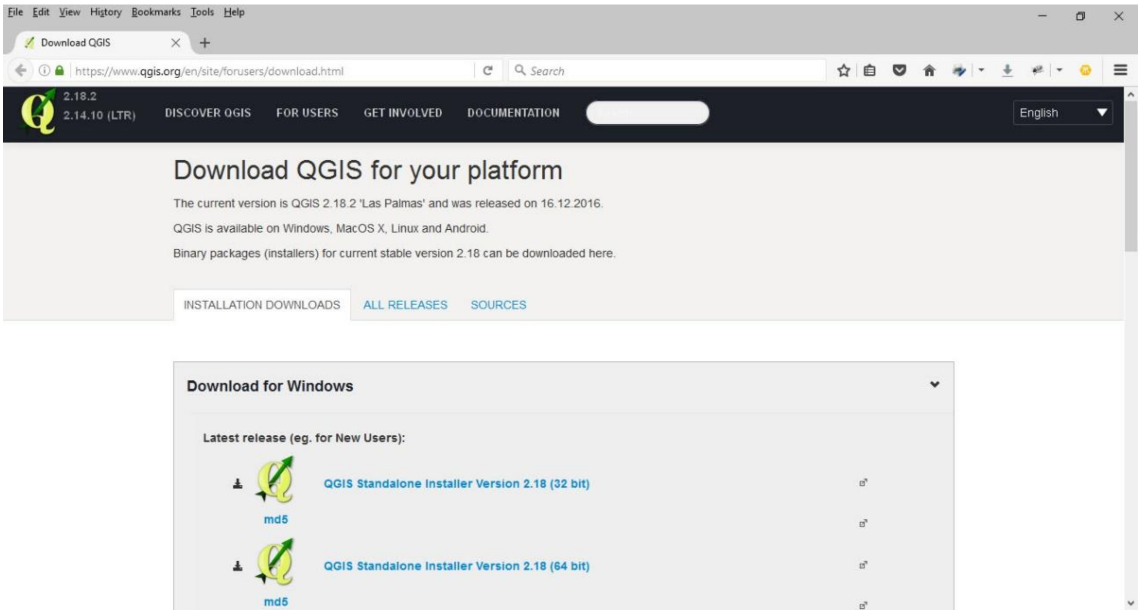
2.3 ANALYSIS WITH GIS

This section explains how to use QGIS to analyze geographical data. Before analysis by QGIS, it is necessary to install QGIS software.

2.3.1 Installation of QGIS Software

QGIS is open source software, and it can be installed on Windows, various Linux distributions, Unix, Mac OS X, and Android. Both binary packages and source code can be downloaded from www.qgis.org. In this section, we will cover how to install QGIS on Windows operation system.

1. Go to QGIS download page.
   https://www.qgis.org/en/site/forusers/download.html



The recommended download file is the QGIS Standalone Installer Version 2.18 (32 bit or 64 bit depending on your computer)

Note: Go to "Computer" → "System Properties" to check if your computer system type is 32 bit or 64 bit.

Start to install QGIS, **double click** on downloaded .exe file.

Click **Next** for all the default properties. You can select the sample datasets if you would like, but it is not necessary. QGIS will then be saved in your Program Files and an icon should appear on your desktop when it has finished installing.

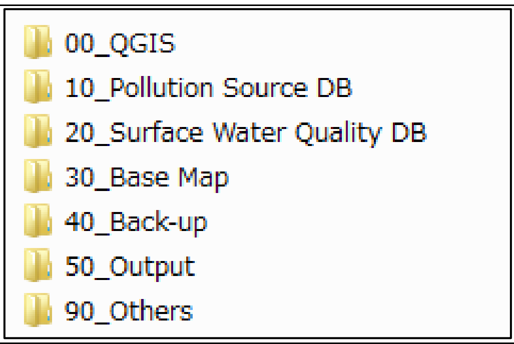
2.3.2 Development of Folder Structure

Before starting QGIS operation, it is desirable to confirm what kinds of data shall be displayed on the map. After confirming and categorizing the necessary data, the folder for each shall be prepared so that the data of QGIS can be shared with others. The samples of folder structure are shown below.

Table 2-1 Sample of Folder Structure

Type of Database	Necessary Data on Map	Category (Folder Name)
Surface Water Quality	- Sampling Point	- Surface Water Quality
	- River - Road - Administrative Boundary	- Base Map
	- Other folders for QGIS operation	- QGIS (for project file) - Back-up - Output

Source: JICA Expert Team



If both of "Pollution Source DB" and "Surface Water Quality DB" are prepared and displayed on the same QGIS map, this kind of folder structure is convenient for updating each data.

Source: JICA Expert Team

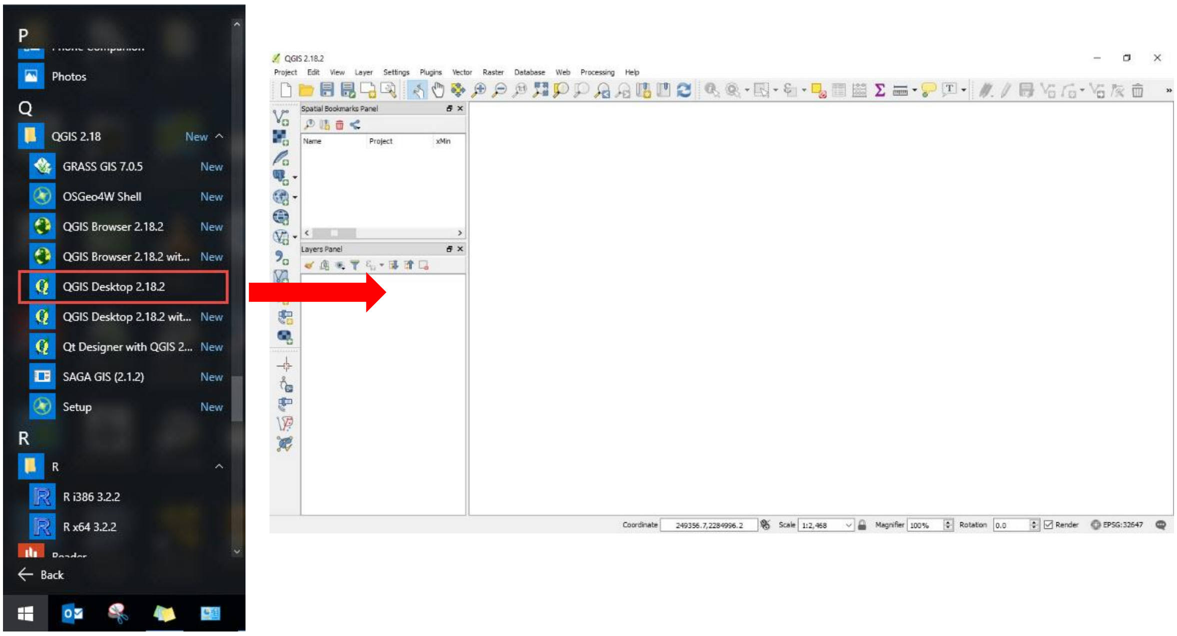
Figure 2-2 Sample of Folder Structure

2.3.3 Start of QGIS Operation

This section explains how to open QGIS, and how to overlay the data in CSV format or other maps.

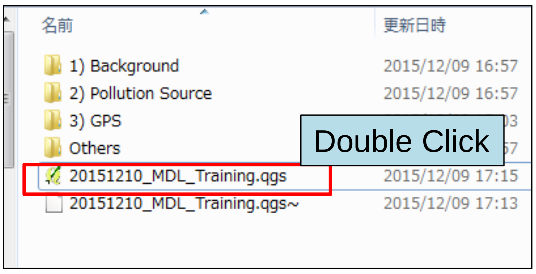
(1) *To Open QGIS*

To open QGIS, you can go to the start menu, and click on the QGIS Desktop.

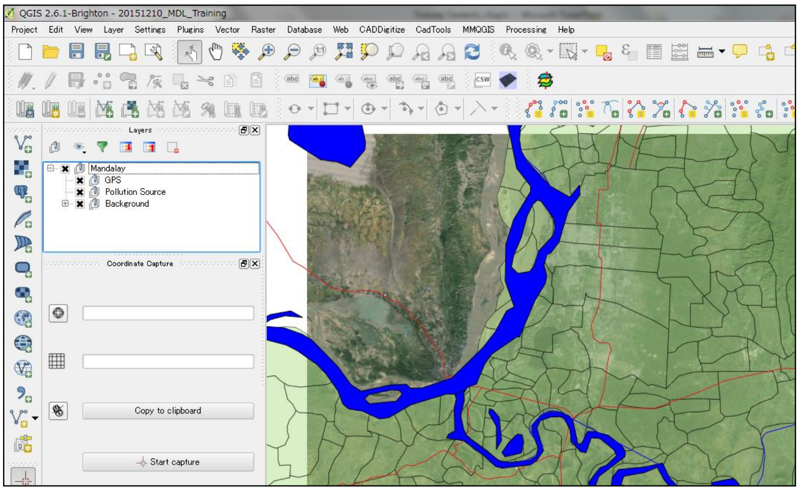


If you have a project file of QGIS with extension “qgs”, you can also open the file by duble clicking on the file.

1) Open “QGIS” “20151210_MDL_Training.qgs”



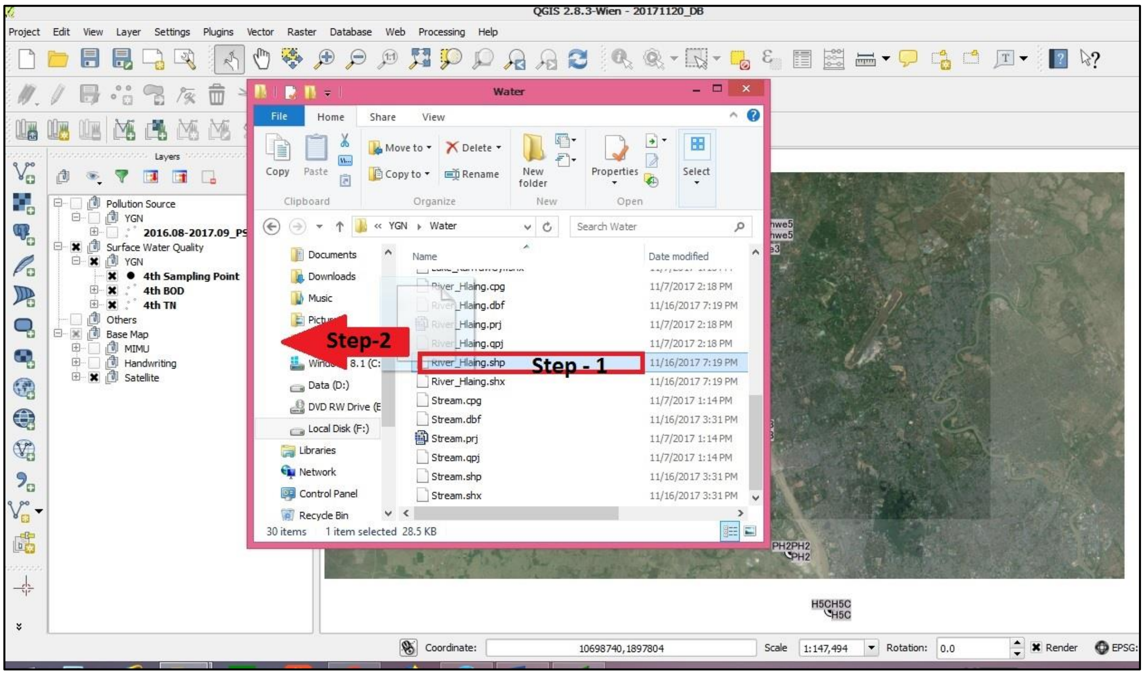
2) You can see “QGIS”



(2) *To Read & Overlay Base-map (River shapefile, Road shapefile, Boundary shapefile, etc.)*

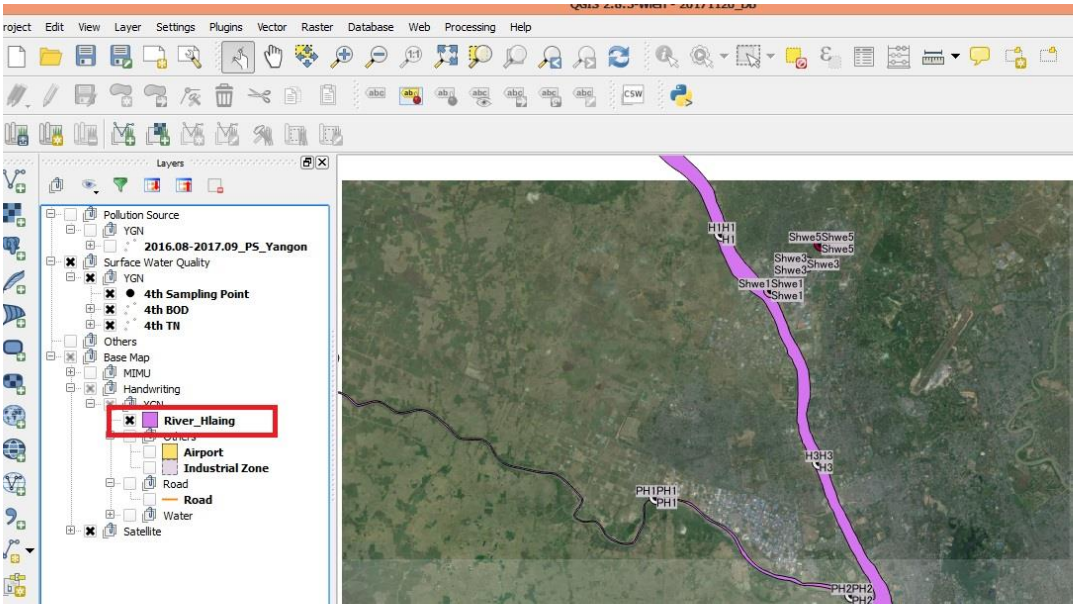
If you already have GIS files in shape-file format, you can easily overlay such files by dragging them on the window of QGIS as a layer.

Firstly, you have to go to the folder that contains the shape-files. Then, among the many types of files, you have to select shape file that means the extension of file must be ".shp". Please see as Step-1 in below figure. Then, you can easily move to QGIS window. Please see as Step-2 in below figure.



Finally, in QGIS window, the shape-file will appears as below figure.

You can add another shape-file such as roads, boundary to QGIS window by the above steps.



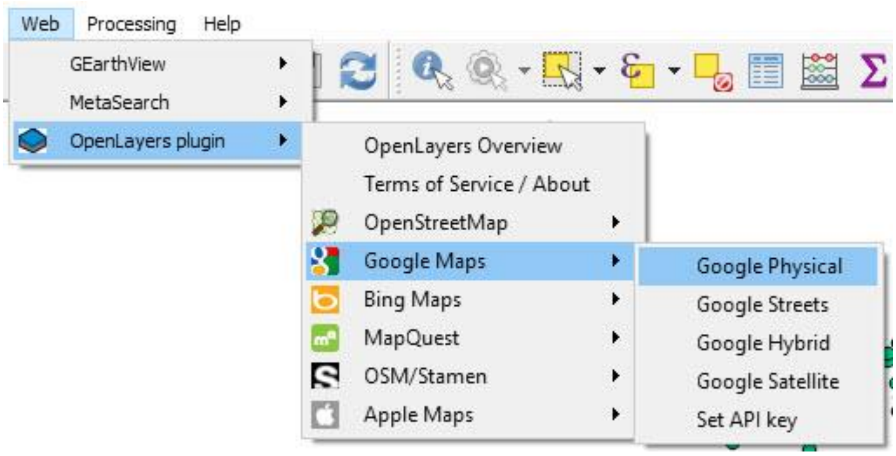
*** Remark – when you move the shape-file to QGIS window, it should be placed under

"Base map > Handwriting > YGN". Most of the shape-files must be under "Base Map > Handwriting" layer feature.

(3) *To Overlay Google Satellite*

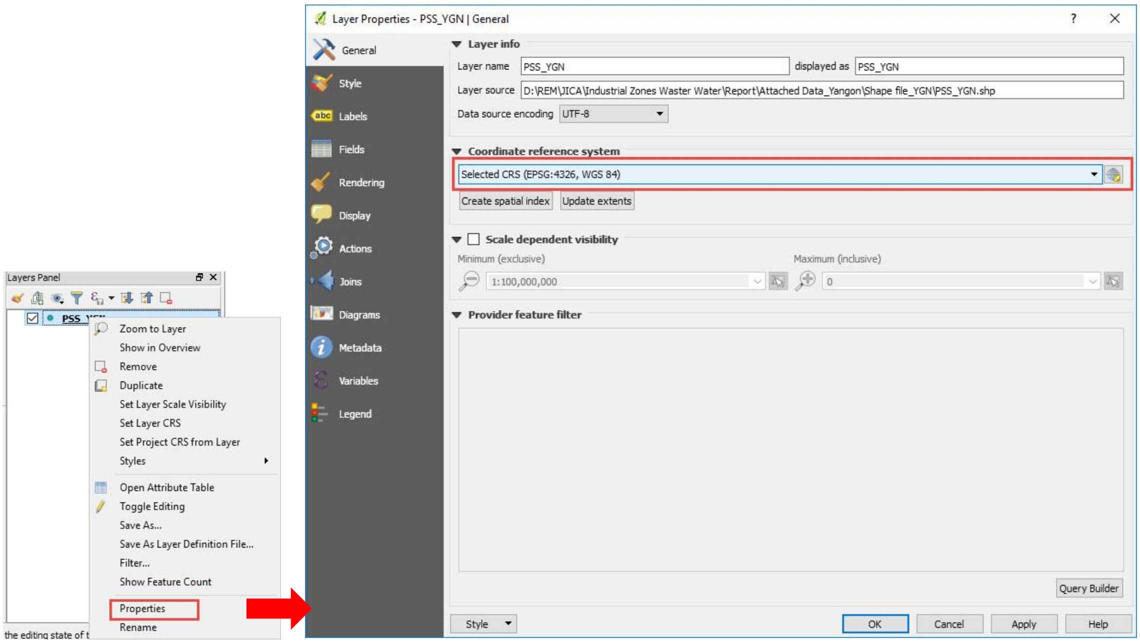
In addition, you can add Google maps by following the following steps.

Web → OpenLayers plugin → OpenStreetMap/Google Maps/Bing Maps/MapQuest/OSM/Stamen/Apple Maps → select the map you want to add.



(4) *To Check Coordinate System*

In order to overlay GIS files, the coordinate system should be the same. Here is how to check coordinate system of a layer.



Right Click on layer → Properties → General

(5) *To Change the Order of Layers*

Sometimes, the order of layer is required to change if the layer that you want to make it appear is not shown in QGIS window. Please see the below Figure (A). In the below Figure (A), the shape-file of river was overlaid by Satellite image. In such case, you need to change the order of layer. Because, the layer of "Satellite" is overlaid on the layer of "River_Hlaing (shape-file).

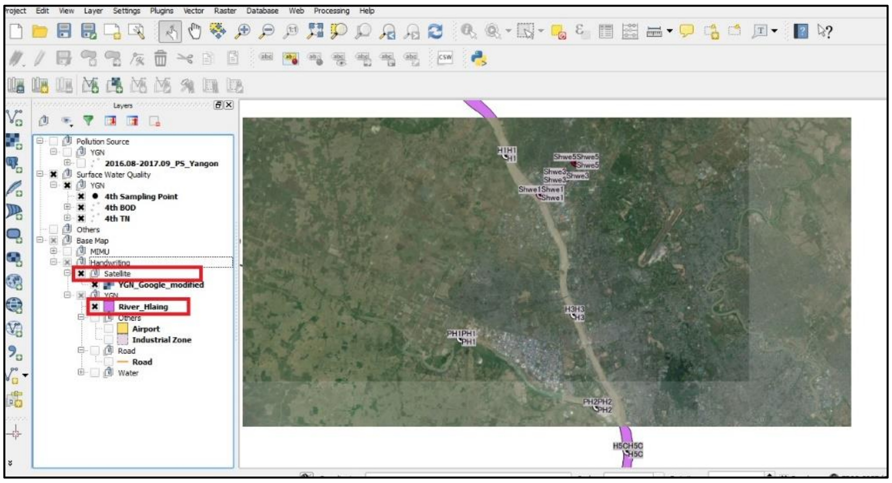


Figure (A)

In such case, you just need to move the layer by dragging. Please compare and see in Figure (B) and Figure (C).

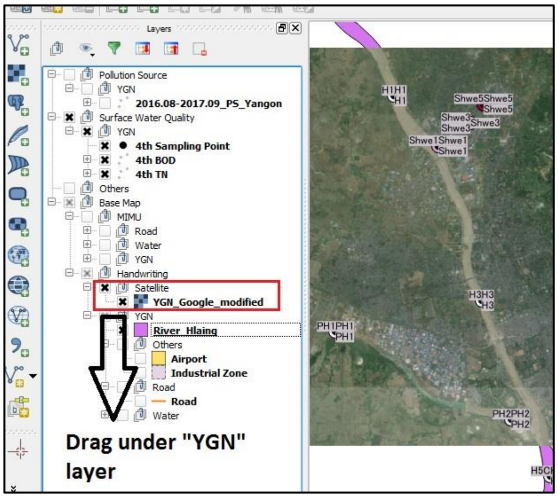


Figure (B)

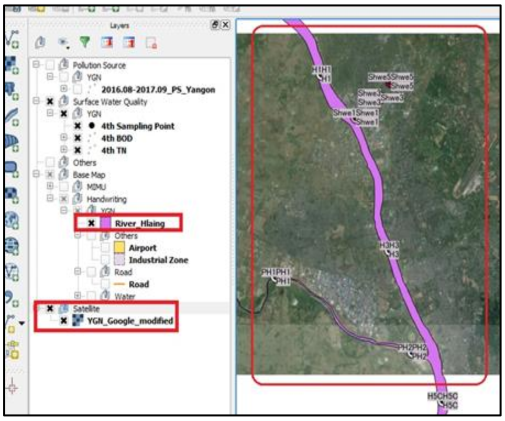
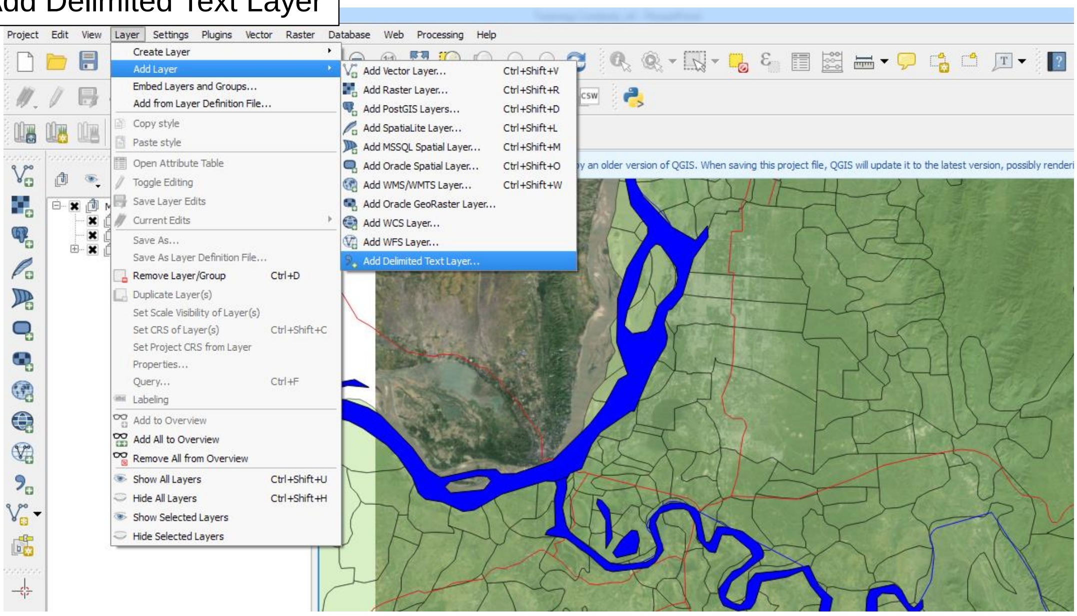


Figure (C)

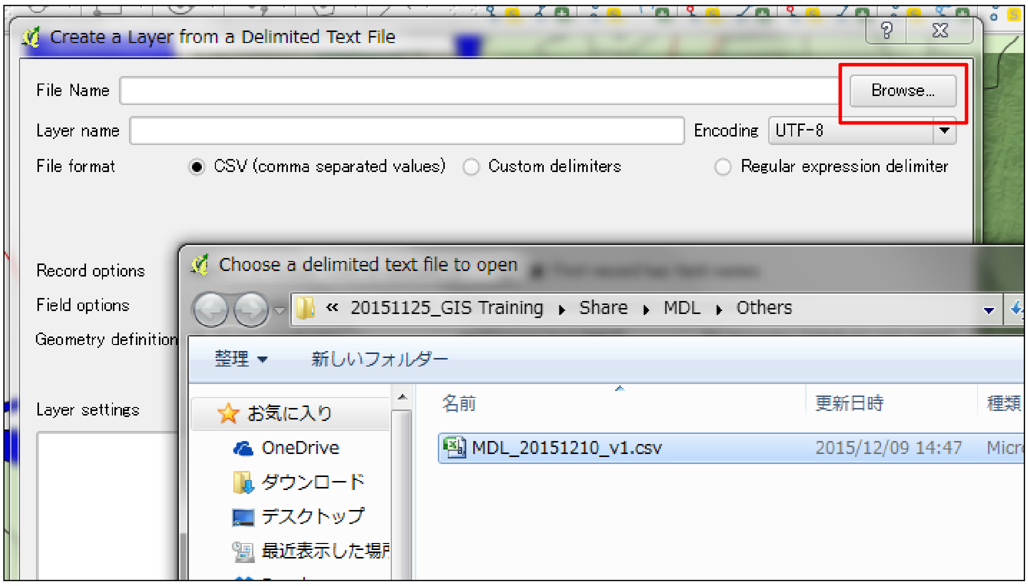
2.3.4 Data Reading and Overlay

In order to read the main data as CSV file into QGIS as a layer, the following steps are necessary.

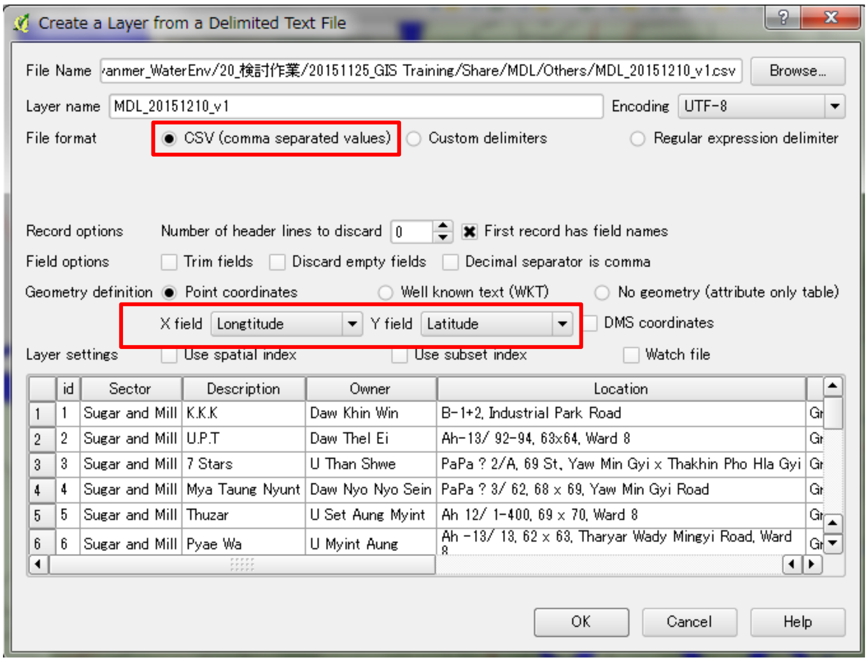
Layer
➢Add Layer
➢Add Delimited Text Layer

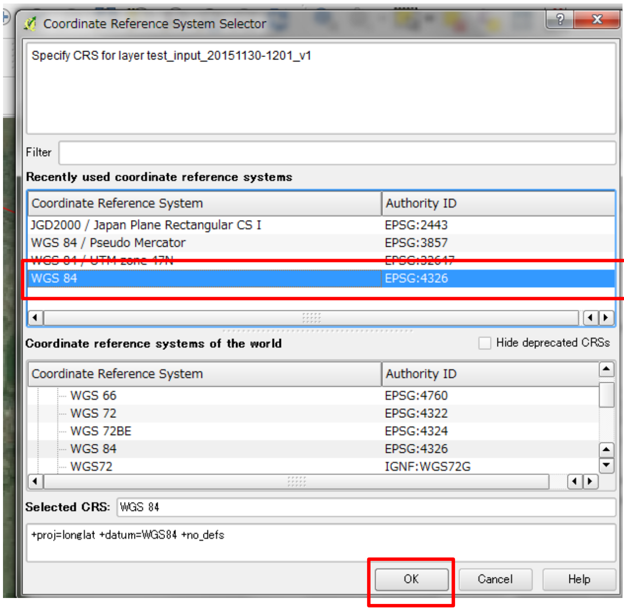


Browse
➢Select the CSV File



➢Check “CSV(comma separated values)
➢Select “X field” as <u>Longitude</u> and “Y field” as <u>Latitude</u>



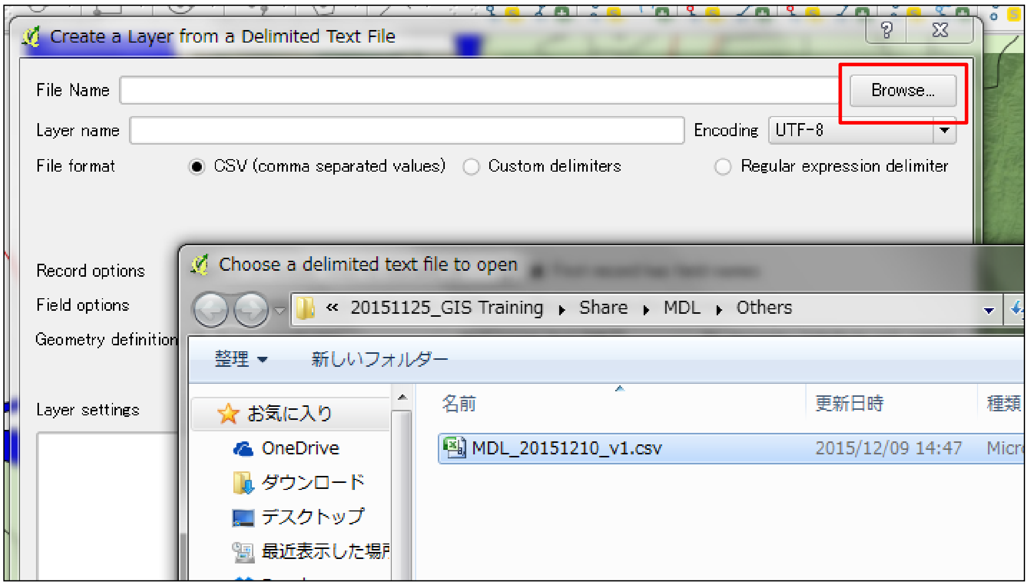


Select “WGS84”

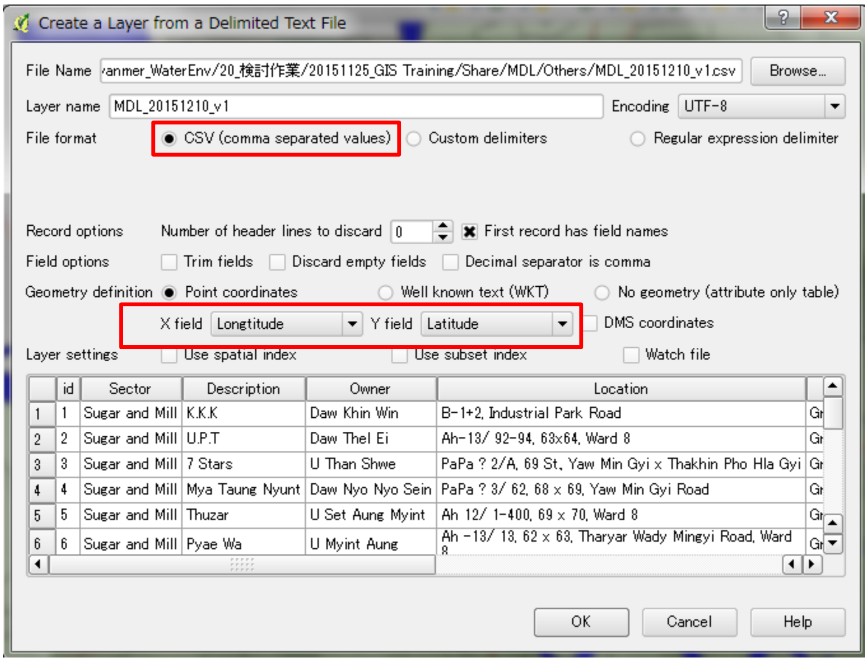
➢You can see the point on the map

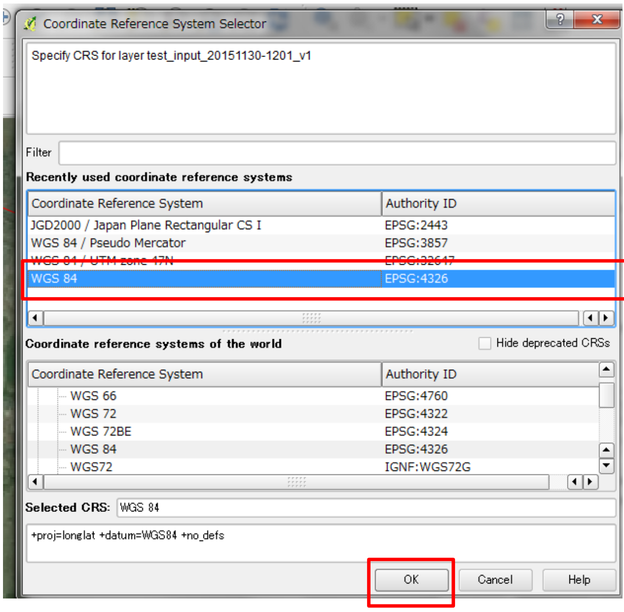
Browse

➢Select the CSV File

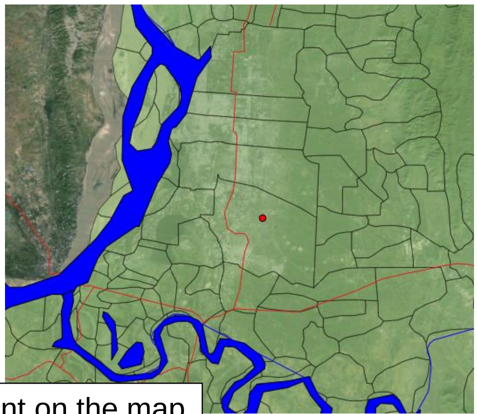


- Check “CSV(comma separated values)
- Select “X field” as <u>Longitude</u> and “Y field” as <u>Latitude</u>





Select “WGS84”



- You can see the point on the map

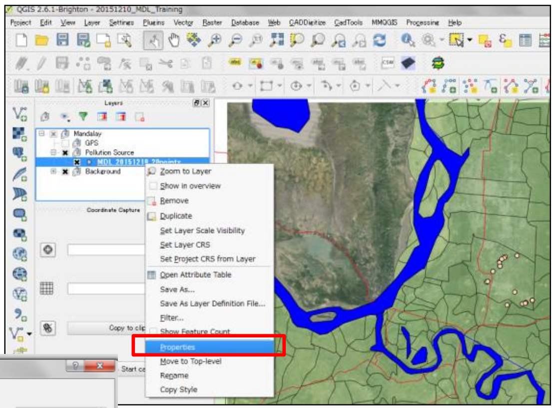
2.3.5 Data Classification & Style Change

(1) *To Change Style (e.g. Change the Color of Points)*

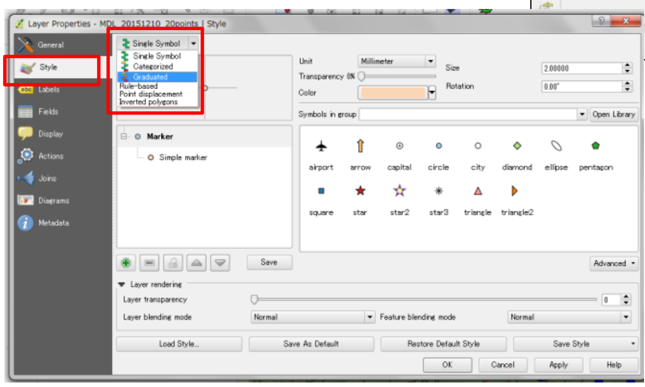
This section explains an example of how to change the appearance of data in a layer.

* To Set "Graduated", number of "Classify", "Color Change" and "Apply"

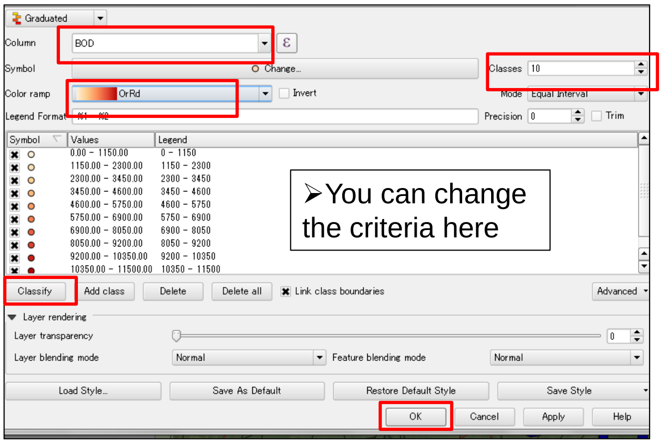
1) Select the Point Data and "Right Click"
2) Select Properties



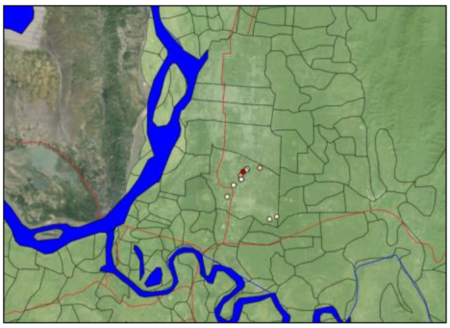
3) Select "Style" and "Graduated"



1) Select "BOD" in Column
2) Input 10 in Classes
3) Select "OrRd" (or other) in Color ramp
4) Select "Classify" and "OK"



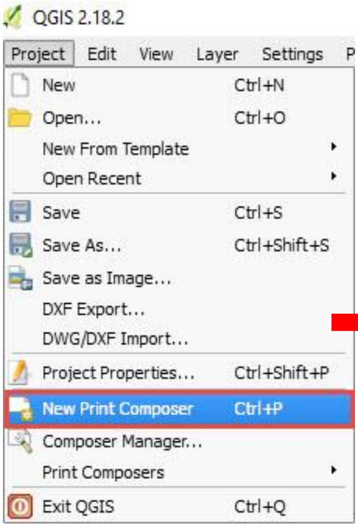
➢You can see the color points on the map



2.3.6 Output

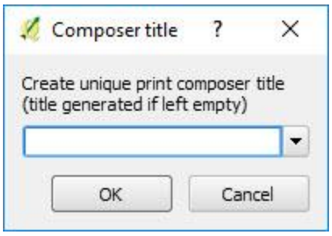
(1) *To Open Print Composer*

To prepare a standardized output map in QGIS, you need to use print composer. With print composer, you can easily add a legend, scale bar, bearing mark or logo of your organization.

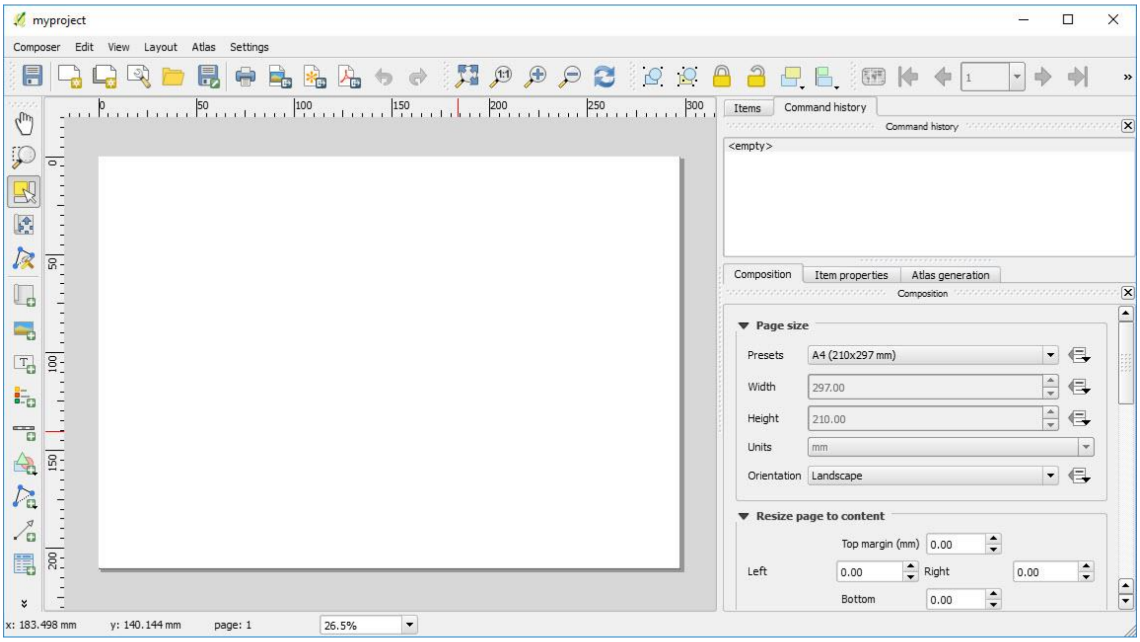


To create new print composer

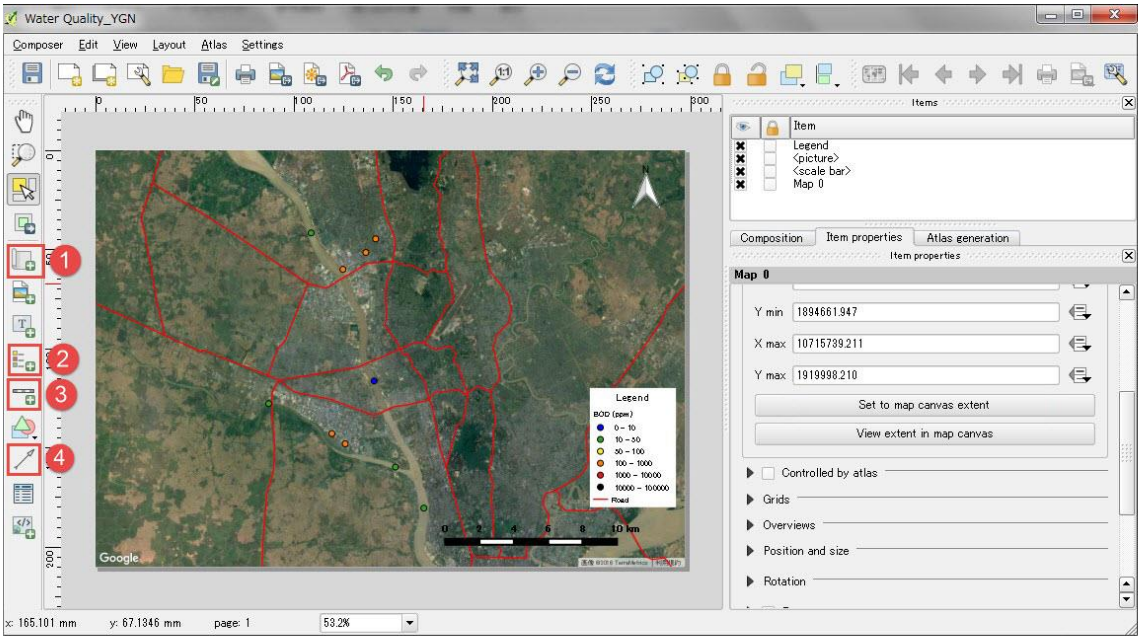
Project → New Print Composer



- Type your composer title
- Composer window will display automatically.



(2) *To Use Print Composer (1st Step)*



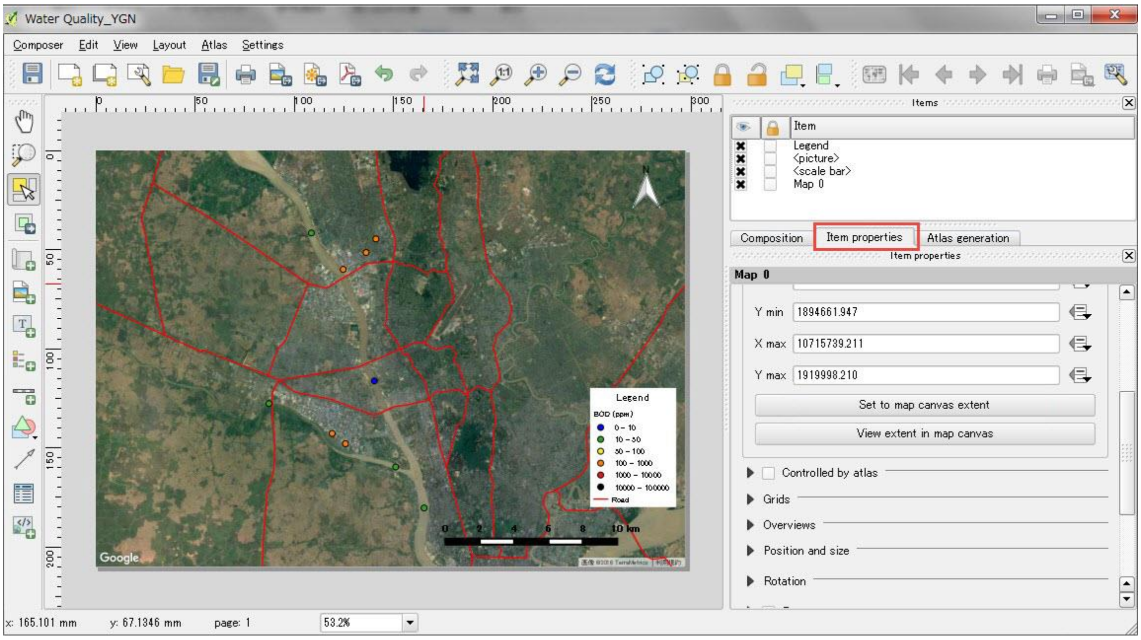
1) To add new map: Click **Add new map** icon  from Toolbar.

2) To Add scale bar: Click **Add new scalebar** icon  from Toolbar.

3) To Add legend bar: Click **Add Legend** icon  from Toolbar.

4) To Add north arrow bar: Click **Add arrow** icon  from Toolbar.

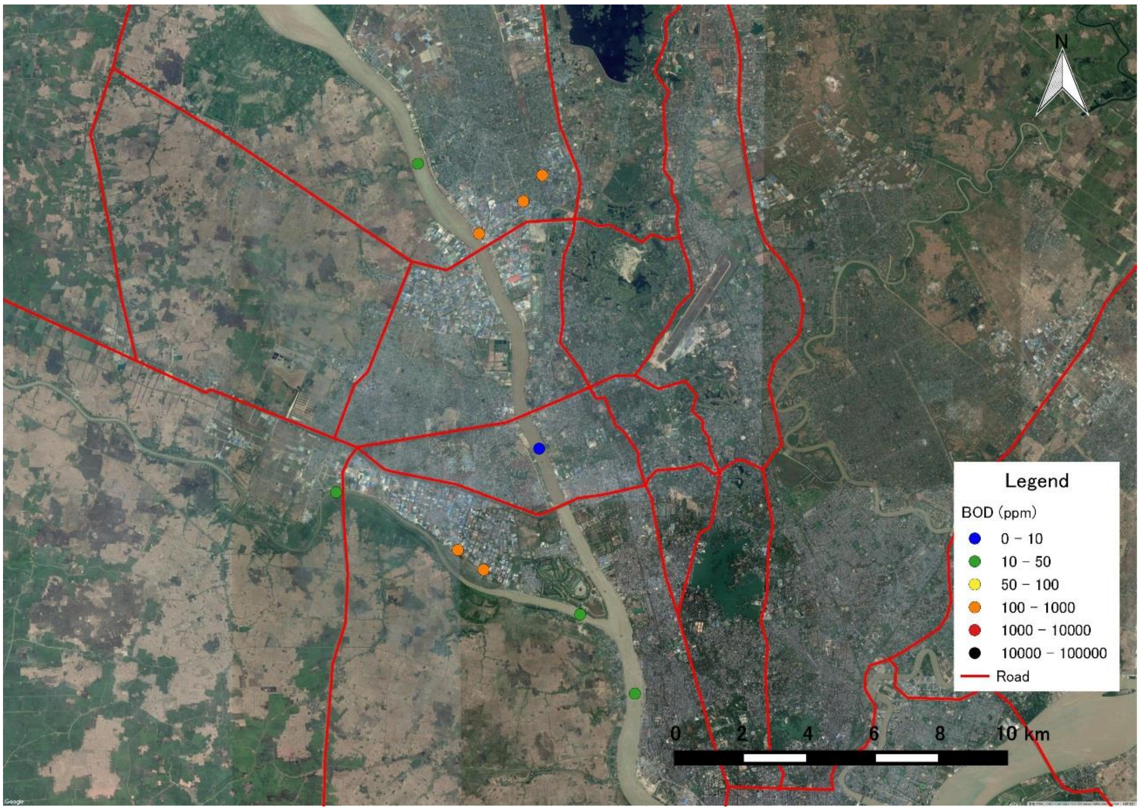
(3) *To Use Print Composer (2nd Step)*

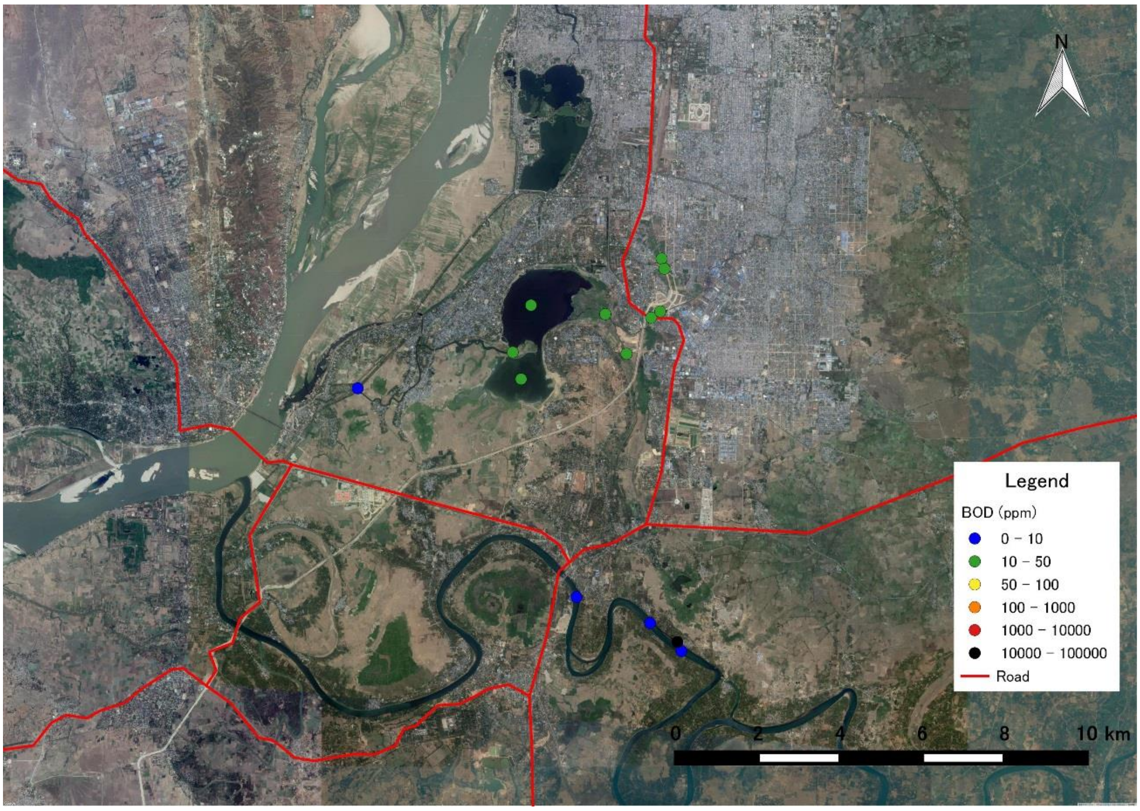


To change the layout properties:

- Select the item (e.g. scalebar, north arrow, legend, etc.)
- Go to Item properties and edit (e.g. font, background, borders, etc.)

(4) *Output Image*





2.4 TUTORIALS

In this section, two tutorial modules are presented for you to practice how to use the Pollution Source Database and the Surface Water Quality Database. In order to follow these modules, you need a set of files distributed by JET for GIS training.

2.4.1 Tutorial 1: To make the location map of Sector (Pollution Source)

(1) *Create CSV File*

1) Open the folder "10_Pollution Source DB"

2) Open the file "20160812-1105_PS_YGN.xlsx"

The data of "1-1) Name of Factory", "1-4) Longitude", "1-5) Latitude" and "1-6) Type of Business" will be extracted.

*Remarks: Longitude and Latitude have already been filled. If you get new data, it is necessary to be filled by yourself.

	A	B	C	D	E	F	G	
1		1) Basic Information						
2		Name & Address			Coordinate		Type of Business	
3	No.	1-1) Name of Factory	1-2) Industrial Zone	1-3) Address	1-4) Longitude	1-5) Latitude	1-6) Type of Business	1-7) Cate
4	Y1-1	Gallant Ocean Trading	Hlaing Tharyar Industrial Zone (2)	No-(2), Min Gyi Mahar Min Khaung Lane,	96.0754056	16.9097944	Food and Beverages Manufacturing	Fish Processing
5	Y1-2	United Beauty Place Myanmar	Hlaing Tharyar Industrial Zone (2)	No-179, U Tun Nyo Lane, Zone(2) Hlaing	96.0990889	16.9531583	Chemicals Manufacturing	
6	Y1-3	Coca Cola Pinya Beverages Myanmar	Hlaing Tharyar Industrial Zone (3)	No-(37,38), Bamaw Atwin Win Lane, Zon	96.0523333	16.9744722	Food and Beverages Manufacturing	Food and Beverage
7	Y1-4	Fame Pharmaceuticals Industry	Hlaing Tharyar Industrial Zone (3)	No.20,Mingyi Maha Min Gaung Road	96.0773306	16.8410139	Chemicals Manufacturing	Pharmaceuticals an
8	Y1-5	Myanma Gonye (Dyeinng)	Shwe Linban Industrial Zone	366,367,368,Daw Pwar Shin Street,Shweli	96.0704667	16.9269833	Garments, Textile and Leather Products	Textiles Manufactu
9	Y1-6	Taw Win Distilley	Shwe Pyi Thar Industrial Zone (1)	No-42/170, Mahawgani lane,Shwe Pyi Th	96.0761639	16.8487139	Food and Beverages Manufacturing	Breweries and Disti
10	Y1-7	Delicious Food	Hlaing Tharyar Industrial Zone (4)	No-108, D Pal Yin Won Htauk U Byal La	96.0712611	16.8457139	Food and Beverages Manufacturing	Dairy Processing
11	Y1-8	Myin Pyan Canned Food Industry	Hlaing Tharyar Industrial Zone (5)	No.115, Ayeyar Lane,Hlaing Thar Yar To	96.0694500	16.8479417	Food and Beverages Manufacturing	Meat Processing
12	Y1-9	Ko Maung Maung and Brothers Leather Producti	Hlaing Tharyar Industrial Zone (5)	No-189,Shwe Yin Aye Kyaung Lane,Hlair	96.0958472	16.9572139	Garments, Textile and Leather Products	Tanning and Leathe
13	Y1-10	Shwe Zinyaw Rice Noodle Factory	Hlaing Tharyar Industrial Zone (7)	No-102,Tapin Shwe Htee Road,Hlaing Th	96.0794972	16.8391333	Food and Beverages Manufacturing	Food and Beverage
14	Y1-11	Thein Toe Aung Distillery	Hlaing Tharyar Industrial Zone (7)	No-(15,16),Yan Gyi Aung Lane, Zone(7) I	96.0695944	16.9172194	Food and Beverages Manufacturing	Breweries and Disti
15	Y1-12	Taung Pyar Dan Co,Ltd(Soft-Drinks)	Shwe Pyi Thar Industrial Zone (1)	No-105 Sat Mhu (7) Lane,Shwe Pyi Thar	96.0742194	16.9114833	Food and Beverages Manufacturing	Food and Beverage
16	Y1-13	PMG Bottle Cleansing/Storage	Shwe Pyi Thar Industrial Zone (1)	No-42/63,64(AB),Sat Mhu -1 lane,Zone(	96.0794556	16.8841833	Food and Beverages Manufacturing	Breweries and Disti
17	Y1-14	First Printing Mfg Co,Ltd	Shwe Pyi Thar Industrial Zone (1)	No-42/306(A),Main Road(4), Zone(1) Shy	96.0556000	16.8580583	Garments, Textile and Leather Products	Textiles Manufactu
18	Y1-15	TOA paint (Myanmar)Co,Ltd	Shwe Pyi Thar Industrial Zone (1)	No-120/Mahaw Ghani, Shwe Pyi Thar Zo	96.0781944	16.9330333	Garments, Textile and Leather Products	Textiles Manufactu
19	Y1-16	Proven Technology Industry Co,ltd	Shwe Pyi Thar Industrial Zone (1)	42/94(A,B), Khayay Lane, Zone(1) Shwe	96.0759000	16.9287722	Metal, Machinery and Electronics	Semiconductors and
20	Y1-17	Shwe Thazin(Fuji)	Shwe Pyi Thar Industrial Zone (1)	42/38 Ka Naung Min Thar Gyi Lane	96.0935306	16.9455194	Chemicals Manufacturing	
21	Y1-18	Min Lwin Paper Mill	Shwe Pyi Thar Industrial Zone (1)	No.(42/17+18), Ka Naung (2) Lane	96.0936778	16.9515139	Wood Mnufacturing	Pulp and / or Paper
22	Y1-19	Unilever (Myanmar)	Shwe Pyi Thar Industrial Zone (2)	No(40,41),Min Theikdi Kyaw Swar Lane.	96.0794556	16.8841833	Food and Beverages Manufacturing	Food and Beverage
23	Y1-20	Ghani Win Int Ltd,	Shwe Pyi Thar Industrial Zone (3)	No-165, U Tun Nyon Road, Industrial Zo	96.0925833	16.8456250	Food and Beverages Manufacturing	Fish Processing

3) Delete the first two rows

4) Delete the column of "C" and "D"

	A	B	C	D	E	F
1		1-1) Name of Factory	1-4) Longitude	1-5) Latitude	1-6) Type of Business	1-7) Category
2	Y1-1	Gallant Ocean Trading	96.0754056	16.9097944	Food and Beverages Manufacturing	Fish Processing
3	Y1-2	United Beauty Place Myanmar	96.0990889	16.9531583	Chemicals Manufacturing	
4	Y1-3	Coca Cola Pinya Beverages Myanmar	96.0523333	16.9744722	Food and Beverages Manufacturing	Food and Beverage Proc
5	Y1-4	Fame Pharmaceuticals Industry	96.0773306	16.8410139	Chemicals Manufacturing	Pharmaceuticals and Bio
6	Y1-5	Myanma Gonye (Dyeinng)	96.0704667	16.9269833	Garments, Textile and Leather Products	Textiles Manufacturing
7	Y1-6	Taw Win Distilley	96.0761639	16.8487139	Food and Beverages Manufacturing	Breweries and Distilleries
8	Y1-7	Delicious Food	96.0712611	16.8457139	Food and Beverages Manufacturing	Dairy Processing
9	Y1-8	Myin Pyan Canned Food Industry	96.0694500	16.8479417	Food and Beverages Manufacturing	Meat Processing
10	Y1-9	Ko Maung Maung and Brothers Leather Product	96.0958472	16.9572139	Garments, Textile and Leather Products	Tanning and Leather Fini
11	Y1-10	Shwe Zinyaw Rice Noodle Factory	96.0794972	16.8391333	Food and Beverages Manufacturing	Food and Beverage Proc
12	Y1-11	Thein Toe Aung Distillery	96.0695944	16.9172194	Food and Beverages Manufacturing	Breweries and Distillerie
13	Y1-12	Taung Pyar Dan Co,Ltd(Soft-Drinks)	96.0742194	16.9114833	Food and Beverages Manufacturing	Food and Beverage Proc
14	Y1-13	PMG Bottle Cleansing/Storage	96.0794556	16.8841833	Food and Beverages Manufacturing	Breweries and Distillerie
15	Y1-14	First Printing Mfg Co,Ltd	96.0556000	16.8580583	Garments, Textile and Leather Products	Textiles Manufacturing
16	Y1-15	TOA paint (Myanmar)Co,Ltd	96.0781944	16.9330333	Garments, Textile and Leather Products	Textiles Manufacturing

5) Copy from "A1" to "E101"

6) Create a new file and paste

	A	B	C	D	E	F
1	1-1)	Name of F	4) Longitu	5) Latitu	ype of Bu	siness
2	Y1-1	Gallant Oc	########	########	Food and B	everages Mar
3	Y1-2	United Bea	########	########	Chemicals	Manufacturing
4	Y1-3	Coca Cola	########	########	Food and B	everages Mar
5	Y1-4	Fame Phar	########	########	Chemicals	Manufacturing
6	Y1-5	Myanma G	########	########	Garments,	Textile and Le
7	Y1-6	Taw Win D	########	########	Food and B	everages Mar
8	Y1-7	Delicious F	########	########	Food and B	everages Mar
9	Y1-8	Myin Pyan	########	########	Food and B	everages Mar
10	Y1-9	Ko Maung	########	########	Garments,	Textile and Le
11	Y1-10	Shwe Zinya	########	########	Food and B	everages Mar
12	Y1-11	Thein Toe	########	########	Food and B	everages Mar
13	Y1-12	Taung Pya	########	########	Food and B	everages Mar
14	Y1-13	PMG Bottle	########	########	Food and B	everages Mar
15	Y1-14	First Printi	########	########	Garments,	Textile and Le
16	Y1-15	TOA paint	########	########	Garments,	Textile and Le

7) Delete the unnecessary word like "1-1) " and Save as CSV file

"Save As" box > "Save as type" in "CSV (Comma delimited) (*.csv)" and store the same folder "10_Pollution Source DB"

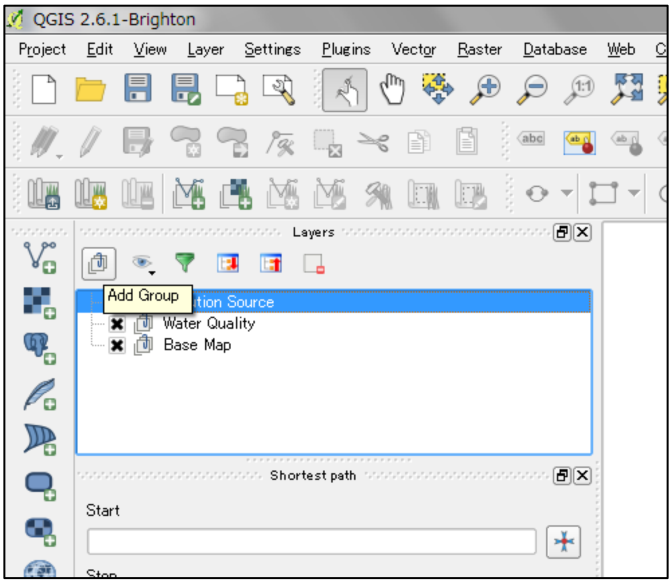
Name: 201701_YGN_PS.csv

	A	B	C	D	E	F	G	H
1		Name of F	Longitude	Latitude	Type of Business			
2	Y1-1	Gallant Oc	96.07541	16.90979	Food and Beverages Manufacturing			
3	Y1-2	United Bea	96.09909	16.95316	Chemicals Manufacturing			
4	Y1-3	Coca Cola	96.05233	16.97447	Food and Beverages Manufacturing			
5	Y1-4	Fame Phar	96.07733	16.84101	Chemicals Manufacturing			
6	Y1-5	Myanma G	96.07047	16.92698	Garments, Textile and Leather Products			
7	Y1-6	Taw Win D	96.07616	16.84871	Food and Beverages Manufacturing			
8	Y1-7	Delicious F	96.07126	16.84571	Food and Beverages Manufacturing			
9	Y1-8	Myin Pyan	96.06945	16.84794	Food and Beverages Manufacturing			
10	Y1-9	Ko Maung	96.09585	16.95721	Garments, Textile and Leather Products			
11	Y1-10	Shwe Zinya	96.0795	16.83913	Food and Beverages Manufacturing			
12	Y1-11	Thein Toe	96.06959	16.91722	Food and Beverages Manufacturing			
13	Y1-12	Taung Pya	96.07422	16.91148	Food and Beverages Manufacturing			
14	Y1-13	PMG Bottle	96.07946	16.88418	Food and Beverages Manufacturing			
15	Y1-14	First Printi	96.0556	16.85806	Garments, Textile and Leather Products			
16	Y1-15	TOA paint	96.07819	16.93303	Garments, Textile and Leather Products			
17	Y1-16	Proven Te	96.0759	16.92877	Metal, Machinery and Electronics			

(2) *Overlay the "Base Map" on QGIS*

1) Open QGIS software (Double click of "QGIS Desktop 2.X.X")

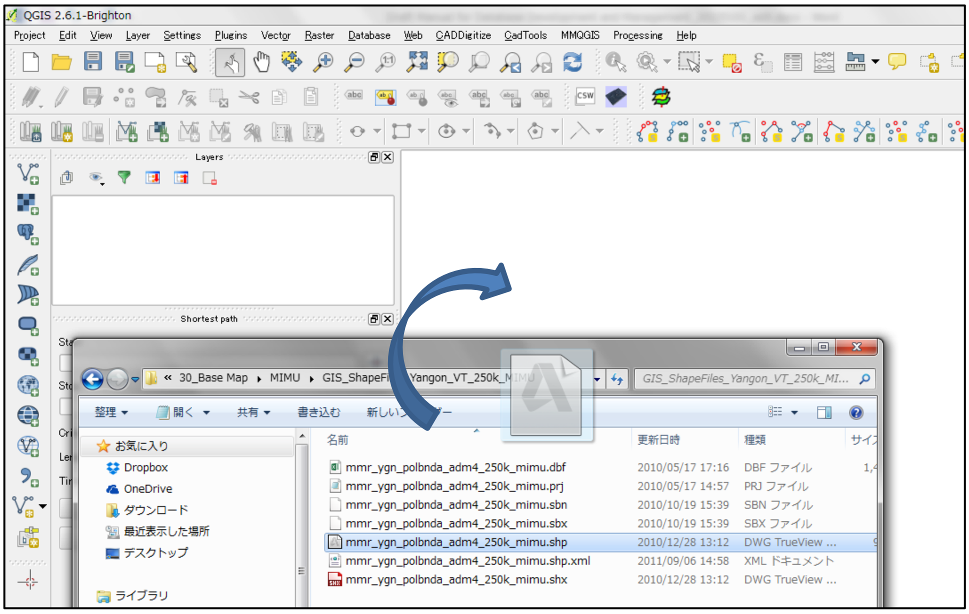
2) Create groups of "Pollution Source", "Water Quality" and "Base Map"

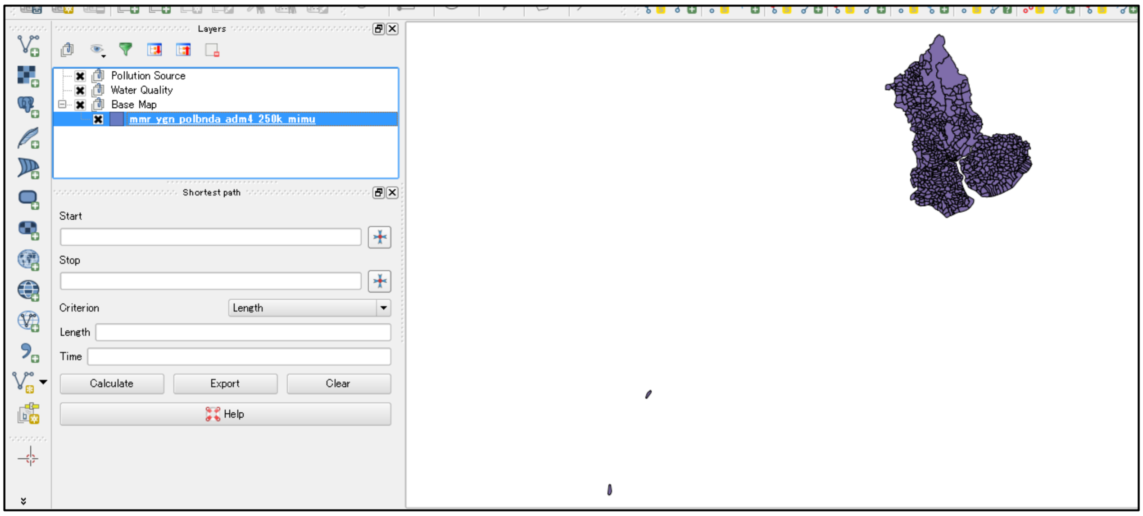


3) Select the group “Base Map”

4) Open the folder of “30_Base Map”, “MIMU” and “GIS_ShapeFiles_Yangon_VT_250k_MIMU”.

5) Select “mmr_ygn_polbnda_adm4_250k_mimu.shp” and drag to QGIS display

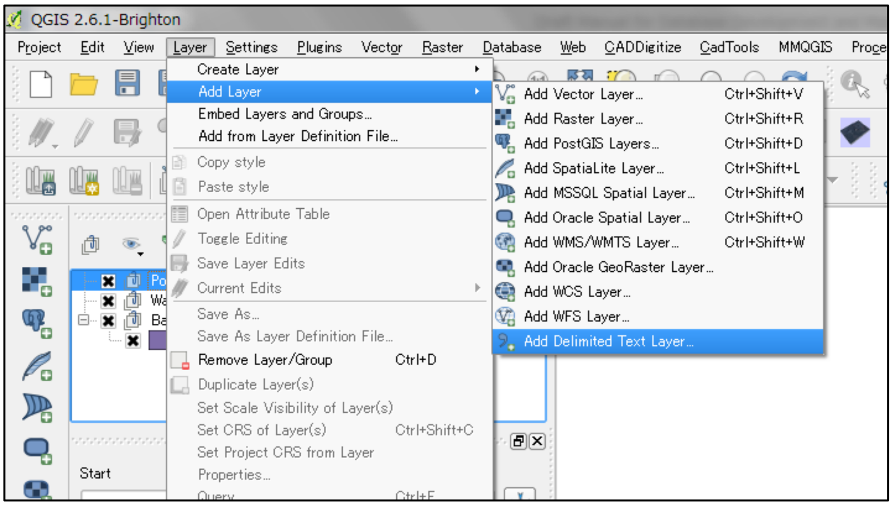




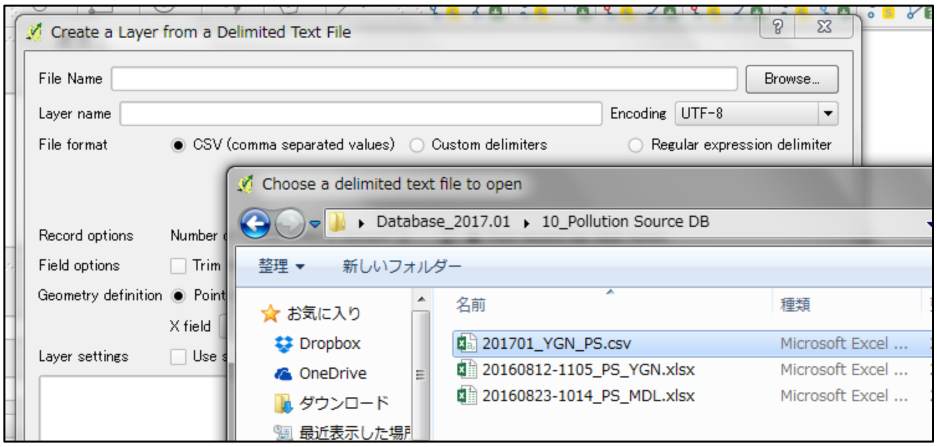
(3) *Overlay the "Pollution Source" data from CSV file on QGIS*

1) Click the group "Pollution Source"

2) Select "Layer", "Add Layer" and "Add Delimited Text Layer"

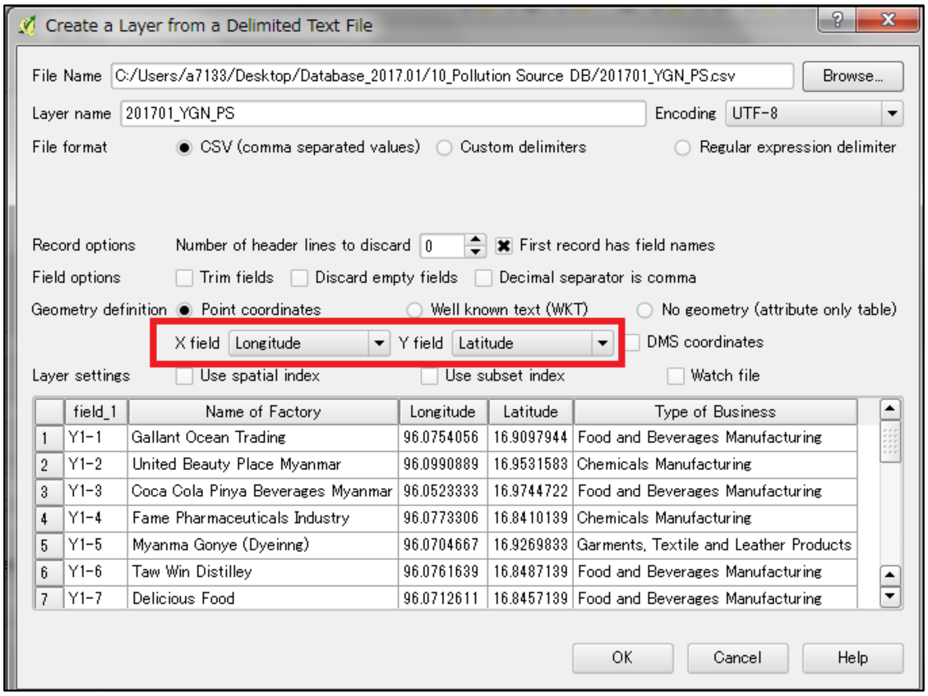


3) Select "Browse" and the CSV file "201701_YGN_PS.csv"



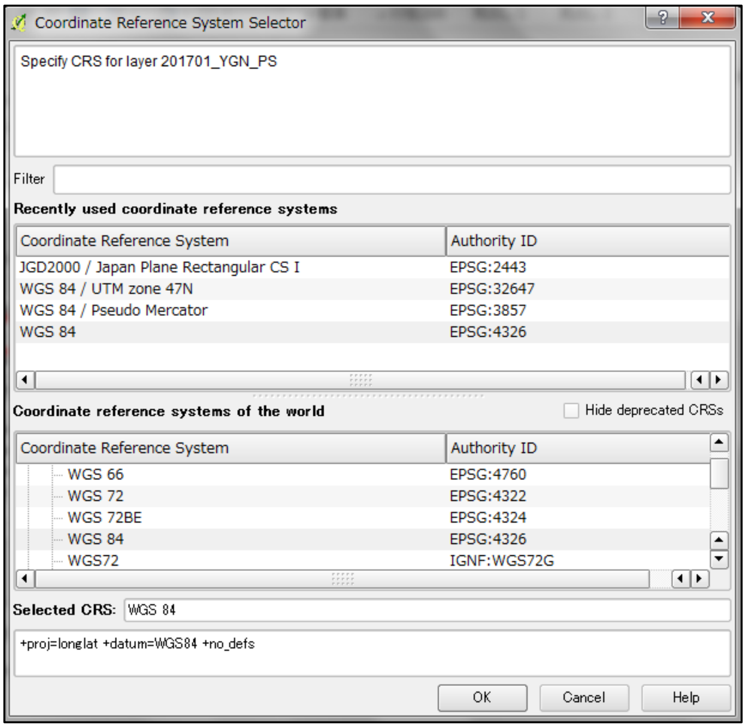
4) Check the setting of "X (Longitude)" and "Y (Latitude)"

If these fields are not properly delineated, you need to set them by yourself.

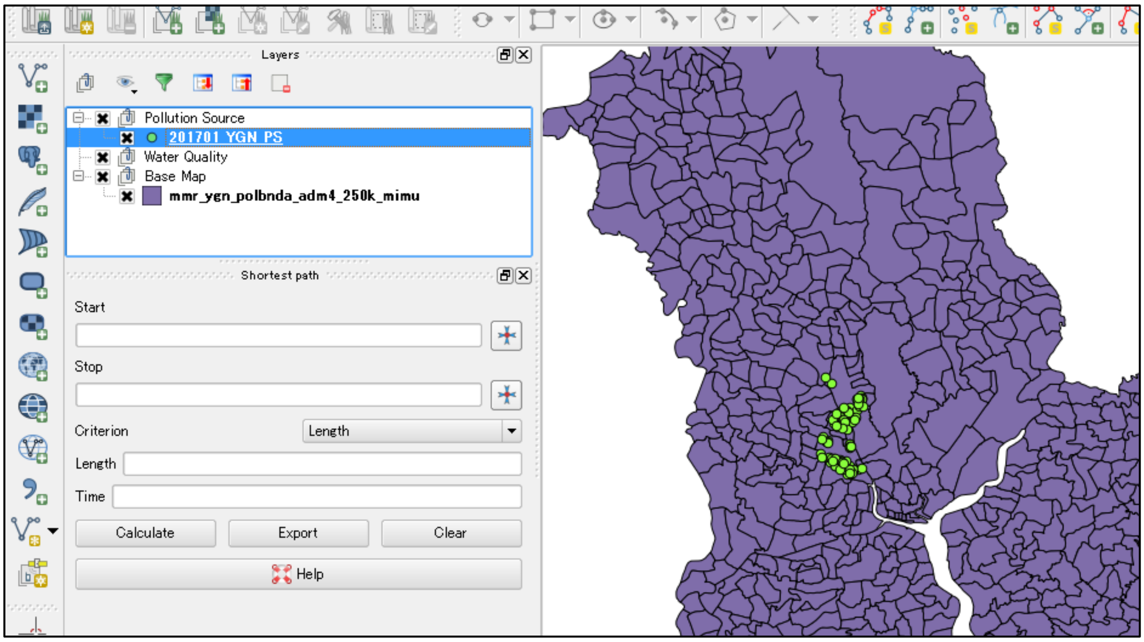


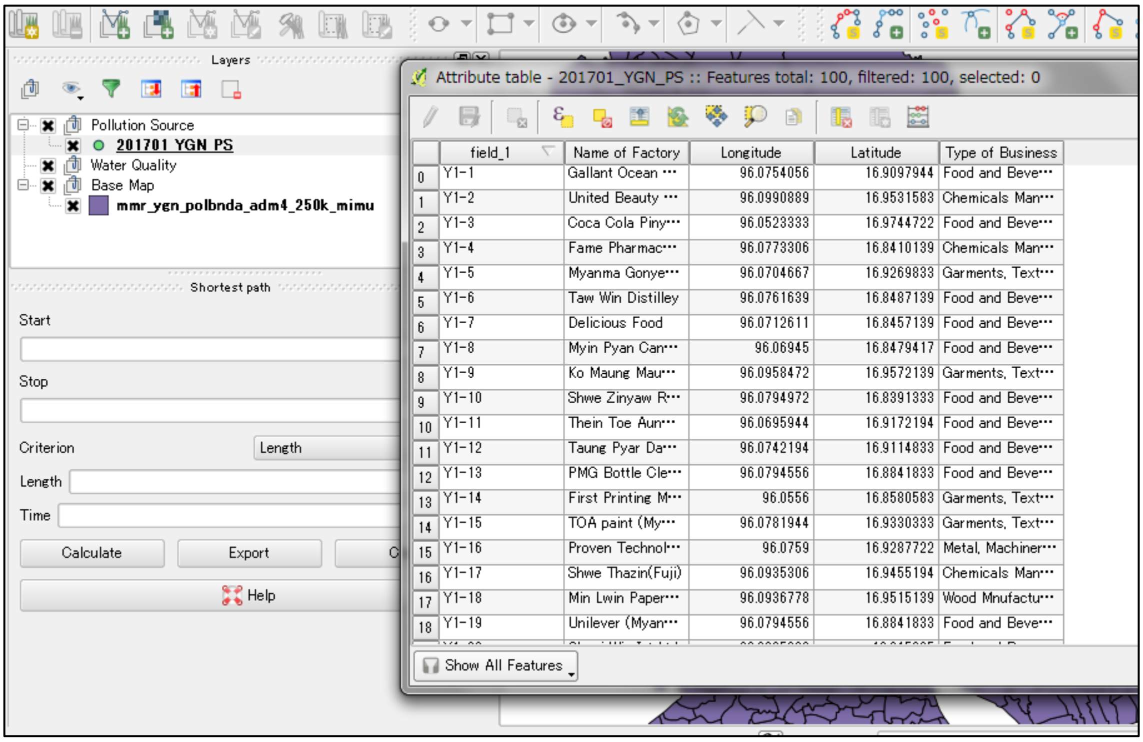
5) Click "OK" and Select the Coordinate Reference System (CRS)

Let's select "WGS 84" here.



The data of pollution source will appear. These points carry the same data as the CSV file. Let's right click "201701_YGN_PS" and select "Open Attribute Table" to check the data.



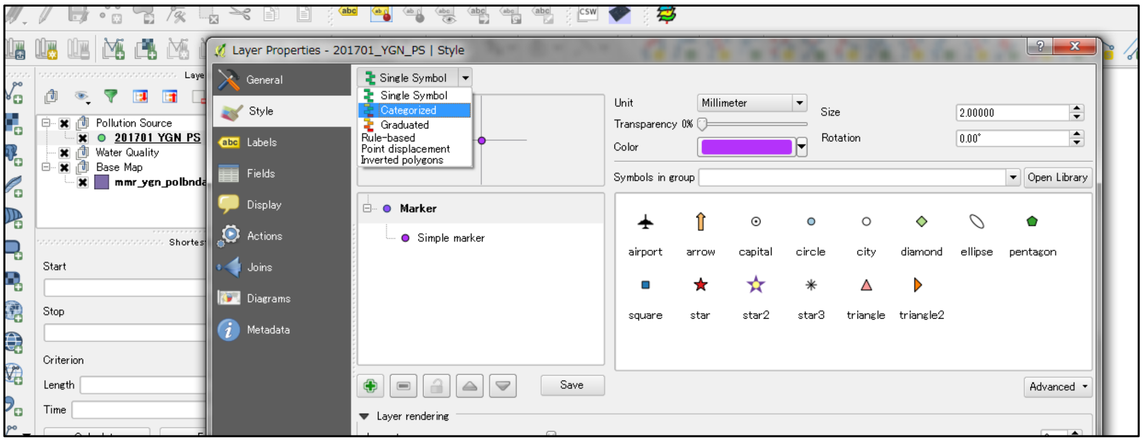


(4) *Change Layer Properties of Pollution Source*

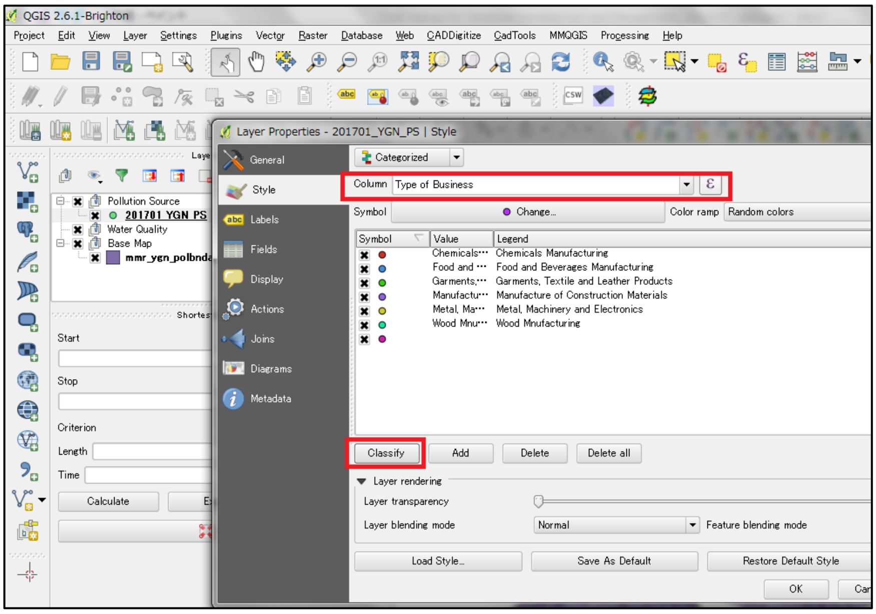
In this exercise, you will display locations of pollution sources with markers of different colors depending on the sector of the business.

1) Right Click of “201701_YGN_PS” and Select “Properties”

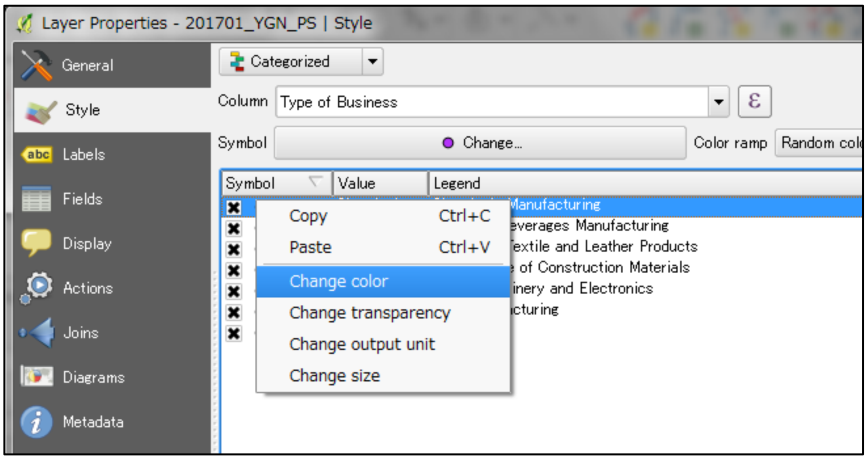
2) Select Style and change “Single Symbol” to “Categorized”



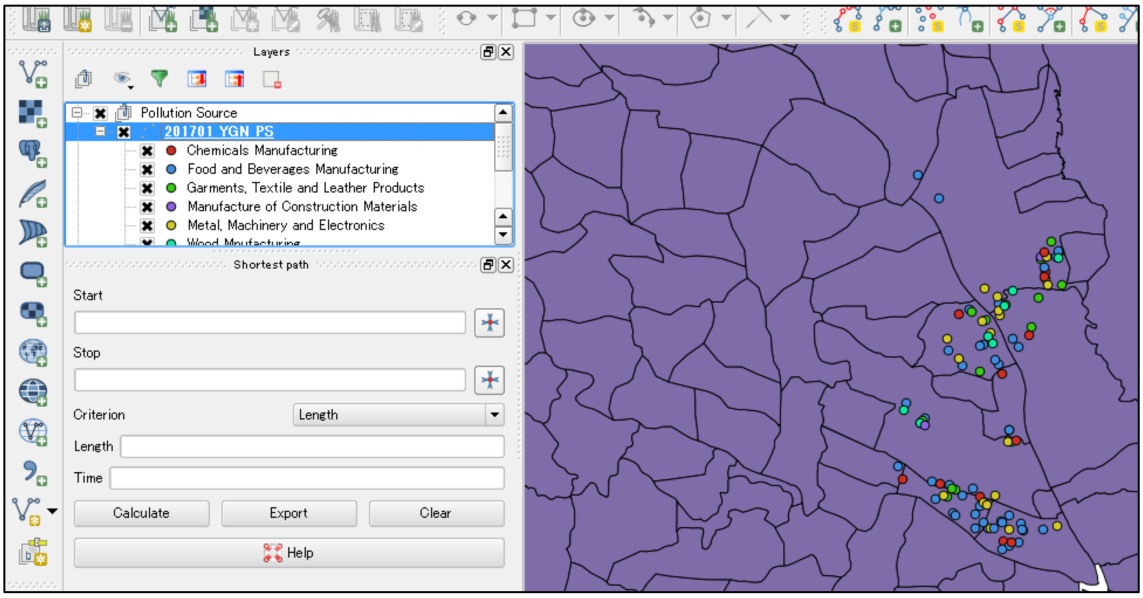
3) Select “Column” and Set “Type of Business”



4) Right Click the symbol and Change Color



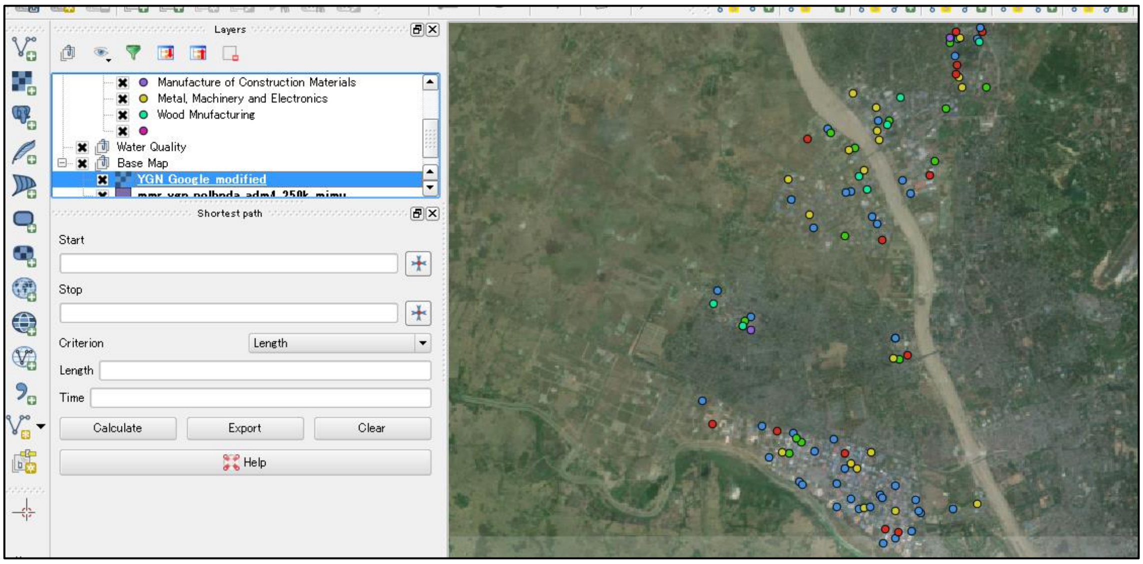
5) Click "OK" and the points will be colored



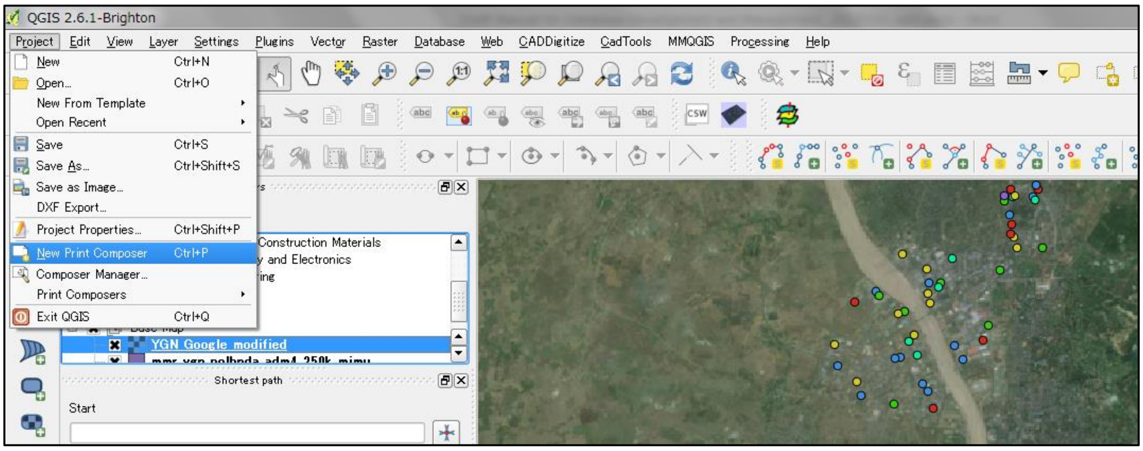
(5) *Output*

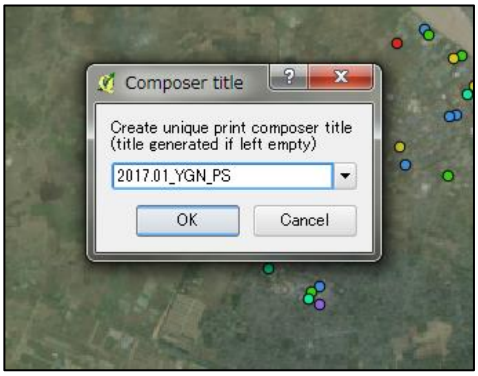
1) Select "Base Map" and Open "30_Base Map", "Satellite" and Drag "YGN_Google_modified.tif" to QGIS display

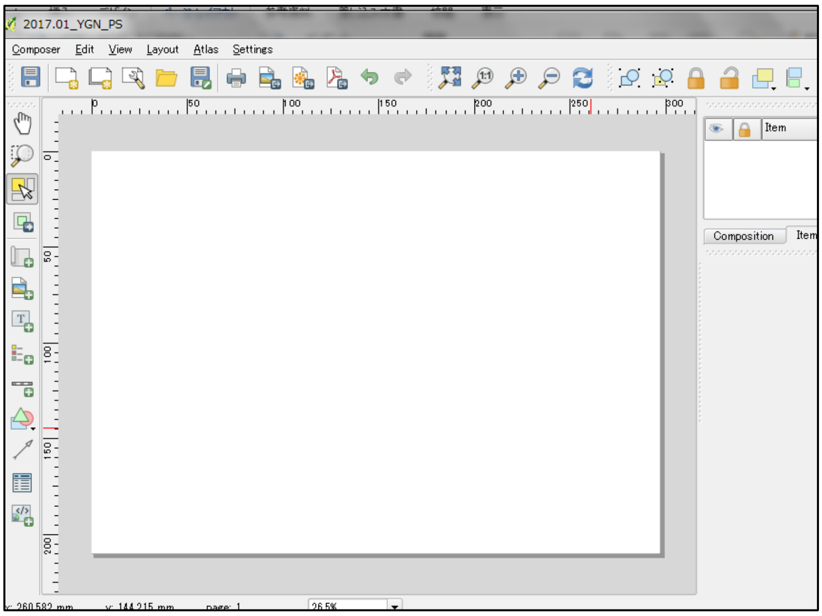
2) Select "WGS 84 / Pseudo Mercator" as CSR



3) Select "Project" and "New Print Composer"







4) Add Map, Legend, Scale Bar and Image as you need

2.4.2 Tutorial 2: To make the BOD map (Water Quality)

(1) *Create CSV File*

Open the folder “20_Water Quality DB”

1) Open the file “20160627-28_WQ_MDL.xlsx”

Let’s see the title is described in the first row and latitude & longitude are described in the column “D” & “E”.

*Remarks: Longitude and Latitude have already been filled. If you get new data, it is necessary to be filled by yourself.

	A	B	C	D	E	F	G	H	I	J	K
1	No.	Name	Sampling Date	Latitude	Longitude	Laboraory	BOD (ppm)	COD (ppm)	pH	DO (mg/l)	TDS (pp
2	1	DHWD1	27-Jun-16	21.82603	96.09447	Water and Sanitation Department Lab	2.1	5.25			154
3	2	DHWD2	27-Jun-16	21.83217	96.08708	Water and Sanitation Department Lab	2.9	7.25			152
4	3	DHWD4	27-Jun-16	21.83783	96.06981	Water and Sanitation Department Lab	2.6	6.5			150
5	4	Discharge Point	27-Jun-16	21.82803	96.09353	Water and Sanitation Department Lab	24800	62000			29
6	5	LKP	27-Jun-16	21.89094	96.08158	Water and Sanitation Department Lab	28	70			196
7	6	UST	27-Jun-16	21.89961	96.07658	Water and Sanitation Department Lab	32	80			23
8	7	TGT	27-Jun-16	21.89885	96.08736	Water and Sanitation Department Lab	31	76			22
9	8	PYTC1	27-Jun-16	21.90021	96.08952	Water and Sanitation Department Lab	36	90			20
10	9	PRE-AERATOR	27-Jun-16	21.91173	96.08984	Water and Sanitation Department Lab	25	65			38
11	10	AFTER-AERATOR	27-Jun-16	21.90949	96.09048	Water and Sanitation Department Lab	31	78			38
12	11	N TTM	28-Jun-16	21.90156	96.05909	Water and Sanitation Department Lab	16	40			21
13	12	S TTM	28-Jun-16	21.88544	96.05676	Water and Sanitation Department Lab	18	45			25
14	13	INLET OF MOC	28-Jun-16	21.89129	96.05479	Water and Sanitation Department Lab	11	28			158
15	14	TADARPHYU	28-Jun-16	21.88341	96.01832	Water and Sanitation Department Lab	5.1	13			29
16											

2) Save as CSV file

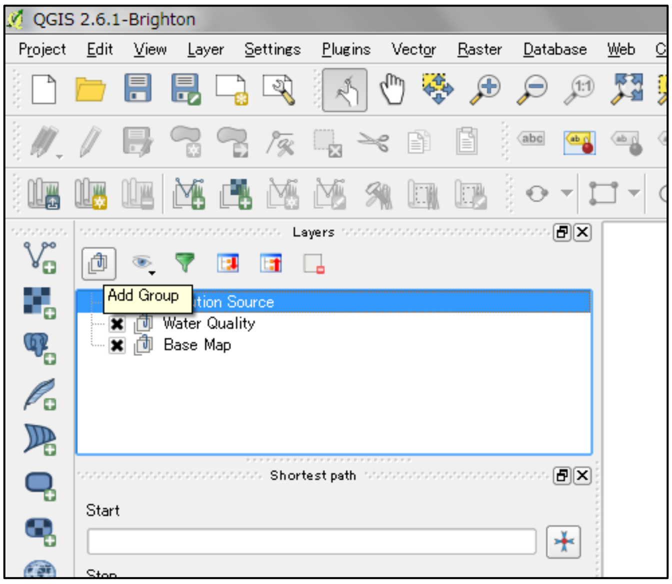
“Save As” box > “Save as type” in “CSV (Comma delimited) (*.csv)” and store the same folder “10_Pollution Source DB”

Name: 20160627-28_WQ_MDL.csv

(2) *Overlay the “Base Map” on QGIS*

1) Open QGIS software (Double click of “QGIS Desktop 2.X.X”)

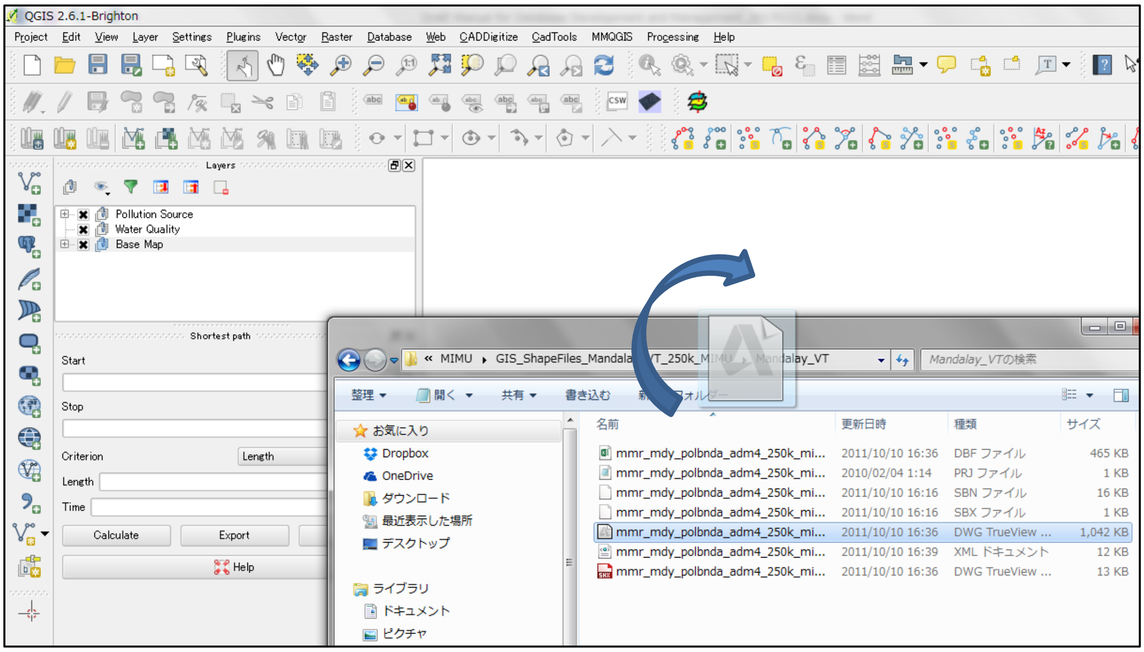
2) Create groups of “Pollution Source”, “Water Quality” and “Base Map”

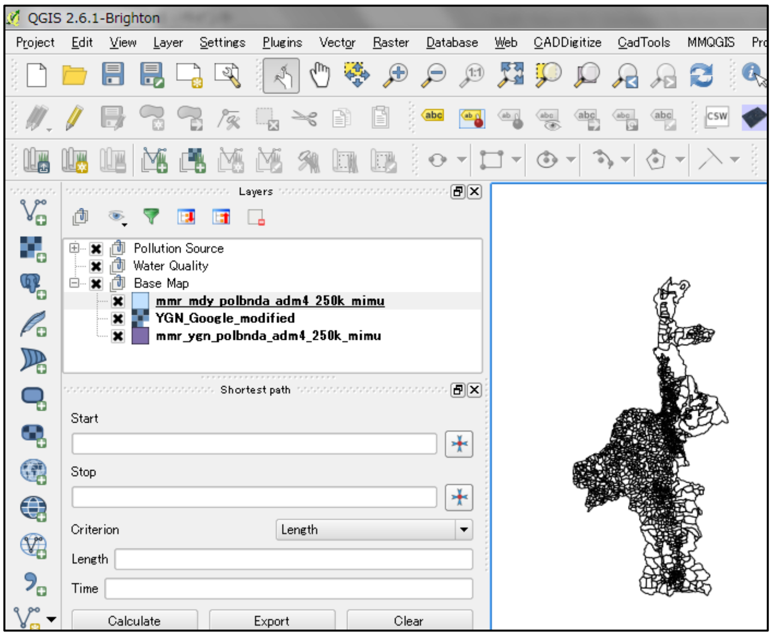


3) Select the group "Base Map"

4) Open the folder of "30_Base Map", "MIMU", "GIS_ShapeFiles_Mandalay_VT_250k_MIMU" and "Mandalay_VT".

5) Select "mmr_mdy_polbnda_adm4_250k_mimu.shp" and drag to QGIS display

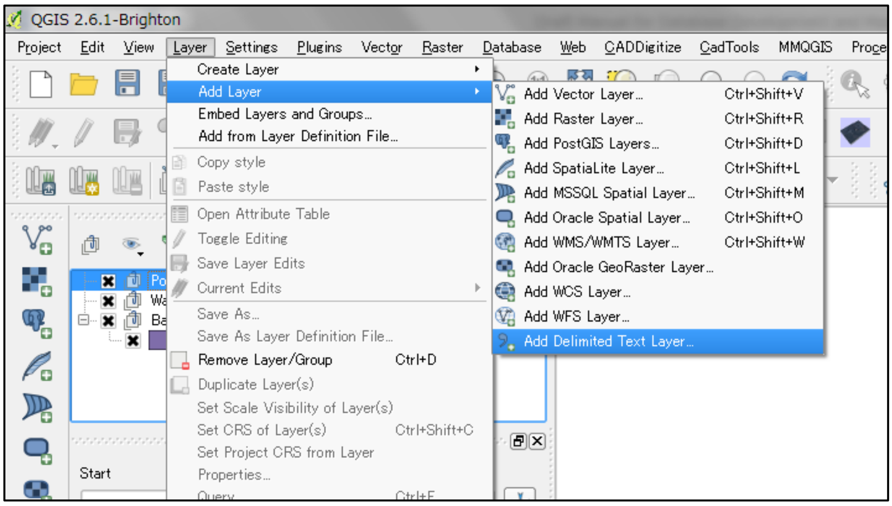




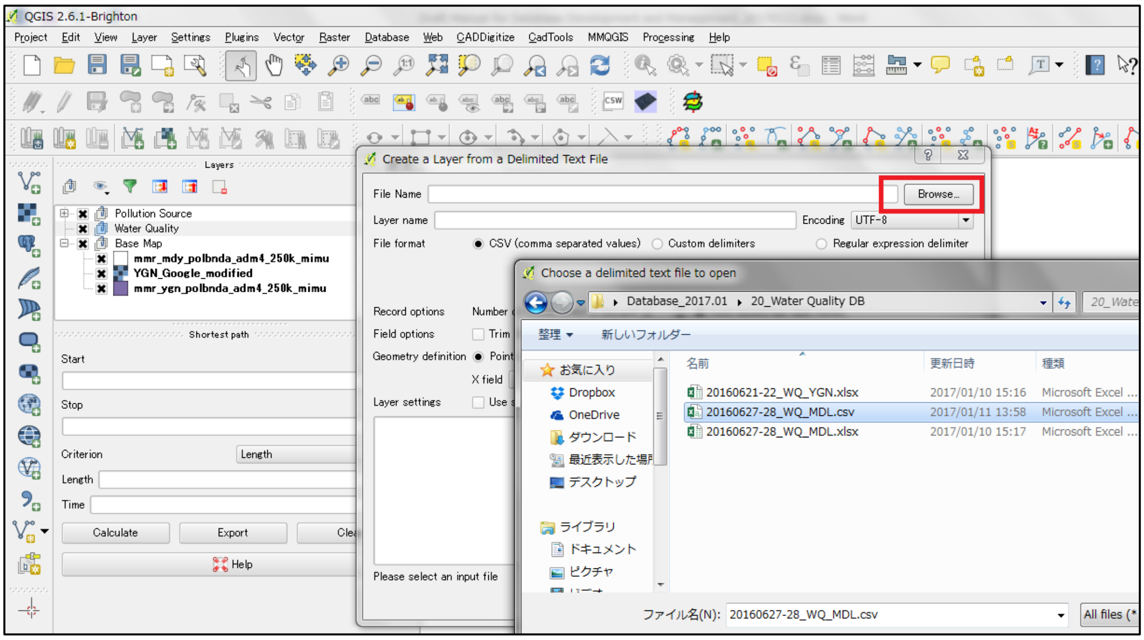
(3) *Overlay the "Water Quality" data from CSV file on QGIS*

1) Click the group "Water Quality"

2) Select "Layer", "Add Layer" and "Add Delimited Text Layer"

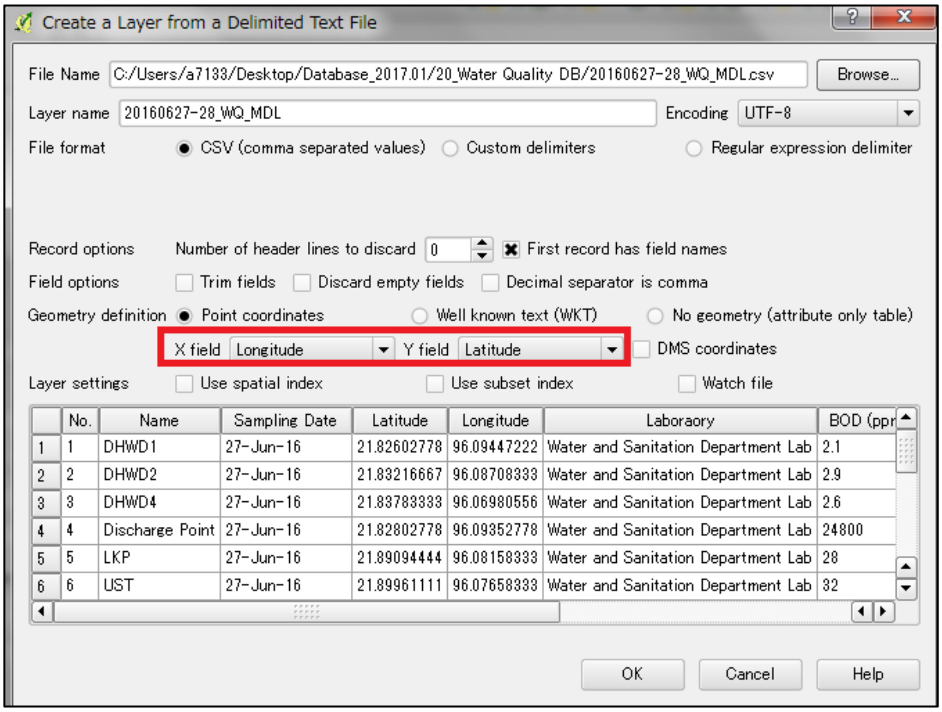


3) Select "Browse" and the CSV file "20160627-28_WQ_MDL.csv"



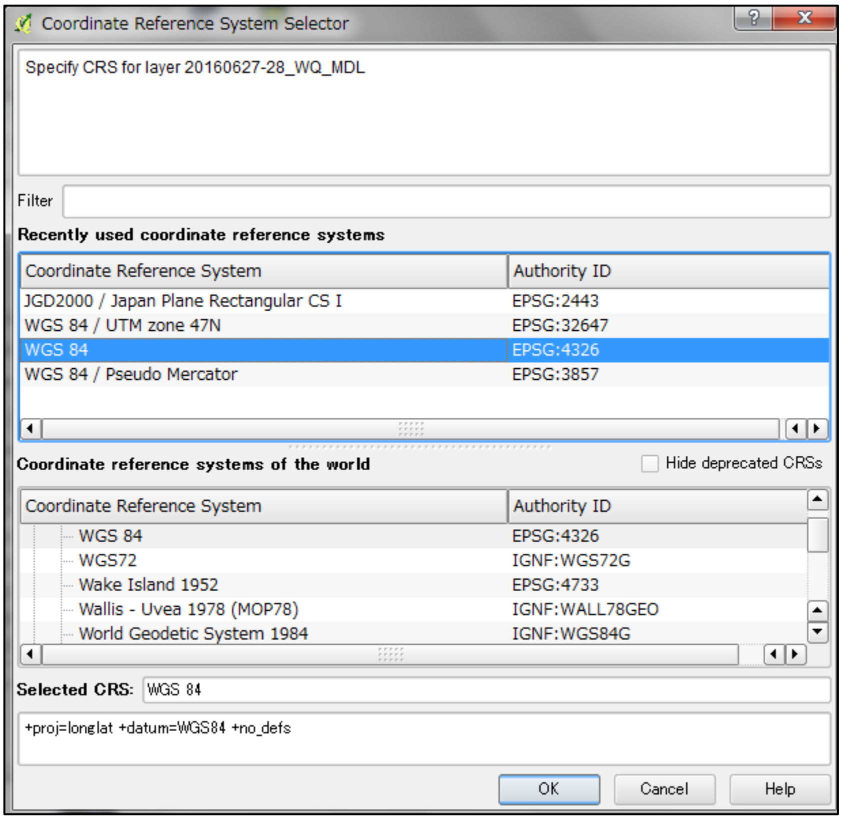
4) Check the setting of "X (Longitude)" and "Y (Latitude)"

If it doesn't fit, it is necessary to be set by yourself.

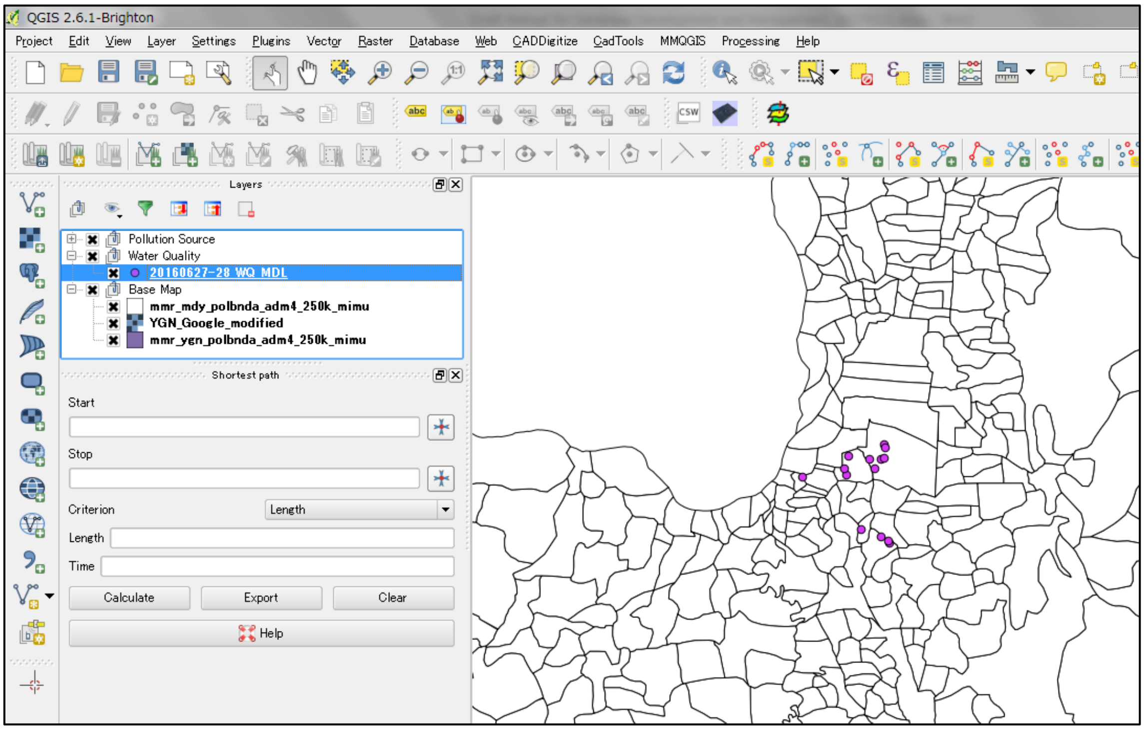


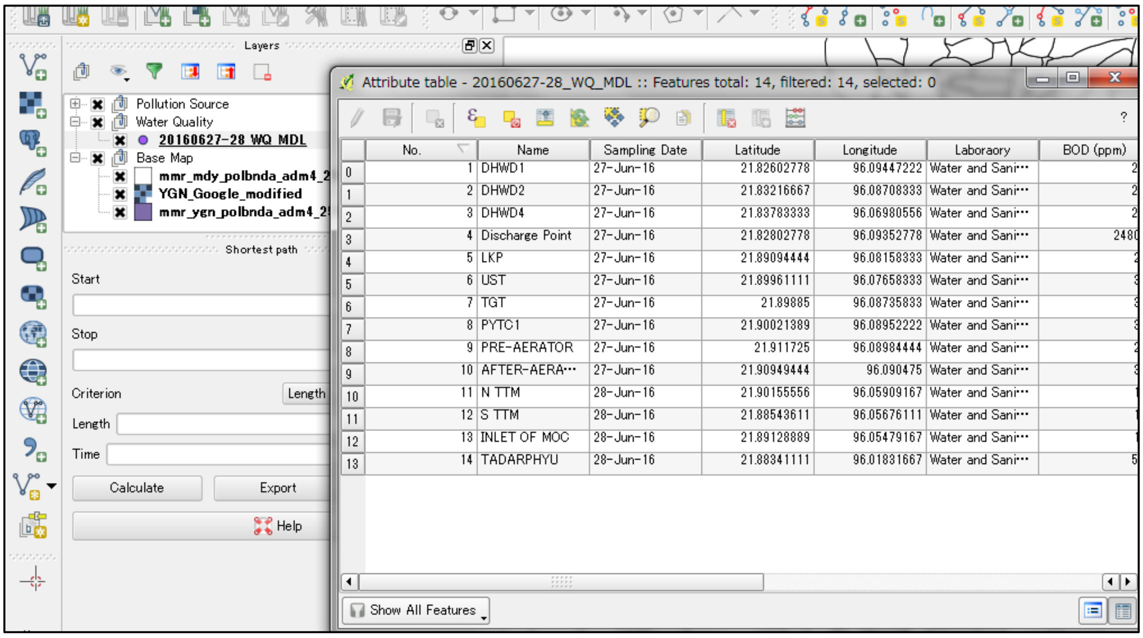
5) Click "OK" and Select the Coordinate Reference System (CRS)

Let's select "WGS 84" here.



The data of water quality will appear. These points carry the same data as the CSV file. Let's right click "20160627-28_WQ_MDL" and select "Open Attribute Table" to check the data.

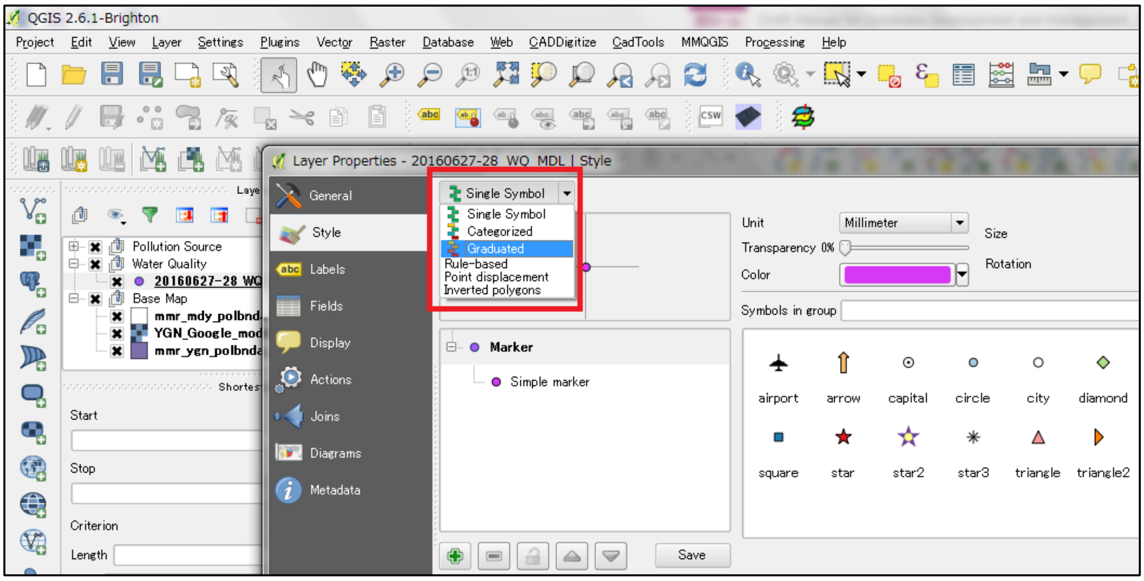




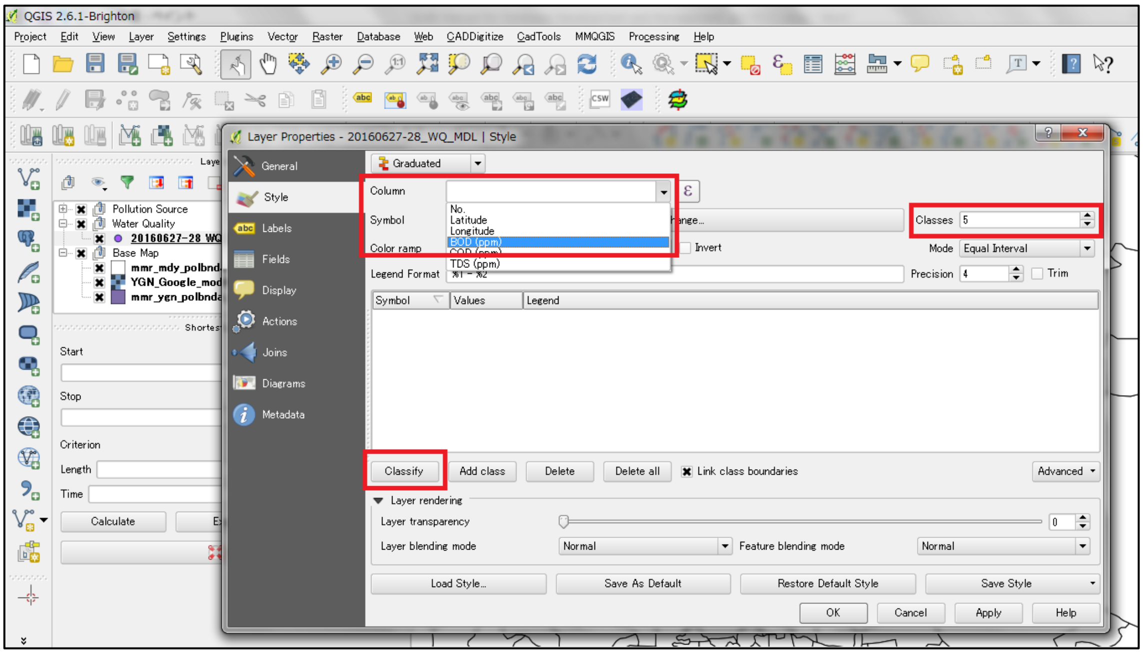
(4) *Change Layer Properties of Pollution Source*

1) Right Click of "20160627-28_WQ_MDL" and Select "Properties"

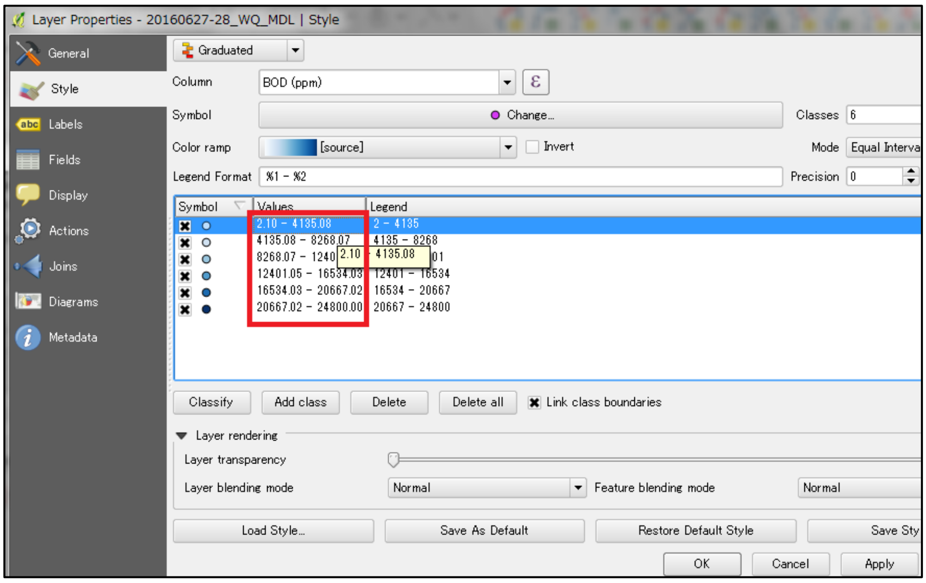
2) Select Style and change "Single Symbol" to "Graduated"

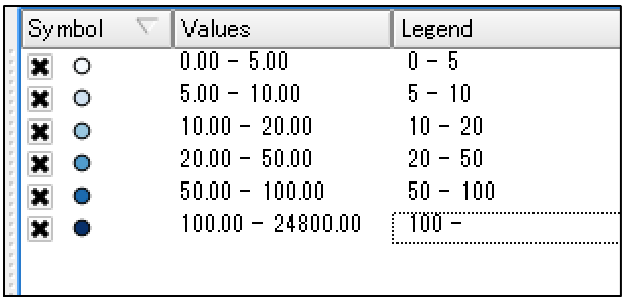


3) Select "Column", Set "BOD (ppm)", Change "Classes" from 5 to 6 and "Classify"

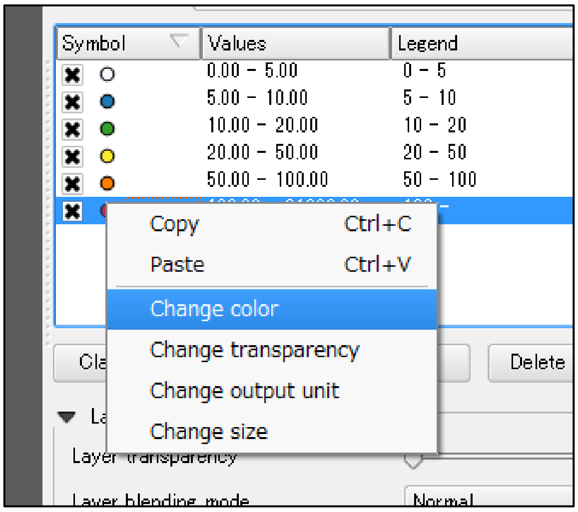


4) Double Click each “Value” and Change as follows

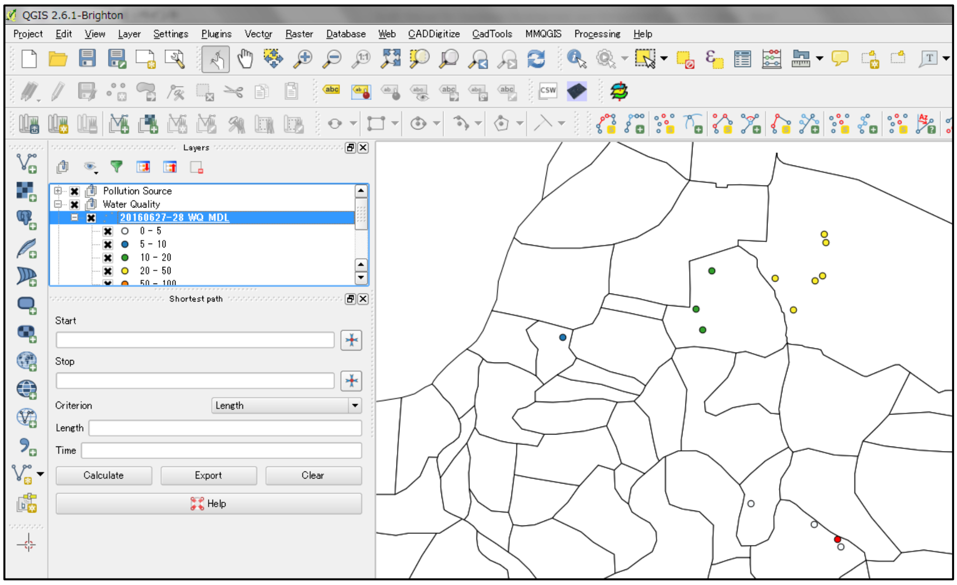




5) Right Click the symbol and Change Color



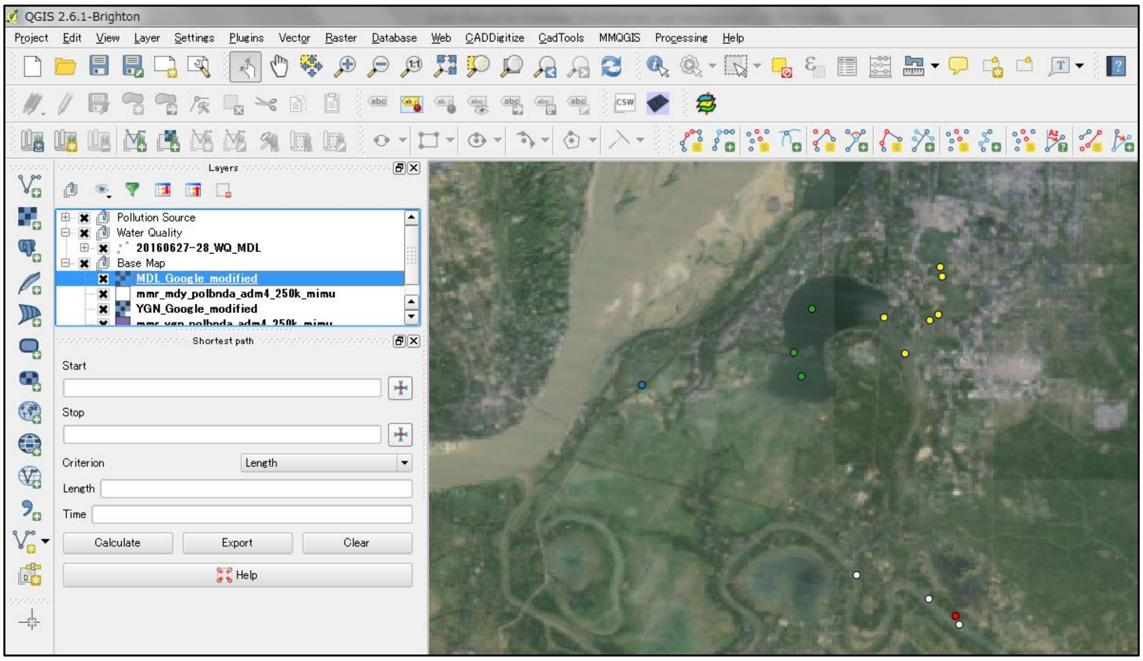
6) Click "OK" and the points will be colored



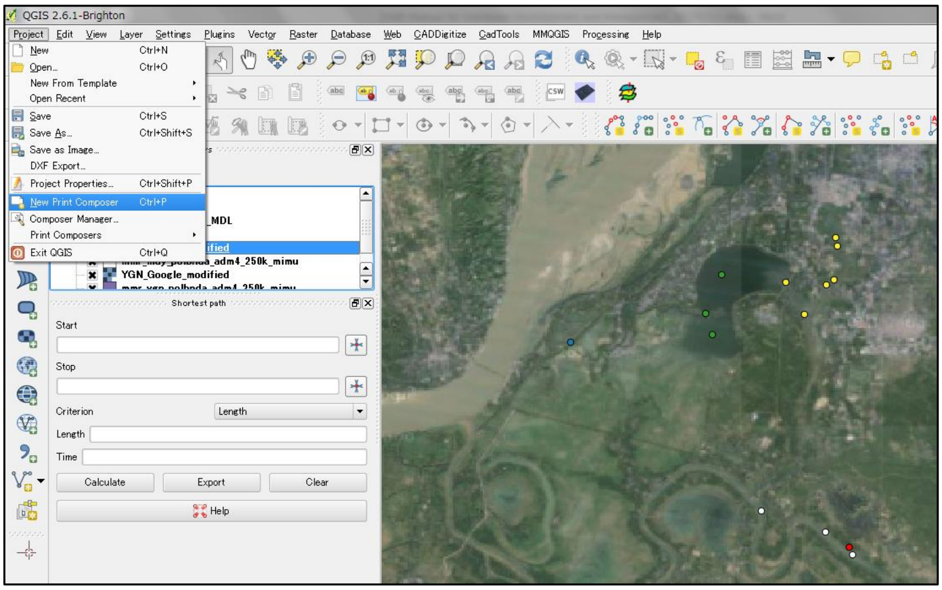
(5) *Output*

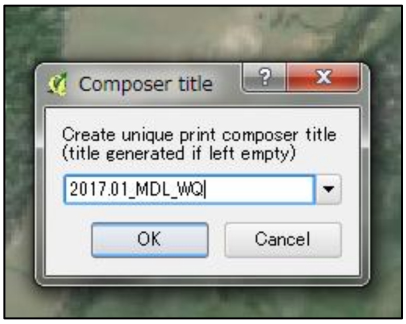
5) Select "Base Map" and Open "30_Base Map", "Satellite" and Drag "MDL_Google_modified.tif" to QGIS display

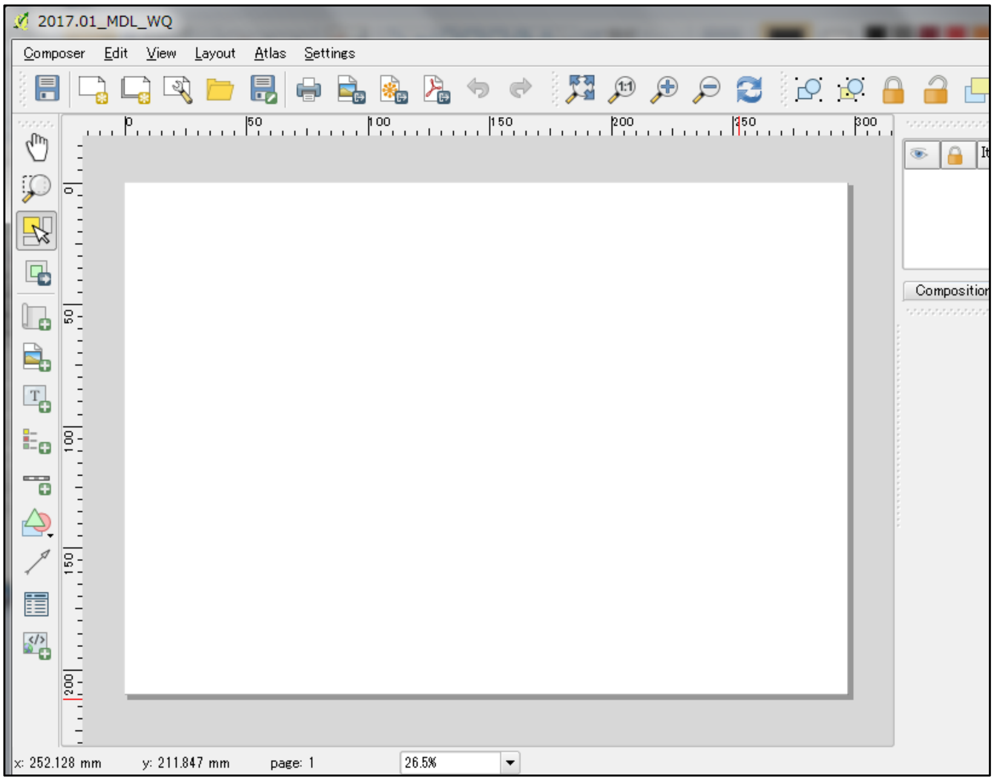
6) Select "WGS 84 / Pseudo Mercator" as CSR



7) Select "Project" and "New Print Composer"







8) Add Map, Legend, Scale Bar and Image as you need

3 DATABASE MAINTENANCE

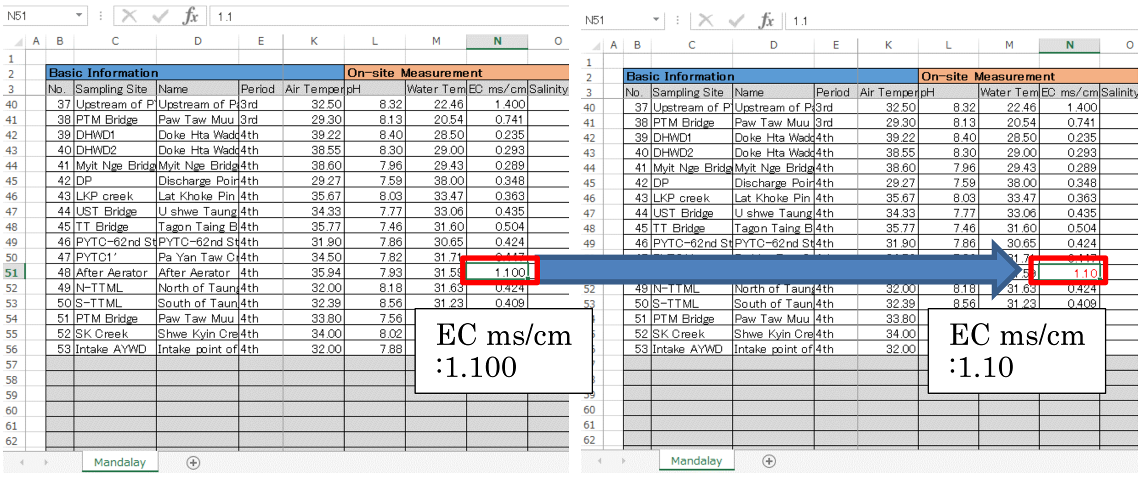
3.1 DATA CHECK & CONFIRMATION

When you digitize the result of the survey, it is necessary to take care of the following issues.

- Data input error,
- Error of data itself (e.g. inaccurate data due to the capacity of laboratory, etc.),
- Missed significant figure, etc.

You can try the following methods to check and confirm the data and/or ask senior staff to overview /supervise.

Methods of Checking	Target	Remarks
[Self-Double Check] To input data twice and compare the results by using the formula in Excel	- Data input error	e.g. - To input "=A1-B1" / "=EXACT (A1, B1) in another cell, - To highlight blank cell by using "Conditional Formatting", etc.
[Insert Chart] To insert chart and see the ratio of relative parameters	- Data input error - Inaccurate data	e.g. - To see the ratio of "BOD" & "COD" (or "T-N" & "T-P") and compare, etc.



In the case of that the value shall be expressed to three significant figures.

3.2 DATABASE BACK-UP

When you manage the database development, it is important to deal with the risk of losing data by database back-up. The risk that you can face are described as follows.

- Operation mistake,
- Error in operation due to the software trouble,
- PC crush, etc.

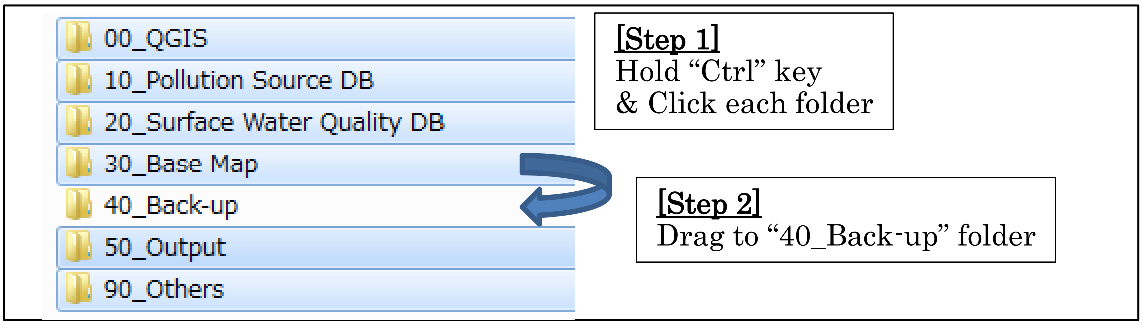
Daily back-up and regular back-up are required to avoid these risk.

3.2.1 Daily Back-up [Save in Different Folder]

When you finish the operation, it is desirable to save the folders in the different folder as follows.

Step 1. Select the folders that you update (Hold "Ctrl" & Click each folder)

Step 2. Copy the folders that you select and Paste in "40_Back-up" folder



3.2.2 Regular Back-up [Save in External Storage Media]

In addition to the daily back-up, it is desirable to save the folders in the external storage media regularly. Below table shows the type of external storage media and each feature. Hard Disk Drive (HDD) or Digital Versatile Disc (DVD) is desirable for regular back-up.

No.	Back-up Media	Additional Setting	Material Management	Data Security	Evaluation
1	HDD /DVD	Good (No Need)	Good	Good[1]	Good for regular back-up
2	USB	Good (No Need)	Easy to lose	Good[1]	Good portability, but easy to lose because of its size
3	On-line	Necessary	Good (No Need)	Risk of PC virus, etc.	Not good to store sensitive data because of its security risk

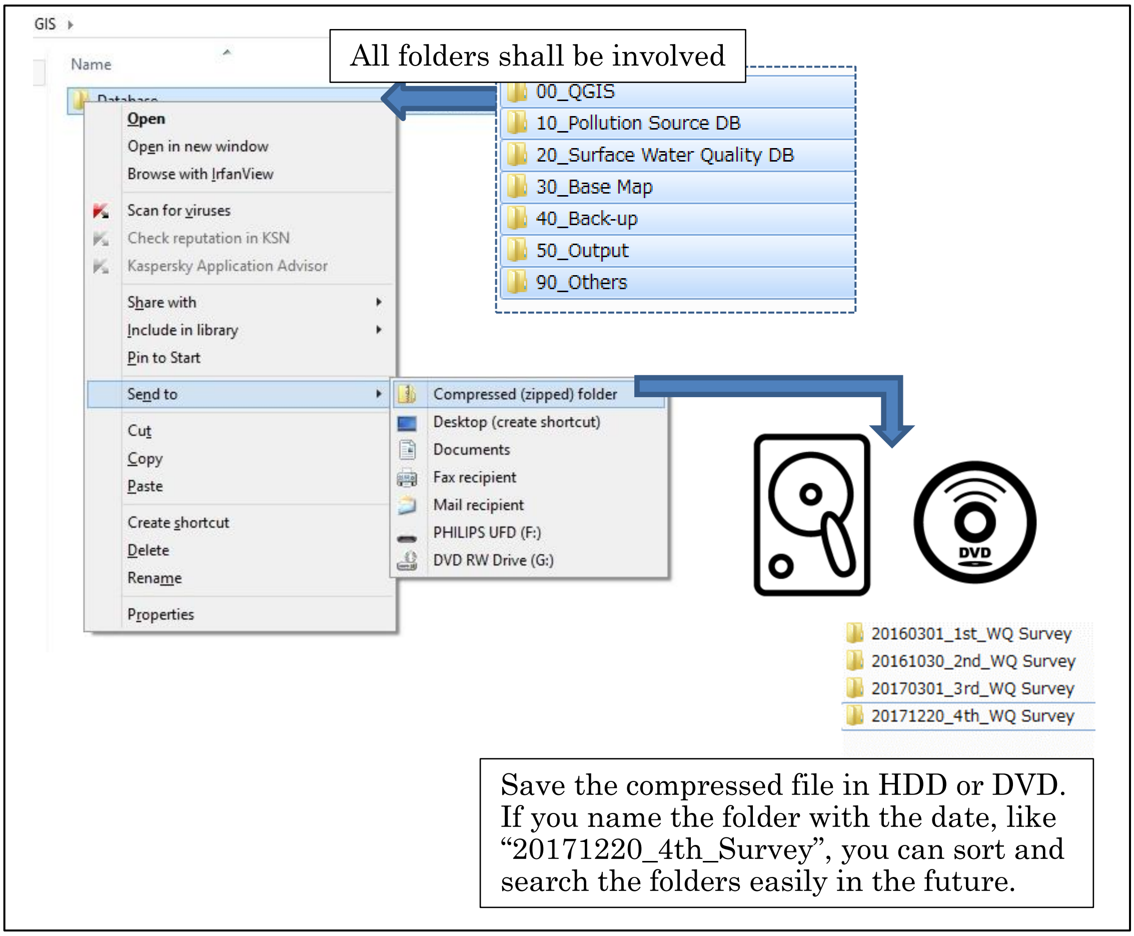
1) If you can keep the back-up media securely, data security can be evaluated as "Good".

Following steps are recommended as regular back-up. It should be noted that it is good to compress the whole folder to avoid missing the file properties.

Step 1. Compress the whole folder (in a zipper file or something similar)

Step 2. Create a folder in HDD/DVD (e.g. "20171220_4th_Survey", etc.)

Step 3. Save the compressed file in the created folder



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Appendix 12:

Water Quality Status Report

PROJECT FOR CAPACITY DEVELOPMENT IN BASIC WATER ENVIRONMENT MANAGEMENT AND EIA SYSTEM IN THE REPUBLIC OF THE UNION OF MYANMAR

WATER QUALITY STATUS REPORT

June 2018

PREPARED BY:

ENVIRONMENTAL CONSERVATION DEPARTMENT, MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL CONSERVATION

YANGON CITY DEVELOPMENT COMMITTEE

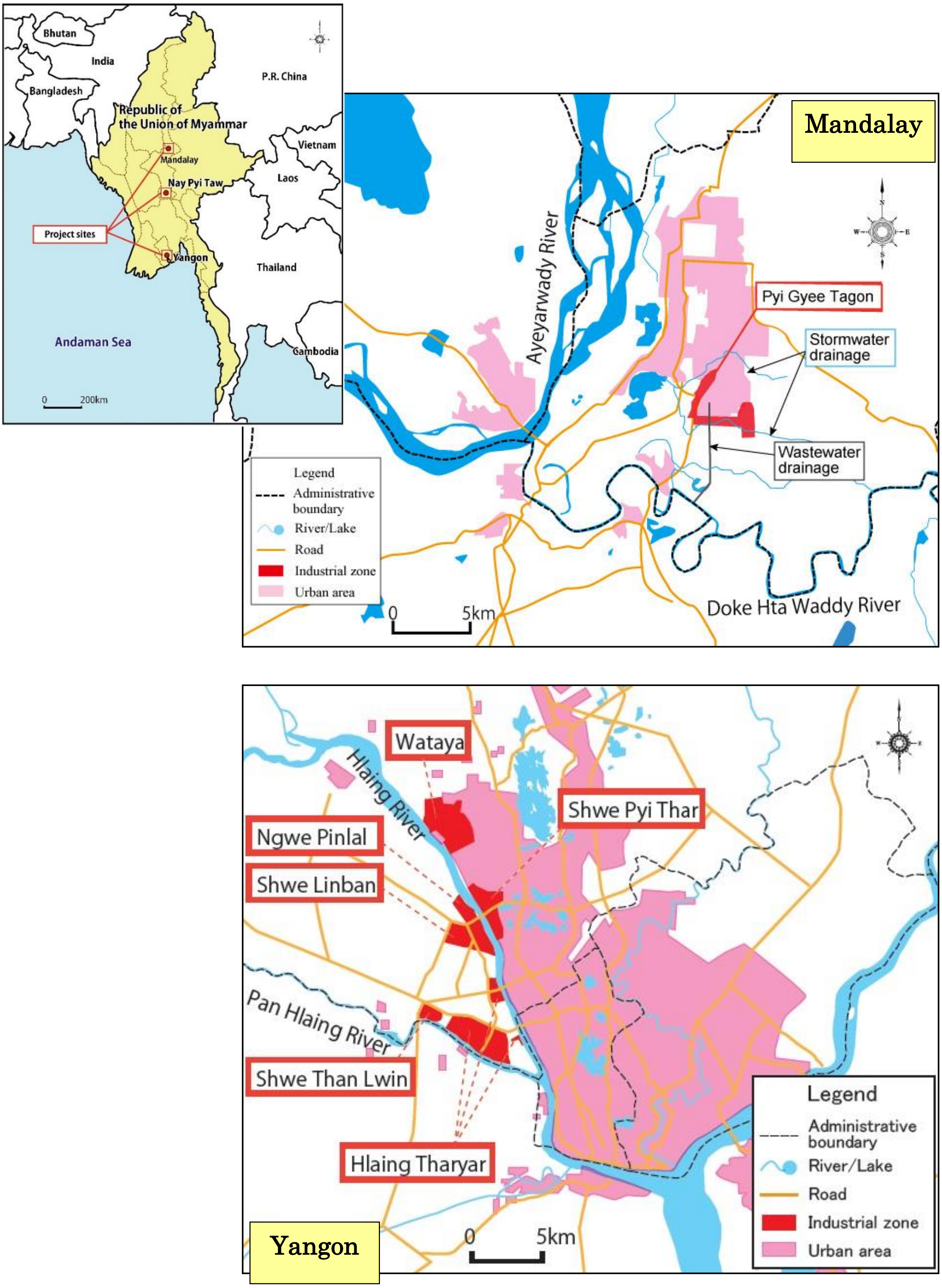
MANDALAY CITY DEVELOPMENT COMMITTEE

JICA EXPERT TEAM

PREFACE

This water quality status report was developed as part of the outputs of the bilateral technical cooperation project between Myanmar and Japan entitled "Project for Capacity Development in Basic Water Environment Management and EIA System in the Republic of the Union of Myanmar (hereinafter referred to as "the Project"). The project has the aim to support and enhance capacities of Ministry of Natural Resources and Environmental Conservation (MONREC), Yangon City Development Committee (YCDC), Mandalay City Development Committee (MCDC), and other organizations concerned to manage water environment and to implement EIA reviews. Among the six outputs of the project, this manual was produced to fulfill the goal of Output 4 "Capacity of interpreting the information for water pollution control measures is enhanced.". We sincerely hope that this report helps each organization to develop strategies for water pollution control and water environment management.

JICA Expert Team



Location Maps of the Project Areas

Table of Contents

1 INTRODUCTION

1.1 BACKGROUND

Myanmar has been facing considerable challenges in environmental management such as water and air pollution due to the increasing infrastructure developments in industrial, urban and rural sectors. In order to control and limit such drawbacks, the Government of Myanmar (hereinafter referred to as "GOM") enacted the Environmental Conservation Law in 2012, subsequently established the Environmental Conservation Rules for implementation of the law in 2014, and also enacted EIA Procedures and National Environmental Quality (Emission) Guidelines in 2015. To enforce such laws and regulations, the Environmental Conservation Department (hereinafter referred to as "ECD") under the Ministry of Natural Resources and Environmental Conservation (hereinafter referred to as "MONREC") was established as the focal institution for pollution control, EIA review and other environmental management activities. Similarly, large municipalities such as Yangon City Development Committee and Mandalay City Development Committee (hereinafter referred to as "YCDC" and "MCDC", respectively) have started requiring pollution sources to install wastewater treatment facilities and carrying out regular inspections. However, in order to firmly establish the framework for environmental management, these institutions have to urgently develop their capacities.

Under these circumstances, GOM requested Japan International Cooperation Agency (JICA) to support and enhance the capacities of MONREC and other organizations to manage water environment and to implement EIA reviews by implementing this project entitled "The Project for Capacity Development in Basic Water Environment Management and EIA System (hereafter named as "the Project"). Table 1-1 shows the overall goal, project purpose and outputs of the Project. This Water Quality Status Report was prepared as one of the activities of Output 4 related to interpretation of information gathered through activities of Output 1, 2, and 3 in the pilot sites namely, the Hlaing River Basin in Yangon and the Doke Hta Waddy River Basin in Mandalay.

Table 1-1 Overall Goal, Project Purpose and Outputs of the Project

Item	Contents		Component
Overall Goal	Impact of industrial effluents from industrial zones on river water quality is alleviated, and advanced EIA approach for complicated issues are taken into account.		
Project Purpose	Capacity for developing basic water pollution control measures based on obtained and interpreted information is enhanced and the institutional framework of the EIA review works is established.		
Outputs	Output 1	Inspection procedure is standardized.	Water environment management
	Output 2	Capacity for implementing water quality survey to obtain reliable information is enhanced.	Water environment management
	Output 3	Database of water pollution sources and river water quality is developed.	Water environment management
	Output 4	Capacity of interpreting the information for water pollution control measures is enhanced.	Water environment management
	Output 5	Necessary technical manuals and forms for the EIA review are developed.	EIA
	Output 6	Capacity of MONREC and the EIA Report Review Body on the EIA review is enhanced.	EIA

Source: JICA Expert Team

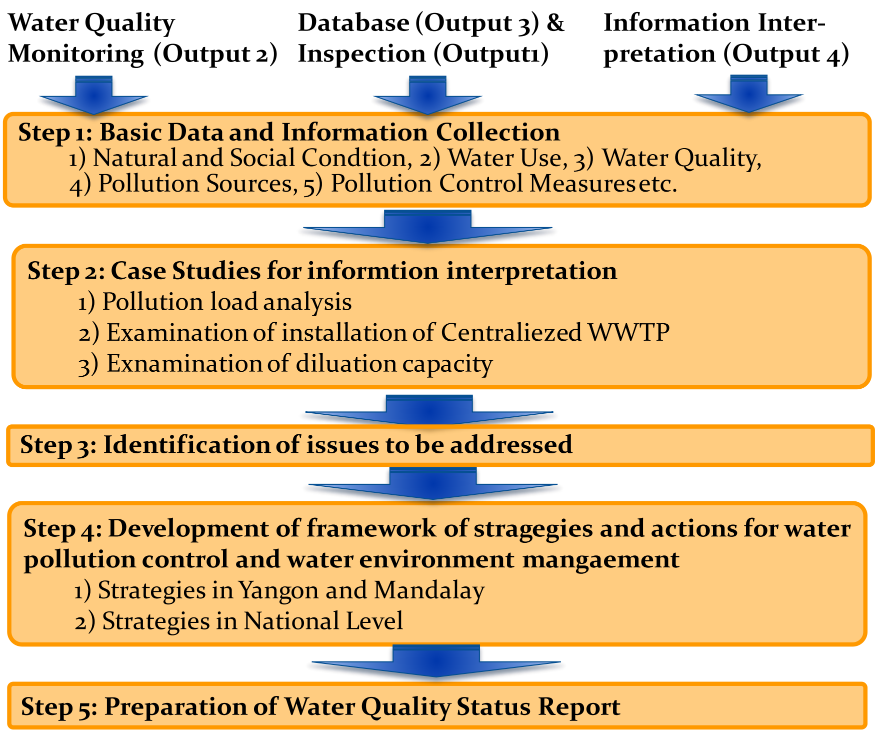
1.2 Objectives

The objectives of preparation of the Water Quality Status Report are as follows:

- To understand water quality status such as current water quality, important sectors for water pollution control, magnitude of water pollution impact from industrial zones and other sectors, and dilution capacity of rivers in the pilot areas of Yangon and Mandalay,
- To identify issues to be addressed in the pilot areas of Yangon and Mandalay
- To formulate framework of strategy for water pollution control from industries and water environment management in the pilot area and national level for development of "Written Strategies", and
- To explain decision makers at regional levels and national levels about water quality status and strategies by MONREC-ECD, YCDC, and MCDC.

1.3 Procedures of Preparation of Water Quality Status Report

The processes of preparing the Water Quality Status Report, including information interpretation, five steps was proceeded as shown in Figure 1-1.



Source: JICA Expert Team

Figure 1-1 Processes of Preparation of Water Quality Status Report

1.4 CASE STUDIES FOR INFORMATION INTERPRETATION FOR WATER QUALITY STATUS

Five case studies were selected through meetings among C/Ps in Yangon, Mandalay, and Nay Pwi Taw to meet the requirements of current water environment management in each pilot area. They were categorized into two types: (i) pollution load analysis in order to prioritize sectors to control wastewater, and (ii) examination of possible countermeasures for water environment management, such as control of industrial wastewater, estimation of dilution capacity leading to future water resource management, and industrial water pollution control measures at national level. These case studies are as follows:

[Pollution Load Analysis in order to prioritize sectors to control wastewater]

Case Study 1: Pollution load analysis in the pilot area of Yangon (See Section 2.8.2 and Attachment 1)

Case Study 2: Pollution load analysis in the pilot area of Mandalay (See Section 3.8.2 and Attachment 2)

[Examination of possible countermeasures for water environment management]

Case Study 3: Installation of centralized wastewater treatment system in Hlaing Thar Yar Industrial Zones (See Section 2.11.1 and Attachment 3)

Case Study 4: Preliminary estimation of dilution capacity for water quality in Doke Hta Waddy River (See Section 3.8.3 and Attachment 4)

Case Study 5: Industrial water pollution control measures at national level (See Section 4.3)

Table 1-2 summarizes outline of case studies to interpret water quality status.

Table 1-2 Case Studies to Interpret Water Quality Status

Case Study	Item	Description
Case Study 1 Pollution load analysis in the Pilot Area of Yangon	Target Level and Area	**[Target level]** Regional Level (Yangon) **[Target Area]** Hlaing River Basin, Yangon
	Objective	To identify key pollution sources to be controlled in the pilot area in Yangon City
	Methodology	Sectoral pollution loads are estimated based on available information and unit of pollution load in order to prioritize sectors required to control wastewater.
	Expected outcome	The results of the pollution load analysis with prioritized sectors required to control wastewater can be a basic information to make a certain strategy for water environment management to conserve water uses in Hlaing River basin in future.
	Target Decision Maker	Mayor and Committee Member of YCDC/Yangon Region Government
Case Study 2 Pollution load analysis in the Pilot Area of Mandalay y	Target Level and Area	**[Target level]** Regional Level (Mandalay) **[Target Area]** The catchment area of Taung Tha Man Lake
	Objective	To identify key pollution sources to be controlled in the catchment of Taung Tha Man Lake.
	Methodology	Sectoral pollution loads are estimated based on the existing available information and unit of pollution load to set prioritize sectors required to control wastewater.

Case Study	Item	Description
	Expected outcome	The results of the pollution load analysis with prioritized sectors required to control wastewater can be a basic information to make a certain strategy for water environment management to conserve water uses in Taung Tha Man Lake.
	Target Decision Maker	Mayor and Committee Member of MCDC/ Mandalay Region Government
Case Study 3 Installation of centralized wastewater treatment system in Hlaing Thar Yar Industrial Zones (under activity of Output 1)	Target Level and Area	**[Target level]** Regional Level (Yangon) **[Target Area]** Hlaing Thar Yar Industrial Zones
	Objective	To examine installation of a centralized industrial wastewater treatment system in the Industrial Zone as an effective tool for water environmental management
	Methodology	As the case study, Hlaing Thar Yar Industrial Zones No.1 to No.4 are selected and an examination is carried out including a possibility of installation of centralized wastewater treatment plant and identification of issues to promote PPP scheme for construction such centralized industrial wastewater plant.
	Expected outcome	The results of the examination can identify issues to promote PPP scheme for construction of the centralized industrial wastewater treatment plant such as financial feasibility, operation and maintenance, fee collection, securing land. The lessons and learned of the case study can be also utilized to other existing industrial zones to install the treatment plant.
	Target Decision Maker	Industrial Zone Steering Committee of Yangon Region Government
Case Study 4 Preliminary estimation of dilution capacity in Doke Hta Waddy River	Target Level and Area	**[Target level]** Regional Level (Mandalay) **[Target Area]** Doke Hta Waddy River
	Objective	To examine dilution capacity for water quality in Doke Hta Waddy River, and to consider available water resource taking into account any future development along the target river such as a new hydropower plant upstream of Yeywa dam, a small weir with hydropower function, and irrigation development.
	Methodology	Water quality in the current and future are estimated based on existing water quality data and water volume information especially water discharge from hydropower dam and water intakes for irrigation. Based on the existing information dilution capacity for water quality in Doke Hta Waddy River will be estimated as preliminary examination.
	Expected Outcome	The results of estimation of dilution capacity for Doke Hta Waddy water quality can be utilized for coordination of water resource management among water users such as MCDC, Irrigation Department and Fishery Department of MOALI, Electricity Power Generation Enterprise of Ministry of Electricity and Energy, Directorate Water Resources and Improvement of River System of Ministry of Transport and Communication.
	Target Decision Maker	Mayor and Committee Member of MCDC, Mandalay Regional Government
Case Study 5 Industrial wastewater pollution control measures at national level	Target Level and Area	**[Target level]** Central Level **[Target Area]** Nationwide
	Background	Recently, industrial pollution control has become one of the key issues to be taken by the governments because some residents started to protest against operation of existing factories without any proper industrial wastewater treatment and construction of new factories. MONREC-ECD has to play a vital role of leading the enforcement of promoting policies of industrial wastewater pollution control to be formulated.

Case Study	Item	Description
	Objective	To develop a framework of strategies and its action plans for water pollution control and water environment management
	Methodology	An examination is carried out to review current and future administration actions on industrial pollution control by MONREC-ECD with international cooperation projects. Then, prioritization of administrative actions to regulate pollution from industries is done through a series of discussions between ECD and JET.
	Expected Outcome	Framework of strategies and action plans for water pollution control and water environment management will be developed on the basis of current and future governmental administration.
	Target Decision Maker	National Environmental Conservation and Climate Change Central Committee (NECCCCC)

Source: JET

1.5 STRUCTURE OF WATER QUALITY STATUS REPORT

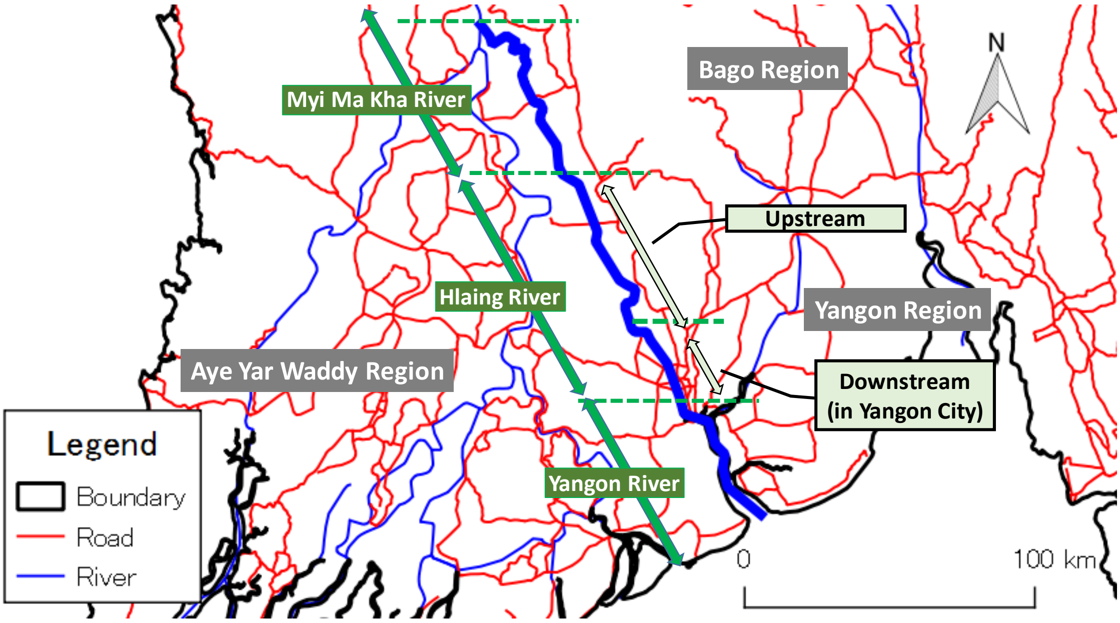
The Water Quality Status Report is structured to describe the water quality status in the pilot area of Yangon (Hlaing River Basin), the water quality status in the pilot area of Mandalay (Doke Hta Waddy River Basin and Taung Tha Man Lake Basin) incorporating with the results of water quality from Output1, the results of pollution source from Output2, the results of pollution load analysis from Output 4, and the results of case studies for each pilot area. Based on the current water quality status in each pilot area, then, the strategy for water pollution control from industries and water environment management in pilot area in both Yangon and Mandalay are proposed with specific key strategies and regional level action plans from short to long term aspects. Moreover, the national level strategies for water environment management in Myanmar are presented with action plans for industrial pollution control, water environmental management, and strengthening organizations from short to long term aspects.

2 WATER QUALITY STATUS IN THE PILOT AREA OF YANGON (HLAING RIVER BASIN)

2.1 OUTLINE OF HLAING RIVER BASIN

2.1.1 Overview of Hlaing River

Hlaing River is the middle section of a tributary of Ayeyarwaddy River and its name evolves as Myit Ma Ka River, Hlaing River, and Yangon River as it flows down toward the sea. The length of Hlaing River is around 110 km and the starting point is the boundary between Yangon Region and Bago Region, and the ending point is before confluence of Pan Hlaing River between Hlaing township and Hlaing Htar Yar township in Yangon City as shown in Figure 2-1.

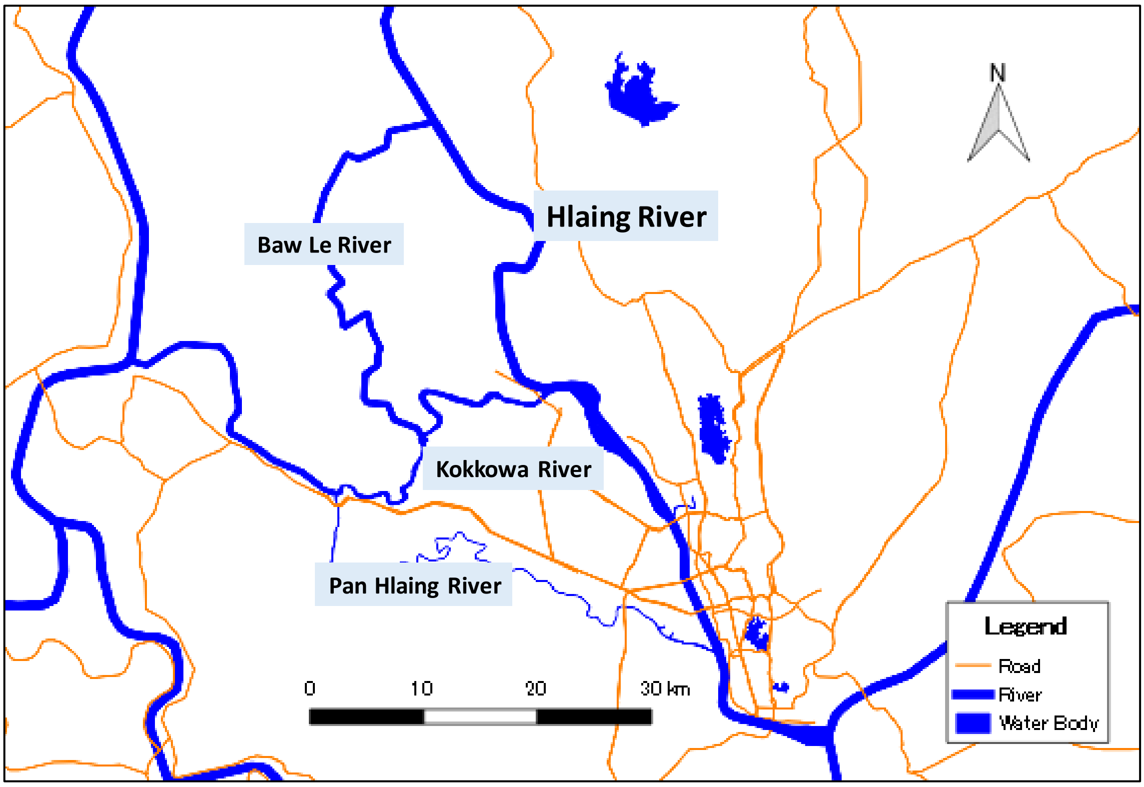


Source: JICA Expert Team based on dataset prepared by MIMU

Figure 2-1 Map of Hlaing River, Myi Ma Kha River, and Yangon River

2.1.2 Downstream area of Hlaing River (Pilot area of Yangon)

This report mainly focuses on the downstream area of Hlaing River located in Yangon City as the pilot area because of the presence of many industrial zones and the water quality may be deteriorated by the impact of wastewater from these industrial zones. Figure 2-2 shows map of the downstream of Hlaing River and its tributaries namely, Pan Hlaing River, Kokkowa River, and Baw Le River.



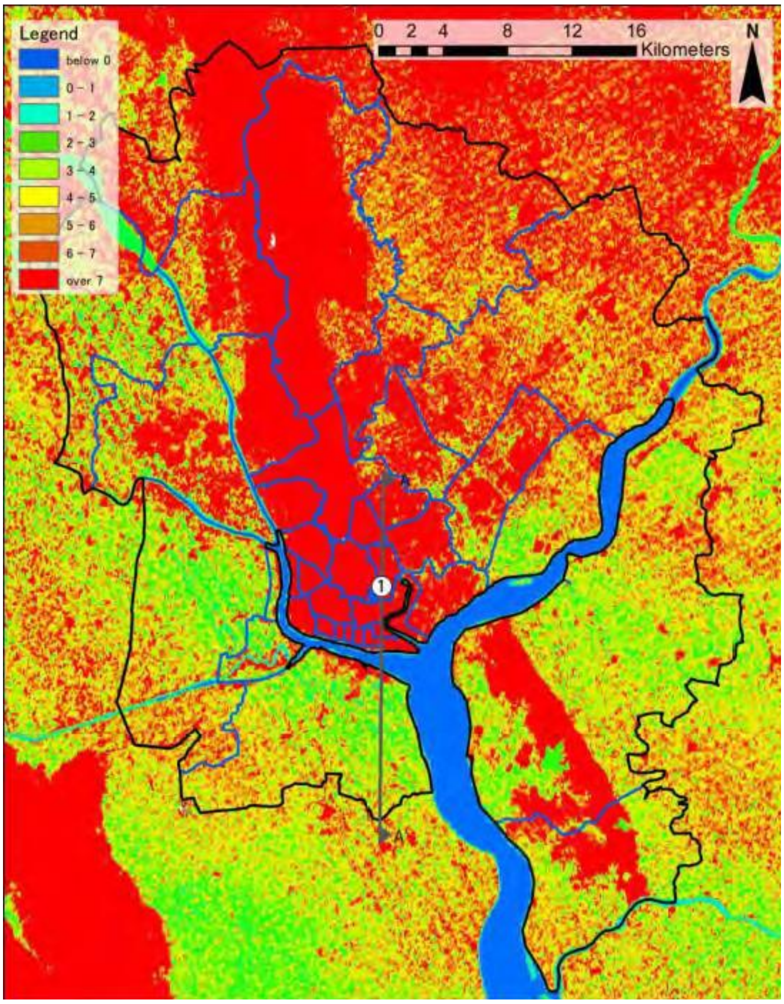
Source: JICA Expert Team based on dataset prepared by MIMU

Figure 2-2 Map of Downstream of Hlaing River and its Tributaries

2.2 Natural Conditions

2.2.1 Topography

The Dala area, which extends to the southern bank of the Yangon River, is generally lower in elevation than the northern bank where the main part of Yangon City is located. Figure 2-3 shows the general topography of the area in terms of elevation. In this figure, the boundary area marked in brown and red indicates that the area is above EL.5 m, while the area shown in yellow, green, and blue is less than EL.5 m. Most of the Dala area has an elevation between EL. 2 m and 6 m, while most of the urban area which is north of the river has an elevation of more than EL. 5 m. It is noteworthy that the EHWL (at the time of Cyclone Nargis) was at EL. 4 m, and there was extensive flooding in the Dala area. Also, the normal high water level of the Yangon River is approximately EL. 3 m.



Source: Final Report of the Project for the Strategic Urban Development Plan of the Greater Yangon (JICA, 2014)

Figure 2-3 Topography of Yangon

2.2.2 Meteorology

Table 2-1 and Table 2-2 show monthly mean temperature and monthly rainfall in Yangon from 2005 to 2014. As for temperature, the hottest month in a year is April (30.5 ºC) and the coldest month is January (24.7 ºC), but the mean monthly temperature does not change drastically through the year. The rainfall pattern is divided into two distinctive seasons namely, rainy season (May to October) and dry season (November to April).

Table 2-1 Monthly Mean Temperature in Yangon (Average), Years 2005-2014

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Temperature (ºC)	24.7	26.8	28.8	30.5	28.7	27.2	26.5	26.5	26.8	27.9	27.4	25.2

Source: 2015 Myanmar Statistical Yearbook, Central Statistical Organization, Ministry of National Planning and Economic Development

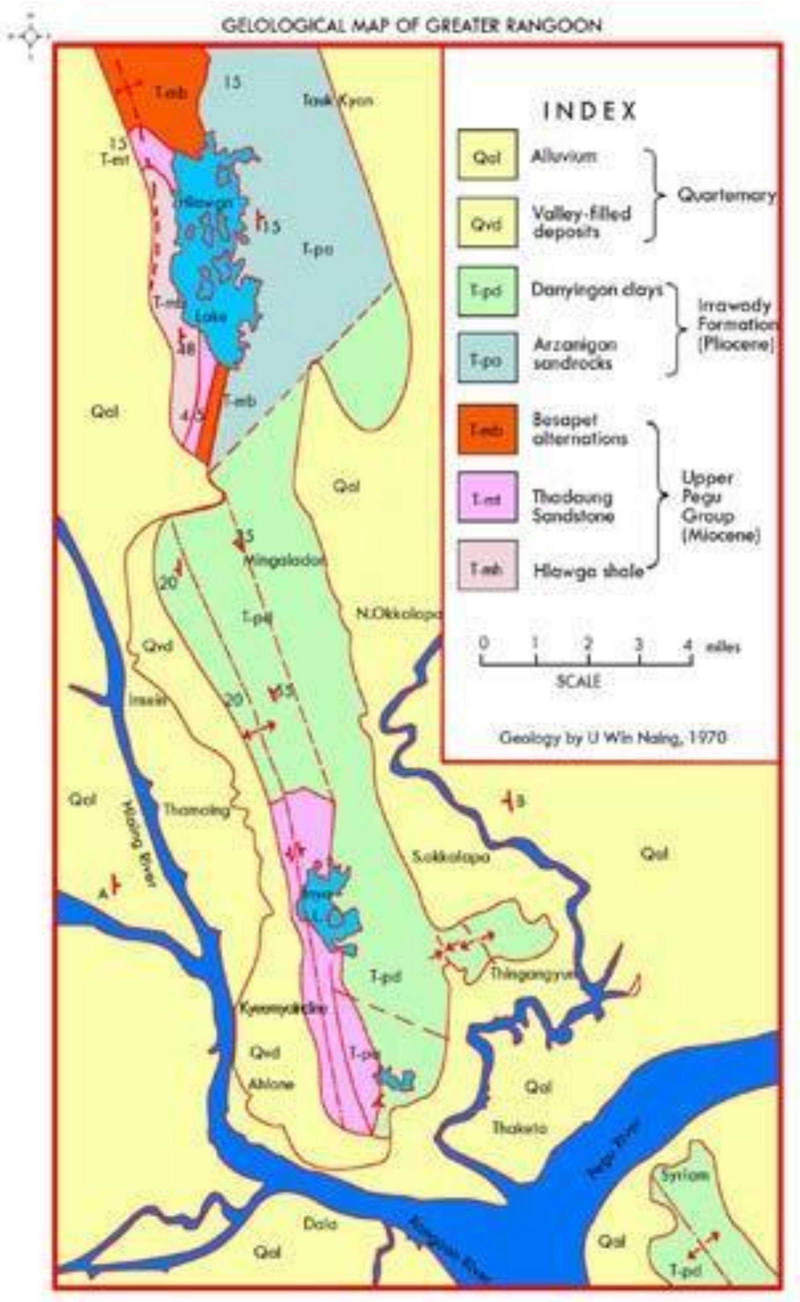
Table 2-2 Monthly Rainfall in Yangon (Average), Years 2005-2014

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rainfall (millimeters)	6	1	20	39	375	520	671	554	480	215	50	16

Source: 2015 Myanmar Statistical Yearbook, Central Statistical Organization, Ministry of National Planning and Economic Development

2.2.3 Geology

The regional geomorphic features of the entire area include ridges and deltaic lands lying south of the Pegu Yoma between the Sittaung River in the east and the Irrawaddy River in the west. This area is in a north-south trending sedimentary basin containing thick sedimentary deposits from the Tertiary to Quaternary periods. The Tertiary deposits are strongly folded into narrow en echelon anticlinal folds such as the Yangon Ridge, the Thanlyin-Kyauktan Ridge, and the Twentay-Kawhmu Ridge. All these ridges are trending south towards the Gulf of Martaban. Rocks of the Tertiary Period contain well consolidated marine sandstone and shale of the Pegu Group and semi-consolidated, continental deltaic, and marginal marine deposits of the Irrawaddy Formation. The synclinal valley or through west of the Yangon Anticlinal Ridge is filled with unconsolidated deposits from the Quaternary Period. There forms a wedge-shaped alluvial accumulation, ranging in thickness from a few feet near the ridge up to 100 m in the synclinal valley. The wedge-shaped form of these sediments extends both in the east-west and north-south directions and shows thickening toward the south and west. These sediments include clay, silt, sand, and very coarse-grained gravel.

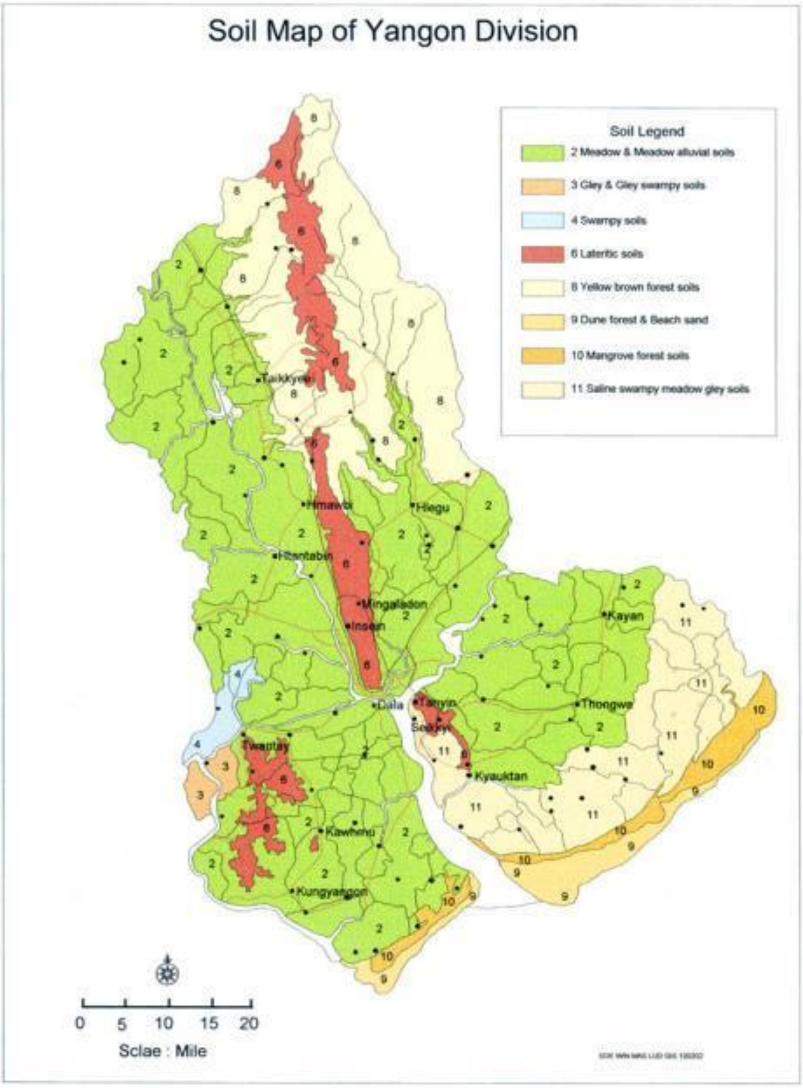


Source: Myanmar Earthquakes History (3rd Edition, August, 2017)

Figure 2-4 Geology of Yangon

2.2.4 Soil Condition

The main types of soil are *Ferrosols, Gleysols, Solovechaks,* and *Arenesols*. Ferrosols (plinthic) or lateritic soils are found on low hills along Thanlyin-Kyauktan. The soil is good for growing rubber and vegetables as well as for gardening. Gleysols (dystric) or meadow gley soils occupy much of the area in the Hlaing River Basin as shown in Figure 2-5. About 90% of these soils are composed of silt and clay, but humus content varies from place to place. These soils are favorable for paddy cultivation. The main problem, however, is the poor drainage and water logged conditions. Meadow *Solonchak* are usually found in lowlands under impeded drainage. In the rainy season, they are covered with flood water. Because of the high content of clay, these soils become very dry and crack in the dry season. Solonchaks (gleyic) or saline swampy gluey soils are found along the coastal area. These soils develop from sediments transported and deposited in the estuaries of the Yangon River.



Source: Data from the Land Use Division, Myanmar

Figure 2-5 Soil Map of Yangon

2.3 SOCIAL CONDITIONS

2.3.1 Administrative Boundary

Figure 2-6 shows township boundaries in Yangon Region. In the pilot side of Hlaing River Basin, there are six townships in the North Yangon District and West Yangon District as follows;

- Insein Township
- Shwe Pyi Thar Township
- Hlaing Tharyar Township
- Mayangon Township
- Hlaing Township

2.3.2 Population

Table 2-3 shows population of five townships located in the pilot site. In total 1.7 million persons live in these townships, and 84.1% of them live in the urban areas of five townships.

Table 2-3 Population of Townships in the Pilot Area

Township	Total	Male	Female	Ratio	Urban	Rural	Urban Population
Insein	305,283	146,158	159,125	91.9%	305,283	-	100%
Shwe Pyi Thar	343,526	164,264	179,262	91.6%	279,795	63,731	81.4%
Hlaing Tharyar	687,867	322,862	365,005	88.5%	482,128	205,739	70.1%
Mayangon	198,113	93,392	104,721	89.2%	198,113	-	100%
Hlaing	160,307	75,029	85,278	88.0%	160,307	-	100%
Total	1,695,096	801,705	893,391	89.7%	1,425,626	269,470	84.1%

Source: The 2014 Myanmar Population and Housing Census, Union Report, Census Report Volume 2.

Source: MIMU

Figure 2-6 Township Boundaries in Yangon Region

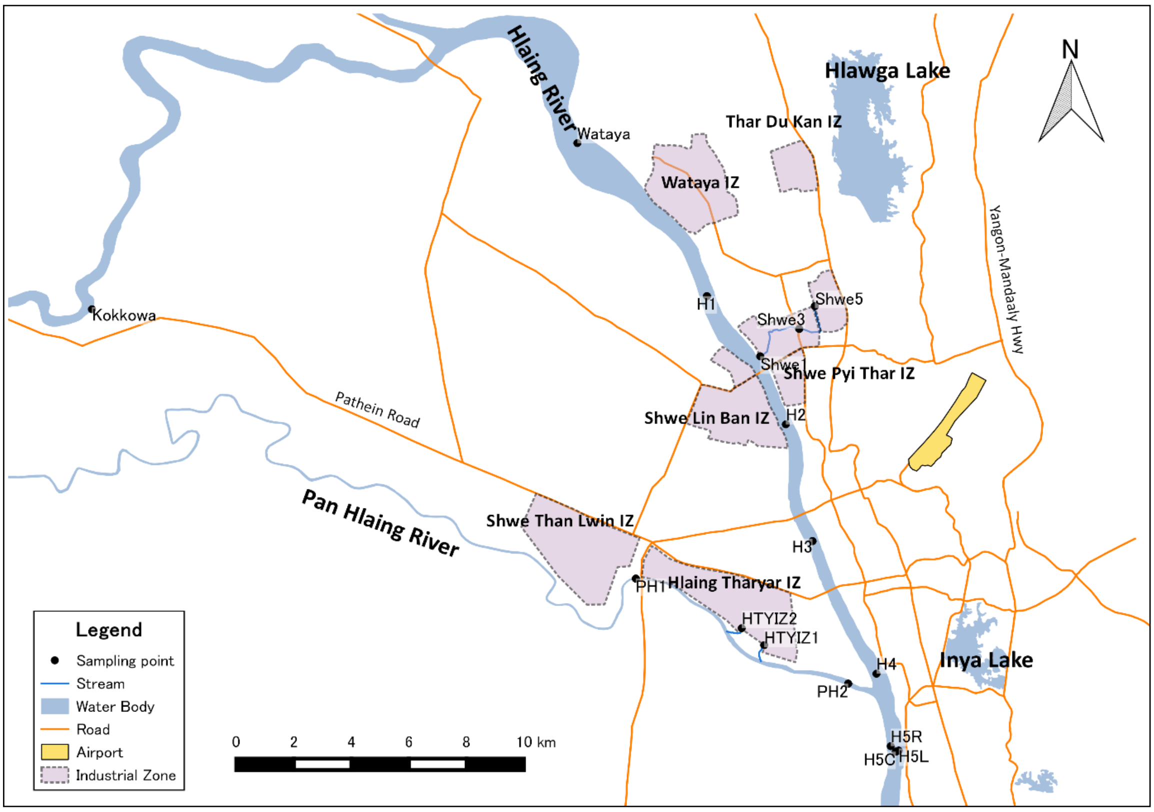
2.3.3 Industrial Zones

Table 2-4 shows industrial zones in the pilot area of Yangon. In total, around 1,100 factories are located in seven industrial zones which opened in during 1995-2014. The major sectors are food and beverage, clothing, accommodation, and general industries. Figure 2-7 shows location of the industrial zones in the pilot area of Yangon.

Table 2-4 Industrial Zones in the Pilot Area of Yangon

Industrial Zone	Township	Established Year	Area [ha]	Number of Factories (2012)	Main Sectors
Hlaing Thar Yar (1,2,3,4,6,7)	Hlaing Tharyar	1995	567.1	519	1. Food and Beverage 2. General 3. Accommodation
Hlaing Thar Yar (5)	Hlaing Tharyar	1996	90.2	164	1. Accommodation 2. Food and Beverage 3. Industrial Equipment/ Machinery
Shwe Than Lwin	Hlaing Tharyar	2001	176.5	10	1. General 2. Food and Beverage 3. Clothing
Shwelinban	Hlaing Tharyar	2002	445.2	203	1. Domestic Material 2. Food and Beverage 3. Accommodation
Shwe Pyi Thar (1)	Shwe Pyi Thar	1990	136	132	1. Food and Beverage 2. Accommodation 3. Clothing
Shwe Pyi Thar (2,3,4)	Insein	1998	399.6	108	1. Food and Beverage 2. Accommodation 3. Clothing
Wataya	Shwe Pyi Thar	2004	445	3	1. Accommodation 2. Food and Beverage
Total				1139	

Source: Myanmar Industrial Association

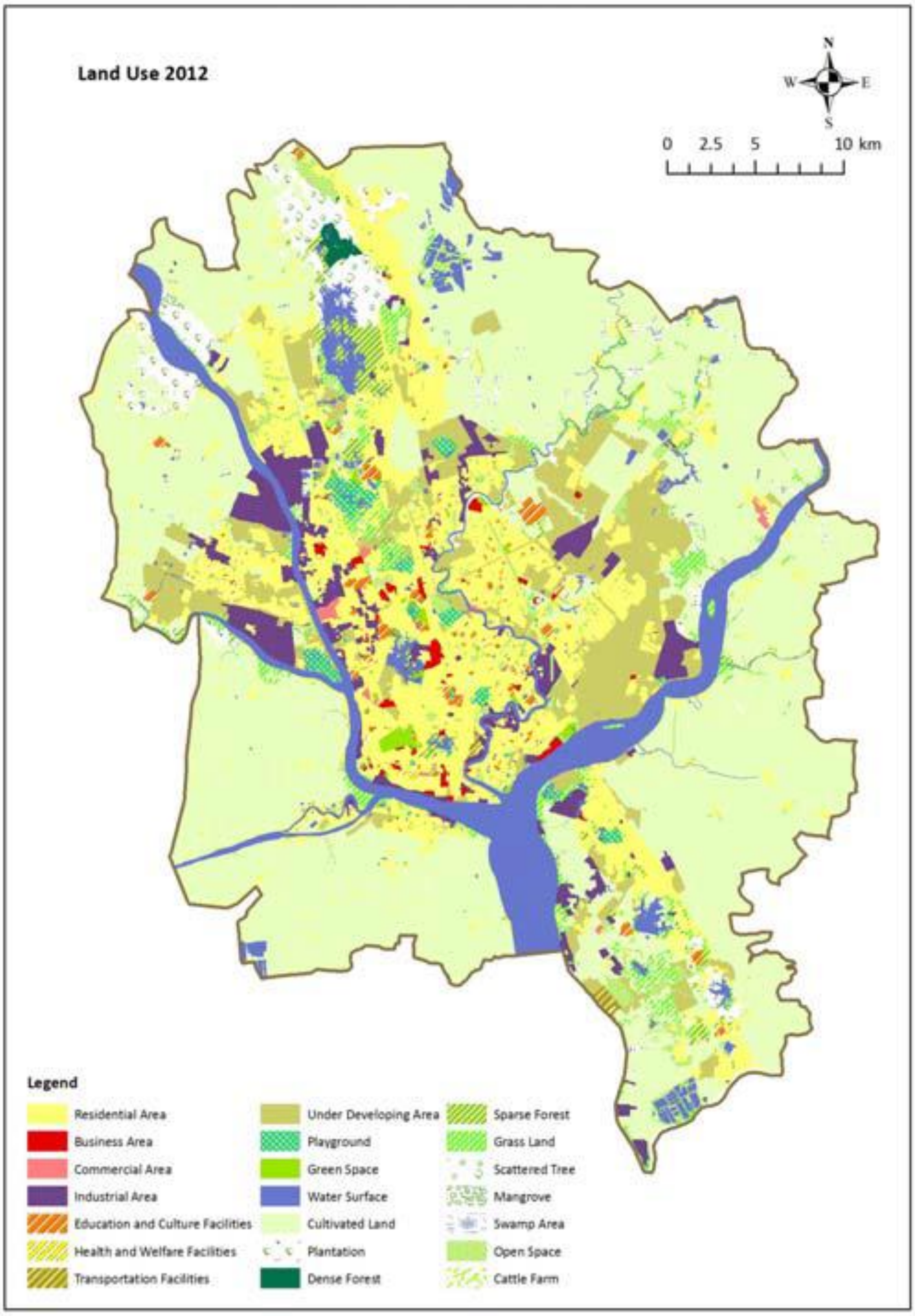


Source: JET

Figure 2-7 Location of Industrial Zones in Pilot Area of Yangon

2.3.4 Land Use

Figure 2-8 shows land use map in Yangon area and in 2012, agricultural area occupied 51% of the total area, followed by 22% of urbanized areas. In the pilot area of Yangon, most land are used as residential area, industrial area and some areas in northern part of the pilot area are used as cultivated area.



Source: Final Report of the Project for the Strategic Urban Development Plan of the Greater Yangon (JICA, 2014)

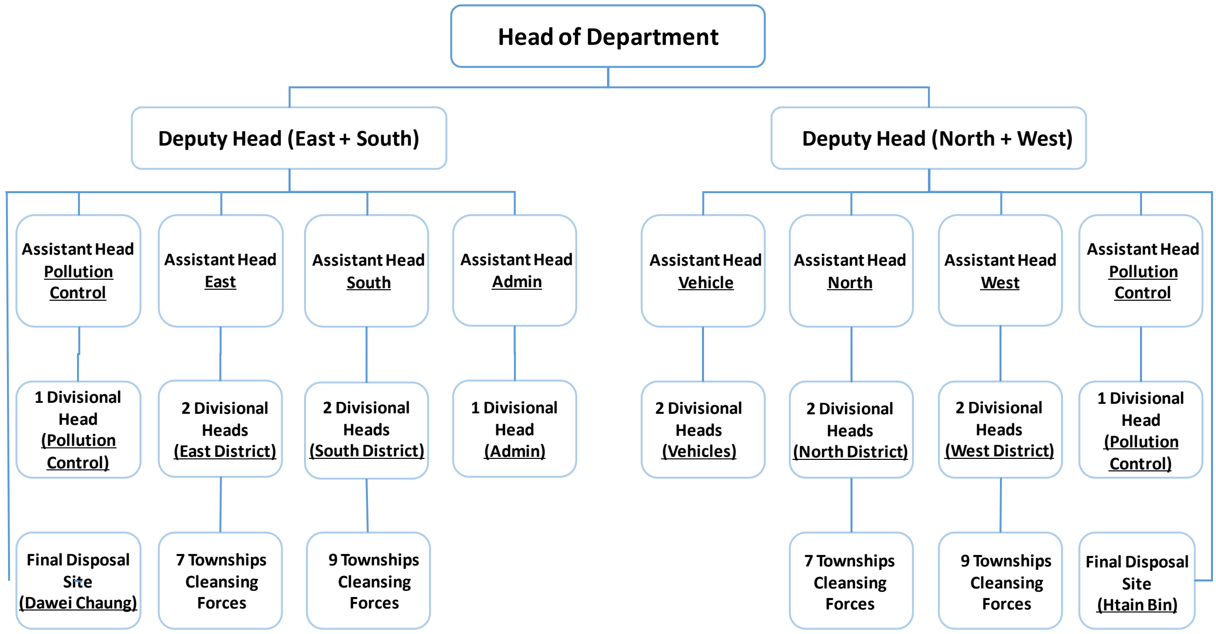
Figure 2-8 Land Use Map in Yangon

2.4 ORGANIZATIONS RELATED TO WATER ENVIRONMENT MANAGEMENT

2.4.1 Yangon City Development Committee

(1) Pollution Control and Cleansing Department (PCCD)

The Pollution Control and Cleansing Department (YCDC-PCCD) is in charge of solid waste management and pollution control in Yangon City. YCDC-PCCD has 39 officers, 1,040 staff, and 3,800 laborers and divided into two areas: (i) east and south and (ii) west and north as shown in Figure 2-9. Activities of YCDC-PCCD include solid waste management such as collection, transportation, final disposal, environmental management, pollution control (air, wastewater and land), and cemeteries management. Most of the activities of YCDC-PCCD are closely related to water environment management.

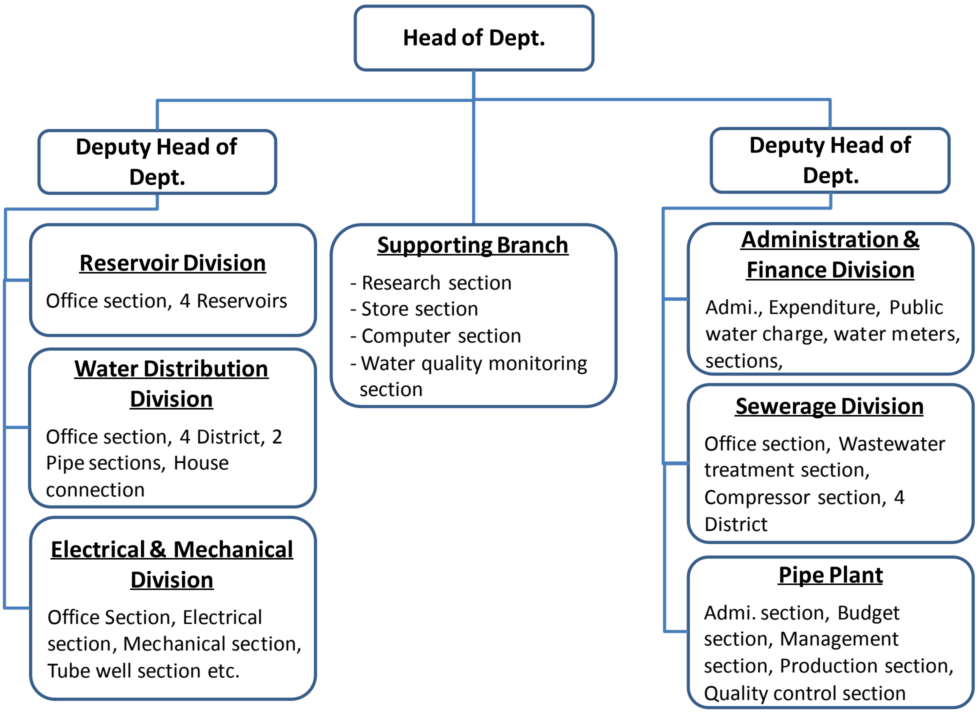


Source: YCDC-PCCD (as of 2016)

Figure 2-9 Organization Chart of YCDC-PCCD

(2) Engineering Department (Water and Sanitation)

The Engineering Department (Water and Sanitation), called "YCDC-DEWS" or simply as WSD in this report, is the department for water supply and distribution, wastewater treatment, and production of pipes. YCDC-DEWS has 6 divisions: (1) Reservoir Division, (2) Water Distribution Division, (3) Electrical & Mechanical Division, (4) Finance & Administration Division, (5) Sewerage Division, (6) Pipe Plant Division and one support branch including research section, store section, computer section, and water quality monitoring section as shown in Figure 2.5. As of January 2016, 195 officers, staff, and workers belong to YCDC-DE (Water and Sanitation) as shown in Figure 2-10. Main activities of YCDC-DE (Water and Saniation) related to water environment management are: (i) wastewater treatment, (ii) water quality monitoring for supplied water and wastewater, and (iii) reservoir management.

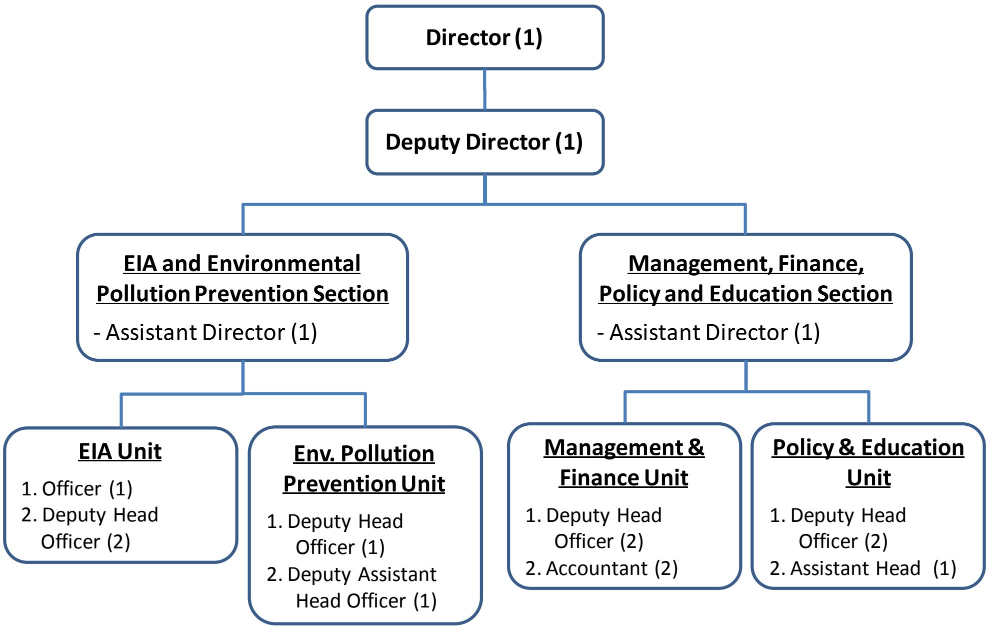


Source: YCDC-DEWS (JET modified based on "The Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City", JICA, 2014)

Figure 2-10 Organization Chart of YCDC-ED (Water and Sanitation)

(3) MONREC-ECD Yangon

ECD Yangon has 14 officers in total: 1 Director, 2 Deputy Directors, 2 Assistant Directors, and 4 Staff Officers, and 5 Assistant Staff Officers. ECD Yangon has four sections: policy section, EIA section, pollution control section, and finance section as shown in Figure 2-11. Main activities of ECD Yangon related to water environment management include conducting/ joining inspections on environmental awareness to school children. As for inspection activities, there are four types: (i) conducting inspection by ECD Yangon, (ii) joining inspection by Directorate of Industrial Supervision and Inspection (DISI) of Ministry of Industry (MOI), (iii) joining inspection by Yangon Environmental Conservation and Management Committee, and (iv) joining inspection by Directorate of Water Resources and Improvement of River Systems (DWIR) of Ministry of Transportation and Communication (MOTC). In April 2018, ECD Yangon Region opened the branch offices at district level named "ECD Yangon North District" and "ECD Yangon South District". Each ECD district office has Assistant Director with 4 staff and will be in charge of implementation of inspection and environmental awareness.

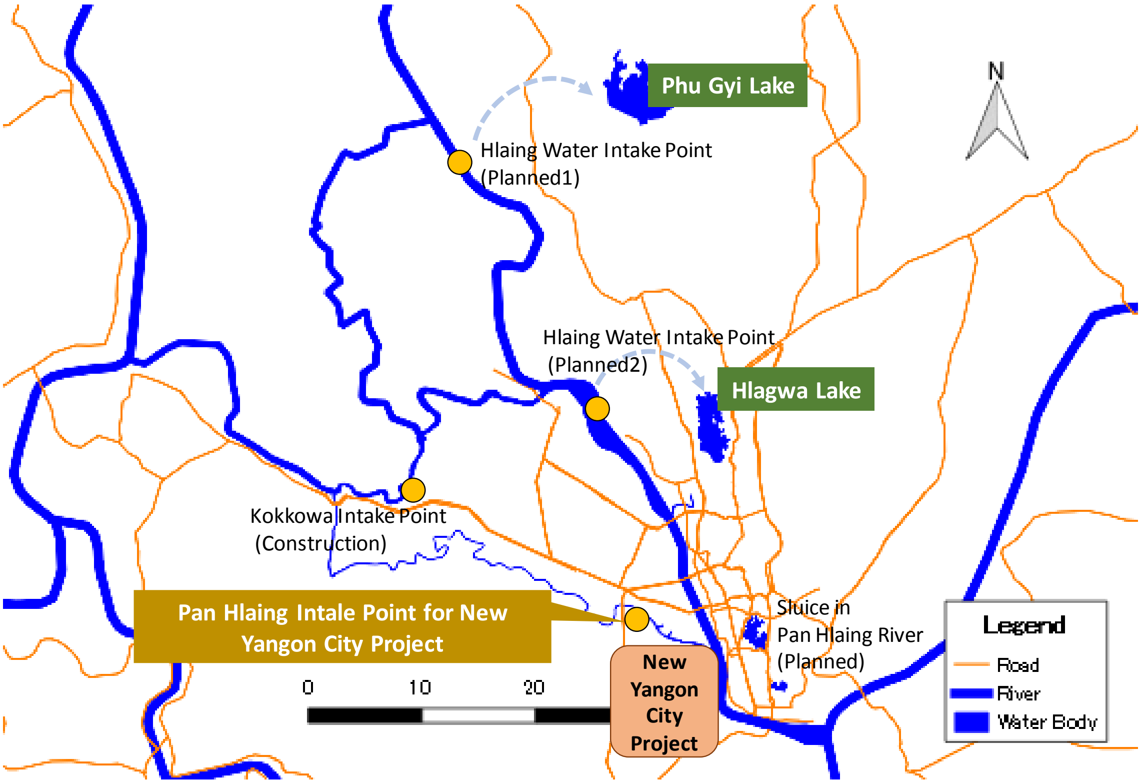


Source: ECD Yangon Region (as of 2016)

Figure 2-11 Organization Chart of ECD Yangon Region

2.5 WATER USE

At present, Hlaing River and its tributaries are used for navigation and fisheries. A water treatment plant is planned for construction by YCDC on the bank of Kokkowa River, a tributary of Hlaing River. In addition to the planned water supply from Kokkowa River as water source of Yangon City, WSD/YCDC is also seeking the possibility to supply water from Hlaing River to Hlawga Lake and Phu Gyi Lake to prevent a drawdown of water level in these lakes during the dry season. Moreover, there is a new city development plan led by Yangon Region Government named "New Yangon City Project". This project involves township and industrial zone development including construction of electricity power plant, water supply system, wastewater treatment facilities and a sluice gate with a function of preventing the inflow of salt water to secure fresh water instead as shown in Figure 2-12.



Source 1: JET based on dataset prepared by MIMU

Source 2: New Yangon City Development Development Company Ltd.

Figure 2-12 Water Supply Plans along Hlaing River and Kokkowa River and New Yangon City Project along Pan Hlaing River

2.6 Water Quality

2.6.1 Outline of water quality survey for the Hlaing River Basin

The water quality surveys were conducted in total five times targeting one time in the rainy season and another time in the dry season for each year. Table 2-5 summarizes water quality survey plan for the Hlaing River Basin. The map of sampling points of the surveys is shown in Table 2-5.

Table 2-5 Summary of Water Quality Survey Plan for the Hlaing River Basin

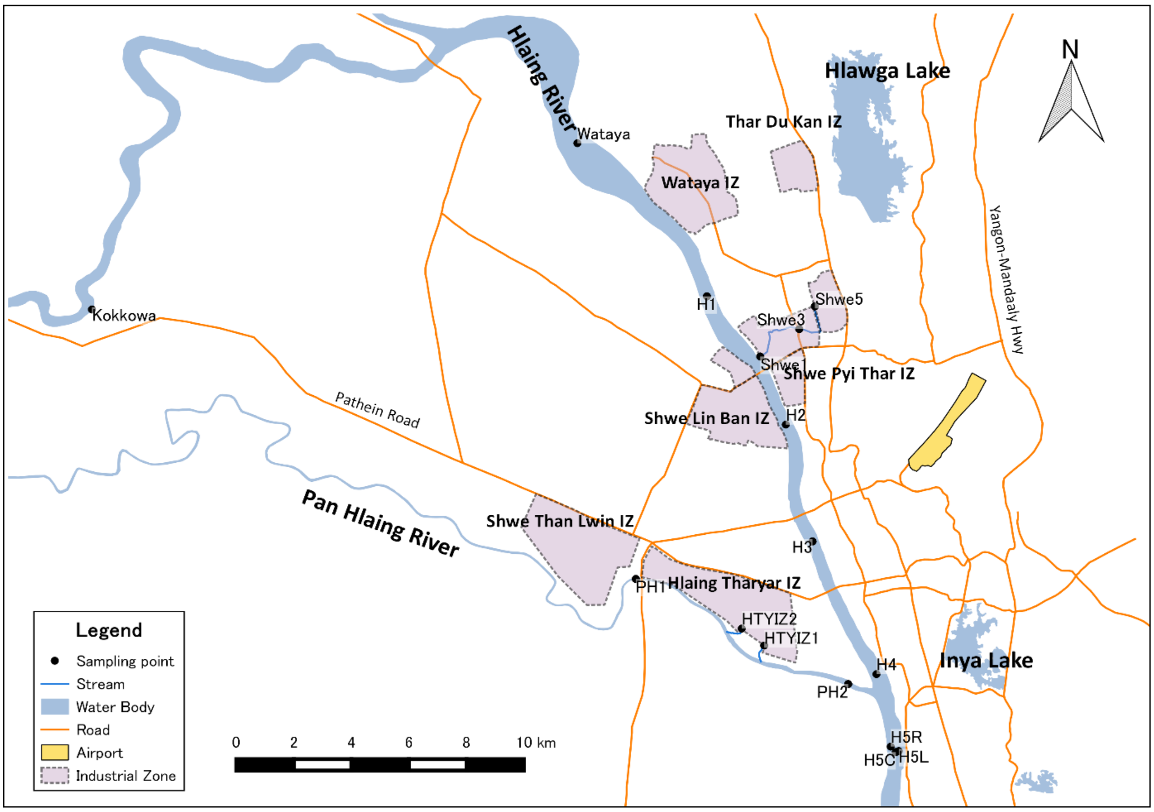
Item	Contents
Sampling Point	Hlaing River: 3 – 5 points, varied upon the survey time Channels in Shwe Pyi Thar IZ: 3 points Channels in Hlaing Tharyar IZ: 0 – 2 points, varied upon the survey time Pan Hlaing River: 2 points Kokkowa River: 0 – 1 point, varied upon the survey time
Sampling Time	[Season] - 1st survey: dry season in 2016 - 2nd survey: rainy season in 2016

Item	Contents
	- 3rd survey: dry season in 2017 - 4th survey: rainy season in 2017 - 5th survey: dry season in 2018 [Time] - At the time of ebb tide near spring-tide day as much as possible
Measurement Parameters	[All points] - pH, EC, DO, TDS, salinity, turbidity, water temperature, ORP [Basic points] - Flow rate (if available), TSS, BOD, COD, oil and grease, total coliform [Representative points] - Total phosphorus, total nitrogen, cyanide, phenols, zinc, total chromium, hexavalent chromium, arsenic, total mercury, cadmium, and lead - Color, odor, iron and manganese in the 1st survey - Copper, phosphate, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen in the 1st – 3rd surveys [Only one or two points] - Pesticides* and PCB

* Total organic chlorine pesticides and total organic phosphorus pesticides for second and third surveys

* Aldrin, atrazine, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endosulfan, endosulfan sulfate, endrin, HCH-alpha (benzene hexachloride-alpha), HCH-beta, HCH-delta, HCH-gamma(Lindane), alachlor, diazinon, chlorpyrifos, dimethoate and imidacloprid for fourth and fifth surveys

Source: JET



Source: JET

Figure 2-13 Sampling Points of Water Quality Surveys in Hlaing River Basin

2.6.2 Refence Standards

Since there is no ambient water environmental quality standard in Myanmar yet, C/Ps and JET evaluated the water qualities based on reference standards and related guidelines in Myanmar, Vietnam and Japan, considering the type and usage of water. They included (i) Vietnamese national technical regulations on surface water quality (QCVN 08, 2015), (ii) Japanese environmental quality standard for water pollution in lakes (Environment Agency Notification No. 59, last amended in 2016), (iii) draft national drinking water quality guideline (MOH, 2014) and (iv) National Environmental Quality (Emission) Guideline (MONREC, 2015) for wastewater. The water quality in each target river basin is summarized below based on the past survey results.

2.6.3 Water quality survey results

The overall view on water quality in Hlaing River basin is described below. All measurement results are shown in the "Water Quality Survey Report (Appendix 10)"

(1) *Pollution levels in Hlaing River and Pan Hlaing River*

- Except TSS (Total Suspended Solid) and total coliform, the water quality in Hlaing River and Pan Hlaing River in the rainy season (September 2017) was acceptable for conservation of aquatic lives, irrigation and water transportation based on the Vietnamese surface water quality guideline values. During the dry season (February 2018), the water quality deteriorated showing the high COD detected at some points and slight oil and grease detected at all points. Only the upstream area of Hlaing River (upstream of Shwe Pyi Thar Bridge) maintained the good water quality desirable for irrigation and water transportation except above-mentioned TSS, total coliform and oil and grease. In the middle-stream of Pan Hlaing River (upstream of Hlaing Bridge), the river water was extremely muddy in February 2018 resulting in very low dissolved oxygen (DO) and high BOD and COD, presumably due to the effect of sediment in the water stirred by a surging tide flow or other reasons. See Table 2-6 for the result list of BOD and COD.
- Moreover, the results in these rivers did not exhibit levels of toxic pollutants harmful for human health. Only slight lead (0.058 mg/L) was detected in downstream area of Pan Hlaing River in February 2018, but it was considered as the one originally contained in the natural sediment.

Table 2-6 Classification of BOD and COD Levels in the Hlaing River Basin

Unit: mg/L

Target		BOD						COD					
		Rainy Season(Sep 2017)			Dry Season(Feb 2018)			Rainy Season(Sep 2017)			Dry Season(Feb 2018)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
River	Hlaing River	1.2	2.3	1.6	2.4	3.7	3.0	10	14	12	20	71	44
	Pan Hlaing River	0.7	1.6	1.1	3.8	44.6	24.2	12	14	13	63	3400	1732
	Kokkowa River	3.7			5.7			8.3			5.2		
Creek	Creek in Shwe Pyi Tar IZ	5.4	32	14	134	268	222	19	44	28	230	5700	3610

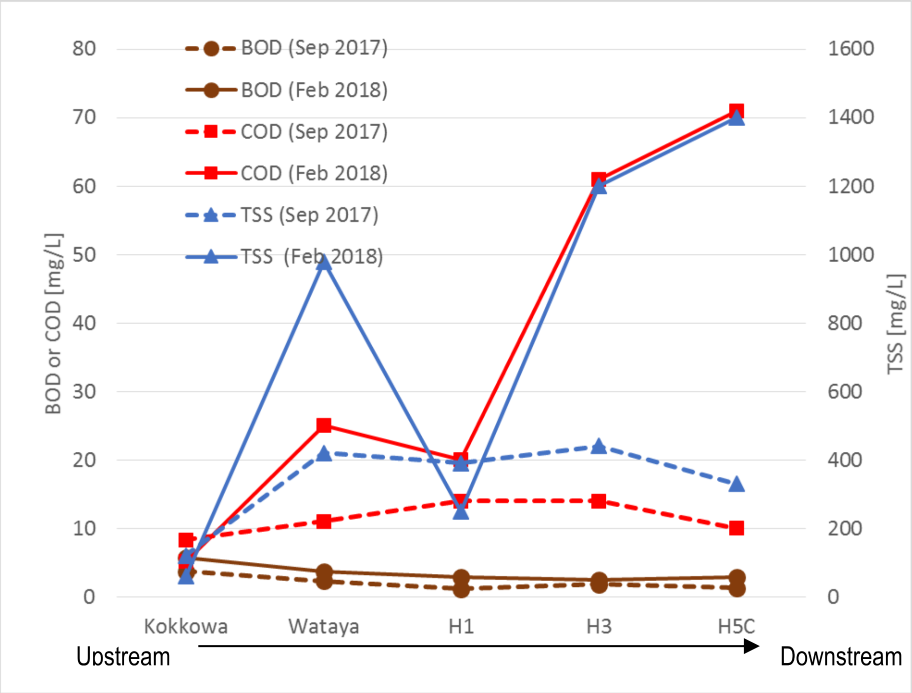
Vietnamese Environmental Standard(QCVN08:2015) for reference

Water Usage		BOD	COD
A1	For domestic water supply	4	10
A2	For domestic water supply with treatment and conservation of aquatic lives	6	15
B1	For irrigation	15	30
B2	For water transportation and other purposes with demand for low-quality water	25	50
Less than B2		>25	>50

Source: JET

(2) *Spatial distribution of pollution in Hlaing River: difference in water quality from upstream to downstream*

- The results in the Hlaing River did not show clear deterioration of the surface water quality in the flow direction during the rainy season (see Figure 2-14).
- During the dry season, the COD level increased from the up-stream to downstream (Figure 2-15). while there was no significant difference in BOD level among the locations. It implies that the high COD in the dry season in the downstream area was largely due to organic matter associated with suspended solid in the water and not soluble organic substance.
- More monitoring data is required to identify spatial and temporal changes of surface water quality in the Hlaing River.

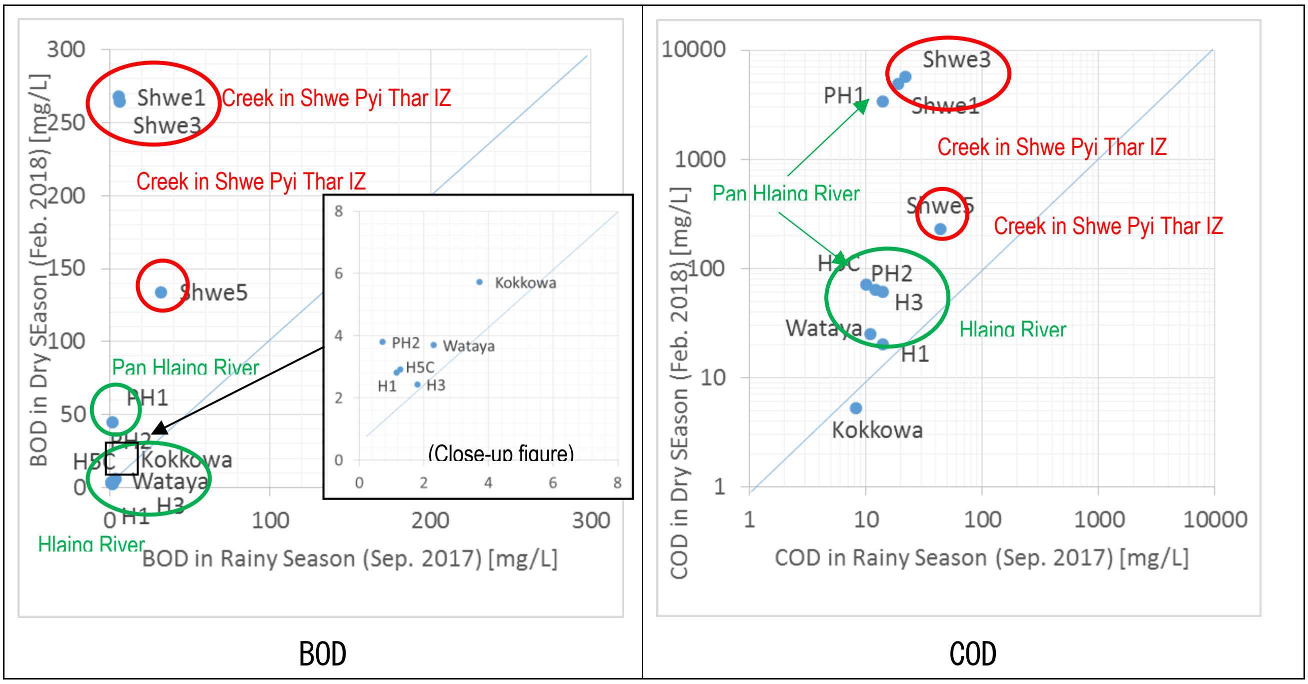


Source: JET

Figure 2-14 Water Quality Distribution in the Hlaing River

(3) *Seasonal changes of water quality*

- The concentration of pollutants in the dry season was higher than one in the rainy season for most sampling points and for most parameters as represented by BOD and COD (see Figure 2-15). It indicated that in the rainy season the storm water diluted such pollutants and alleviated the pollution impact in the river. The result revealed that the pollution impact of industrial wastewater and domestic wastewater from the basin gets larger during the dry season basically due to the less water capacity in the river, making it difficult to fully maintain the desired water quality in the Hlaing River during the dry season.



Source: JET

Figure 2-15 Water Quality Changes between Rainy Season and Dry Season (Hlaing River Basin)

(4) *Pollution impact from IZs*

- In order to evaluate the pollution impact from IZ to the water body, the water quality of the Ta Gu Chan creek flowing through Shwe Pyi Thar Industrial Zone(IZ) to Hlaing River was monitored. In the creek, the water quality in the past surveys until February 2017 was significantly worse due to the inflow of wastewater, which was indicated by low DO as well as high concentrations of COD, BOD, oil and grease, nutrients, phenol and others.

- The water quality of this creek improved in September 2017 probably because the operation of distilleries along the creek was suspended. This order was given by the Yangon Region Government to six distilleries in the IZ in August 2017. However, after the new pipeline from distilleries was constructed in the creek, the water quality deteriorated again (see Figure 2-16).

- The water quality in the creek hinges on the impact of wastewater from these factories. It is important to continue to monitor the wastewater from these pollution sources which could improve or deteriorate depending on the factories' operation status and performance of wastewater treatment in each factory.

- Overall, Hlaing River has a significant capacity to dilute water from the creek and the pollution impact to Hlaing River does not appear to be so high, though the impact of localized pollution such as pollution of creek passing through IZs would be a concern.

 Pollution plume from a pipeline discharging the wastewater in the creek in Shwe Pyi Tar IZ(downstream of Shwe-3)	 Brown-colored water flow in the creek to Hlaing River (downstream of Shwe-1)

Source: JET

Figure 2-16 Pollution Plume in the Creek of Shwe Pyi Tar IZ

(5) *Water quality for domestic water supply at Kokkowa River and Wataya*

- The sampling points of Kokkowa and Wataya were investigated as possible future intake point(s) of domestic water supply to Yangon City. The water treatment plant is planned for construction on the bank of the Kokkowa river, upstream of Hlaing River. WSD-YCDC is also seeking the possibility to withdraw water from Hlaing River to Hlawga Lake to prevent a drawdown of Hlawga lake in the dry season. Judging from the results, the water qualities at Kokkowa and Wataya in rainy season was suitable enough for domestic water supply use if the water is treated at a water treatment facility using filters and other ordinary means. It satisfied the draft national drinking water guideline values (MOH, 2014) with respect to the measured parameters except turbidity at both sampling points in September 2017 and February 2018 as well as total chromium and lead at Wataya point in February 2018 (see Table 2-7). It was hypothesized that chromium and lead, whose concentrations were not very high, were contained in the suspended sediment and are of natural origin. Whether they can be removed during water treatment or not should be confirmed.
- The pesticides were not detected in both surveys in September 2017 and February 2018, but needs to be further investigated in other seasons including the farming season.
- There are some potential pollution sources along Hlaing River in the surrounding of Wataya. The water samples in these surveys were taken during the spring tide time and when the water was flowing downward after high-tide. However, the pollution level might change in a farming season, or when the water flows upward after low-tide.
- It should be noted that these surveys were conducted as part of the environmental monitoring under the Project activities, and the results do not guarantee the safety of waters for drinking and other purposes. The measurement parameter in these surveys were limited and did not cover all the guideline values. Thus, it is crucial to continue to check the water quality throughout the year for a wider range of parameters and with continuous monitoring in one tide cycle per day and between spring tide and neap tide.

Table 2-7 Comparison with Draft Drinking Water Quality Standard for Possible Domestic Water Supply (Hlaing River Basin)

Parameter	Unit	Kokkowa		Wataya		MOH Draft National Drinking Water Quality Std(2014)
		Sep 2017	Feb 2018	Sep 2017	Feb 2018	
pH	-	7.89	8.35	7.61	8.21	6.5 - 8.5
Turbidity	NTU	545	169	618	>1000	5
TDS	mg/L	66	140	81	156	1000
Cyanide(total)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	0.07
Zinc (Zn)	mg/L	0.029	0.014	0.054	0.13	3
Total chromium (T-Cr)	mg/L	0.019	0.010	0.048	0.11	0.05
Arsenic (As)	mg/L	0.0016	0.0015	0.0026	0.011	0.05
Copper (Cu)	mg/L	0.010	0.0054	0.017	0.045	2
Total Mercury (Hg)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.001
Cadmium (Cd)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.003
Lead (Pb)	mg/L	< 0.005	< 0.005	0.0097	0.024	0.01
Pesticides (total 17 paramete	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	Specified for some parameters respectively

(Blue) : Satisfied with reference standard
(Yellow) : Not satisfied with reference standard

Source: JET

2.7 Pollution Source

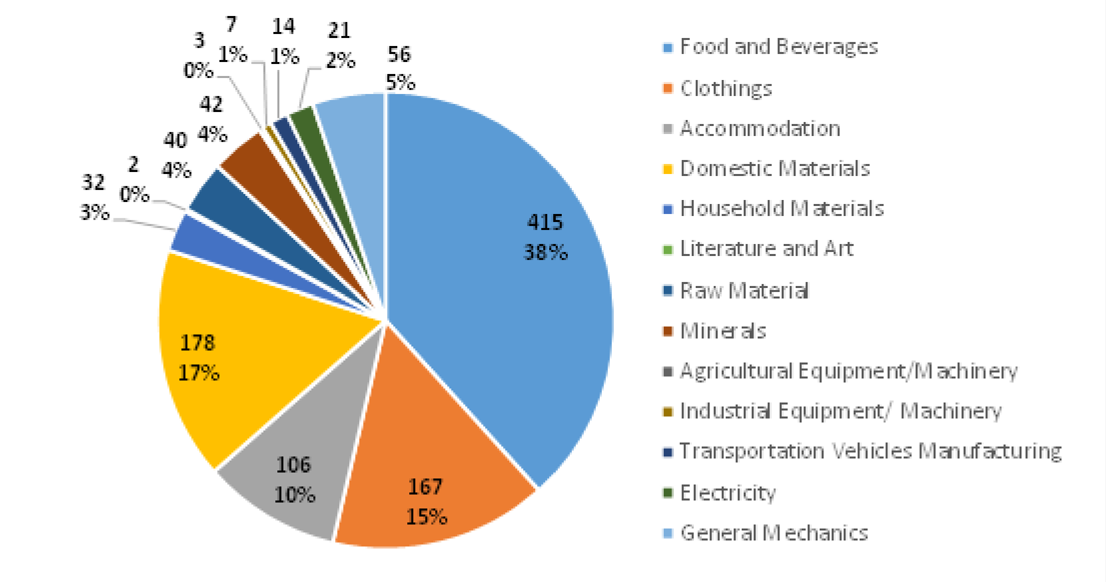
2.7.1 Industrial pollution source

(1) *Factories in Industrial Zones*

In Yangon, there are as many as 3,500 factories under the jurisdiction of YCDC and based on the January 2015 data from DISI, there are 1,083 factories in the six target IZs (see Figure 3-17). Food and beverage is the most common sector with a share of 38%, followed by clothing with 15%. With respect to employment, there are in total 90,211 employees working in the 1,083 factories in the IZs and the clothing sector employs as much as 63% of them.

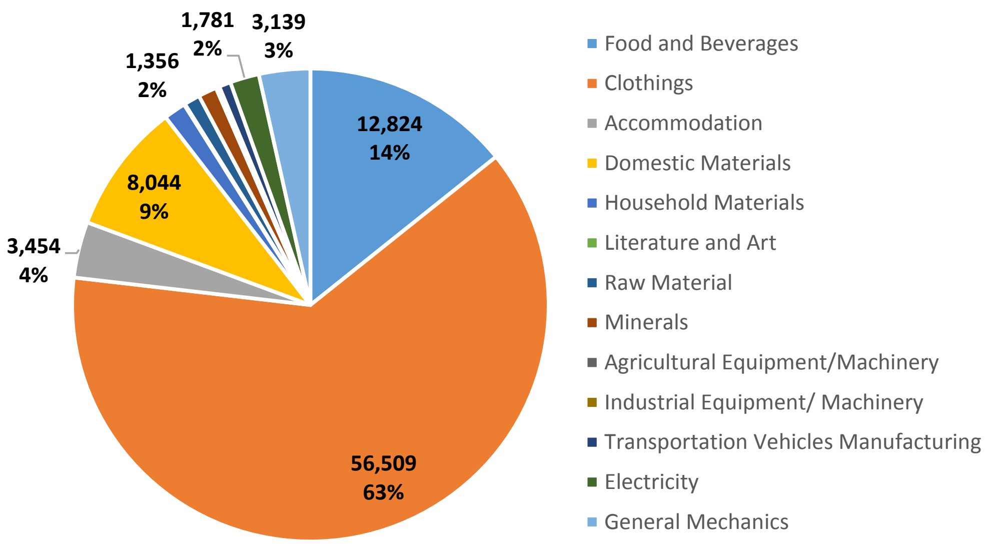
In Mandalay, there are 1,228 DISI-registered factories in Pyi Gyi Tagon IZ as shown in Figure 3-16 where 48% is from general mechanics sector such as small machine shops, 18% is from mineral sector such as metal processing, and 15% is food and beverage sector including distilleries.

The labor figure in Pyi Gyi Tagon IZ is shown in Figure 3-17 where 24%, the largest number of employees, comes from the food and beverage sector, 16% is from general mechanics sector, and 13% is from accommodation sector. While the number of factories in Pyi Gyi Tagon IZ (1,228 factories) is comparable to those of IZs in the Hlaing River basin in Yangon (1,083), only 16,150 people are employed by factories in Pyi Gyi Tagon IZ compared to 90,211 in Hlaing River basin. Factories in Pyi Gyi Tagon IZ are much smaller in scale than those in IZs in Hlaing River basin.



Source: JET based on DISI's data

Figure 2-17 Number of Factories in Industrial Zones in Hlaing River Basin

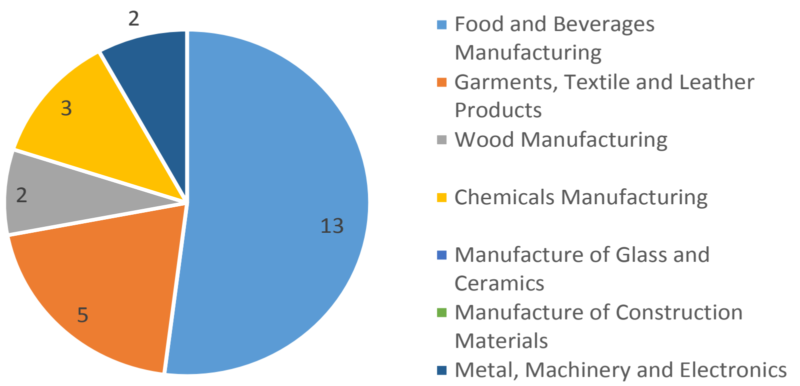


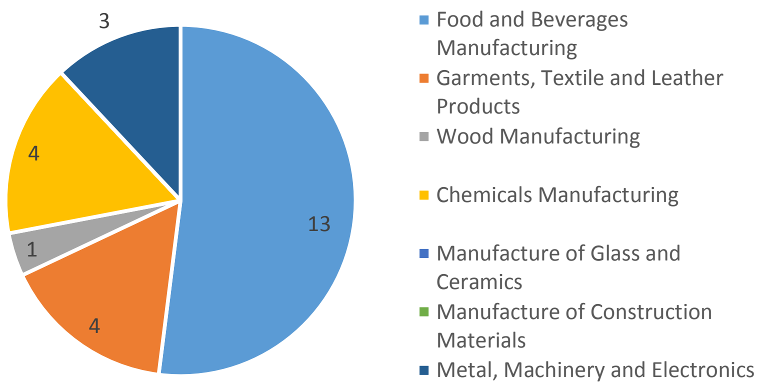
Source: JET based on DISI's data

Figure 2-18 Number of Employees in Industrial Zones in Hlaing River Basin

(2) *Industrial Effluent Status*

In the summer of 2016 (hereafter Period 1), 25 factories that were major dischargers and/or representative of the industrial sectors in the Hlaing River Basin were selected, and wastewater samples were collected and analyzed[1]. Figure 2-19 shows target sectors for wastewater sampling in the Period 1 and Period 2. The analytical parameters were selected based on NEQEG (2015) of corresponding sectors so that percentage of factories meeting the guideline could be evaluated. In addition, a follow-up survey was implemented from August to September 2017 (hereafter Period 2) targeting 25 factories. In 2017, some effluent samples were analyzed at laboratories not only in Myanmar and Thailand but also in Japan to confirm data reliability. Details of both surveys in 2016 and 2017 are available in the "Pollution Source Survey Report (Appendix 13)".





Source: JET

Figure 2-19 Target Sectors for Wastewater Sampling in Period 1 (Upper) and Period 2 (Lower) in Hlaing River Basin

[1] Some of the results, such as the analytical results of total nitrogen, were deemed suspicious.

1) Organic Pollution and Nutrient

Table 2-8 and Table 2-9 show effluent concentrations of BOD and COD. The values of NEQEG for BOD and COD are 50 mg/L for BOD and 250 mg/L respectively, for most industrial sectors. It should be noted that NEQEG (2015) was not legally-binding even at the time of the follow-up survey in 2017 and thus, these factories have no obligation to satisfy the guideline. Although some target factories in Period 2 are different from those in Period 1, there was no difference in the trend that most of the wastewaters did not meet the guideline values for BOD and COD.

Table 2-8 Comparison Results of BOD (Period 1 and Period 2) in Hlaing River Basin

Category	Period 1 (in 2016)	Period 2 (2017)
0-20 mg/L	6	1
20-50 mg/L	1	4
50-100 mg/L	1	8
100-1,000 mg/L	10	12
1,000- mg/L	5	0
No Data	2	0
Total	**25**	**25**

Note: The BOD value of NEQEG is "50 mg/L".
Source: JET

Table 2-9 Comparison Results of COD (Period 1 and Period 2) in Hlaing River Basin

Category	Period 1 (in 2016)	Period 2 (2017)
0-100 mg/L	9	0
100-250 mg/L	2	1
250-1,000 mg/L	7	6
1,000-2,000 mg/L	1	15
2,000- mg/L	4	3
No Data	2	0
Total	**25**	**25**

Note: The COD value of NEQEG is "250 mg/L".
Source: JET

Table 2-10 summarizes the results of comparison with the guideline values for BOD, COD, total nitrogen (T-N) and total phosphorus (T-P) which are different by sector for survey in Period 2 in Yangon. Wastewater from around 50% of factories (13 out of factories for COD, 11 out of 21 factories for T-N and 12 out of 24 factories for T-P) met the guideline values of COD, T-N, and T-P. COD, T-N, and T-P are high ratio of meeting the guideline value than the value for BOD because only 20% of factories (5 out of 24 factories for BOD) met the guideline value.

Table 2-10 Results of BOD, COD, T-N, and T-P with NEQEG in Yangon (Period 2)

Category	BOD	COD	T-N	T-P
Equal to or under NEQEG Value	5	13	11	12
Over NEQEG Value	19	11	10	12
No Evaluation	1	1	4	1
Total	25	25	25	25

Note: "Pulp and / or Paper Mills" have NEQEG value with different unit as "kg/Air dried metric ton" and some sectors do not have NEQEG value for these parameter.
Source: JET

2) Heavy Metals, Toxic Substance

In the survey in Period 1 (2016), differences in wastewater quality were investigated by sector but some of the data were deemed not reliable. Thus, in the follow-up survey in Period 2 (2017), wastewaters from a total 9 factories representing different sectors, such as food and beverage, textile manufacturing, Semiconductors and Other Electronics Manufacturing, etc., were analyzed at a certified laboratory in Japan. They were selected considering their potential impacts on water environment (e.g. volume of wastewater, concentration of main parameters such as BOD or COD, existence of heavy metal pollutants, etc.). Although the number of investigated factories in each sector was very limited (see Table 3-12), the results confirmed the general characteristics of different sectors as follows:

- Lead was detected from the wastewater of one battery factory as “Semiconductors and Other Electronics Manufacturing”.
- Zinc was detected from the “Textiles Manufacturing” factories.

Table 2-11 Number of Target Factories for each Sector in Yangon (analyzed in Japan)

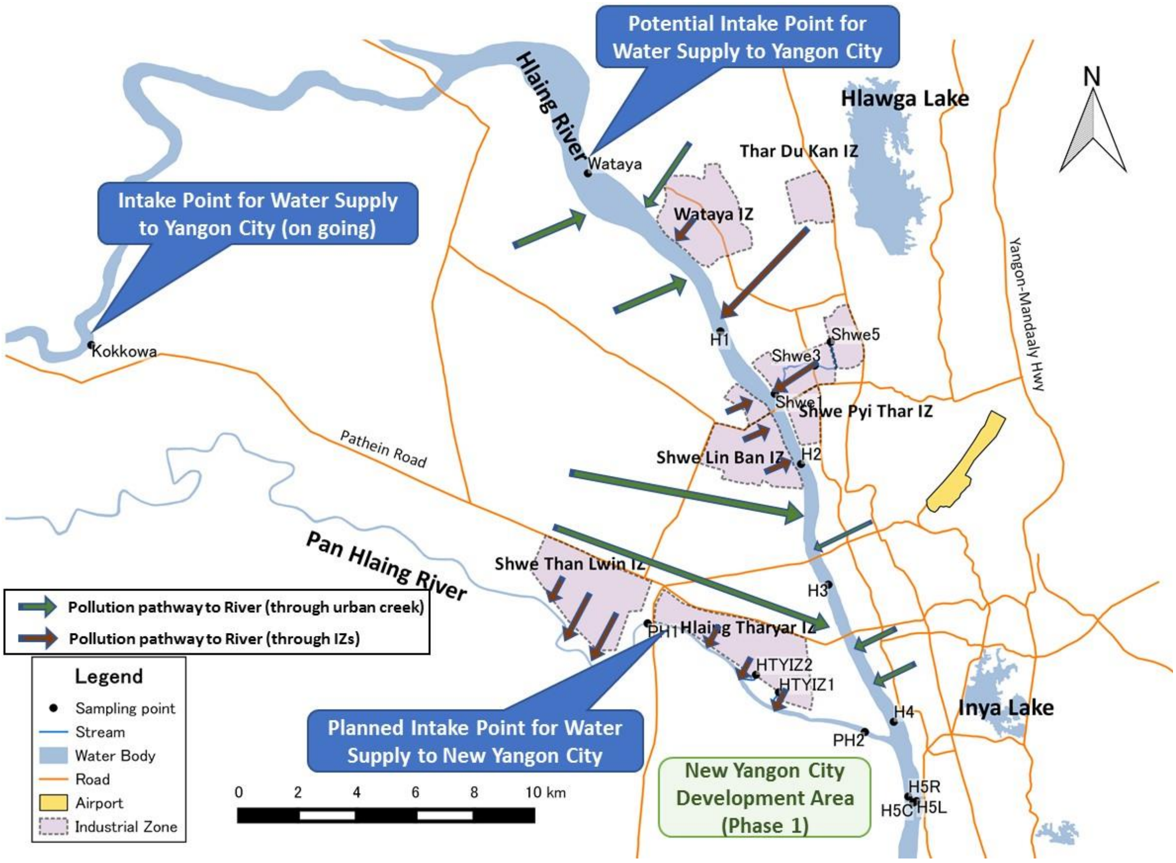
No.	Serial Number (NEQEG)	Sector	Number of Factories
1	2.3.1.3	Fish Processing	2
2	2.3.1.4	Food and Beverage Processing	3
3	2.3.2.1	Textiles Manufacturing	2
4	2.3.3.3	Pulp and / or Paper Mills	1
5	2.3.7.5	Semiconductors and Other Electronics Manufacturing * Battery factories were selected.	1
Total			9

Source: JET

2.8 IMPACT OF POLLUTION ON RIVER WATER QUALITY

2.8.1 Overall pollution pathways to rivers

Figure 2-20 shows pollution pathways to Hlaing River and Pan Hlaing River with locations of industrial zones and intake points for water supply in the pilot area in Yangon. The pollution pathways are divided into three areas: left bank (east side) of Hlaing River, right bank (west side) of Hlaing River, and left bank (north side) of Pan Hlaing River. Pollution generated in each area reaches the rivers through creeks and drainage channels and some creeks and drainage channels flow through industrial zones. As for intake points from the rivers, there are three planned intake points: (i) intake point at Kokkowa in Kokkowa River for water supply project by YCDC, (ii) potential intake point at Wataya in Hlaing River for future water supply project by YCDC, and (iii) potential intake point at a point between Hlaing Thayar industrial zone and Shwe Than Lwin industrial zone in Pan Hlaing River for planned water supply to New Yangon City Development Area.

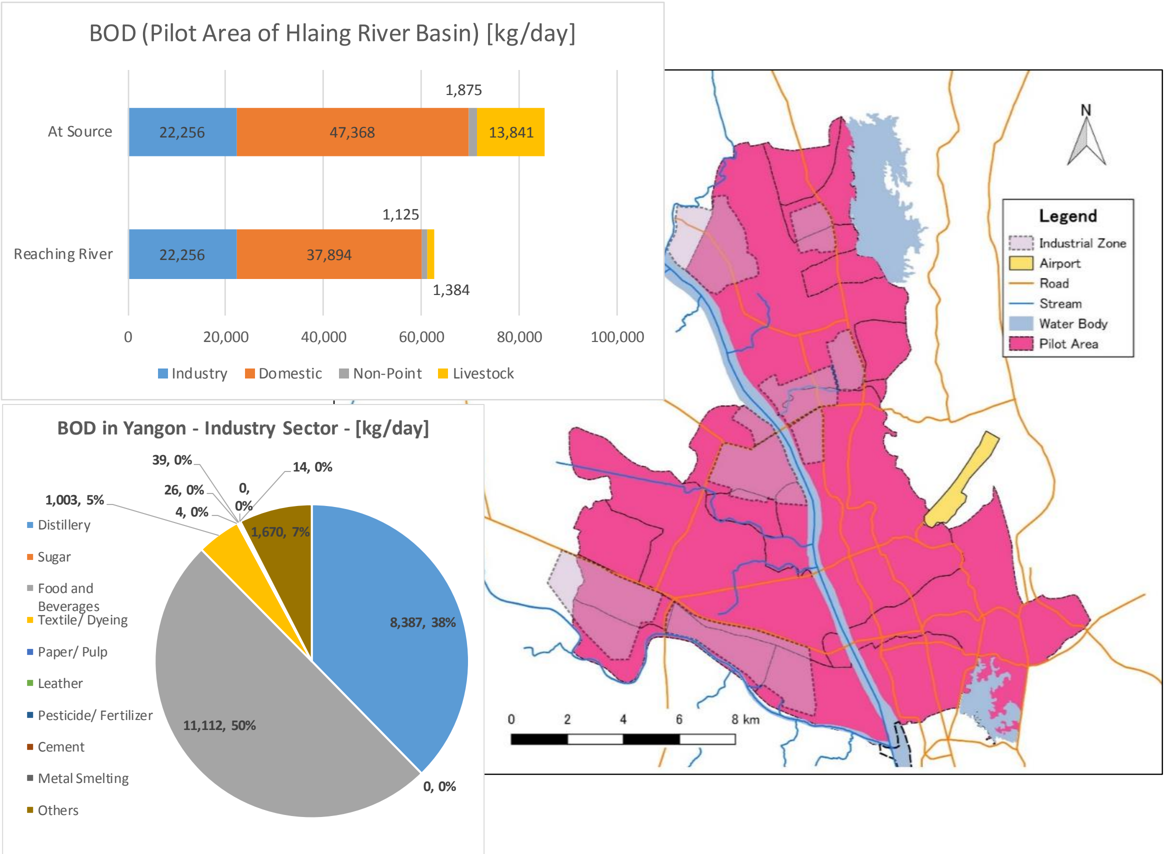


Source: JET based on dataset prepared by MIMU

Figure 2-20 Pollution Pathway to Rivers with Location of Industrial Zones and Planned Intake Points for Water Supply in the Pilot Area of Yangon

2.8.2 Pollution load analysis

The results of the pollution load analysis in the pilot area of Yangon is summarized in Figure 2-21. In this analysis, pollution loads from industrial, domestic and non-point sources, such as agricultural fields, were estimated using the results of the pollution source survey as well as unit pollution load for different pollution sources established in different countries. According to the results, 85,000 kg/day of BOD pollution load is generated in the townships of Yangon City (Hlaingtharya, Mayangone, Insein, Hlaing, Shwepyithar townships) in the Hlaing River basin, and 63,000 kg/day of generated BOD reaches Hlaing River and Pan Hlaing River. Among 63,000 kg/day of pollution load reaching the rivers, 60% is from domestic wastewater, 36% is from industries, and 4% is from livestock and non-point sources. Evidently, sewage from domestic sources is the main source of BOD load but the contribution of industrial sources is also significant. The major types of industries which generate large pollution load are distillery, food and beverage, and textile, and these three industries generate 93% of BOD pollution load from industrial sources. The detailed results of pollution load estimation is shown in Attachment-1.



Source: JET based on dataset prepared by MIMU

Figure 2-21 Estimated Pollution Load in the Pilot Area of Yangon (Upper Left: Pollution Load Generated at Source and Reaching Rivers by Sector, Lower Left: Industrial Pollution Load by Industries)

2.8.3 Impact of pollution on river water quality

(1) *Upstream area of Hlaing River*

In the upstream area of Hlang River at Kokkowa, the water quality met the Vietnamese standard for domestic water supply (Class A1 or A2) except for TSS and total coliform both in the latest rainy season (September 2017) and dry season (February 2018) because there are no large-scale towns, industrial zones, and intensive agriculture/livestock activities in the upstream area. There are no new town development and industrial zone development plans in the upstream till now, thus most likely the water quality at Kokkowa can be maintained at the current level (possible for domestic water supply in accordance with Vietnam surface water quality standard in another 5-10 years), though more detailed assessment is needed.

(2) *Downstream area of Hlaing River*

In the downstream area of Hlaing River (at Wataya, Hlaing-1, -3, and -5), the water quality in the latest rainy season met the surface water quality standard for domestic water supply in Vietnam (Class A1 or A2) except for TSS and total coliform. In the latest dry season, the levels of CODCr, which is one of the key parameters for water use, at Wataya and Hlaing-1 in the upstream of Shwe Pyi Thar IZ were less than 30 mg/L (the Vietnam standard for irrigation water supply; Class B1), but at Hlaing-3 and Hlaing-5 in the downstream of the industrial zone, the levels were more than 50 mg/L (the Vietnam standard for navigation; Class B2). As shown in Section 2.4.9, it was hypothesized that the high value of CODCr in this area is due to organic matter associated with suspended solid in the water and not soluble organic substance because there was no significant difference in BOD level among the locations, though this is not conclusive at the moment. Moreover, this elevated CODCr could also be the direct or indirect results of a number of factors related to pollution: (i) insufficient capacity to absorb impact of wastewater from industry, domestic, and other activities[2], (ii) pollution from Myaung Dagar IZ and domestic wastewater from Hmawbi Township located at 25km upstream of Wataya, (iii) pollution from Shwe Pyi Thar IZ and domestic wastewater from Shwe Pyi Thar Township in case of back-flow by tidal effect, and (iv) limited mixing and slowdown of river flow in the downstream area due to sea water intrusion. Further investigation is needed to clarify whether or not the water quality at Wataya intake point can be used for domestic water supply, and for this, pollution mechanism should be elucidated based on long-term water monitoring data, hydrological data, and water use information. As for the impact of industrial pollution on water quality, Ta Gu Chan Creek, which is a tributary draining to Haing River through the Shwe Pyi Htar Industrial Zone, is a good example of how industrial wastewater could affect water quality. This creek was polluted by industrial wastewater and domestic wastewater in the dry season at the downstream point (Shwe1) of the creek, and the concentrations of organic matter and nutrients were high (BOD: 267 mg/L, CODCr: 4,900 mg/L, T-N: 130 mg/L, T-P: 10 mg/L). Lead concentration was also somewhat elevated (Pb: 0.066 mg/L). Thus, one of the reasons for water deterioration in Hlaing River in the dry season is the impact of industries, though the impact of reduced river flow and the impact domestic wastewater are also significant.

(3) *Pan Hlaing River*

In the latest rainy season, water quality in Pan Hlaing River ranged between Class A2 (for domestic water with treatment and conservation of aquatic life) and Class B1 (for irrigation) except for total coliform and TSS. The water quality is slightly worse than water quality in Hlaing River because Pan Hlaing River has smaller capacity of receiving wastewater from domestic and industrial sources.

In the latest dry season, water quality at “PH1” located between Hlaing Tharyar IZ and Shwe Than Lwin IZ, where the planned water intake point for development of New Yangon Development is located, was worse than the rainy season presumably because the flow was limited and the bottom sediment was suspended in water. The levels of organic matter and nitrogen compounds were high (BOD: 47 mg/L, COD: 3,400 mg/L, T-N: 92 mg/L). The water quality at PH2 located before confluence of Hlaing River was the same level as Hlaing-5 because water was mixed by tidal flow. One heavy metal parameter exceeded the Vietnam

[2] Water discharge of Yangon River before confluence of Bago Rover is estimated as around 200 m3/s in the lowest month (April), 7,000 m3/s in the highest month (Aug) by Delft3D-FLOW Model of the Yangon Port, Dec 2015 (R.J. DE KOING & M.P.J. Janssen).

standard (Pb: 0.058 mg/L) presumably because the stirred sediment containing naturally-occurring lead affected the result. In addition to the impact by reduced river discharge in the dry season, there are three possible impacts by pollution: (i) pollution from Shwe Than Lwin IZ and domestic wastewater around the industrial zone located at 500m upstream of the planned intake point of Yangon New Development water supply, (ii) pollution from Hlaing Tharyar IZ and domestic wastewater around the industrial zone 100m to 5km downstream of the intake point in case of back-flow by tidal effect, and (iii) limited mixing and slowdown of river flow over the stretch of the river from the potential intake point at PH1 to the downstream due to sea water intrusion, which also caused stirring of polluted bottom sediment. However, more investigation on pollution mechanism is needed based on long-term water monitoring data, hydrological data, and water use information.

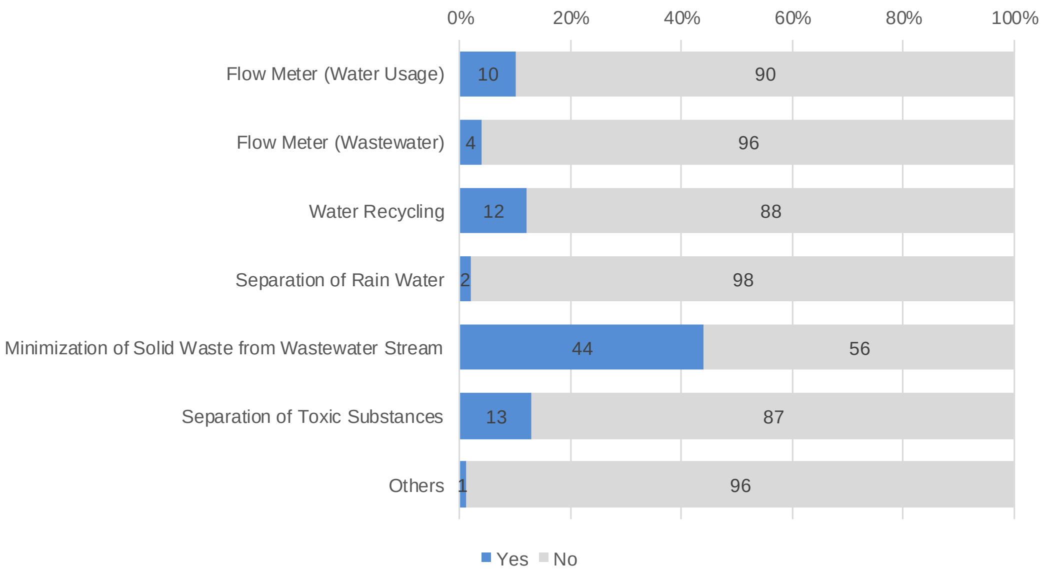
2.9 Pollution Control Activities

2.9.1 Pollution Control Activities by Factories

In 2016, a questionnaire survey of 100 factories in the Hlaing River basin was conducted to examine operations as well as environmental management of the target factories. For detail, see the "Pollution Source Survey Report (Appendix 13)".

(1) *Measures to minimize pollution*

With respect to measures to minimize pollution, it was found that only 10% of factories in Yangon are equipped with water meters to monitor water usage (see Figure 2-22) and many factories are not aware of their water consumption. On the other hand, about half of 100 factories replied that they are trying to minimize solid waste from entering wastewater stream.



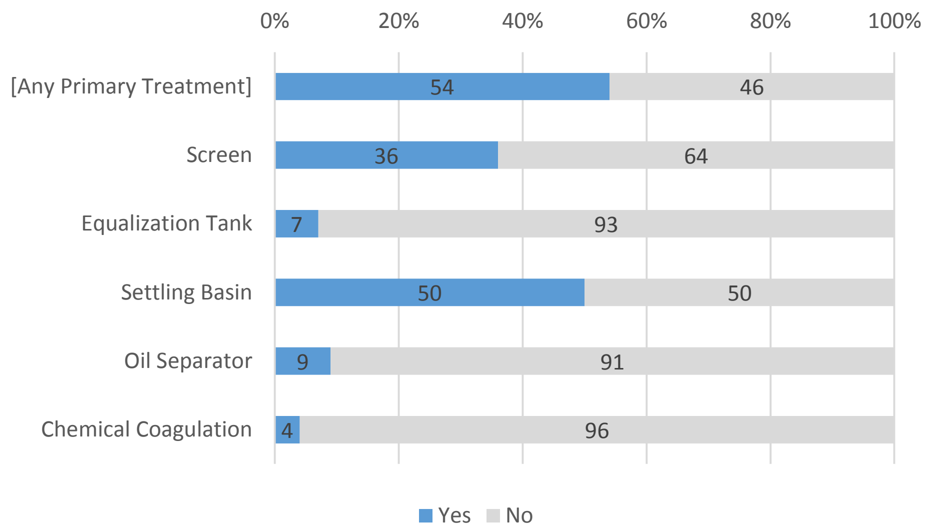
Source: JET based on Pollution Source Survey in 2016

Figure 2-22 Measures to Minimize Water Pollution in Factories in the Hlaing River Basin

(2) *Installation of Wastewater Treatment*

One of the key questions related to wastewater treatment was how many of the factories are equipped with primary treatment facilities[3] mainly to remove solids. According to the results of the questionnaire survey in 2016, 54% of 100 factories surveyed in the Hlaing River basin are equipped with some kind of primary treatment facilities and simple settling basin to remove settleable solids, which is the most common primary treatment facilities, as shown in Figure 2-23. Screens to remove large solids and settling basin to remove settleable solids are among the simplest wastewater treatment facilities and this means roughly half of factories have essentially no treatment facilities at all.

With respect to the secondary treatment[4] to remove organic matter, 6% of the factories in IZs in Hlaing River basin were equipped with treatment facilities in 2016 (see Figure 2-24).



Source: JET based on Pollution Source Survey in 2016

Figure 2-23 Status of Primary Treatment Installation in the Hlaing River Basin

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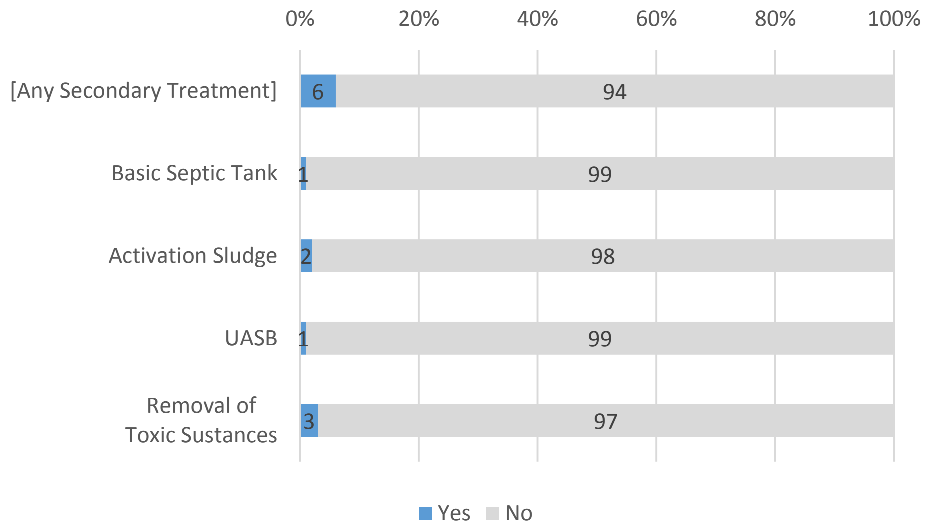
3 In this survey, facilities such as equalization tank and chemical coagulation, were included in primary treatment, though primary treatment usually refers to physical removal of solid by screening and settling.

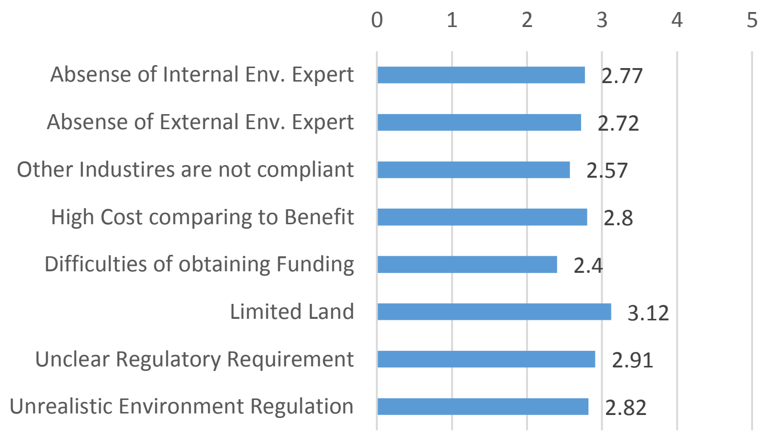
4 In this survey, basic septic tank was included in secondary treatment. Also, removal of toxic substances was included in this category for simplicity, although the process of removal of toxic substances is often chemical and not biological.



Source: JET based on Pollution Source Survey in 2016 and 2017

Figure 2-24 Status of Secondary Treatment Installation in the Hlaing River Basin

Another question is the difficulties these factories are facing to install an adequate wastewater treatment plant (WWTP). There could be many reasons, such as absence of internal or external expert, other factories are not compliant, high cost compared with benefit, limited land, etc. The results of factories in the Hlaing River basin are mixed and none of the reasons stood out as the main reasons common to most factories (see Figure 2-25).



Source: JET based on Pollution Source Survey in 2016

Figure 2-25 Difficulties of WWTP Installation in the Hlaing River Basin

2.9.2 Pollution control measures by government organizations

(1) *Inspections by government organizations*

At present, inspection activities by government organizations is under business licensing/ registration and inspection for YCDC business license, DISI business legislations, and ECD Environmental License (Environmental Compliance Certificate: ECC). In the business licensing/registration and inspection activities, there are two types of environmental inspections: (a) environmental inspection related to business licensing and registration, and (b) inspection to resolve environmental complaints by YDCD-PCCD, ECD Yangon Region. Please see the "Inspection Manual (Appendix 6)" in detail. Table 3-5 summarizes inspections by ECD Yangon Region in April 2016 – March 2017.

Table 2-12 Inspections by ECD Yangon Region in April 2016 – March 2017

State/ Region	Types of Inspection	Number of Inspections (Apr. 2016 – Mar. 2017)
Yangon	1) Regular Inspection of ECD (Yangon)	83
	2) Inspection by ECD (Yangon) according to Complaints	7
	3) Inspection by ECD (Yangon) according to instruction of Union Minister	2
	4) Inspection by ECD (Yangon) according to instruction of Region Government	3
	Sub-Total	95

Source: JET based on information provided by ECD

(2) *Notification No.03/2018 on preparation of EMP and obtain ECC to existing large scaled factories in 9 industrial sectors*

MONREC issued notification No.03/2018 in January 2018 to prepare Environmental Management Plans (EMP) and acquire Environmental Compliance Certificates (ECC) within 9 to 12 months in accordance with EIA procedures to existing factories in 9 industrial sectors that are considered pollution intensive (e.g. distilleries, food and beverage, paper and pulp, and cement). On the other hand, MONREC-ECD has to play a central role in controlling environmental performance of factories in 9 target sectors, and it has been already requested to set criteria of issuing ECCs (e.g., wastewater control, emission control and environmental management) for 9 sectors and to issue ECCs to the factories accordingly. ECD Yangon Region will face various difficulties to implement these tasks in near future because the number of target factories are expected be more than thousand and the number of officers in ECD who have expertise of pollution control is limited.

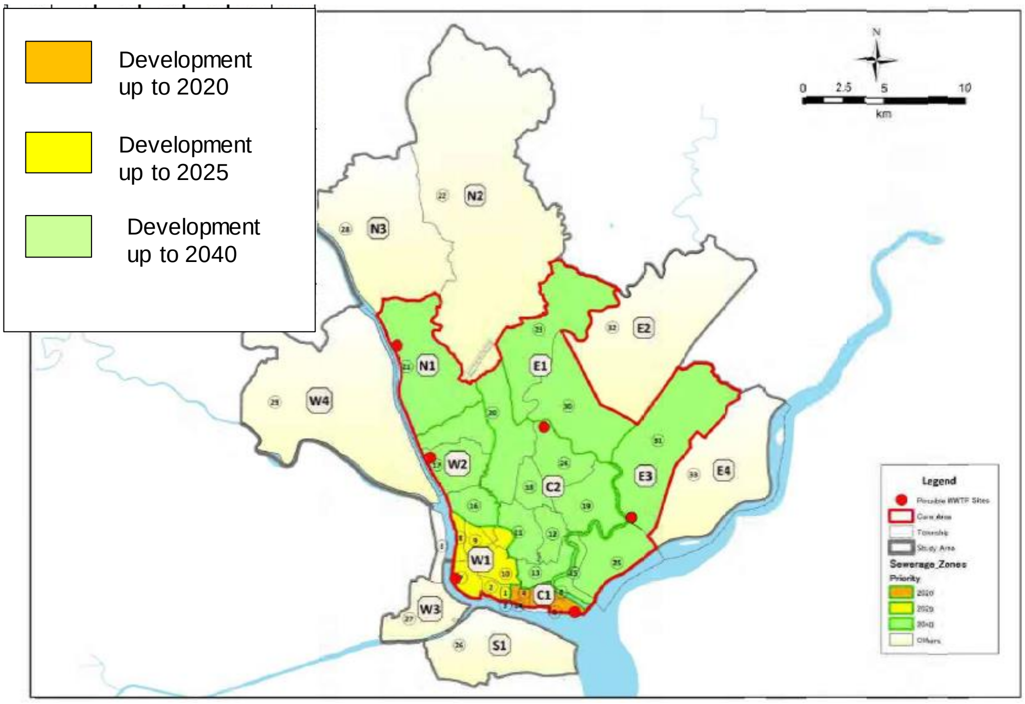
(3) *Centralized wastewater treatment plant in industrial zones*

As for pollution control in industrial zones, Yangon Region Industrial Supervision Committee has been discussing the upgrade of infrastructure of existing industrial zones in order to improve provision of utilities, such as electricity, water, wastewater treatment and solid waste treatment services. An example of these is the Public Private Partnership (PPP) scheme. YRG is the organization who can promote installation of centralized wastewater treatment plants in the existing industrial zones in Yangon Region including Yangon City. However, any industrial zones has not been started to construct the centralized wastewater treatment plan yet.

(4) *Domestic wastewater treatment*

As for domestic wastewater treatment, YCDC is conducting feasibility studies with JICA (C1 and W1 areas) and ADB (W2 area) as shown in Figure 2-26. However these planned sewerage areas are located in south and east pars of Yangon City and far from the pilot area. So, it may take time to construct sewerage system in the pilot area of Yangon.

At present, YCDC-WSD is collecting black water (toilet wastewater) from households by YCDC septic tank trucks and send it to the existing sewerage treatment plant in downtown of Yangon City. Sometimes stored wastewater are overflowed and discharging to channel network. On the other hand, gray water (wastewater other than toilet wastewater) from household are discharged to channel network directly. As the first step to take actions for domestic wastewater pollution control, YCDC-WSD issued the notification letter for new houses and facilities not to infiltrate toilet wastewater. YCDC-WSD also checks wastewater treatment system of new households and facilities at the timing of issuing building permit by construction section of YCDC.



Source: Preparatory survey report on the project for the improvement of water supply, sewerage and drainage system in Yangon city (JICA, 2014)

Figure 2-26 Sewerage Development Plan in Yangon

2.10 ISSUES TO BE ADDRESSED FOR WATER POLLUTION CONTROL AND WATER ENVIRONMENT MANAGEMENT

As described in the above sections, current water quality status in the pilot area of Yangon was investigated based on the collected information and activities of the project, and some issues related to water pollution control and water environment management were found. Table 2-13 summarizes the issues and the suggested measures to control water pollution and to improve water environment management.

Table 2-13 Issues on Water Environment Management to be addressed, its Expected Measures in the Pilot Area of Yangon

Categories	Identified Issues on Water Environment Management to be Addressed	Necessary Measures
1) Water use and water quality	[Upstream of Hlaing River] - Current water uses are mainly for irrigation, navigation, and fishery. Important planned water use is for public water supply to Yangon City at Kokkowa and the public water supply project has been started. - Water quality in the Kokkowa River can be maintained at the current level in another 5-10 years because there are no development plans such as township development and industrial development. However, more detailed assessment is needed whether water quality at Kokkowa River can be maintained in 10-20 years. [Downstream of Hlaing River] - Current water uses are mainly for navigation and fishery. YCDC has a plan to intake water at Wataya for public water supply to Yangon City. - Water quality in the latest rainy season met the surface water quality standard for domestic water supply in Vietnam (Class A1 or A2) except for TSS and total coliform. In the latest dry season, water quality was worse than the rainy season and indicate relatively high such as COD_{Cr}. Further investigation is needed to clarify whether or not the water quality at Wataya intake point can be used for domestic water supply, and for this, pollution mechanism should be elucidated based on long-term water monitoring data, hydrological data, and water use information. [Pan Hlaing River] - Current water uses are mainly for irrigation, navigation, and fishery. Yangon Regon Government has a plan to intake water at a location between Hlaing Thar Yar industrial zone and Shwe Than Lwin industrial zone for public water supply to New Yangon City. - Water quality in the latest rainy season was ranged between Class A2 (for domestic water and aquatic life) and Class B1 (for irrigation) except for total coliform and TSS. In the latest dry season, water quality near planned intake point was worse than the rainy season presumably because the flow was limited and the bottom sediment was suspended in water. However, more investigation on pollution mechanism is needed based on long-term water monitoring data, hydrological data, and water use information.	- Water environment management plan in the priority areas (Kokkowa, Wataya, Pan Hlaing) shall be developed and implemented. - Long-term surface water quality monitoring in the priority areas shall be implemented to understand pollution mechanism and trend of water quality and to check whether water can be used or not.
2) Impact of industrial pollution on water quality	[Water quality in tributaries] - Ta Gu Chan Creek, which is a tributary draining to Haing River through the Shwe Pyi Htar Industrial Zone, is a good example of how industrial wastewater could affect water quality. Water quality of the creek was polluted by industrial wastewater and domestic wastewater especially in the dry season. At the downstream point of the creek, the concentrations of organic matter and nutrients were high (BOD: 267 mg/L, COD_{Cr}: 4,900 mg/L, T-N: 130 mg/L, T-P:	- A centralized wastewater treatment system shall be installed in each industrial zone. - Some support tools for factories to promote water pollution control

Categories	Identified Issues on Water Environment Management to be Addressed	Necessary Measures
	10 mg/L). Lead concentration was also somewhat elevated (Pb: 0.066 mg/L). Thus, one of the reasons for water deterioration in Hlaing River in the dry season is the impact of industries, though the impact of reduced river flow and the impact domestic wastewater are also significant. Thus, some countermeasures to improve water quality of tributaries shall be taken. [Wastewater treatment by factories] - According to the questionnaire survey to 100 factories in the pilot area of Yangon, only 6% of factories installed secondary wastewater treatment plant. In addition, labor-intensive industries such as food processing and clothing. Major pollutants from such sectors may be organic pollution (BOD, T-N, T-P) and coliforms. Moreover, it was found that 83% of the factories have sales of less than 1 billion MMK, and about 55% fall under the category of less than 100 million MMK or 85,000 USD and many factories are not very large, and have limited capacity to invest in environmental measures. Thus, it takes a certain time that all of the factories in industrial zones install individual wastewater treatment plants.	themselves shall be introduced.
3) Impact of pollution sources other than industries on water quality	[Major pollution sources] - As the results of BOD pollution load analysis, 60% is from domestic wastewater, 36% is from industries, and 4% is from livestock and non-point sources. Evidently, sewage from domestic sources is the main source of BOD load but the contribution of industrial sources is also significant. [Status of sewerage system development] - YCDC is conducting feasibility studies with JICA and ADB in Yangon City. However, these planned sewerage areas are located in south and east pars of Yangon City and far from the pilot area. So, it may take time to construct sewerage system in the pilot area.	- Improvement of water pollution from existing residential area, commercial area, large scale facilities are required. - Expansion of sewerage network is required.
4)Industrial pollution control	[Regulation by government] - There are some issues on inspection activities such as i) clarification of environmental requirements and ii) clarification of inspection procedures for each environmental requirement, and iii) implementation of inspection without measurement as the identified issues through the Project activities (Output 1). - ECD Yangon Region will face various difficulties to implement tasks of Notification No.03/2018 in near future because the number of target factories are expected be more than thousand and the number of officers in ECD Yangon Region who have expertise of pollution control is limited. - Most of the factories discharges wastewater without any treatment and there is no system of charging wastewater fee from factories to discharge water body. [Pollution control activities by factories (other than wastewater treatment)] - Most factories in the industrial zones in the pilot areas are small- and medium-scale enterprises, and they have many constraints to improve water pollution control because of insufficient budget, human resources, land, and so on. Thus, it is necessary to not only strengthen supervision of factories by the government, but also to support factories to promote implementation of water pollution control measures	- Improvement of inspection activities are required - Examining the possibility to introduce wastewater discharge fee system are required. - Strengthening to implement tasks of Notification No.03/2018 for preparation of EMP and obtain ECC is required. - Development of support tools for water environment management by factories is required.

Source: JET

2.11 STRATEGIES FOR WATER POLLUTION CONTROL AND WATER ENVIRONMENT MANAGEMENT IN THE PILOT AREA OF YANGON

2.11.1 Strategies for water pollution control and water environment management

To formulate strategies for water pollution control from industrial zones and other pollution sources, a draft framework of key strategies was created following a thorough brainstorming discussions with C/Ps based on related project activities on inspection, water quality surveys, pollution source survey, development of databases, and information interpretation, as shown below:

- Key Strategy 1: Installation of centralized wastewater treatment plants in industrial zones to prevent pollution to surrounding area
- Key Strategy 2: Development of a mechanism for promoting water environment management by factories
- Key Strategy 3: Development of water environment management plans and its implementation in priority areas

The key strategies shall be finalized by the C/P organizations within a few years after completion of the project to achieve the overall goal indicators.

(1) *Key Strategy 1: Installation of centralized wastewater treatment plants in industrial zones*

As for pollution control in industrial zones, the Yangon Region Industrial Supervision Committee has been discussing the upgrade of infrastructure of existing industrial zones in order to improve provision of utilities, such as electricity, water, wastewater treatment and solid waste treatment services. An example of these is the Public Private Partnership (PPP) scheme. YRG is the organization who can promote installation of centralized wastewater treatment plants in the existing industrial zones in Yangon Region including Yangon City. Currently, YRG and the Urban and Housing Development Department of Ministry of Construction, which has experience in the construction of a centralized wastewater treatment in Mingaladon Industrial Park with a Japanese developer in 1990s, together with other relevant stakeholders such as UNIDO, are starting a pilot project to install a centralized wastewater treatment plant in an existing industrial zone. The knowledge and experience of building a centralized wastewater treatment plant, including its operations, through this pilot project will provide good lessons learnt to be applied in other industrial zones.

The installation of a centralized wastewater treatment plant is one of the critical actions for water pollution control in industrial zones. A key factor to actualize the installation of a treatment plant in this consideration is financing, such as securing a government subsidiary (and/or ODA loan) and finding partners (investors) of a government organization that can supply utility services (electricity, water, wastewater treatment, solid waste treatment) to reduce the financial burden of installation of the treatment plant. Moreover, in the case of application of PPP scheme for this kind of installation of the treatment plant, there are several issues to consider such as securing land, guarantee of minimum volume of wastewater to be treated, demarcation of government responsibilities and private sector responsibilities, etc. Thus, a prompt initiative led by YRG to install centralized wastewater treatment plants is a key strategy for wastewater management in industrial zones.

(2) *Key Strategy 2: Development of mechanism for promoting water environment management by factories*

Currently, most of the actions implemented by the C/Ps are oriented toward strengthening governmental control over factories. However, most factories in the industrial zones in the pilot areas are small- and medium-scale enterprises, and they have many constraints to improve water pollution control because of insufficient budget, human resources, land, and so on. Thus, it is necessary to not only strengthen supervision of factories by the government, but also to develop support tools for factories to promote implementation of water pollution control measures by their own initiatives. In the future, the following tools can be prepared by the government at the regional level:

- Organizing seminars for introduction of good practices on pollution control in Myanmar
- Setting consultation desks in district/township ECD offices to provide advices/information to factories on pollution control
- Establishment of an award system for factories and provision of some incentives (reduction of monitoring frequency and reduction of tax rate)
- Establishment of a low interest loan for factories to install a wastewater treatment plant and other pollution control facilities

(3) *Key Strategy 3: Development of water environment management plans and its implementation in priority areas*

In the pilot area in Yangon, one of the important issues on water environment management is to conserve water quality at the planned intake points for water supply to the new Yangon City development areas in Pan Hlaing River, and to Yangon City in Hlaing River (at Kokkowa and Wataya). These planned intake points for water supply shall be selected and identified as the priority areas, and water environment management plans in priority areas shall be developed.

- Setting the target water quality level to meet the objective of water use
- Setting socio-economic development scenarios in the future
- Examination of dilution capacity at the planned intake points in the future
- Development of water pollution reduction plans for each sector in main pollution sources
- Formulation of support programs for factories and facilities on pollution control
- Development of water quality monitoring plan
- Development of budget plan for implementation of water environment management

- Summarizing water environment management plan for each sector in the priority areas on the bases of the above examinations

2.11.2 Actions plans for water pollution control from water environment management

On the basis of the above strategies, actions for water pollution control and water environment management were identified through the results of a series of discussions and workshops among YCDC, ECD Yangon Region Office, and JET. Table 2-14 summarizes the outline of the action plans for water pollution control from industrial zones in the pilot area of Yangon. The actions are divided into three terms: short-term (within three years), middle-term (within five years), and long-term (within 10 years).

Table 2-14 Outline of Action Plans for Water Pollution Control and Water Environment Management in the Pilot Area of Yangon

Target year	Short term: FY2020-21 (from October 2018 to September 2021) Middle term: FY2022-23 (from October 2021 to September 2023) Long term: FY2027-28 (from October 2023 to September 2028)
Key Strategies	Key Strategy 1: Installation of centralized wastewater treatment plants in industrial zones to prevent pollution to surrounding area Key Strategy 2: Development of a mechanism for promoting water environment management by factories Key Strategy 3: Development of water environment management plans and its implementation in priority areas
Actions and Schedule	Key Strategy 1: Installation of centralized wastewater treatment plants in industrial zones to prevent pollution to surrounding area [Yangon Region Government] AY1-1: Setting policy for installation of centralized wastewater treatment plants in industrial zones <u>(short-term)</u> AY1-2: Construction and operation of a pilot centralized wastewater treatment plant in an industrial zone <u>(short-term to middle-term)</u> AY1-3: Formulation of PPP scheme on construction and operation of centralized wastewater treatment plants in priority industrial zones (short-term) AY1-4: Construction and operation of centralized wastewater treatment plants in priority industrial zones <u>(middle-term to long-term)</u>
	Key Strategy 2: Development of a mechanism for promoting water environment management by factories [YCDC] AY2-1: Improvement of inspection activities for issuing/renewing licenses by YCDC Administration Department in accordance with the revised YCDC law to be enacted <u>(short-term)</u> AY2-2: Strengthening on-site monitoring such as wastewater monitoring, noise monitoring, air emission monitoring <u>(short-term)</u> AY2-3: Examining the possibility to introduce wastewater discharge fee system in Yangon City, such as research for similar systems in ASEAN countries <u>(middle-term)</u> [ECD Yangon Region] AY2-1: Collection of information on existing factories which have been requested to prepare EMPs in accordance with the Notification No. 03/2018, and identification of

	important factories associated with large pollution load through guidance seminars to each industrial zone for collection of target factories and awareness raising to factories by ECD Yangon Region, collection of information from DISI/MOI, collection through inspection activity by ECD Yangon Region, DICA/MOPF and collection from PCCD/YCDC (short-term) AY2-2: Establishment of monitoring/supervising system to check status of preparation of EMPs by the prioritized factories, such as monitoring/supervising through inspection activities (short-term) AY2-3: Organizing seminars for introduction of good practice on pollution control in Myanmar (short-term) AY2-4: Setting consultation desks in district/township ECD offices to provide advices/information to factories on pollution control (middle-term) AY2-5: Examining the possibility to promote water environment management (e.g. awarding system with some incentives, establishment of low interest fund, consultation on cleaner production) in Yangon Region, through research for similar systems in ASEAN countries (middle-term)
	Key Strategy 3: Development of water environment management plans and its implementation in priority areas [YCDC] AY3-1: Improvement of domestic and commercial wastewater of existing factories (short-term to middle-term) AY3-2: Expansion of sewerage areas (middle-term to long-term) AY3-3: Development of water environment management plans and its implementation in the priority areas (short-term to middle term) [ECD Yangon Region] AY3-4: Establishment of water quality testing laboratory (middle-term) AY3-5: Starting-up and implementation of surface water quality monitoring in rivers in the Region (middle-term to long-term)

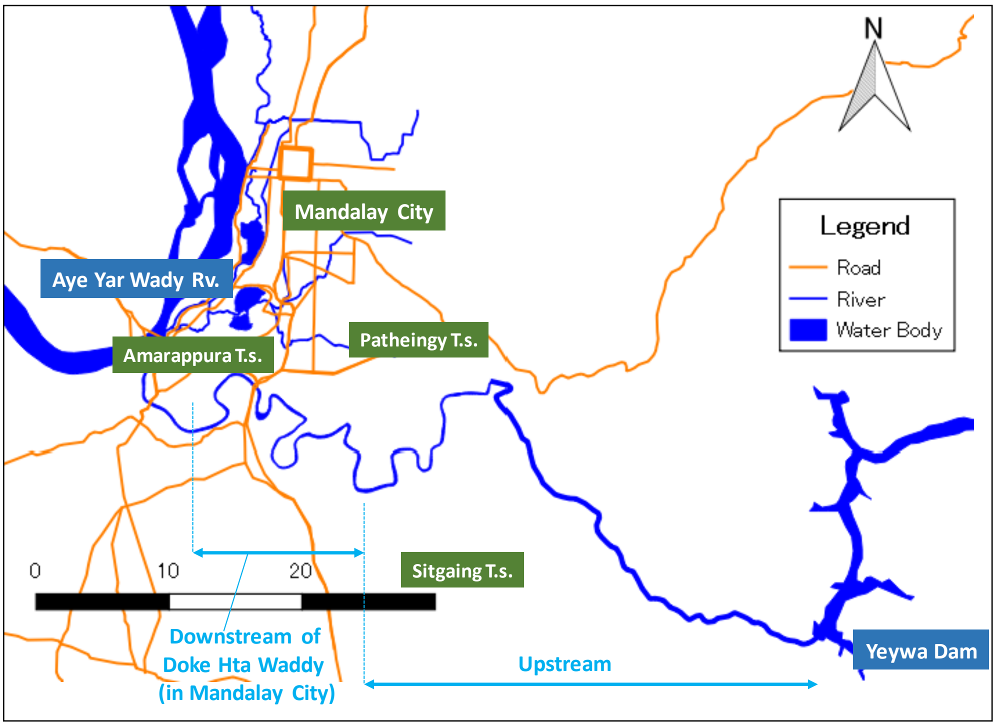
Source: YCDC, ECD Yangon Region, and JET

3 WATER QUALITY STATUS IN THE PILOT AREA OF MANDALAY (DOKE HTA WADDY RIVER BASING AND TAUNG THA MAN LAKE BASIN)

3.1 OUTLINE OF HLAING RIVER BASIN

3.1.1 Overview of Doke Hta Waddy River

Doke Hta Waddy River is the downstream section of a tributary of Ayeyarwady River, named Myitnge River or Nam Tu River. The length of Myitnge River is approximately 350 km and the starting point is the northern part of Shan State while the ending point is before the confluence of Ayeyarwady River. Doke Hta Waddy River is the part of Myitnge River starting from Yeywa Dam to before confluence of Ayeyarwady River with around 95 km length as shown in Figure 3-1.

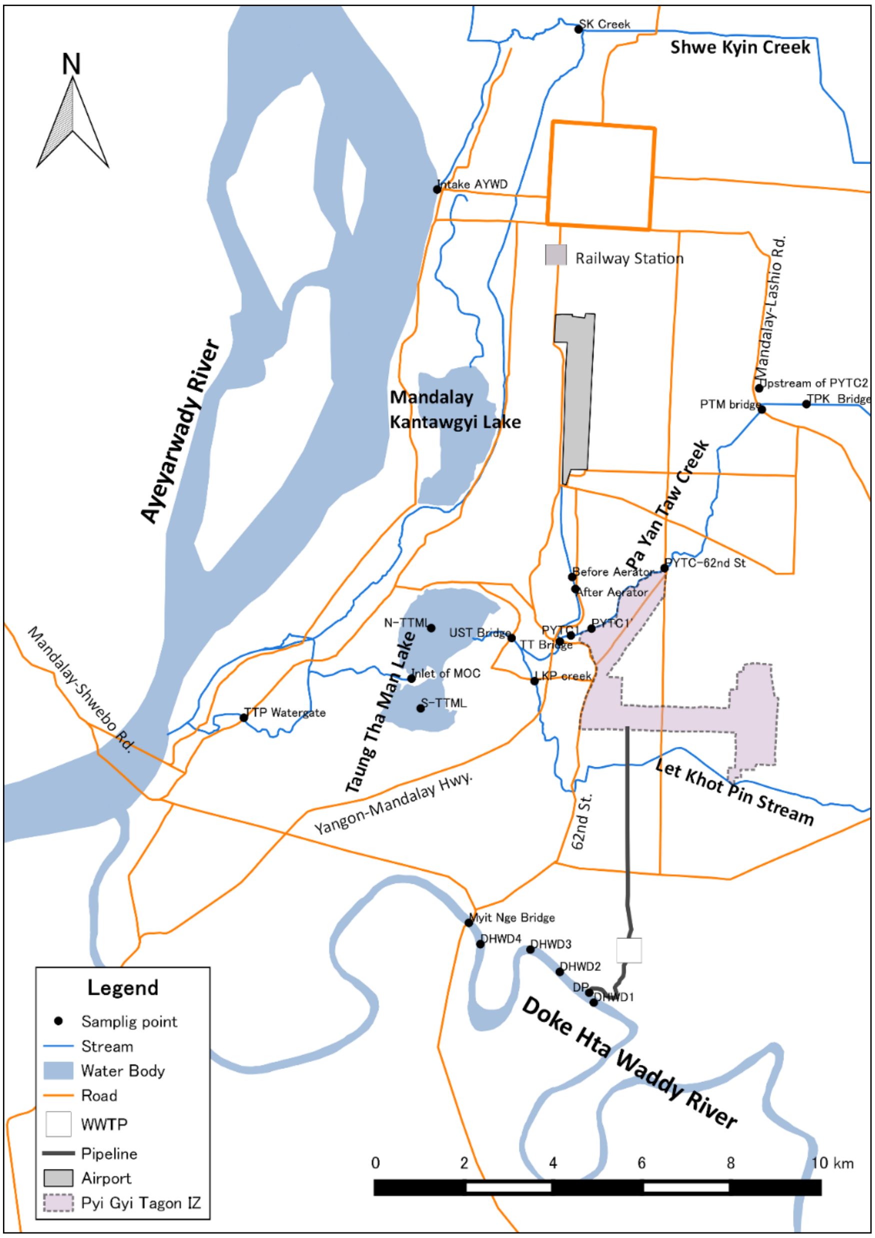


Source: JET based on dataset prepared by MIMU

Figure 3-1 Map of Doke Hta Waddy River

3.1.2 Downstream area of Doke Hta Waddy River and Taung Tha Man Lake (Pilot Area of Mandalay)

As shown in Figure 3-2, this report mainly focuses on the downstream area of the Doke Hta Waddy River and the Taung Tha Man Lake Basin in Mandalay City and Amarappura, Patheingy, and Sitgaing townships as the pilot area because the wastewater from the industrial zones such as the Pyi Gyee Tagon industrial zone which is the biggest industrial zone in Mandalay City, may deteriorate the water quality in these areas.



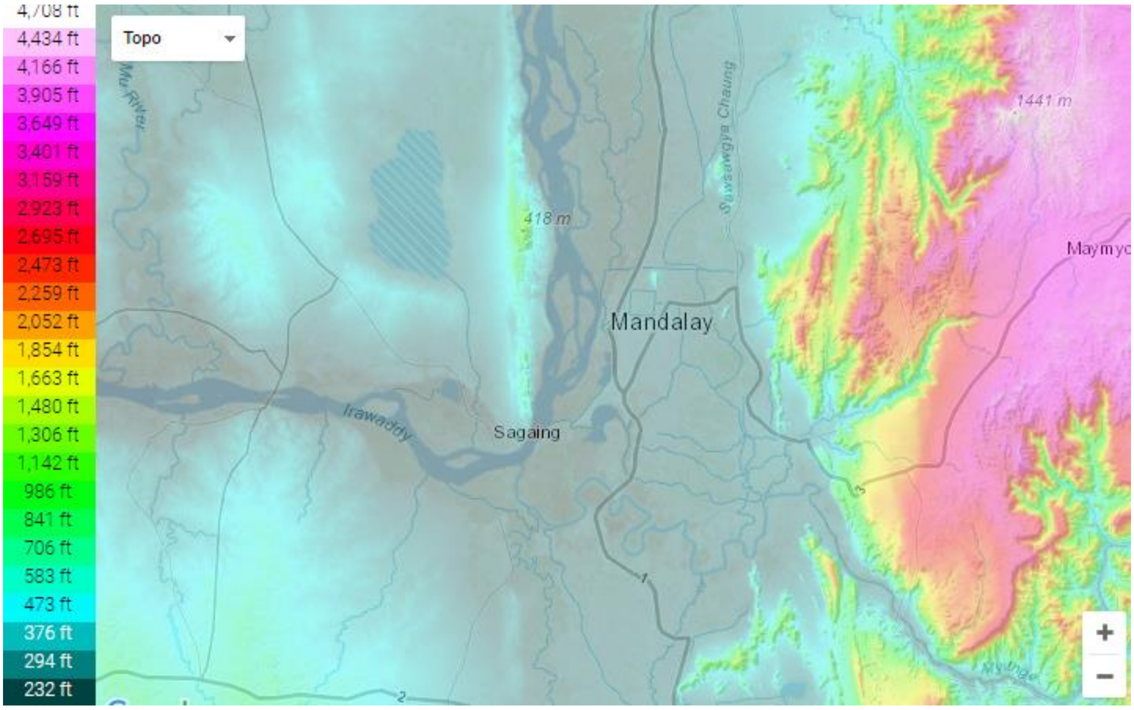
Source: JICA Expert Team

Figure 3-2 Map of Downstream of Doke Hta Waddy River and Taung Tha Man Lake (Pilot Area of Mandalay)

3.2 Natural Conditions

3.2.1 Topography

Figure 3-3 shows a topography map around Mandalay City including Doke Hta Waddy River basin. The area in and around Mandalay City along Ayawaddy River including the area downstream of Doke Hta Waddy River is largely floodplain. The city is bound by hills and the mountain ranges in the east side of city.



Source: Topographic-map.com

Figure 3-3 Topography of Mandalay Area

3.2.2 Metrology

Table 3-1 and Table 3-2 show monthly mean temperature and monthly rainfall in Mandalay from 2005 to 2014. As for temperature, the hottest month in a year is April (33.3 ºC) and the coldest month is January (22.4 ºC). The difference between the highest and the lowest monthly average temperature is around 10 ºC. The rainfall pattern in Mandalay is distinctly divided into rainy season (May to October) and dry season (November to April).

Table 3-1 Monthly Mean Temperature in Mandalay District (Average), Years 2005-2014

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Temperature (ºC)	22.4	25.0	29.2	32.3	31.9	31.2	31.1	30.4	29.8	28.9	26.4	22.6

Source: 2015 Myanmar Statistical Yearbook, Central Statistical Organization, Ministry of National Planning and Economic Development

Table 3-2 Monthly Rainfall in Mandalay District (Average), Years 2005-2014

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (millimeters)	2	2	8	36	152	99	56	158	199	178	22	12

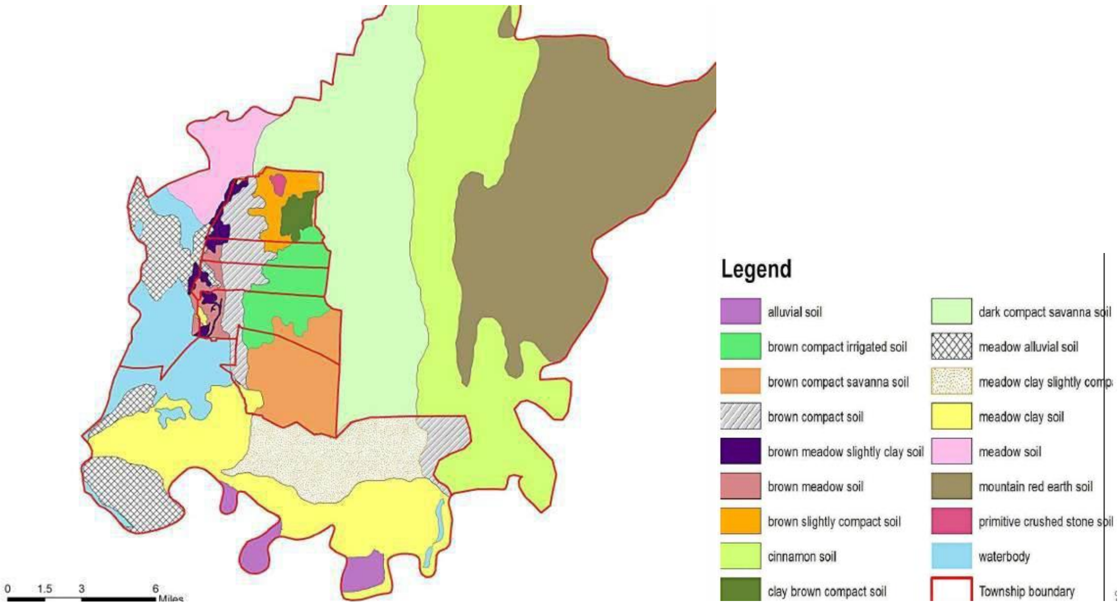
Source: 2015 Myanmar Statistical Yearbook, Central Statistical Organization, Ministry of National Planning and Economic Development

3.2.3 Geology

Geology information in Mandalay is limited during basic information and data collection in the Project activities. According to Initial Environmental Examination (IEE) for the Mandalay Urban Services Improvement Project funded by ADB, the geology of Mandalay City is composed of Quaternary unconsolidated sediments of Middle Pleistocene to Holocene age: the fluvial sediments of the Ayeyarwaddy River and the piedmont colluvium deposits from the marginal highlands of the Shan Plateau. Rock types in Mandalay region include both hard rocks such as limestone, dolomite, gneiss, schist, and granitic rocks, and soft rocks such as sandstone, shale, limestone and conglomerate.

3.2.4 Soil Condition

Figure 3-4 shows soil map of Mandalay. Several types of soils are observed in Mandalay City area and Ayeyarwaddy River. Mountain red earth soils, cinnamon soils and dark compact savannah soils cover together more than the eastern half of the city.



Source: IEE for the Mandalay Urban Services Improvement Project (ADB, 2015)

Figure 3-4 Soil Map of Mandalay

3.3 SOCIAL CONDITIONS

3.3.1 Administrative Boundary

Figure 3-5 shows township boundaries in Mandalay Region. In the pilot area of Doke Hta Waddy River and Taung Tha Man Lake, there are seven townships in the Mandalay District as follows;

1. Aungmyetharzan Township.
2. Chanayetharzan Township.
3. Mahaaungmye Township.
4. Chanmyatharzi Township.
5. Pyigyidagun Township.
6. Amarapura Township.
7. Patheingyi Township.

3.3.2 Population

Table 3-3 shows the population of the seven townships which are located in the pilot area. 1.5 million people live in these townships and 84.1% of them live in urban area of the townships.

Table 3-3 Population of Townships located in the project area in Mandalay shown as gender and urban/rural population

Township	Total	Male	Female	Ratio	Urban	Rural	Urban Population
Aungmyetharzan	265,779	129,959	135,820	95.7	265,779	-	100
Chanayetharzan	197,175	93,245	103,930	89.7	197,175	-	100
Mahaaungmye	241,113	116,903	124,210	94.1	241,113	-	100
Chanmyatharzi	283,781	137,528	146,253	94	283,781	-	100
Pyigyidagun	237,698	120,794	116,904	103.3	237,698	-	100
Amarapura	237,618	114,481	123,137	93	80,824	156,794	34
Patheingyi	263,725	129,004	134,721	95.8	13,082	250,643	5
Total	1,695,096	801,705	893,391	89.7	1,425,626	269,470	84.1

Source: The 2014 Myanmar Population and Housing Census, Union Report, Census Report Volume 2.

Source: MIMU

Figure 3-5 Township Boundary of Industrial Zones in Mandalay

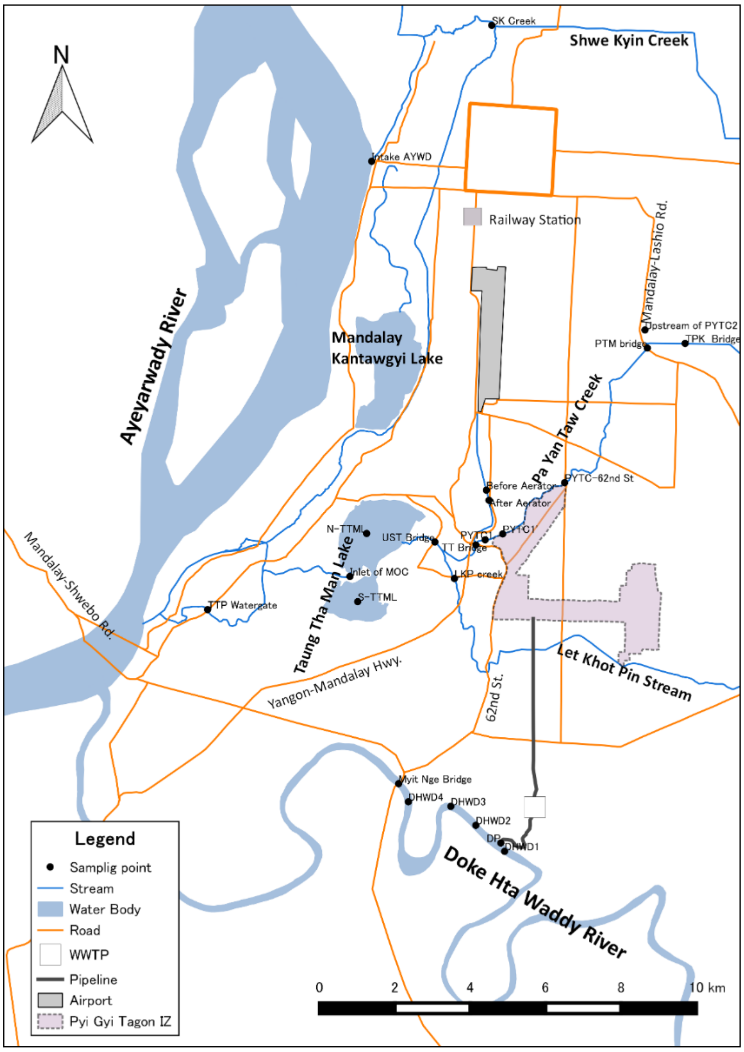
3.3.3 Industrial Activities

Table 3-4 shows the industrial zone in the pilot area of Mandalay. There is the only one industrial zone; named "Pyi Gyi Tagon industrial zone" in Mandalay City. Around 1,400 factories are located in the indusrial zone which opened in during 1990. The major sectors are general, mineral, and food and beverage factories. shows location of the Pyi Gyi Tagon industrial zone in the pilot area of Mandalay.

Table 3-4 Industrial Zones in the Pilot Area of Yangon

Industrial Zone	Township	Established Year	Area [ha]	Number of Factories (2012)	Main Sectors
Pyi Gyi Tagon	Pyi Gyi Tagon	1990	501.5	1379	1. General 2. Mineral 3. Food and Beverage

Source: Myanmar Industrial Association

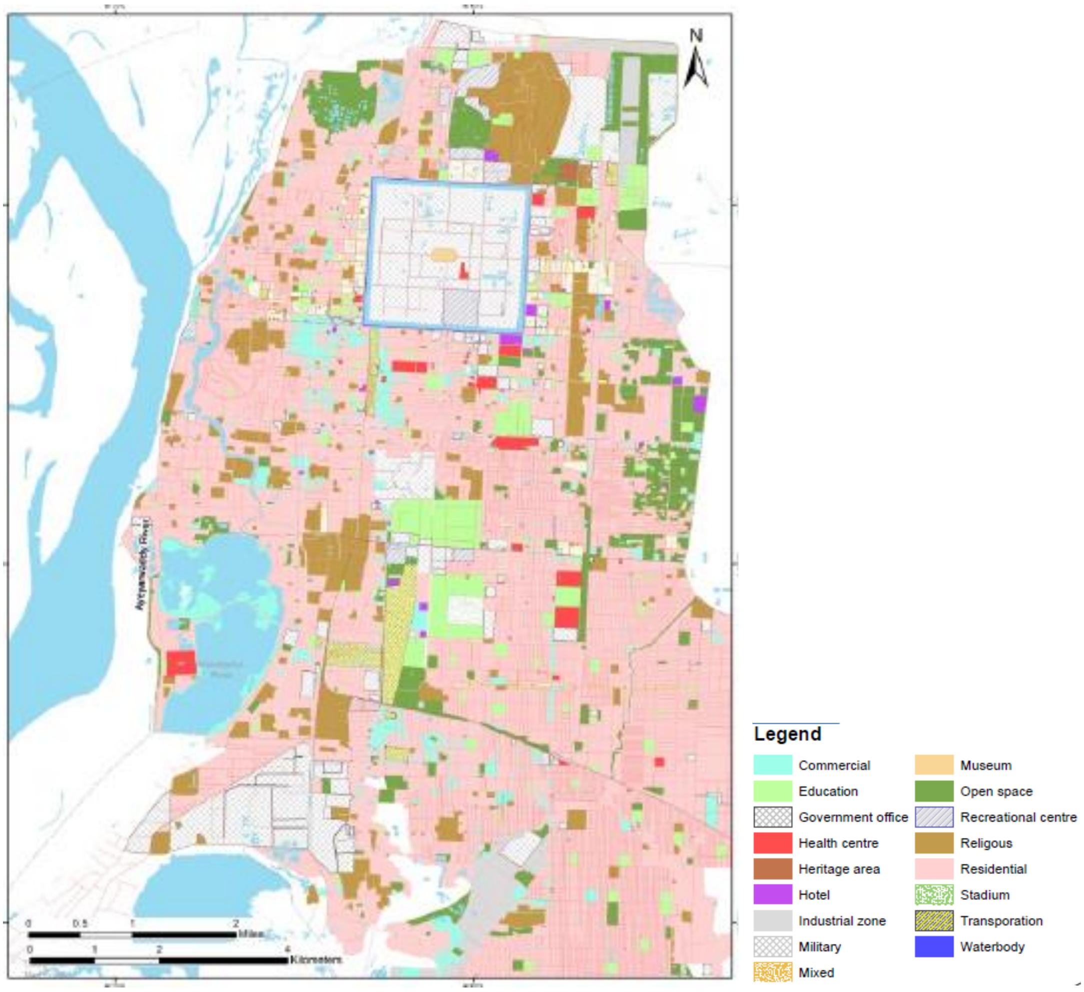


Source: JET

Figure 3-6 Location of Pyi Gyi Tagon Industrial Zone in Mandalay City

3.3.4 Land Use

Figure 3-7 shows land use map in Mandalay City in 2014, the largest portion is residential area, and followed by military and heritage areas. Outside of the map, Pyi Gyi Tagon Industrial Zone is located in the western part of the city and agricultural area is also located in west from the Mandalay City.



Source: Land Use/Land Cover Change Mapping of Mandalay City presented by Dr. Myint Myint Khaing, Mandalay Technology University (International Land Cover/Land Use Changes Regional Science Team Meeting in South/Southeast Asia, 2016)

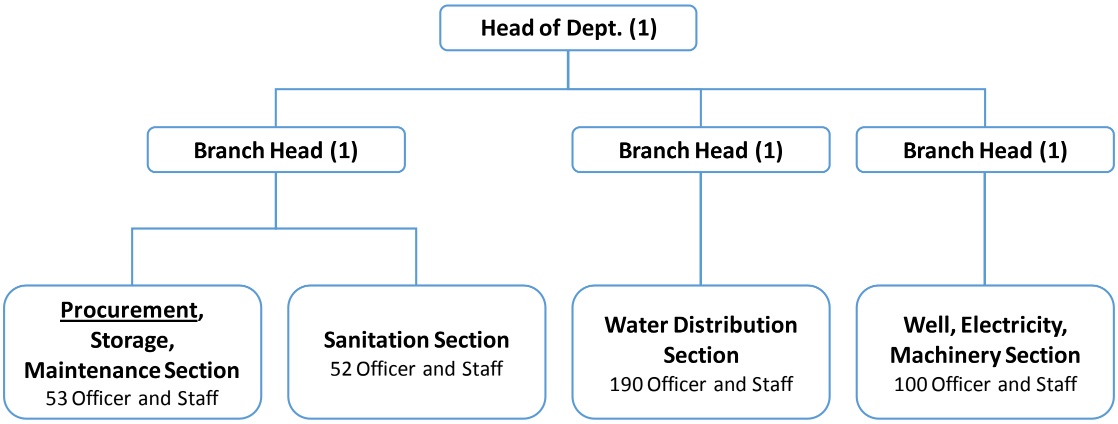
Figure 3-7 Land Use Condition in Mandalay City

3.4 ORGANIZATIONS RELATED TO WATER ENVIRONMENT MANAGEMENT

3.4.1 Mandalay City Development Committee

(1) *Water and Sanitation Department*

The Water and Sanitation Department (MCDC-WSD) is responsible for the water supply and distribution, wastewater treatment, and water environmental monitoring in Mandalay City. MCDC-WSD has one head of department, one deputy head of department, more than 400 officers and staffs as of May 2014, and consists of four sections: (i) Procurement, storage, maintenance section, (ii) Sanitation section, (iii) Water distribution section, and (iv) Well, electricity, machinery section as shown in Figure 3-8. Main activities of MCDC-WSD related to water environment management are: (i) wastewater treatment, (ii) surface and industrial water quality monitoring, and (iii) laboratory analysis under Sanitation section.

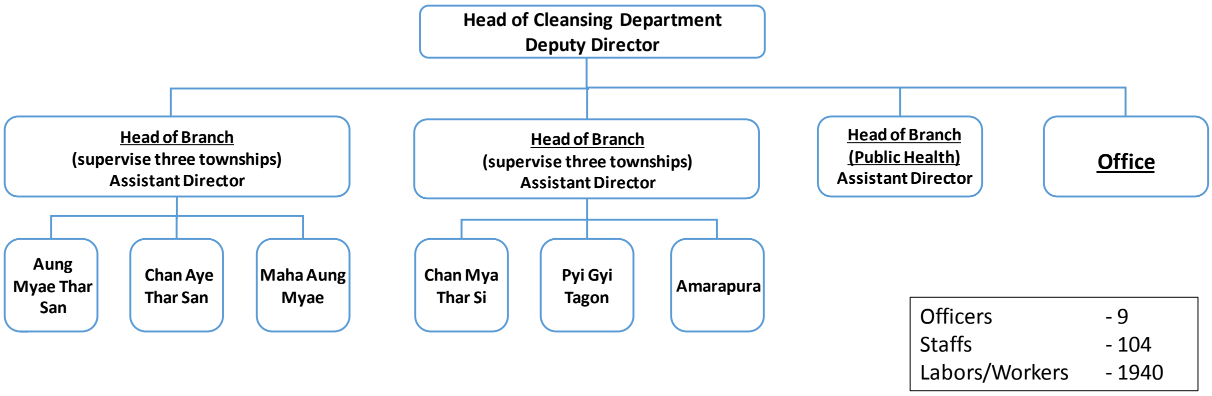


Source: MCDC-WSD (JET modified based on "PREPARATORY SURVEY for the Project for Implement of Water Supply System in Mandalay City in Japanes", JICA, 2015)

Figure 3-8 Organization Chart of MCDC-WSD

(2) *Cleaning Department*

The Cleaning Department (MCDC-CD) is in charge of solid waste management, license issuance and inspection including pollution control in Mandalay City. CD has more than 2,000 officers, staffs, workers and consists of: (i) Branch controlling three townships, (ii) Branch controlling three townships including Pyi Gyi Tagon township, (iii) Head of Branch for Public Branch, and (iv) other offices as shown in Figure 3-9. Main activities of MCDC-CD related to water environment management are (i) inspection, and (ii) solid waste management.

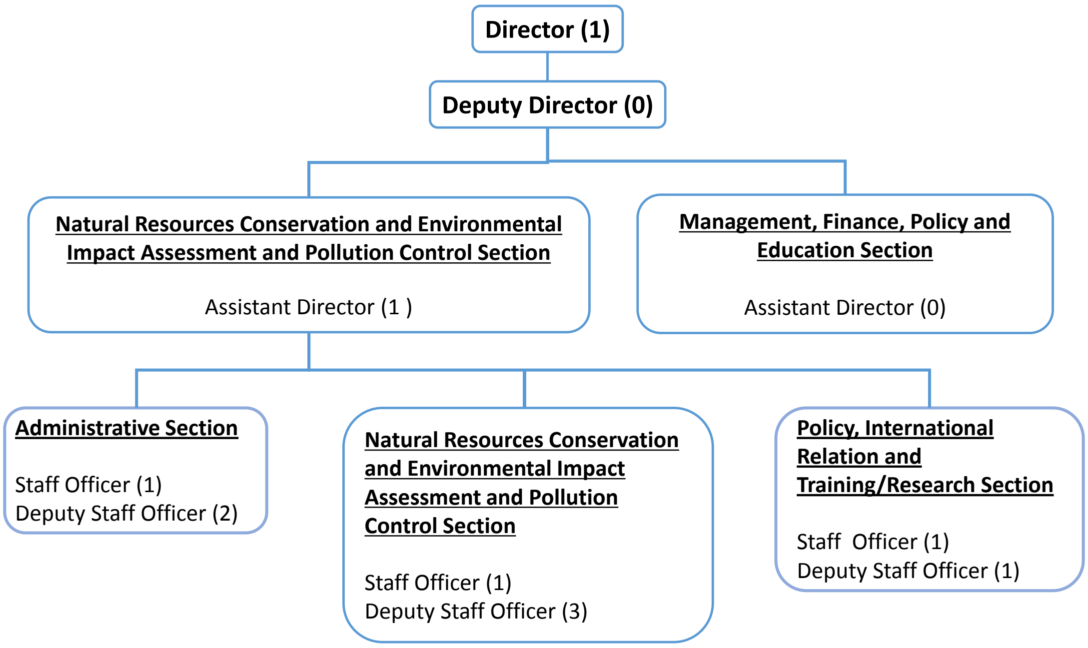


Source: MCDC-CD (as of 2016

Figure 3-9 Organization Chart of MCDC-CD

3.4.2 ECD Mandalay

ECD Mandalay was established in 2013 and has 21 officers in total: one Director, one Assistant Director, three Staff Officers and six Deputy Staff Officers. ECD Mandalay has two sections (Natural Resources Conservations, EIA and PCD section and Management, Finance, Policy and Education section), but there is no staff for Management, Finance, Policy and Education section as of December 2015 as shown in Figure 3.6. Main activities of ECD Mandalay related to water environment management include conducting/joining inspections and environmental education to school children. As for activities of inspections, there are three types of inspections: (i) conducting inspection by ECD Mandalay, (ii) joining inspection by Ministry of Industry (MOI), (iii) joining inspection by MCDC.



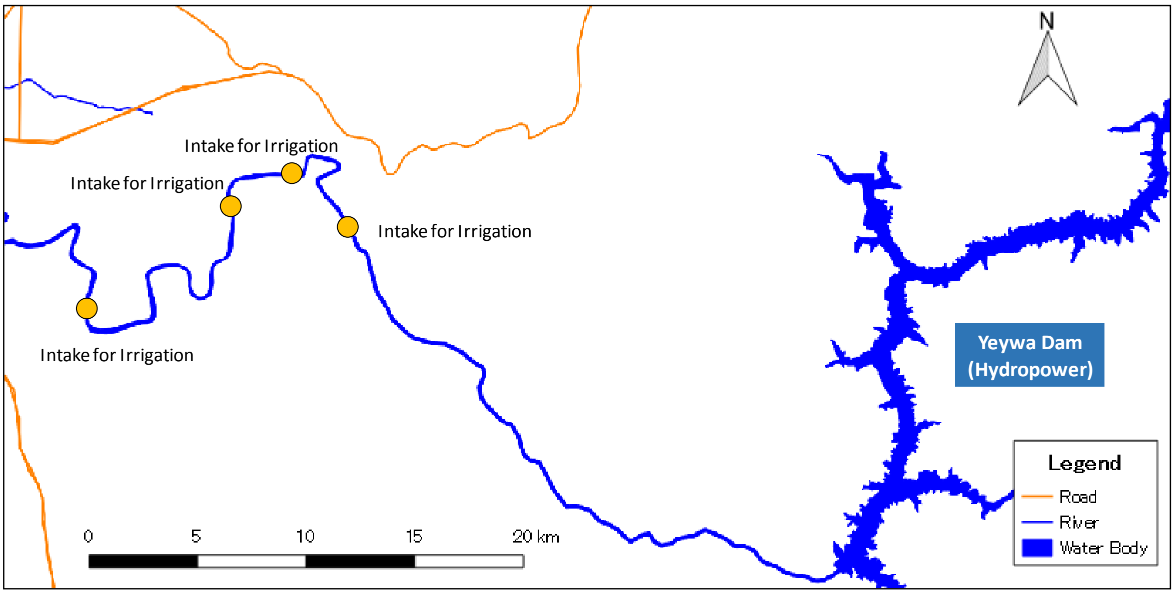
Source: JET based on the hering from ECD Mandalay (as of 2016)

Figure 3-10 Organization Chart of ECD Mandalay

3.5 WATER USE

(1) *Upstream Area*

In the upstream area of Doke Hta Waddy River, main water uses are hydropower and irrigation as shown in Figure 3-11. Yeywa Dam is the largest hydropower dam in Myanmar (790 MW) which has been in operations since 2010. According to Electric Power Generation Enterprise (EPGE), Ministry of Energy and Electricity (MOEE), the average monthly water discharge at highest and lowest month in 2016 are in August (1,160 m^3/s) and in March (210 m^3/s). There are four main intake points for irrigation in the upstream of the river.

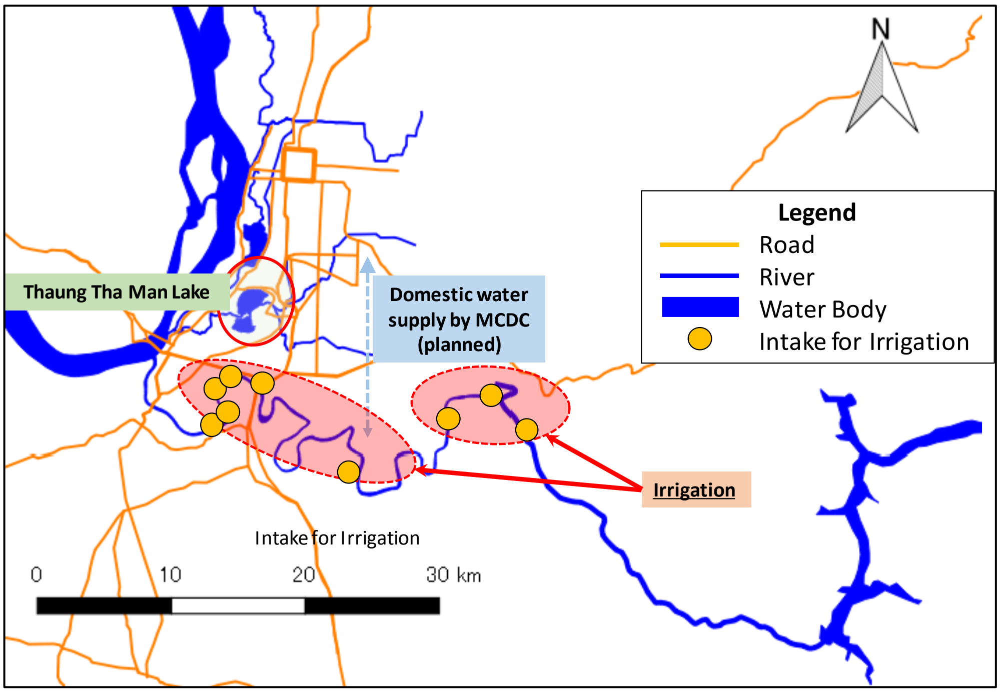


Source: JET based on MOEE, MOALI and dataset prepared by MIMU

Figure 3-11 Water Uses in the upstream of Doke Hta Waddy River

(4) Downstream Area

In the downstream area of Doke Hta Waddy River, main water uses are irrigation as shown in Figure 3-12. Some individual water uses for domestic (drinking, washing and bathing), recreation (swimming), navigation, and fisheries are also found. There are ten intake points for irrigation in the downstream of the river. A water treatment plant for domestic water supply is planned by MCDC in the downstream area of the river. Taung Tha Man Lake is an important water body for fishery, agriculture, and tourism in Mandalay City.



Source: JET based MCDC, MOALI and dataset prepared by MIMU

Figure 3-12 Water Uses in the downstream of Doke Hta Waddy River

3.6 Water Quality

3.6.1 Outline of water quality survey in the pilot area of Mandalay

The water quality surveys were conducted in total five times targeting one time in the rainy season and another time in the dry season for each year. Table 3-5 summarizes water quality survey plan for the Doke Hta Waddy River Basin. The map of sampling points of the surveys is shown in Figure 3-21.

Table 3-5 Summary of Water Quality Survey Plan for Doke Hta Waddy River Basin

Item	Contents
Sampling Point	Doke Hta Waddy River: 3 – 4 points, depending on the survey time Wastewater pipeline discharging to Doke Hta Waddy: 1 point Taung Tha Man Lake: 2 – 3 points Flow path to Taung Tha Man Lake :4 – 7 points depending on the survey time Ayeyarwaddy River: 0 – 1 point, depending on the survey time Shwe Kyin Creek: 0 – 1 point, depending on the survey time
Sampling Time	1st survey: dry season in 2016 2nd survey: rainy season in 2016 3rd survey: dry season in 2017 4th survey: rainy season in 2017 5th survey: dry season in 2018
Measurement Parameters	[All points]

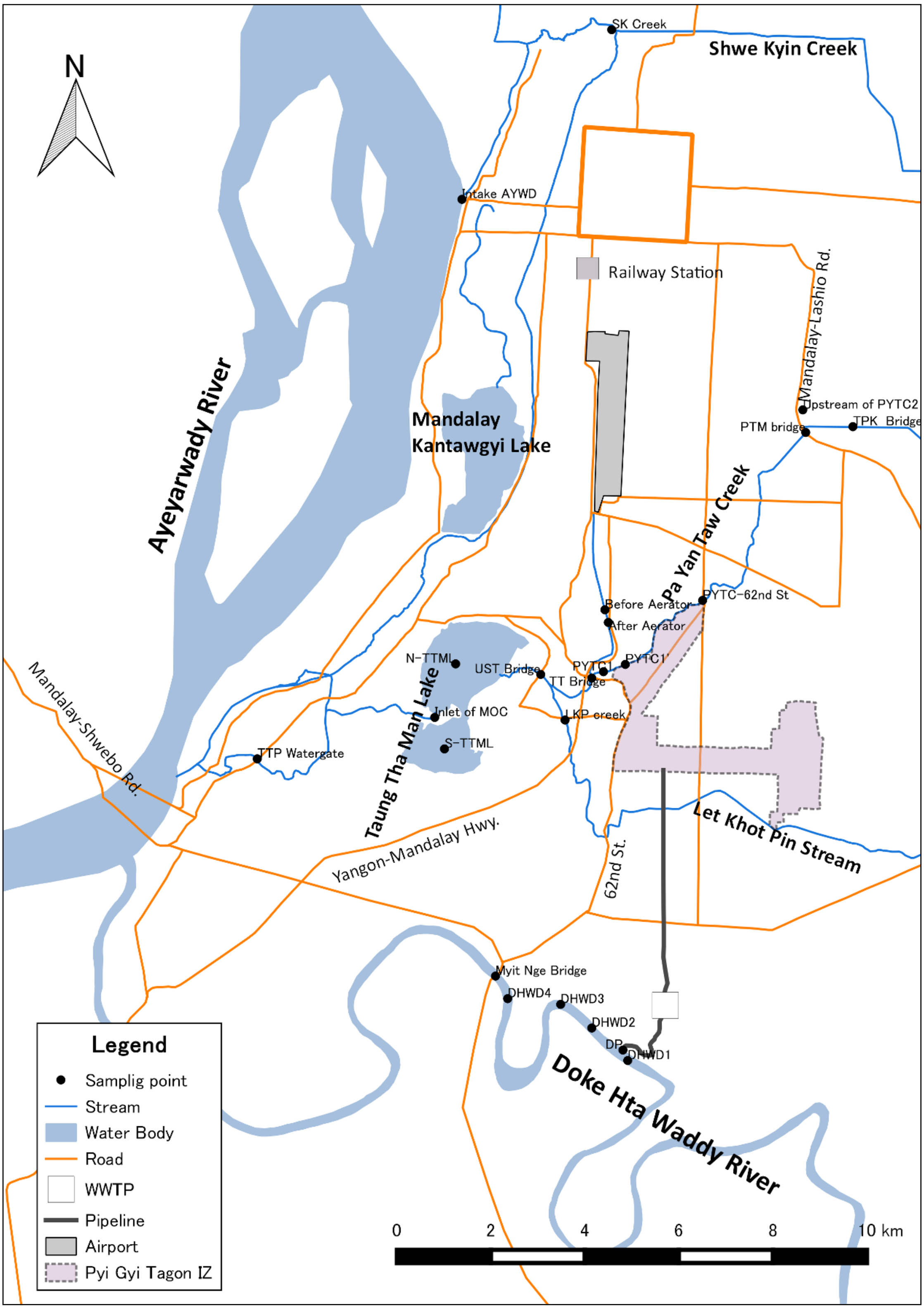
Item	Contents
	pH, EC, DO, TDS, salinity, turbidity, water temperature, ORP [Basic points] Flow rate (if available), TSS, BOD, COD, oil and grease, total coliform [Representative points] Total phosphorus, total nitrogen, cyanide, phenols, zinc, total chromium, hexavalent chromium, arsenic, total mercury, cadmium, and lead Color, odor, iron and manganese in the 1st survey Copper phosphate, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen in the 1st – 3rd surveys [Only one or two points] Pesticides* and PCB

* Total organic chlorine pesticides and total organic phosphorus pesticides for second and third surveys.
* Aldrin, atrazine, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, endosulfan, endosulfan sulfate, endrin, HCH-alpha (benzene hexachloride-alpha), HCH-beta, HCH-delta, HCH-gamma(Lindane), alachlor, diazinon, chlorpyrifos, dimethoate and imidacloprid for fourth and fifth surveys

Source: JET

3.6.2 Overall view on water quality in the Doke Hta Waddy River

The overall view on water quality in Doke Hta Waddy River basin is described below. All measurement results are shown in the “Water Quality Survey Report (Appendix 10)”.



Source: JET

Figure 3-13 Sampling Points of Water Quality Surveys in Doke Hta Waddy River Basin

(1) *Pollution impact of the industrial wastewater to Doke Hta Waddy River*

- The Doke Hta Waddy River seems to have adequate water quality for domestic water supply with water treatment facility using filters and other ordinary means. The level of organic pollution does not appear to be very high. None of the results in this project showed elevated levels of toxic substances. The water quality did not dramatically vary in seasons or from point to point. See Table 3-6 for the results of BOD and COD, and see Table 3-7 for the results of water qualities at future intake points compared with drinking water quality guideline value.

- Until the 3rd water quality survey in February 2017, the wastewater discharged from 10-inch pipeline contained high concentrations of pollutants that included oil and grease, phenols and hexavalent chromium in addition to organic materials and nutrients. The concentrations of these pollutants were higher than the guideline values applied to general wastewater (general application, National Environmental Quality (Emission) Guidelines, 2015). It was noted that the pollution impact of this 10-inch pipe wastewater on water quality of Doke Hta Waddy River was limited because of the large dilution capacity of the river, though localized pollution and adverse impact such as unpleasant odor affecting residents in the vicinity of the discharging point, were undeniable.

- After several distilleries in Pyi Gyi Tagon IZ shut down their operation temporarily from June - August 2017 under instructions from the Mandalay Region Government and MCDC, the pollution load decreased from the 10-pipe line. However, the wastewater discharges still contained oil and grease, phenols, and other pollutants.

- The concentrations of pollutants in the dry season was higher than those in the rainy season for most sampling points and for most parameters. This is similar to the Hlaing River basin (Figure 3-14). On the other hand, the pollution loads of organic substances, i.e., BOD and COD, in Doke Hta Waddy River in October 2017 seemed larger than those in February 2018 (DHWD-1 in Figure 3-20). It indicated that the storm water in the rainy season flushed more organic substances with soils from the upper basin to the river, though the concentrations of organic substances is not higher because of the dilution effect.

Table 3-6 Classification of BOD and COD Levels in Doke Hta Waddy River Basin

Unit: mg/L

Target		BOD						COD					
		Rainy Season(Sep 2017)			Dry Season(Feb 2018)			Rainy Season(Sep 2017)			Dry Season(Feb 2018)		
		Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
River	Doke Hta Waddy River	1.1	5.4	3.7	4.7	5.7	5.0	4.2	6	5.2	2.8	5.2	3.6
	Ayeyarwaddy River	5.4			4.7			11			4.4		
Lake	Taung Tha Man Lake	5.4	6.0	5.7	23	357	190	28	28	28	130	280	205
Creek	Inflow to Taung Tha Man Lake (LKP Stream, UST Bridge, Pa Yan Taw Creek, Columbo Creek)	2.3	6.6	4.4	9.8	354	206	14	70	32	21	540	209

Vietnamese Environmental Standard(QCVN08:2015) for reference

Water Usage		BOD	COD
A1	For domestic water supply	4	10
A2	For domestic water supply with treatment and conservation of aquatic lives	6	15
B1	For irrigation	15	30
B2	For water transportation and other purposes with demand for low-quality water	25	50
Less than B2		>25	>50

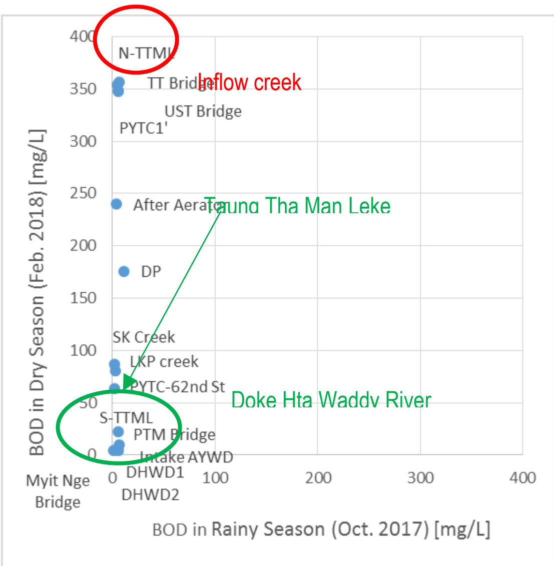
Source: JET

Table 3-7 Comparison with Draft Drinking Water Quality Standard for Existing/Possible Domestic Water Supply (Doke Hta Waddy River Basin)

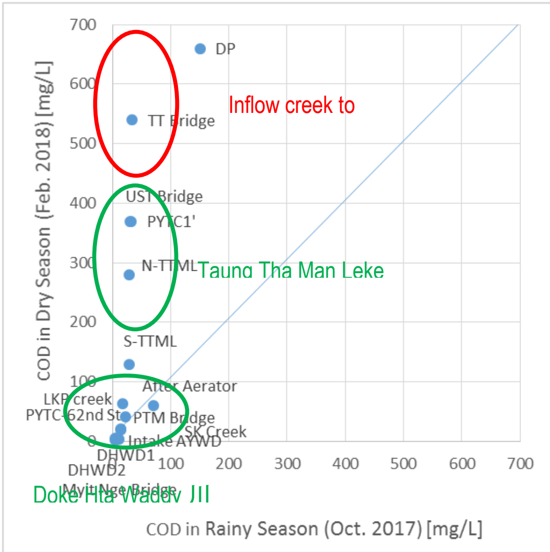
Location Name	Unit	DHWD1		Intake AYWD		MOH Draft National Drinking Water Quality Std(2014)
		Sep 2017	Feb 2018	Sep 2017	Feb 2018	
pH	-	8.40	8.15	7.88	8.06	6.5 - 8.5
Turbidity	NTU	39.5	9.5	74.1	80	5
TDS	mg/L	160	0.245	133	0.101	1000
Cyanide(total)	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	0.07
Zinc (Zn)	mg/L	0.0081	< 0.005	0.0087	0.0078	3
Total chromium (T-Cr)	mg/L	0.0058	< 0.005	0.0056	< 0.005	0.05
Arsenic (As)	mg/L	0.0016	0.0023	0.0017	0.0013	0.05
Copper (Cu)	mg/L	< 0.005	< 0.005	< 0.005	0.014	2
Total Mercury (Hg)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.001
Cadmium (Cd)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.003
Lead (Pb)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	0.01
Pesticides	mg/L		-	< 0.0005	< 0.0005	Specified for some parameters respectively

(blue) : Satisfied with reference standard
(yellow) : Not satisfied with reference standard

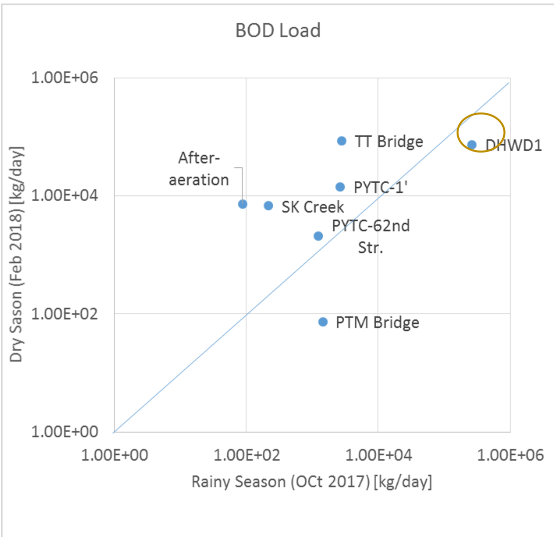
Source: JET



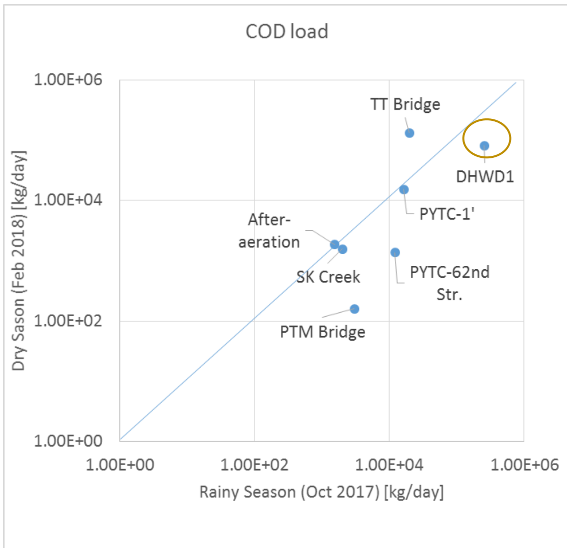
BOD Concentration



COD Concentration



BOD Load



COD Load

Source: JET

Figure 3-14 Water Quality and Pollution Load Changes between Rainy Season and Dry Season (Doke Hta Waddy River Basin)

(2) *Pollution level of Taung Tha Man Lake*

- The water quality in Taung Tha Man Lake is characterized as eutrophic. The lake manifested traits like higher phosphorus and nitrogen concentrations compared to general indicators for eutrophication: 0.01 mg/L for total phosphorus and 0.15 mg/L for total nitrogen (USEPA, Nutrient Criteria Technical Guidance Manual, 2000), and has relatively low DO but high COD and pH.

- As a whole, the water quality in the lake significantly deteriorated in the dry season compared with the rainy season (Table 3-8 and Figure 3-15) especially in February 2018, when the nutrient level was very high (4.3 mg/L for total phosphorus and 25 mg/L of total nitrogen) in the northern lake. At that period, the lake’s water level was quite low and the water area was enclosed without enough water exchanges between the lake and other water bodies in the dry season. In such condition, the influent nutrients are further accumulated in the lake and will likely increase algae and phytoplankton and may result in internal organic production, which accelerates eutrophication. There is no doubt that the lake is eutrophic, even hypereutrophic. However, the detailed eutrophication mechanism in the lake is not clear and complicated. Since the water quality in the lake has changed or fluctuated dramatically over time or with seasons, further monitoring data is necessary to examine the mechanism of water pollution in the lake.

- The creek flowing through U Shwe Taung Bridge, which is a confluence of Pa Yan Taw creek, Let Khot Pin stream and Columbo creek, is one of the major pollution paths to Taung Tha Man Lake. Among these creeks, the highest pollution loads of organic material and nutrients were found in Pa Yan Taw creek except the total nitrogen in the dry season. This implies that the Pa Yan Taw creek basin would be given the highest priority for pollution control measures among these three basins in order to reduce the load to Taung Tha Man Lake. Pollution control measures based on pollution load are discussed in Section 3.6.2.

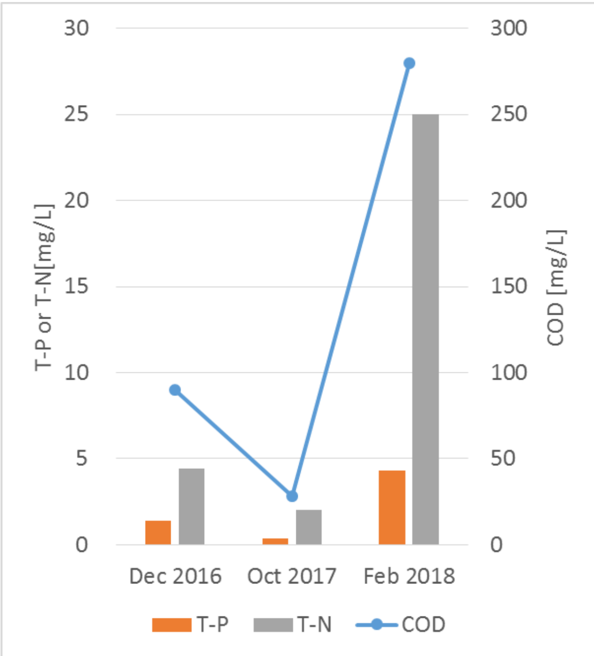
- In addition to BOD and COD, moderate levels of oil and grease (max. 10 mg/L) and phenols (max. 0.06 mg/L) were detected from these creeks, which are considered to originate from domestic wastewater and industrial wastewater.

- Harmful levels of toxic substances for human health such as heavy metals were not detected.

Table 3-8 Nutrients Level in Taung Tha Man Lake

mg/L

Location Name		Total Phosphorus		Total Nitrogen	
		Oct 2017	Feb 2018	Oct 2017	Feb 2018
N-TTML		0.38	4.3	2.0	25
S-TTML		0.36	1.7	1.7	9.2
Comparison with Japanese Environmental Standard (lake) for reference					
I	Conservation of natural environment	0.005 mg/L or less		0.1 mg/L or less	
II	Water supply for purify water using filters and other simple means, fishery for salmon/troun, sweetfish, bathing etc.	0.01 mg/L or less		0.2 mg/L or less	
III	Water supply for purify water using pre-treatment and other advanced methods	0.03 mg/L or less		0.4 mg/L or less	
IV	Fishery for smelt etc.	0.05 mg/L or less		0.6 mg/L or less	
V	Fishery for smelt etc., industrial water, agricultural water, and conservation of the environment	0.1 mg/L or less		1 mg/L or less	
Remarks	1 Standard values are based on daily average values. 2 Standard values for total phosphorous are not applicable to water for agricultural use.				



Source: JET

Figure 3-15 Water Quality Changes in Northern Taung Tha Man Lake

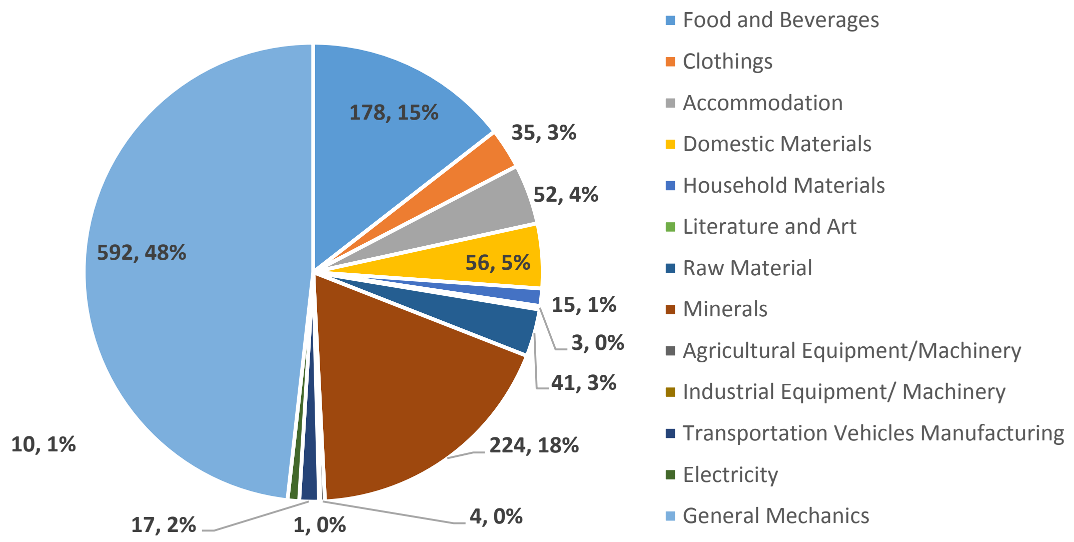
3.7 Pollution Sources

3.7.1 Industrial Pollution Sources

(1) *Factories in Industrial Zones*

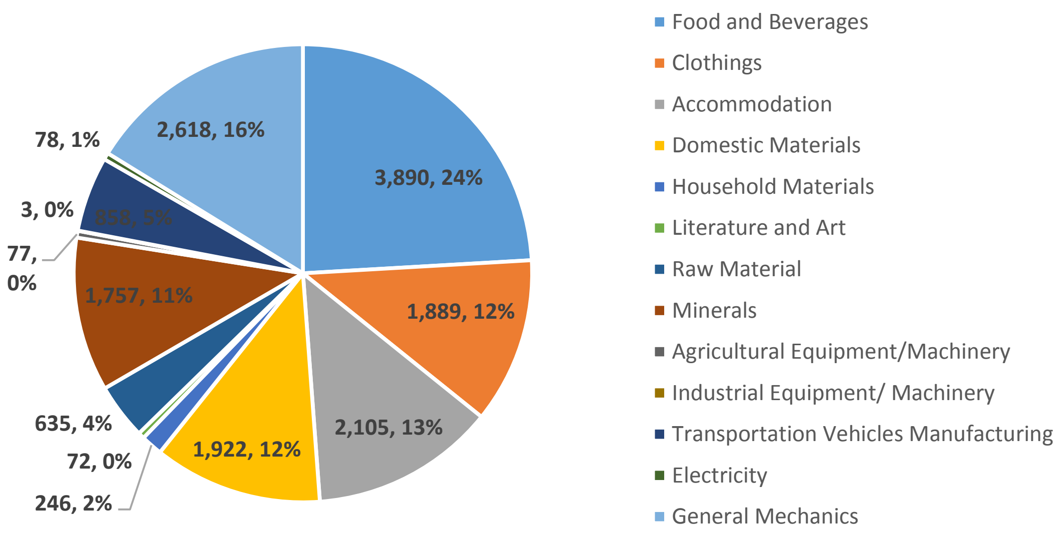
In Mandalay, there are 1,228 DISI-registered factories in Pyi Gyi Tagon IZ as shown in Figure 3-16 of which 48% is from general mechanics sector such as small machine shops, 18% is from mineral sector such as metal processing, and 15% is food and beverage sector including distilleries.

The number of employees in Pyi Gyi Tagon IZ is shown in Figure 3-17 where 24% is from food and beverage sector and is considered as the largest number of employees, 16% is from general mechanics sector, and 13% is from accommodation sector. While the number of factories in Pyi Gyi Tagon IZ (1,228 factories) is comparable to those of IZs in the Hlaing River basin in Yangon (1,083), only 16,150 people are employed by factories in Pyi Gyi Tagon IZ, compared to 90,211 in Hlaing River basin. Factories in Pyi Gyi Tagon IZ are much more small-scaled than those in IZs in Hlaing River basin.



Source: JET based on DISI's data

Figure 3-16 Number of Factories in Industrial Zones in Doke Hta Waddy River Basin



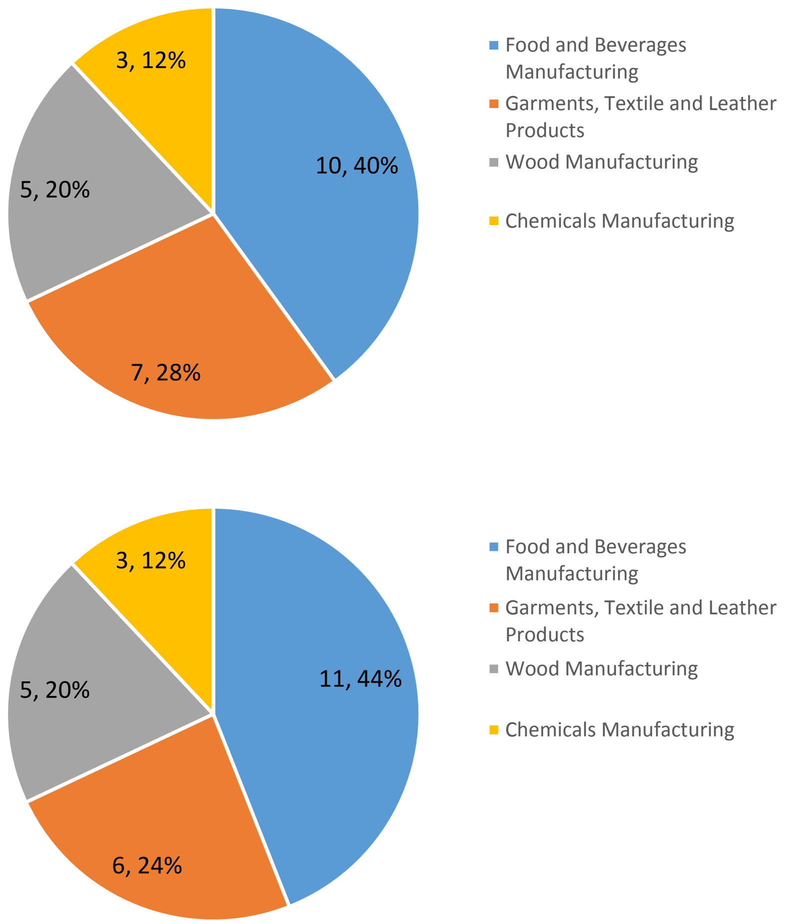
Source: JET based on DISI's data

Figure 3-17 Number of Employees in Industrial Zones in Doke Hta Waddy River Basin

(1) *Industrial Effluent Status*

25 factories that were considered major dischargers and/or representatives of the industrial sectors in the Doke Hta Waddy River Basin were selected, and wastewater samples were collected and analyzed in the summer of 2016[5]. Figure 3-18 shows target sectors for wastewater sampling in the Period 1 and Period 2. The analytical parameters were selected based on NEQEG (2015) of corresponding sectors so that percentage of factories meeting the guideline could be evaluated. A follow-up survey was implemented from August to September 2017 targeting 25 factories. In 2017, some effluent samples were analyzed not only in Myanmar and Thailand but also in Japan to confirm data reliability. Details of both surveys in 2016 and 2017 are available in the "Pollution Source Survey Report (Appendix 13)".

[5] Some of the results, such as the analytical results of total nitrogen, were deemed suspicious.



Source: JET

Figure 3-18 Target Sectors for Wastewater Sampling in Period 1 (Upper) and Period 2 (Lower) in Doke Hta Waddy River Basin

1) Organic Pollution and Nutrient

Table 3-9 and Table 3-10 show effluent concentrations of BOD and COD. The values of NEQEG for BOD and COD are 50 mg/L for BOD and 250 mg/L, respectively, for most industrial sectors. It should be noted that NEQEG (2015) was not legally-binding even at the time of the follow-up survey in 2017 and thus, these factories have no obligation to satisfy the guideline. Although some target factories in Period 2 are different from those in Period 1, there was no difference in the trend that most of the wastewaters did not meet the guideline values for BOD and COD.

Table 3-9 Comparison Results of BOD (Period 1 and Period 2) in Doke Hta Waddy River Basin

Category	Period 1 (in 2016)	Period 2 (2017)
0-20 mg/L	2	0
20-50 mg/L	1	0
50-100 mg/L	2	0
100-1,000 mg/L	6	16
1,000- mg/L	8	9
No Data	6	0
Total	**25**	**25**

Note: The BOD value of NEQEG is “50 mg/L”.
Source: JET

Table 3-10 Comparison Results of COD (Period 1 and Period 2) in Doke Hta Waddy River Basin

Category	Period 1 (in 2016)	Period 2 (2017)
0-100 mg/L	1	0
100-250 mg/L	2	1
250-1,000 mg/L	4	2
1,000-2,000 mg/L	1	9
2,000- mg/L	11	13
No Data	6	0
Total	**25**	**25**

Note: The COD value of NEQEG is “250 mg/L”.
Source: JET

Table 3-11 summarizes the results of comparison with the guideline values for BOD, COD, total nitrogen (T-N) and total phosphorus (T-P) which are different by sector. Wastewater from around 60% of factories (12 out of 19 factories for T-N and 12 out of 19 factories for T-P) met the guideline values of T-N and T-P. T-N, and T-P are high ratio of meeting the guideline value than the value for BOD and COD because no factories met the guideline value for BOD and only around 10% of factories (3 out of 20 factories for COD) met the guideline value for COD.

Table 3-11 Comparison Results of BOD, COD, T-N, and T-P with NEQEG in Mandalay (Period 2)

Category	BOD	COD	T-N	T-P
Equal to or under NEQEG Value	0	3	12	12
Over NEQEG Value	20	17	7	8
No Evaluation	5	5	6	5
Total	25	25	25	25

Note: "Pulp and / or Paper Mills" have NEQEG value with different unit as "kg/Air dried metric ton" and some sectors do not have NEQEG value for these parameter.
Source: JET

2) Heavy Metals, Toxic Substance

In the 2016 survey, differences in wastewater quality were investigated by sector but some of the data were deemed not reliable. Thus, in the follow-up survey in 2017, wastewaters from the total 9 factories representing different sectors, such as distillery, textile manufacturing, tanning and leather finishing, etc., were analyzed at a certified laboratory in Japan. They were selected considering their potential impacts on water environment (e.g. volume of wastewater, concentration of main parameters such as BOD or COD, existence of heavy metal pollutants, etc.). Although the number of investigated factories in each sector was very limited (see Table 3-12), the results confirmed the general characteristics of different sectors as follows:

- Phenol and Sulfate were detected from both factories of "Tanning and Leather Finishing" sector investigated.
- Total Chromium was detected from the wastewater of one of the "Tanning and Leather Finishing" factories. It was noted that many tanneries in Myanmar employ vegetable tanning method.
- Zinc, Mercury and Manganese were detected from the wastewater of one battery factory as "Semiconductors and Other Electronics Manufacturing".
- Zinc was detected from the "Textiles Manufacturing" factories.

Table 3-12 Number of Target Factories for each Sector (analyzed in Japan)

No.	Serial Number (NEQEG)	Sector	Number of Factories
1	2.3.1.4	Food and Beverage Processing	1
2	2.3.1.8	Breweries and Distilleries	2
3	2.3.2.1	Textiles Manufacturing	1
4	2.3.2.2	Tanning and Leather Finishing	2
5	2.3.3.3	Pulp and / or Paper Mills	1
6	2.3.4.8	Pharmaceuticals and Biotechnology Manufacturing	1
7	2.3.7.5	Semiconductors and Other Electronics Manufacturing * Battery factories were selected.	1
Total			9

Source: JET

3.8 Impact of Pollution on River/ Lake Water Quality

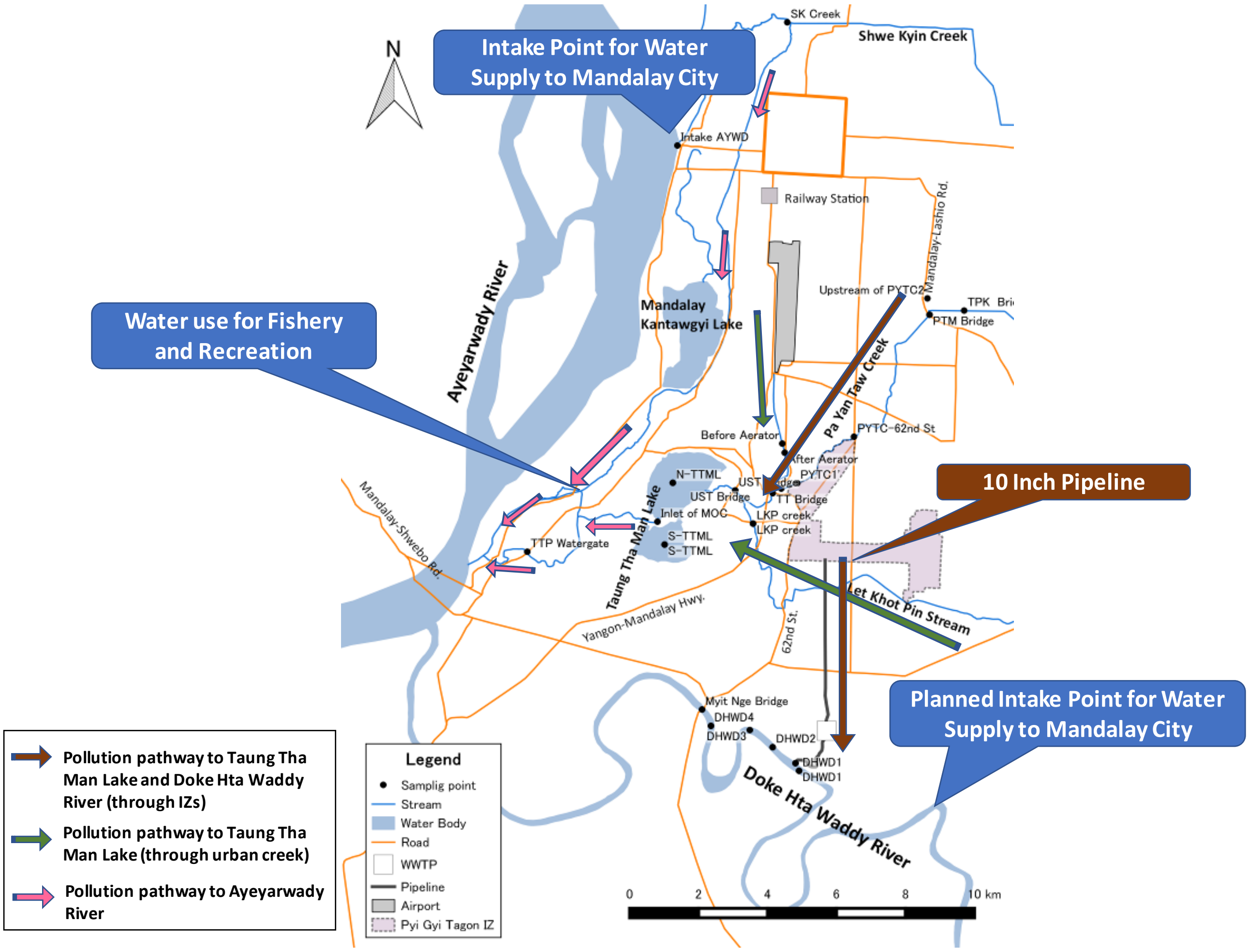
3.8.1 Overall pollution pathways to rivers and lakes

Figure 3-19 shows the pollution pathways with locations of industrial zones and intake points for water supply in Mandalay City and its surrounding area. The pollution pathways in Mandalay City are divided into two areas: (i) Taung Tha Man Lake basin in the central and east part of Mandalay City, and (ii) Shwe Kyin Creek, Mandaly Kantawgyi Lake, and some small creeks in west part of Mandalay City. In the central and east part of Mandalay City, pollution from Pa Yan Taw Creek, Let Khot Pin Stream, other small creeks and drainages reaches Thaung Tha Man Lake then discharges to Ayeyarwaddy River. Among the creeks and stream, Pa Yan Taw Creek flows through Pyi Gyi Tagon industrial zone into the lake. In the west part of the city, pollution from Shwe Kyin Creek, Mandalay Kantawgyi Lake, and some small creeks reach

Ayeyarwaddy River directly, so this area was excluded from the pilot area because the wastewater in west part of Mandalay City is not linked with Doke Hta Waddy River.

Doke Hta Waddy River is located in the southern part of Mandalay City and the wastewater from Pyi Gyi Tagon IZ is collected through a 10-inch-pipeline constructed by MCDC and discharged to the river. MCDC has entrusted a private company to construct a centralized wastewater treatment plant by Build-Operation-Transfer (BOT) scheme in the outskirt of the industrial zone before the outlet of the pipeline to the river.

As for intake points for domestic water supply from rivers, there is currently one and another one being planned by MCDC: (i) intake point from Ayeyarwaddy River for water supply to Mandalay City, and (ii) planned intake point at 10km upstream from the discharge point of the 10-inch-pipeline in Doke Hta Waddy River. As for other water use, Taung Tha Man Lake is used for fisheries, recreation, and flood control. Doke Hta Waddy River is used for irrigation, ship navigation, recreation, and domestic for residences along the river.



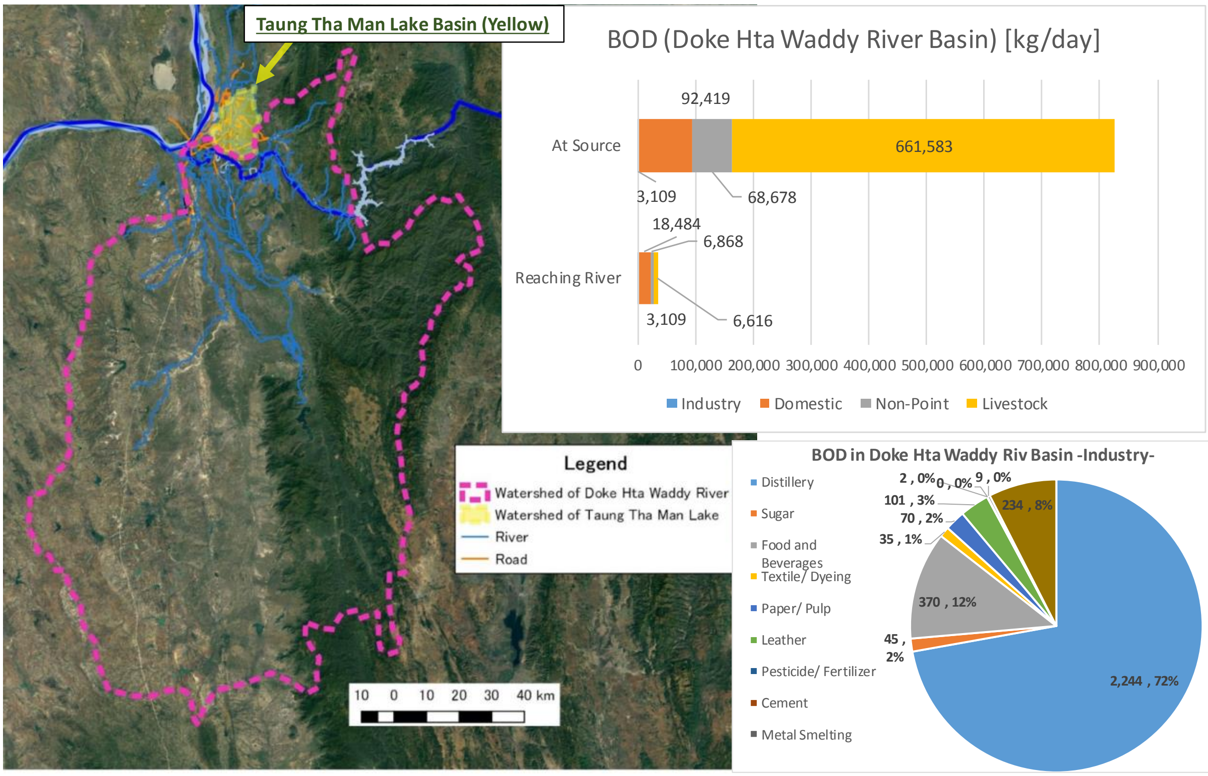
Source: JET based on dataset prepared by MIMU

Figure 3-19 Pollution Pathways to Rivers with Locations of Industrial Zones and Existing and Planned Intake Points for Water Supply in the Pilot Area of Mandalay

3.8.2 Pollution Load Analysis

(1) *Doke Hta Waddy River basin*

The results of pollution load analysis in Doke Hta Waddy River basin (the basin from the outlet of Yeywa dam to before the confluence of Ayeyawaddy River with 17,000km^2) are summarized in Figure 3-20. 825,000 kg/day of BOD pollution load is generated in the basin and 35,000 kg/day of BOD is reaching Doke Hta Waddy River. Among 35,000 kg/day of pollution load reaching the river, 53% is from domestic wastewater, 9%[6] is from industries, 19% is from livestock, and 19% is from non-point sources. The ratio of pollution load reaching the river is less than 10% only due to natural attenuation in the basin, especially in the rural areas. The major types of industries which generate large pollution load are distillery and food and beverage, and these two industrial sectors are responsible for 84% of the BOD pollution load. The detailed results of pollution load estimation is shown in Attachment-2.



Source: JET based on dataset prepared by MIMU

Figure 3-20 Estimated Pollution Load in Doke Hta Waddy River Basin (Upper Right: Pollution Load at Source and reaching to Rivers by Sector, Lower Right: Industrial Pollution Load by Industries)

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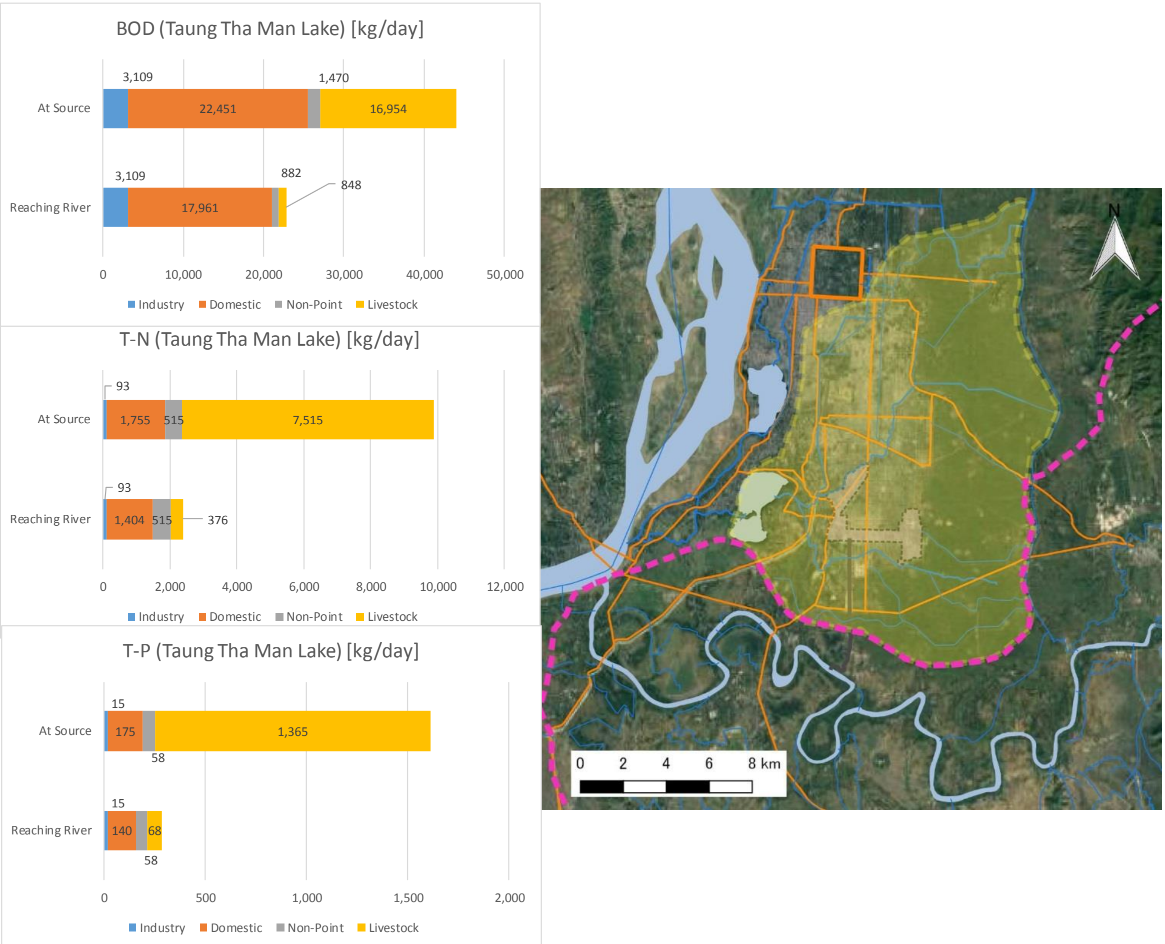
[6] Industrial wastewater from Pyi Gyi Tagon Industrial Zone is discharges in two directions: discharge to Doke Hta Waddy River through 10-inch pipeline and discharge to Taung Tha Man Lake through creeks. The amount of each wastewater discharge is fifty and fifty.

(2) *Taung Tha Man Lake basin*

The results of BOD, T-N, and T-P pollution load analysis in Taung Tha Man Lake basin are summarized in Figure 3-21. BOD pollution loads generated at source and reaching the lake are 44,000 kg/day (at source) and 23,000 kg/day (to the lake), respectively. Among the 23,000 kg/day of pollution load reaching the lake, 79% is from domestic wastewater, 13% is from industries, 4% is from livestock, and 4% is from non-point sources. As for T-N and T-P pollution loads related to eutrophication, 10,000 kg/day of T-N is generated at source while 2,400 kg/day is reaching the lake. As for T-P, 1,600 kg/day is generated at source and 300 kg/day is reaching the lake. Among the T-N and T-P pollution loads reaching the lake, 59% of T-N pollution load (50% of T-P pollution load) is from domestic wastewater, 4% of T-N (5% of T-P) is from industries, 16% of T-N (24% of T-P) is from livestock, and 16% of T-N (21% of T-P) is from non-point sources. The major pollution source of T-N and T-P is from domestic wastewater as well as BOD pollution load, whereas the second and third largest pollution load are from livestock and non-point sources. These ratios are relatively high compared with BOD pollution load. The detailed results of pollution load estimation is shown in Attachment-2.



Source: JET based on dataset prepared by MIMU

Figure 3-21 Estimated Pollution Load in Taung Tha Man Lake Basin

(BOD, T-N, and T-P Pollution Load at Source and reaching to Rivers by Sector)

3.8.3 Impact of pollution on river/ lake water quality

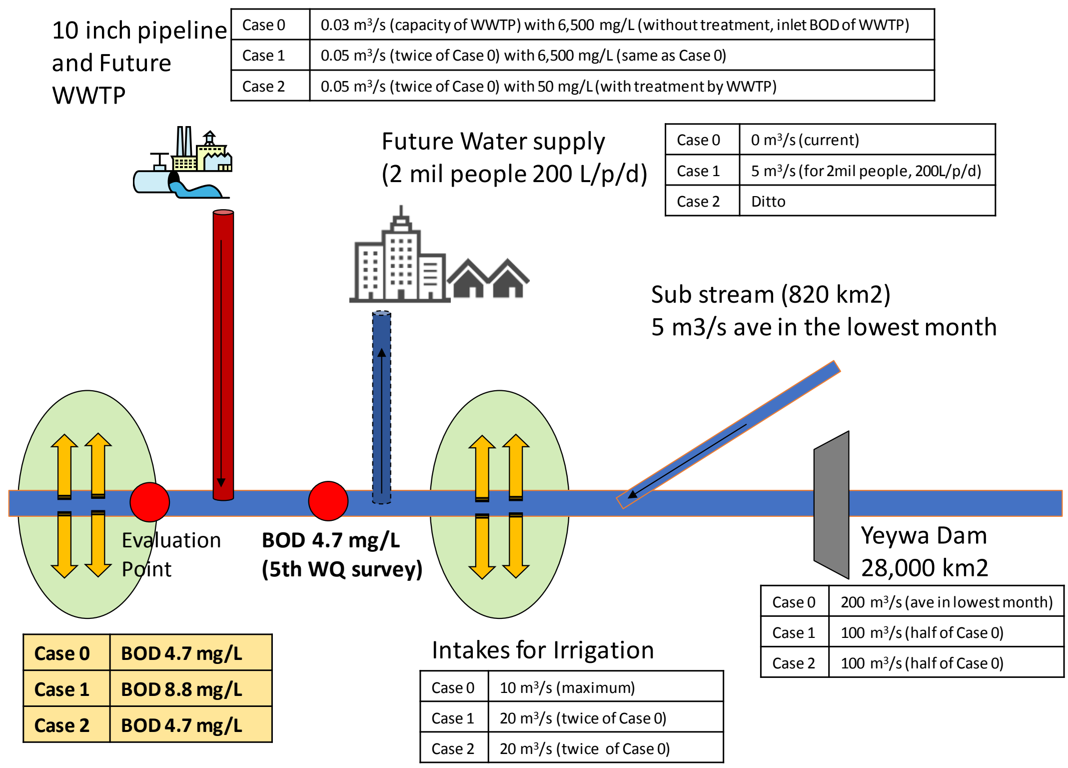
(1) *Doke Hta Waddy River*

The water quality of Doke Hta Waddy River near Mandalay City (DHWD1, DHWD2, Myint Nge bridge) met the Vietnam standard for domestic water supply (Class A1 or A2) both in the latest rainy season (September 2017) and dry season (February 2018) except for total coliform in the rainy season. This is due to the following factors:

- There are no large towns, industrial zones, and intensive agriculture/ livestock activities in the upstream area
- The river has enough capacity to receive untreated wastewater from Pyi Gyi Tagon IZ transmitted through the 10-inch pipeline[7]
- The volume of wastewater from the 10-inch-pipeline was limited at the times of water quality surveys.

In the future, MCDC has plans to utilize water for domestic supply from Doke Hta Waddy River from a point upstream of the outlet of the 10-inch-pipeline. Meanwhile, new hydropower development projects such as upper Yeywa dam project and Deedoke hydropower project, are planned in addition to the Yeywa dam development. If these hydropower projects and other industrial and urban developments would take place in the future, water quality of Doke Hta Waddy River may deteriorate due to reduced water volume from the dams and increased industrial pollution. In order to examine such impact, a preliminary study of the dilution capacity of the Doke Hta Waddy River was implemented as a case study for information interpretation (See Attachment 4). Figure 3-22 summarizes the result of the study. Compared with the current situation (Case 0), BOD concentration in the downstream of the 10-inch pipeline could double if the river flow rate decreases due to the operation of the dam(s) as well as the increased water use for irrigation and domestic water supply, and if the industrial wastewater discharge from 10-inch pipeline increases without centralized wastewater treatment (Case 1). If the operation of the centralized wastewater treatment plant started, the water quality in the downstream would remain at current level, even if the river flow decreased (Case 2).

[7] Monthly average of water discharge from Yeywa dam is around 200 m^3/s in the lowest month (Jul), 1,100 m^3/s in the highest month (Aug) according to daily data in 2016 provided by EPGE under MOEE.



Source: JET

Figure 3-22 Results of Preliminary Examination of Dilution Capacity in Doke Hta Waddy River

(2) *Taung Tha Man Lake*

As explained in Section 3.6 on the results of the water quality surveys, the water quality in Taung Tha Man Lake is characterized as eutrophic due to high phosphorus and nitrogen concentrations as well as relatively low DO and high COD in both the latest rainy season (September 2017) and the dry season (February 2018). The main stream/creeks feeding Taung Tha Man Lake are Let Khot Pin stream, Pa Yan Taw creek, and Colombo creek, and these stream/creeks are receiving pollution loads from the domestic sources in the city, including industries in the Pyi Gyi Tagon IZ not connected to the 10-inch pipeline, livestock and non-point sources. The lake water quality has worsened in the dry season due to the reduced lake water level. The water quality of the lake changes dramatically or fluctuate over time/seasons, and additional monitoring data are necessary to examine the mechanism of water pollution in the lake. As for the impact of industrial pollution to the lake, it has shown decline year by year because most of the large factories connected to the 10-inch pipeline constructed by MCDC divert the industrial wastewater to Doke Hta Waddy River.

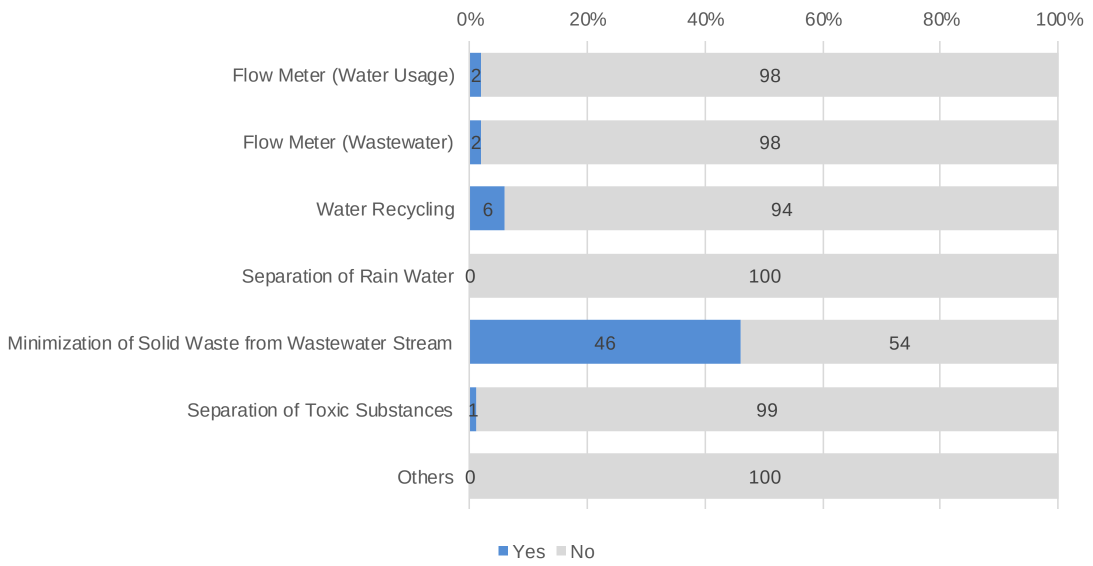
3.9 POLLUTION CONTROL ACTIVITIES

3.9.1 Pollution control measures by factories

In 2016, a questionnaire survey of 100 factories in the Doke Hta Waddy River basin was conducted to examine operations as well as environmental management of the target factories. For details, see the "Pollution Source Survey Report (Appendix 13)".

(1) *Measures to Minimize Pollution*

With respect to measures to minimize pollution, it was found that only 2% of the factories in Mandalay are equipped with water meters to monitor water usage (see Figure 3-23). Many factories are not aware of their water consumption. On the other hand, about half of the 100 factories replied that they are trying to minimize solid waste from entering wastewater stream.



Source: JET based on Pollution Source Survey in 2016

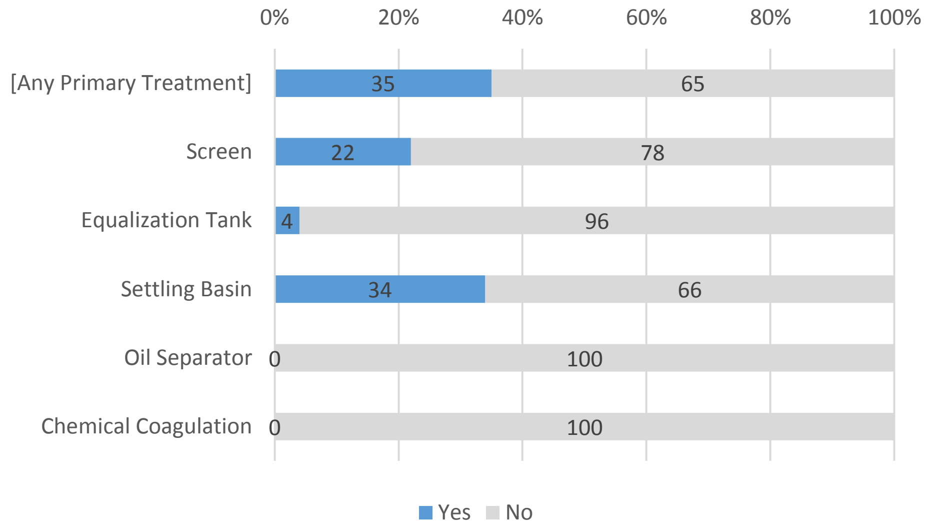
Figure 3-23 Measures to Minimize Water Pollution in Factories in Doke Hta Waddy River Basin

(2) *Installation of Wastewater Treatment Facilities*

One of the key questions related to wastewater treatment was how many of the factories are equipped with primary treatment facilities[8] mainly to remove solids. Based on the survey results in 2016, only 35% of the factories are equipped with a primary treatment facility in Pyi Gyi Tagon IZ (see Figure 3-24). Screens to remove large solids and settling basin to remove settleable solids are among the most basic wastewater treatment facilities being used, and this means more than half of the factories have essentially no treatment facilities at all. With respect

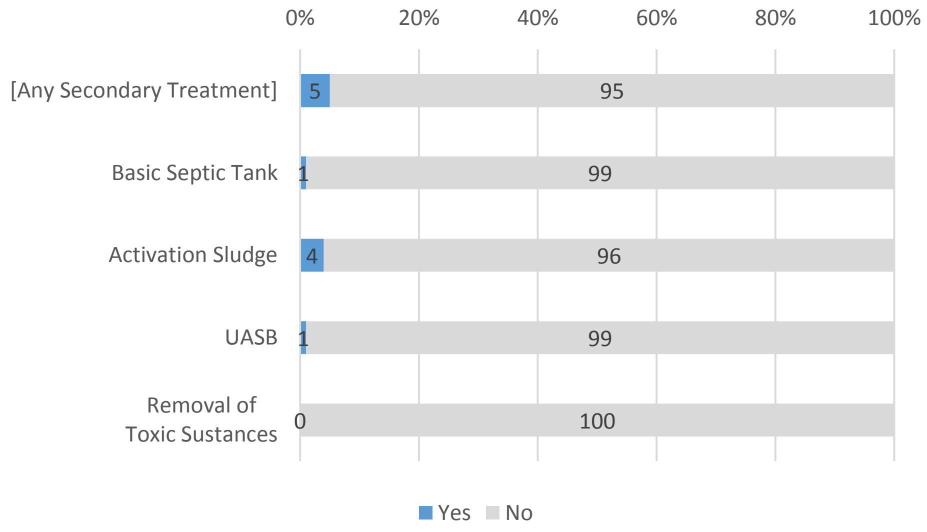
[8] In this survey, facilities, such as equalization tank and chemical coagulation, were included in primary treatment, though primary treatment usually refers to physical removal of solid by screening and settling.

to the secondary treatment[9] to remove organic matter, 5 % of the factories were equipped with facility in Pyi Gyi Tagon IZ in Mandalay (see Figure 3-25).



Source: JET based on Pollution Source Survey in 2016

Figure 3-24 Status of Primary Treatment Installation in the Doke Hta Waddy River Basin

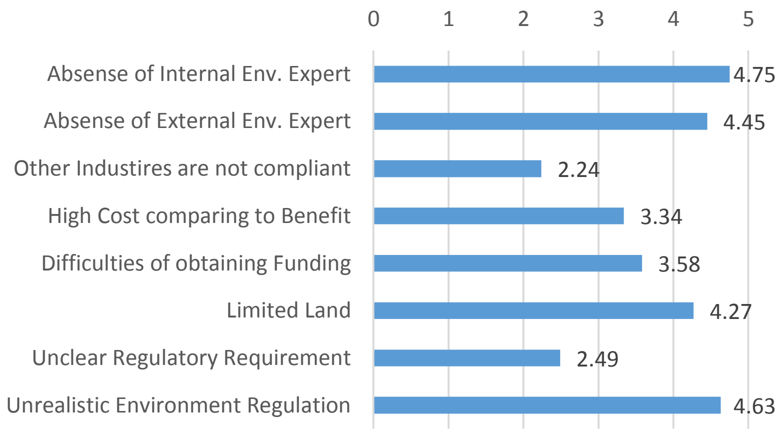


Source: JET based on Pollution Source Survey in 2016 and 2017

Figure 3-25 Status of Secondary Treatment Installation in Doke Hta Waddy River Basin

[9] In this survey, basic septic tank was included in secondary treatment. Also, removal of toxic substances was included in this category for simplicity, although the process of removal of toxic substances is often chemical and not biological.

Another concern these factories are facing is the difficulty to install an adequate wastewater treatment plant (WWTP). These factories cite various reasons, such as absence of internal or external expert, other factories are not compliant, high cost compared with benefit, limited land, etc. In Mandalay, lack of expertise, unrealistic regulation and limited land appear to be the main difficulties factories are facing to install treatment facilities (see Figure 3-26).



Source: JET based on Pollution Source Survey in 2016

Figure 3-26 Difficulties of WWTP Installation in the Doke Hta Waddy River Basin

3.9.2 Pollution control measures by government organizations

(1) *Inspections by government organizations*

At present, inspection activities by government organizations is under business licensing/ registration and inspection for MCDC business license, DISI business legislations, and ECD Environmental License (ECC). In the business licensing/ registration and inspection activities, there are two types of environmental inspections: (a) environmental inspection related to business licensing and registration and (b) inspection to resolve environmental complaints by MDCD-CD, WSD, ECD Mandalay Region. Please see the Inspection Manual (Appendix 6) in detail. Table 3-5 summarizes ECD Mandalay Region in April 2016 – March 2017.

Table 3-13 Inspections by ECD Mandalay Region in April 2016 – March 2017

State/ Region	Types of Inspection	Number of Inspections (Apr. 2016 – Mar. 2017)
Mandalay	1) Regular Inspection of ECD (Mandalay)	46
	2) Inspection by ECD (Mandalay) according to Complaints	16
	3) Inspection by ECD (Mandalay) according to instruction of Union Minister	18
	4) Inspection by ECD (Mandalay) according to instruction of Region Government	108
	Total	188

Source: JET based on information provided by ECD

(2) *Installation of central wastewater treatment plant for factories*

MCDC made a contract with a Thailand-Myanmar joint venture to construct and operate the centralized wastewater treatment plant (WWTP) by BOT (Build-Operation Transfer) scheme in order to treat industrial wastewater from the Pyi Gyi Tagon industrial zone through the 10-inch pipeline. As of May 2018, the centralized WWTP is under construction. The designed capacity of the centralized WWTP is 2,500 m^3/day and the designed inlet and outlet BOD concentrations are 6,500 mg/L (inlet) and 50 mg/L (outlet). As mentioned in Section 3.8.3 about preliminary examination of dilution capacity in the Doke Hta Waddy River, in case that the operation of the centralized wastewater treatment plant is started, the water quality in the downstream would remain at current level, even if the river flow decreases to half of monthly average volume in the lowest month (June in 2016).

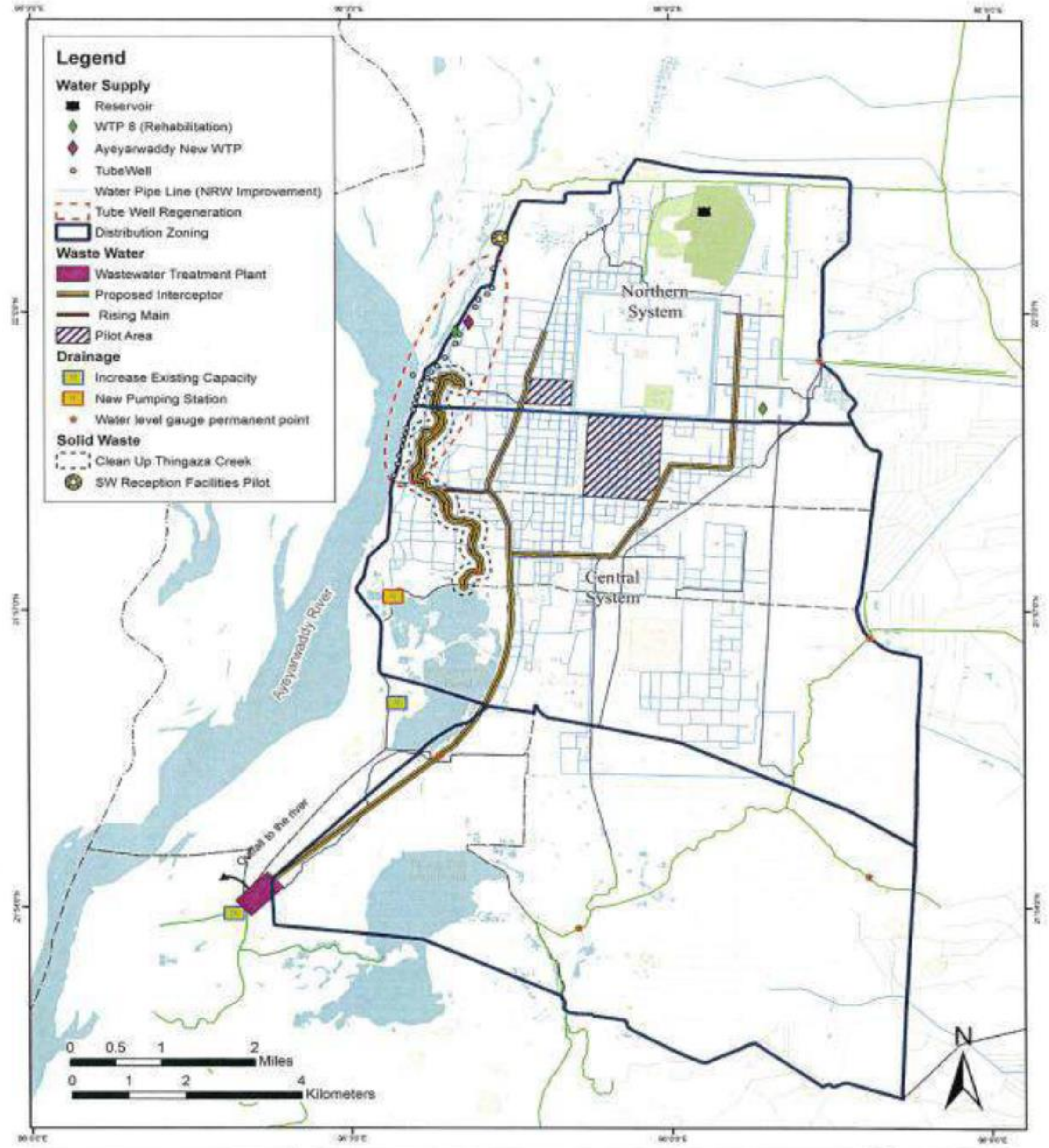
(3) *Domestic wastewater treatment*

MCDC has implementing a sub-project on improvement of wastewater and drainage management under the Mandalay Urban Services Improvement Project (MUSIP) co-financed by the Asian Development Bank (ADB) and the French Development Agency (AFD). A public sewerage system has been started in the western area of the Mandalay City (outside of the Taung Tha Man Lake Basin) as shown in Figure 3-27. MCDC also has a plan to expand sewerage area including the Taung Tha Man Lake Basin. However, it will take time to start the sewerage expansion project within several years in the Taung Tha Man Lake Basin.

At present, MCDC-WSD is collecting black water (toilet wastewater) from households by MCDC septic tank trucks and send it to ponds like a lagoon located 15 km north of Mandalay. Sometimes stored wastewater are overflowed and discharging to channel network. On the other hand, gray water (wastewater other than toilet wastewater) from household are discharged to channel network directly. As the first step to take actions for domestic wastewater pollution control, MCDC is preparing to issue a notification letter for new large scaled facilities such as housing, condominium, shopping center, school, hospital, hotel to install wastewater treatment system under instruction of Mandalay Region Government and Mayor of Mandalay.

(4) *Other pollution control*

Another pollution control activities is awareness raising for famers about application of fertilizer by Department of Agriculture in Mandalay Region (DOA Mandalay Region) According to DOA Mandalay Region, rice is primary crop and bean, cone, tomato, cucumber, watermelon, and other fruits and vegetables are also common crops. The agricultural areas, which supplied irrigation water from Sedaw dam located 50km northern from the central area of Mandalay City, are cultivated two seasons a year and water from agriculture land is discharging to Pa Yan Taw Creek and Lat Khote Pin Creek then reaching to Taung Tha Man Lake. On the other hand, agriculture areas around Taung Tha Man Lake are cultivated only one season a year due to effect of high water level during rainy season from June to October. The peak month of application of fertilizer is November and May after planting, and application of pesticide is steady for insecticide and herbicide. DOA Mandalay Region has workshops for famers to introduce how to use fertilizers and pesticides before each crop season.



Source: IEE for the Mandalay Urban Services Improvement Project (ADB and AFD, 2015)

Figure 3-27 Plans for Project on Improvement of Wastewater and Drainage Management in Mandalay City

3.10 Issues to be Addressed for Water Pollution Control and Water Environment Management

As described in the above sections, current water quality status in the pilot area of Mandalay was investigated based on the collected information and activities of the project, and some issues related to water pollution control and water environment management were found. Table

3-14 and Table 3-15 summarize the issues and suggested measures to control pollution and improve water environment management.

Table 3-14 Issues on Water Environment Management to be addressed, its Expected Measures in the Pilot Area of Mandalay (Doke Hta Waddy River Basin)

Categories	Identified Issues on Water Environment Management to be Addressed	Necessary Measures
1) Water use and water quality	- In the upstream area, there is a hydropower dam, named "Yeywa Dam". Yeywa Dam" is the largest hydropower dam in Myanmar (790 MW) which has been in operations since 2010. In the downstream of Yeywa Dam, current water use is mainly for irrigation. Some individual water uses for domestic (drinking, washing and bathing), recreation (swimming), navigation, and fisheries are also found. Important planned water use is for public water supply to Mandalay City by MCDC to intake water at around 10km upstream of the 10-inch pipeline. - Water quality in the latest rainy and rainy seasons met the surface water quality standard for domestic water supply in Vietnam (Class A1 or A2). However, MCDC has plans to utilize water for domestic supply from the Doke Hta Waddy River from a point upstream of the outlet of the 10-inch-pipeline. Meanwhile, new hydropower development projects such as upper Yeywa dam project and Deedoke hydropower project, are planned in addition to the Yeywa dam development. If these hydropower projects and other industrial and urban developments would take place in the future, water quality of Doke Hta Waddy River may deteriorate due to reduced water volume from the dams and increased industrial pollution.	- A committee which has a function to coordinate among water users shall be established. - In addition to current water quality monitoring program in Mandalay City by MCDC, surface water quality monitoring outside of the Mandalay City shall be implemented to understand trend of water quality and to check whether water can be used or not.
2) Impact of industrial pollution on water quality	[Water quality from outlet of the 10-inch pipeline] - Currently, impact of industrial water pollution from outlet of the 10-inch is limited even though the centralized wastewater treatment plant for the Pyi Gyi Tagon industrial zone has not been operated. However, if new hydropower projects and other industrial and urban developments would take place in the future, water quality of Doke Hta Waddy River may deteriorate due to reduced water volume from the dams and increased industrial pollution. [Wastewater treatment by factories] - According to the questionnaire survey to 100 factories in the pilot area of Mandalay, only 5% of factories installed secondary wastewater treatment plant. Number of the factories which connect the 10-inch pipeline is increasing due to instruction of MCDC. However, factories cite various reasons, such as absence of internal or external expert, other factories are not compliant, high cost compared with benefit, limited land, etc.	- Construction of the centralized wastewater treatment system for Pyi Gyi Tagon industrial zone shall be completed. - Some support tools for factories to promote water pollution control themselves shall be introduced.
3) Impact of pollution sources other than industries on water quality	[Major pollution sources] - As the results of BOD pollution load analysis, among 35,000 kg/day of pollution load reaching the river, 53% is from domestic wastewater, 9% is from industries, 19% is from livestock, and 19% is from non-point sources. On the other hand, water quality in the latest rainy and rainy seasons met the surface water quality standard for domestic water supply in Vietnam (Class A1 or A2). Thus, water pollution from other than industries are also limited.	N/A
4)Industrial pollution control	[Regulation by government] - There are some issues on inspection activities such as i) clarification of environmental requirements and ii) clarification of inspection procedures for each environmental requirement, and iii) implementation of inspection without measurement as the identified issues through the Project activities (Output 1). - ECD Mandalay Region will face various difficulties to implement tasks of Notification No.03/2018 in near future because the number of target factories are expected be more than hundred and the	- Strengthening to implement tasks of Notification No.03/2018 for preparation of EMP and obtain ECC is required. - Support tools for water environment management by

Categories	Identified Issues on Water Environment Management to be Addressed	Necessary Measures
	number of officers in ECD Mandalay Region who have expertise of pollution control is limited. [Pollution control activities by factories (other than wastewater treatment)] - Most factories in the industrial zones in the pilot areas are small- and medium-scale enterprises, and they have many constraints to improve water pollution control because of insufficient budget, human resources, land, and so on. Thus, it is necessary to not only strengthen supervision of factories by the government, but also to support factories to promote implementation of water pollution control measures	factories shall be developed.

Source: JET

Table 3-15 Issues on Water Environment Management to be addressed, its Expected Measures in the Pilot Area of Mandalay (Taung Tha Man Lake Basin)

Categories	Identified Issues on Water Environment Management to be Addressed	Necessary Measures
1) Water use and water quality	- Taung Tha Man Lake is an important water body for fishery, agriculture, and tourism, navigation, and fishery. - Water quality in Taung Tha Man Lake is characterized as eutrophic. The lake manifested traits like higher phosphorus and nitrogen concentrations compared to general indicators for eutrophication: 0.01 mg/L for total phosphorus and 0.15 mg/L for total nitrogen (USEPA, Nutrient Criteria Technical Guidance Manual, 2000), and has relatively low DO but high COD and pH.	- Water pollution reduction plan of Taung Tha Man Lake shall be developed and implemented. - A plan for monitoring of eutrophication status in Taung Tha Man Lake shall be established.
2) Impact of industrial pollution on water quality	[Water quality in tributaries] - Same as description of Doke Hta Waddy River Basin [Wastewater treatment by factories] - Same as description of Doke Hta Waddy River Basin	- Connection status of the 10-inch-pipeline shall be supervised. - Some support tools for factories to promote water pollution control themselves shall be introduced.
3) Impact of pollution sources other than industries on water quality	[Major pollution sources] - As the results of BOD pollution load analysis, 79% is from domestic wastewater, 13% is from industries, 4% is from livestock, and 4% is from non-point sources. - As the results of T-N and T-P pollution load analysis, 59% of T-N pollution load (50% of T-P pollution load) is from domestic wastewater, 4% of T-N (5% of T-P) is from industries, 16% of T-N (24% of T-P) is from livestock, and 16% of T-N (21% of T-P) is from non-point sources. Thus, measures for pollution control for domestic wastewater, agricultural wastewater are required to improve water quality of Taung Tha Man Lake. [Status of domestic wastewater treatment] - Public sewerage system has been started in the western area of the Mandalay City (outside of the Taung Tha Man Lake Basin). MCDC also has a plan to expand sewerage area including the Taung Tha Man Lake Basin. However, it will take time to start the sewerage expansion project within several years in the Taung Tha Man Lake Basin.	- Improvement of water pollution from existing residential area, commercial area, large scale facilities are required. - Reduction of pollution load from agriculture and livestock sectors is required. - Expansion of sewerage network is required.
4)Industrial pollution control	Same as description of Doke Hta Waddy River Basin	Same as description of Doke Hta Waddy River Basin

Source: JET

3.11 STRATEGIES FOR WATER POLLUTION CONTROL AND WATER ENVIRONMENT MANAGEMENT IN THE PILOT AREA OF MANDALAY

3.11.1 Strategies for water pollution control and water environment management

To formulate strategies for water pollution control and water environment management, a draft framework of key strategies was developed following a comprehensive brainstorming discussion with C/Ps based on related project activities on inspection, water quality surveys, pollution source survey, development of databases, and information interpretation, as shown below:

- Key Strategy 1: Water environment conservation for future water use of Doke Hta Waddy River
- Key Strategy 2: Improvement of water quality of Taung Tha Man Lake to increase value of the lake for tourism, recreation, fisheries, etc.

The key strategies shall be finalized by the CP organizations themselves within a few years after completion of the project to achieve the overall goal indicators.

(1) *Key Strategy1: Water environment conservation for future water use of Doke Hta Waddy River*

In Doke Hta Waddy River basin, water quality is very good at the moment and sufficient volume of river water is available even in the dry season due to controlled operation of Yeywa hydropower dam. In addition, there are few pollution sources except the 10-inch pipeline discharging industrial wastewater from Pyi Gyi Tagon IZ. Two key actions were proposed, namely, (i) organizing a coordination committee for water use right and setting maintenance flow, and (ii) operation of the centralized wastewater treatment plant currently under construction to control pollution in Doke Hta Waddy River basin led by MCDC. Moreover, the following actions are necessary and should be added to the key strategies from the view point of prevention of pollution and water conservation:

- Increasing the capacity to treat industrial wastewater from Pyi Gyi Tagon IZ in the event more factories start operations on the vacant areas in the IZ
- Setting regulations or rules for investment in large-volume water intake and/or discharging of wastewater from/to Doke Hta Waddy River in the future especially in the upstream of the river

(2) *Key Strategy2: Improvement of water quality of Taung Tha Man Lake to increase value of the lake for tourism, recreation, fisheries, etc.*

MCDC and ECD Mandalay Region have already prepared some actions, such as issuing a notification of installation of wastewater treatment systems to new large-scale facilities, participation in awareness raising activities for farmers regarding proper application of fertilizer organized by DOA Mandalay Region, and following-up on the notification on preparation of EMPs by existing factories in nine sectors. Based on the results of the pollution load analysis, control of domestic wastewater is considered critical in reducing pollution load to the lake, and MCDC plans to expand the sewerage coverage area in the future.

It should be noted that, as the water quality and hydrology of the lake change dramatically or fluctuated over time/seasons, further monitoring data are necessary to examine the mechanism of water pollution in the lake. It may take time to improve water quality of the lake based on experiences in improving lake water quality compared to developed countries such as Japan. Thus, development of water pollution reduction plan in Taung Tha Man Lake basin should be added to the key strategies based on the results of detailed examination of the mechanism of water pollution in the lake.

3.11.2 Action plans for water pollution control and environment management

On the basis of the above strategies, actions for water pollution control and water environment management in Mandalay were identified through a series of discussions and workshops among MCDC, ECD Mandalay Region Office, and JET. Table 3-16 summarizes the outline of the action plans for water pollution from industrial zones and other pollution sources in the pilot area of Mandalay. The actions are divided into three terms: short-term (within three years), middle-term (within five years), and long-term (within 10 years). A number of key actions for industrial wastewater control, such as construction of the10-inch pipeline to divert industrial wastewater, construction of a centralized wastewater treatment plant, and installation of individual wastewater treatment plants in large factories, have been started and/or have been completed by MCDC and other stakeholders.

Table 3-16 Outline of Action Plans for Water Pollution Control and Water Environment Management in the Pilot Area of Mandalay

Target year	Short term: FY2020-21 (from October 2018 to September 2021) Middle term: FY2022-23 (from October 2021 to September 2023) Long term: FY2027-28 (from October 2023 to September 2028)
Key Strategies	Key Strategy 1: Water environment conservation for future water use of Doke Hta Waddy River Key Strategy 2: Improvement of water quality of Taung Tha Man Lake to increase value of resource of the lake for tourism, recreation, fisheries, etc.
Actions and Schedule	Key Strategy 1: Water environment conservation for future water use of Doke Hta Waddy River [MCDC] AM1-1: Setting a coordination committee among DWIR/MOT, MOALI, MOEE, ECD Mandalay Region, MCDC for water use right and setting the maintenance flow of Doke Hta Waddy River (short-term) AM1-2: Completion of construction and starting operation of the centralized wastewater treatment plant (on-going, short-term to middle-term) AM1-3: Installation of the water supply system from Doke Hta Waddy River (middle-term) [ECD Mandalay Region] AM1-4: Collection of information on existing factories which are requested to prepare EMPs in accordance with the Notification No. 03/2018, and identification of important

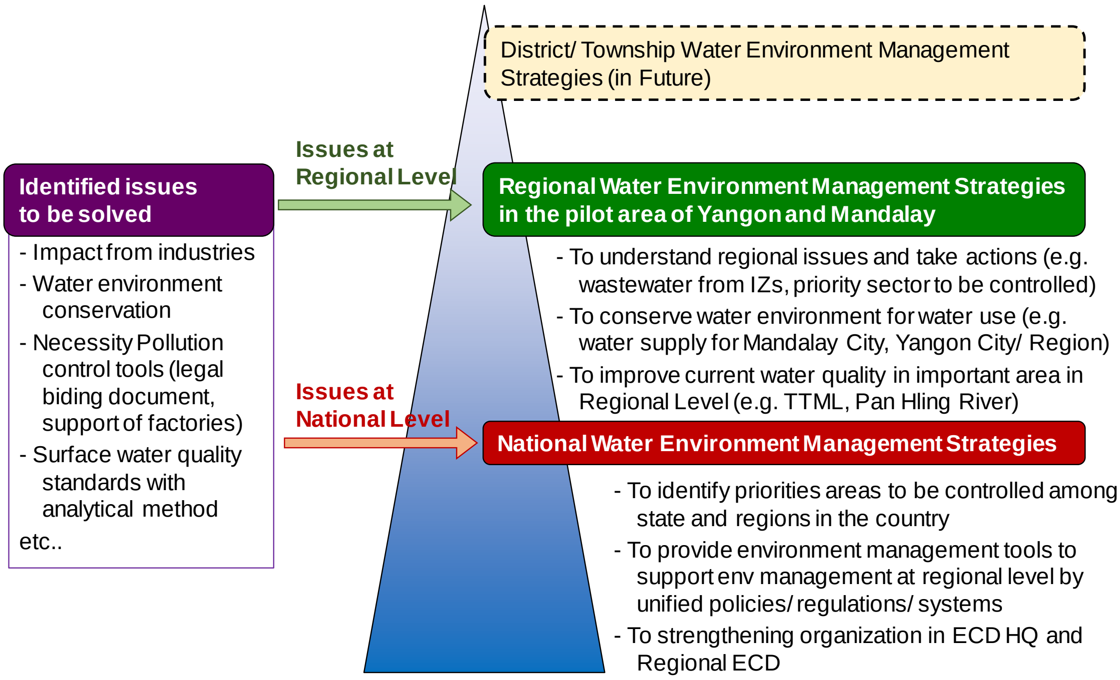
	factories associated with large pollution load through guidance seminars to each industrial zone, collection from DISI/MOI, collection through inspection activity by ECD Mandalay Region and collection from CD/MCDC out of Mandalay City (short-term) AM1-5 Establishment of monitoring/supervising system to check status of preparation of EMPs by the prioritized factories, such as monitoring/supervising through inspection activities out of Mandalay City (short-term) AM1-6: Starting-up and implementation of surface water quality monitoring in rivers in the Region out of Mandalay City (middle-term to long-term)
	Key Strategy 2: Improvement of water quality of Taung Tha Man Lake to increase value of the lake for tourism, recreation, fisheries, etc. [MCDC] AM2-1: Monitoring of connection status of the 10-inch-pipeline (started, short-term) AM2-2: Issuing a notification of installation of wastewater treatment system to new large scaled facilities, such as housing, commercial, hotel, hospital, and school development (drafting, short-term) AM2-3: Participation in awareness raising activities for farmers by Department of Agriculture (DOA) in Mandalay Region regarding proper application of fertilizer to reduce impact of nitrogen and phosphorus to Taung Tha Man Lake and collaboration of the activities with DOA (already implemented by DOA, short-term) AM2-4: Establishment of a plan for monitoring of eutrophication status in Taung Tha Man Lake including water quality, flow rate, water level (short-term) AM2-5: Expansion of the sewerage area in Mandalay City (middle-term to long-term) [ECD Yangon Region] AM2-6: Collection of information on existing factories which are requested to prepare EMPs in accordance with the Notification No. 03/2018, and identification of important factories associated with large pollution load (short-term) AM2-7: Establishment of monitoring/supervising system to check status of preparation of EMPs by the prioritized factories, such as monitoring/supervising through inspection activities (short-term)
	Other actions to support implementation of key strategies [ECD Mandalay Region] AM3-1: Organizing seminars for introduction of good practice on pollution control in Myanmar (short-term) AM3-2: Setting consultation desks in district/township ECD offices to provide advices/information to factories on pollution control (middle-term) AM3-3: Examining the possibility to promote water environment management (e.g. awarding system with some incentives, establishment of low interest fund, consultation on cleaner production) in Yangon Region, through research for similar systems in ASEAN countries (middle-term) AM3-4: Arrangement of ad hoc coordination meetings to exchange information on pollution sources and results of inspections among DISI, MCDC, ECD Mandalay Region (short-term)

Source: MCDC, ECD Mandalay Region, and JET

4 STRATEGY FOR WATER POLLUTION CONTROL AND WATER ENVIRONMENT MANAGEMENT AT NATIONAL LEVEL

4.1 APPROACHES FOR DEVELOPMENT OF STRATEGY FOR WATER POLLUTION CONTROL AND WATER ENVIRONMENT MANAGEMENT

As described in Sections 2.10 and 3.10, issues on water pollution and water environment management were found in some areas, and areas to conserve water environment were identified in the both pilot areas in Yangon and Mandalay. In addition, some issues on technical, institutional, and organizations aspects were identified through the project activities. In order to solve these identified issues, they are categorized into two levels, i.e., at the regional and the national levels, and the strategies for water pollution control from industries and water environment management at the national level and the strategies in the pilot areas in Yangon and Mandalay as regional strategy were developed. Figure 4-1 shows the approaches to development for water pollution control from industries and water environment management at national and regional levels and its functions.



Source: JET

Figure 4-1 Approaches to Development of Strategies for Water Pollution Control from Industries and Water Environment Management at the National and Regional Levels and Their Functions

4.2 Issues to be Addressed for Water Pollution Control and Water Environment Management at the National Level

As described in Section 2.10 and Section 3.10, some issues related to water pollution control and water environment management were found in the pilot areas of Yangon and Mandalay at the regional level. In addition, the following issues related to water pollution control and water environment management at the national level were identified through the project activities (Output 1, Output 2, and Output 3). For details, please see Section 2.3.7 (Output 1), Section 2.4.10 (Output 2), and Section 2.5.8 (Output 3) of the main part of the Final Report about the issues and recommendations of each output. Based on the identified issues, a framework of strategies for water pollution control from industries and water environment management at the national level was formulated.

- Clarification of environmental requirements (Output 1)
- Clarification of inspection procedures for each environmental requirement (Output 1)
- Support to Factories on Pollution Control (Output 1 and 3)
- Improvement of monitoring data quality (Output 2 and 3)
- Development of proper water environmental standard (Output 2)
- Establishment of regular surface water monitoring (Output 2)
- Gathering information from factories (Output 3)
- Development of database of pollution sources (Output 3)
- Improving Environmental Measures by Factories (Output 1 and 3)

4.3 Strategy for Water Pollution Control and Water Environment Management at National Level

PCD of ECD Headquarters in MONREC has been making various efforts to control industrial water pollution, such as expansion of inspection activities to all Region/State-level ECDs, development of National Environmental Quality (Emission) Guidelines (2015), and implementation of water quality monitoring by on-site equipment. Additionally, PCD is developing a master plan for hazardous waste management and drafting surface water quality standards with technical assistance from international cooperation organizations. However, PCD does not have a comprehensive plan for water pollution control with a time frame yet. Thus, PCD formulated a draft framework of key strategies for water environment management focusing on water pollution control from industrial sectors through discussions with JET. The key strategies will be finalized by PCD within a few years after completion of the project to achieve the indicators of the overall goal of the project.

As a first step to develop a draft framework of strategies for the water environmental management, the following three principles were set:

- To utilize the functions of regional ECDs as much as possible in line with the strategy of localization by ECD Headquarters, such as expanding ECD office at the district and township levels;

- To develop actions for "pollution control" and "environment management other than pollution control (PCD)" separately because PCD has been divided into "pollution control division" and "environmental quality standard division (EQSD)" since April 2018; and
- To utilize current regulation tools and activities on pollution control, such as EIA procedures, National Environment Quality (Emission) Guidelines, notification on preparation of EMPs by existing factories in the 9 sectors, and inspection.

Based on the above three principles, the strategies for Water Environment Management (Water Pollution Control from Industries) at the National Level and their action plans were developed. The actions under the strategies are divided into three terms: short term plan (within three years), mid-term plan (within five years), and long-term plan (within 10 years) with the following goals:

- Short term goal: Important industrial pollution sources associated with large pollution emission in the country are identified and surface water quality in key rivers at national level are started to be monitored by FY 2020-21 (within three years)
- Middle term goal: All of the industrial pollution sources in the country are identified and some pollution control tools are introduced by FY 2022-23 (within five years)
- Long term goal: Industrial pollution control and environmental management system by government organizations are in the level of ASEAN top five by FY2027-28 (within 10 years)

Table 4-1 shows the action plans for industrial wastewater pollution control and environment management at the national level. Table 4-2 shows detailed action plans and implementation schedule.

[Industrial Pollution Control]

- Key Strategy 1: Development of National Pollution Source Inventory
- Key Strategy 2: Strengthening Pollution Control System

[Water Environmental Management]

- Key Strategy 3: Development of Surface Water Quality Standards and National Water Quality Monitoring Network
- Key Strategy 4: Promoting actions for water environment management

[Strengthening Organizations]

- Key Strategy 5: Strengthening organizations in response to decentralization

Table 4-1 Outline of Action Plans for Industrial Wastewater Pollution Control and Environment Management at National Level

Goal	Short term goal: Important industrial pollution sources associated with large pollution emission in the country are identified and surface water quality in key rivers at national level are started to be monitored by FY 2020-21 Middle term goal: All of the industrial pollution sources in the country are identified and some pollution control tools are introduced by FY 2022-23 Long term goal: Industrial pollution control and environmental management system by government organizations are in the level of ASEAN top five by FY2027-38
Target year	Short term: FY2020-21 (from October 2018 to September 2021) Middle term: FY2022-23 (from October 2021 to September 2023) Long term: FY2027-28 (from October 2023 to September 2028)
Key Strategies	[Industrial Pollution Control] Key Strategy 1: Development of National Pollution Source Inventory Key Strategy 2: Strengthening pollution control system [Water Environmental Management] Key Strategy 3: Development of Surface Water Quality Standards and National Water Quality Monitoring Network Key Strategy 4: Promoting actions for water environment management [Strengthening Organizations] Key Strategy 5: Strengthening organizations in response to decentralization
Actions and Schedule	[Industrial Pollution Control] Key Strategy 1: Development of National Pollution Source Inventory NA 1-1: Follow-up notification on preparation of EMP by existing factories in 9 sectors (Short to Middle Term) NA1-2: Strengthening monitoring system after issuing ECCs (or completion of EIA/ IEE/ EMP Study) (Short to Middle Term) NA1-3: Development of pollution source inventory system (upgrading pollution source database) (Short to Middle Term) NA1-4: Development of National Pollution Source Inventory (Middle Term) Key Strategy 2: Strengthening Pollution Control System NA2-1: Strengthening Enforcement and Promotion of Environmental Compliance (Short Term) NA2-2: Formulating National Environmental Quality (Emission) Standards (Short Term) NA2-3: Promotion of centralized wastewater treatment plants (Short to Long Term) NA2-4: Strengthening inspection activities (Short to Middle Term) NA2-5: Development of pollution control tools (Short to Long Term) [Water Environmental Management] Key Strategy 3: Development of Surface Water Quality Standards and National Water Quality Monitoring Network NA3-1: Formulating Surface Water Quality Standards (Short Term) NA3-2: Development of national surface water quality monitoring network (Short to Long term) NA3-3: Establishment of Water Quality Testing Laboratory and Standardization of Environmental Analytical Method (Short to Long Term) Key Strategy 4: Promoting Actions for Water Environment Management NA4-1: Preparation of environmental statistics (Short Term) NA4-2: Promoting environmental awareness (Short to Long term) NA4-3: Preparation of the state of pollution report (Middle term to Long term) [Strengthening Organizations]

	Key Strategy 5: Strengthening Organizations in Response to Decentralization NA5-1: Training for industrial pollution control (Short to Middle term) NA5-2: Training for Water environment management (Middle to long term)

Source: ECD and JET

Table 4-2 Detailed Action Plans and Implementation Schedule for Industrial Wastewater Pollution Control and Environment Management at National Level

Strategy/ Key Activity	Implementers	Short Term												Middle Term		Long Term				
		FY2018-19				FY2019-20				FY2020-21				FY21-22	FY22-23	FY23-24	FY24-25	FY25-26	FY26-27	FY27-28
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4							
1. Industrial Pollution Control																				
Key Strategy 1: Development of National Pollution Source Inventory																				
Action 1-1: Follow-up Notification on Preparation of EMP by Existing Factories in 9																				
1-1-1) Preparation of list of factories each sector, industrial zone, and State/ Region through past inspections in ECD	PCD/ Regional ECD	━				━				━				━						
1-1-2) Preparation of format of EMP for existing 9 sectors	EIA Div.	━	━			━				━				━						
1-1-3) Collection of information from DISI/ MOI, YCDC, MCDC, NCDC	PCD/ Regional ECD	━	━			━				━				━						
1-1-4) Preparation of report on status of preparation of EMP of 9 Sectors and guidance through inspection activities	PCD				━															
1-1-5) Listing 1st priority factories of 9 sectors to prepare EMP (200 factories)	PCD/ Regional ECD		━	━																
1-1-6) Checking status of preparation of EMP to 1st priority factories (200 factories) of 9 Sectors and guidance through inspection activities	PCD/ Regional ECD				━	━	━	━												
1-1-7) Preparation of report on status of preparation of EMP to 1st priority factories (200 factories) of 9 sectors and guidance through inspection activities	PCD/ Regional ECD								━											
1-1-8) Listing 2nd priority factories of 9 sectors to prepare EMP (300 factories)	PCD/ Regional ECD						━	━												
1-1-9) Checking status of preparation of EMP to 2nd priority factories (300 factories) of 9 sectors and guidance through inspection activities	PCD/ Regional ECD								━	━	━	━								
1-1-10) Preparation of report on status of preparation of EMP to 2nd priority factories (300 factories) of 9 sectors and guidance through inspection activities	PCD/ Regional ECD												━							
1-1-11) Listing 3rd priority factories of 9 sectors to prepare EMP (500 factories)	PCD/ Regional ECD										━	━								
1-1-12) Checking status of preparation of EMP to 3rd priority factories (500 factories) of 9 sectors and guidance through inspection activities	PCD/ Regional ECD												━	━						
1-1-13) Preparation of report on status of preparation of EMP to 3rd priority factories (500 factories) of 9 sectors and guidance through inspection activities	PCD/ Regional ECD													━						
1-1-14) Continues to implement the above actions	PCD/ Regional ECD														┅					
Action 1-2: Strengthening monitoring system after Issuing ECC for new factories (completion of EIA/ IEE/ EMP Studies)																				
1-2-1) Preparation of list of status of factories which have been required to carry out EIA/ IEE/ EMP (before construction, construction, operation)	EIA/ PCD	━	━	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅
1-2-2) Checking monitoring report from factories which start to operate in accordance with EIA/ IEE/ EMP	PCD			━		━		━		━		━								
1-2-3) Inspections to factories which start to operate in accordance with ECC (or EIA/ IEE/ EMP)	PCD/ Regional ECD			━		━		━		━		━								
1-2-4) Preparation of report on status of factories which are required to carry out EIA/ IEE/ EMP, status of monitoring, and results of inspection	PCD/ Regional ECD				━				━				━							
1-2-5) Continues to implement the above actions	PCD/ Regional ECD													┅	┅	┅	┅	┅	┅	┅
Action 1-3: Development of Pollution Source Inventory System (Upgrading Pollution Source Database)																				
1-3-1) Conceptual designing of web-based pollution source inventory system	PCD						━													
1-3-2) Identification of necessary devices and budget claim	PCD							━												
1-3-3) Development of PSIS for trial	PCD							━												
1-3-4) Trial operation of PSIS	PCD								━	━	━									
1-3-5) Training to operate PSIS	PCD/ Regional ECD											━	━							
1-3-6) Operation of PSIS and its updating	PCD/ Regional ECD													┅	┅	┅	┅	┅	┅	┅
Action 1-4: Development of National Pollution Source Inventory																				
1-4-1) Development of PSI for existing factories of 9 sectors	PCD									━	━	━	━	┅	┅	┅	┅	┅	┅	┅
1-4-2) Development of PSI for existing factories other than 9 sectors	PCD													━	┅	┅	┅	┅	┅	┅
1-4-3) Development of PSI for new factories which is required to carry out EIA/ IEE/ EMP	PCD/ EIA									━	━	━	━	┅	┅	┅	┅	┅	┅	┅

━ Continuous activities
┅ Intermediate activities

Source: ECD and JET

Strategy/ Key Activity	Implementers
Key Strategy 2: Strengthening Pollution Control	
Action 2-1: Strengthening Enforcement and Promotion of Environmental Compliance	
2-1-1) Selection of priptoty target sectors to be Investigated	PCD
2-1-2) Analyzing operation and environmental performance of key target industrial	PCD
2-1-3) Strengthening enforcement of environmental law and regulations	PCD
2-1-4) Strengthening promotion and facilitation of environmental compliance	PCD
2-1-5) Development of a roadmap to control industrial pollution	PCD
Action 2-2: Formulating Wastewater Quality Standards	
2-2-1) Development of draft Wastewater Quality Standards	PCD
2-2-2) Public consultations	PCD
2-2-3) Issuing Wastewater Quality Standards and its updating	PCD
Action 2-3: Promotion of Centralized Wastewater Treatment Plant	
2-3-1) Issuing notfication of instruction of measurement water usage and wastewater qualities	ECD
2-3-2) Checking status of installation of water flow meter and monitoring wastewater quality by priority factories	PCD/ Regional ECD
2-3-3) Checking status of installation of Centralized Wastewater Treatment Plant (WWTP) in existing/ new industrial zones and preparation of the report	PCD/ Regional ECD
2-3-4) Discussions how to promote installation of Centralized WWTP in NECCCCC	ECD HQ
2-3-5) Issuing Instruction from Presidential Office to Regional Governments to promote Installation of Centralized WWTP in industrial zones	ECD HQ/ NECCCCC
Action 2-4: Strengthening Inspection Activities	
2-4-1) Inspection by Regional/ State ECDs and its reporting to ECD HQ	PCD/ Regional ECD
2-4-2) Inspection by District ECDs and its reporting to Regional ECD and ECD HQ	PCD/ Regional ECD
2-4-2) Inspection by Township ECDs and its reporting to District/ Regional ECD and ECD HQ	PCD/ Regional ECD
2-4-4) Inspection by ECD HQ and summarize inspection report at national level	PCD
2-4-5) Updating Inspection Manual	PCD
Action 2-5: Development of Pollution Control Tools	
2-5-1) Investigation of Pollution Control Tools in ASEAN countries	PCD
2-5-2) Formulation of National Water Pollution Control Strategies	PCD
2-5-3) Formulation of Wastewater Discharge Fee System	PCD
2-5-4) Development of Performance Rating and Awarding System	PCD
2-5-5) Development of Pollution Control Manager System	PCD
2-5-6) Establishment of Cleaner Production Technology Center	PCD
2-5-7) Establishment of Pollution Control Agreement Scheme	PCD
2-5-8) Formulation of Pollution Control Act	PCD
2. Water Environment Management	
Key Strategy 3: Development of Surface Water Quality Standards and National Water Quality Monitoring Network	
Action 3-1: Development of Surface Water Quality Standards	
3-1-1) Development of draft Surface Water Quality Standards	EQSD
3-1-2) Public Consultations	EQSD
3-1-3) Issuing Surface Water Quality Standards and its updating	EQSD
Action 3-2: Development of National Surface Water Quality Monitoring Network	
3-2-1) Setting demarcation of Surface Water Quality Monitoring between Central ECD and Regional ECDs	PCD/ Regional ECD
3-2-2) Identification of important water bodies to be conserved at rivers and lakes at National Level	EQSD/ Regional ECD
3-2-3) Phasing to develop National Surface Water Quality Monitoring Network (3 Phases)	EQSD/ Regional ECD
3-2-4) Trial Surface Water Quality Monitoring (1st Phase) and Report Preparation	EQSD/ Regional ECD
3-2-5) Starting National Surface Water Quality Monitoring (1st Phase)	EQSD/ Regional ECD
3-2-6) Development of National Surface Water Quality Monitoring Network (2nd	EQSD
3-2-7) Starting National Surface Water Quality Monitoring (2nd Phase)	EQSD
3-2-8) Development of National Surface Water Quality Monitoring Network (3rd	EQSD
3-2-9) Starting National Surface Water Quality Monitoring (3rd Phase)	EQSD

Continuous activities
Intermediate activities

Source: ECD and JET

Strategy/ Key Activity	Implementers	Short Term												Middle Term		Long Term				
		FY2018-19				FY2019-20				FY2020-21				FY21-22	FY22-23	FY23-24	FY24-25	FY25-26	FY26-27	FY27-28
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4							
Action 3-3: Establishment of Water Quality Testing Laboratory and Standardization of Environmental Analytical Method																				
3-3-1) Procurement of equipment & construction of building	EQSD	━	━	━	━	━	━													
3-3-2) Preparation of laboratory analysis and SOPs (Technical guideline for laboratory analysis)	EQSD							━	━	━	━	━	━							
3-3-3) Starting laboratory analysis & stepwise upgrading the laboratory	EQSD											━	━	━	━	━	━	━	━	━
3-3-4) Setting standards of environmental analytical method (wastewater)	EQSD/ MOE	━	━	━	━	━	━													
3-3-5) Setting standards of environmental analytical method (surface water)	EQSD/ MOE							━	━	━	━	━	━							
3-3-6) Establishment of accrediaton system of laboratories	EQSD													━	━	━	━	━	━	━
Key Strategy 4: Promoting Actions for Water Environment Management																				
Action 4-1: Preparation of Environmental Statistics (Water)																				
4-1-1) Identification of items to be described in Environmental Statistic	EQSD/ GIS Div.		━																	
4-1-2) Data and information collection	EQSD/ GIS Div.			━																
4-1-3) Preparation of Environmental Statistic	EQSD/ GIS Div.				━															
4-1-4) Continues to implement the above actions	EQSD/ GIS Div.					┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅
Action 4-2: Promoting Environmental Awareness																				
4-2-1) Preparation of awareness raising plan for water environment management	EQSD					━	━													
4-2-2) Preparation of materials and equipment for water environment management	EQSD							━	━											
4-2-3) Awareness raising activities for industries (on going and upgrading)	PCD/ Regional ECD	┅	┅	┅	┅	┅	┅	┅	┅	━	━	━	━	━	━					
4-2-4) Awareness raising activities for publics (on going and upgrading)	EQSD/ Regional ECD	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	━	━					
4-2-5) Awareness raising activities for students (on going and upgrading)	EQSD/ Regional ECD	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	┅	━					
4-2-6) Organizing clean up campaign	PCD/ Regional ECD															━	━	━		
4-2-7) Organizing water quality monitoring by simple test kits for awareness raising	EQSD/ Regional ECD																	━		
4-2-8) Continues to implement the above actions	PCD/ EQSD/ Regional ECD																		┅	┅
Action 4-3: Preparation of State of Pollution every 5 years																				
4-3-1) Identification of items to be described in State of Pollution	PCD/ EQSD									━	━									
4-3-2) Data and Information Collection (2016-2020)	PCD/ EQSD											━	━							
4-3-3) Preparation of State of Pollution (2016-2020)	PCD/ EQSD													━						
4-3-4) Data and Information Collection (2021-2025)	PCD/ EQSD													┅	┅	┅	┅━			
4-3-5) Preparation of State of Pollution (2021-2025)	PCD/ EQSD																	━		
4-3-6) Continue to implement the above actions	PCD/ EQSD																		┅	┅
3. Strengthening Organizations																				
Key Strategy 5: Strengthening Organizations in accordance with decentralization																				
Action 5-1: Key Trainings for Industrial Pollution Control																				
5-1-1) Identification of role and responsibilities on industrial pollution control at Region, District, and Township (in future) ECD	PCD			━	━															
5-1-2) Development of handbook for pollution control by local ECD officers (fundamental environmental items, inspection, on-site measurement, instruction to	PCD					━	━	━	━											
5-1-3) Implementation of initial training for local ECD officers	PCD									━	━	━	━							
5-1-4) Continue to implement the above actions	PCD													┅	┅	┅	┅	┅	┅	┅
Action 5-2: Key Trainings for Water Environment Management																				
5-2-1) Identification of role and responsibilities on water environment management at Region, District, and Township (in future) ECD	EQSD													━						
5-2-2) Development of handbook for water environment management by local ECD officers (fundamental environmental items, water quality monitoring, environmental awareness, reporting)	EQSD														━					
5-2-3) Implementation of initial training for local ECD officers	EQSD																			
5-2-4) Continue to implement the above actions	EQSD															┅	┅	┅	┅	┅

━ Continuous activities
┅ Intermediate activities

Source: ECD and JET

5 RECOMMENDATIONS

5.1 PROMOTING ACTIONS FOR WATER POLLUTION CONTROL AND WATER ENVIRONMENT MANAGEMENT IN THE PILOT AREA OF YANGON AND MANDALAY

5.1.1 Presentation of Action Plans to Decision Makers

Some of the actions in Yangon and Mandalay are large investment projects, such as sewerage development and development of centralized wastewater treatment plants, and it may take time to start the projects. However, many actions can be started without large amount budget and human resources. In order to get an approval and necessary budget for implementation of action plans smoothly, official presentations of the plans to decision makers shall be conducted based on this water quality status report. It was noted that the secretary and a committee member of YCDC, Environment Minister of Mandalay Region, Vice Mayor and committee members of MCDC attended the final seminars of the project as the decision makers, and most likely they are aware of the needs to take actions.

5.1.2 Preparation of "Written Strategies"

In order to implement the developed action plans for water pollution control and water environment management, a written strategy with detailed action plans (including budget, implementers, timeframe, outcome etc.) shall be developed in the pilot areas of Yangon and Mandalay within a few years based on this water quality status report. In addition to the regional level, a written strategy at the national level shall also be developed.

5.1.3 Periodical Updating of Water Quality Status Report

In Myanmar, socio economic conditions are rapidly changing year by year, and the roles of the region and the state ECD offices will change dramatically in the future. Such changes include expansion of ECD office to the district and township levels. Moreover, new city/township development (e.g. New Yangon City Development Project), new industrial zone development, and new infrastructure development (e.g. sewerage development project in Yangon) will appear suddenly. Due to these development activities, water quality status may also change somehow. Thus, periodical updating of the water quality status report is desired. In this project, the water pollution mechanism in the Hlaing River could not be identified because of limitation of data to interpret water pollution mechanism in a tidal area. To understand water pollution mechanisms, accumulating monitoring data is also required.

5.2 PROMOTING ACTIONS FOR WATER POLLUTION CONTROL AND WATER ENVIRONMENT MANAGEMENT AT NATIONAL LEVELS

5.2.1 Starting Up Priority Actions

Among action plans for industrial pollution control and environmental management plan at national level, "Strengthening Enforcement and Promotion of Environmental Compliance (NA2-1)" is one of the urgent action plans. Environmental Compliance Certificate (ECC) is a certificate of environmental compliance for factories stipulated in Environmental Impact Assessment Procedures (2015), however, most factories have yet to obtain ECC. MONREC has already issued Notification of No. 03/2018 to advise existing large-scale factories in nine important sectors (1. Alcohol, Wine and Beer Production Factories, 2. Food and Beverage Processing Facilities, 3. Pesticide Manufacturing, Formulation, and Packaging Plants, 4. Cement and Lime Manufacturing Plants, 5. Textile and Dying Facilities, 6. Foundry Industry, 7. Tanning and Leather Finishing, 8. Pulp and/or Paper Mills, 9. Sugar Manufacturing Plants) to prepare Environmental Management Plan in accordance with EIAP and to obtain ECC by October 2018 or January 2019. In order to strengthen the enforcement and promotion of environmental compliance in line with the requirement of ECC under the Environmental Conservation Law (2012), a special purpose project which consists of the following four activities, is desired for implementation in the short term. Figure 5-1 shows outline of the special purpose project on strengthening enforcement and promotion of environmental compliance.

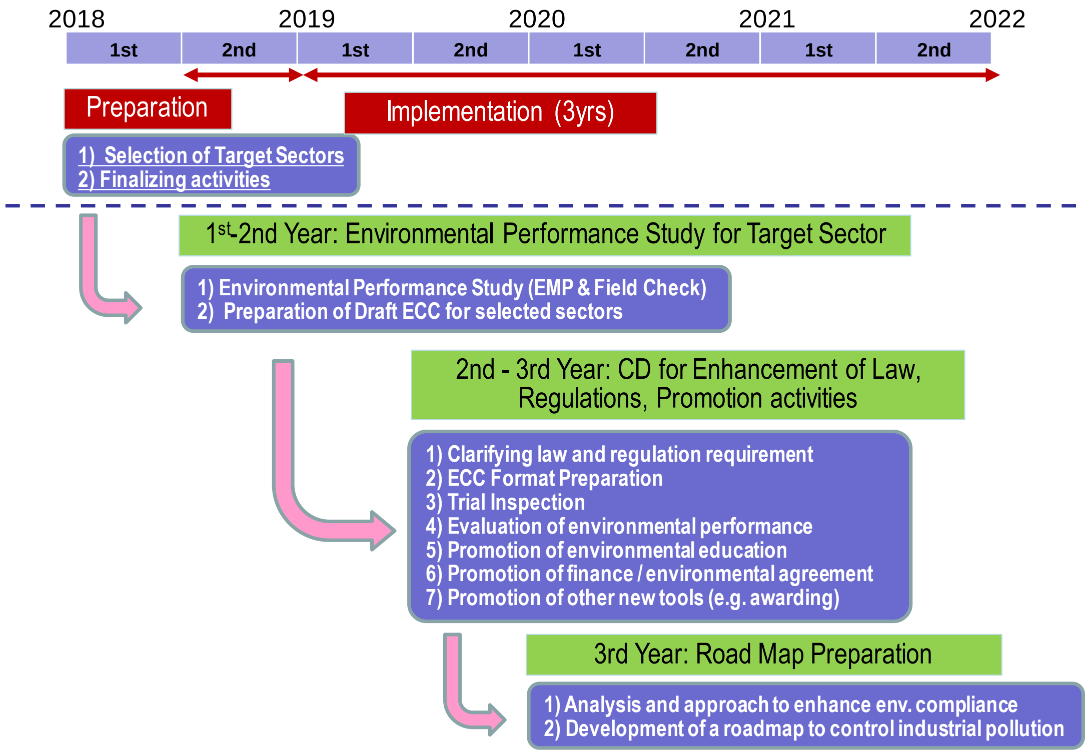
1) Selection of priority target sectors to be investigated

2) Analyzing operation and environmental performance of key target industrial sectors

3) Strengthening enforcement of environmental law and regulations

4) Strengthening promotion and facilitation of environmental compliance

5) Development of a roadmap to control industrial pollution



Source: ECD and JET

Figure 5-1 Outline of the Special Purpose Project on Strengthening Enforcement and Promotion of Environmental Compliance

5.2.2 Approaches to National Environmental Conservation and Climate Change Central Committee (NECCCCC) for High Decision

Among the action plans at the national level, some of the actions are beyond the power of MONREC. For example, MONREC cannot make a decision about which government organization(s) should lead development of centralized wastewater treatment plants, including how to secure a necessary budget. However, without such decision, issues on industrial water pollution cannot be solved. Thus, it is desired that MONREC-ECD will use an opportunity of regular meeting of sub-working committee of National Environmental Conservation and Climate Change Central Committee (NECCCCC), which is the highest decision-making body for environmental issues in Myanmar, to make such decisions.

5.2.3 Investigation for Introduction of Pollution Control Tools

Currently, most of the actions implemented by YCDC, MCDC, MONREC-ECD are oriented toward strengthening governmental control over factories. As mentioned in a strategy for water pollution control in Yangon, most factories in the industrial zones are small- and medium-scale enterprises, and they have many constraints to improve water pollution control, such as insufficient budget, human resources, land, and so on. Meanwhile, many water environment management tools are available as summarized in

Figure 5-2, and they are commonly used in ASEAN countries. Thus, it is recommended that MONREC will investigate which environment management tools can be introduced to Myanmar.

Regulatory approach	EIA, Water pollution control act, effluent standard, inspection, penalty, monitoring, pollution control agreement
Economic approach	Tax, environmental fund, wastewater discharge fee, trading, subsidy
Technical renovation approach	Cleaner production, reducing water use, information sharing platform
Awareness raising approach	Environmental performance rating and awarding system, awareness raising
Information approach	Information disclosure, publish, database development, self monitoring and disclosure by factory side
Infrastructure development	Promoting centralized wastewater treatment system
Legislation	Pollution control manager system, ISO 14001
Officer Training/ localization	Unified training system, decentralization

Source: JET

Figure 5-2 Water Environment Management Tools and its Applications

ATTACHMENTS

Attachment 1: Pollution load analysis in the pilot area of Yangon (Case Study 1)

Attachment 2: Pollution load analysis in the pilot area of Mandalay (Case Study 2)

Attachment 3: Installation of centralized wastewater treatment system in Hlaing Thar Yar Industrial Zones (Case Study 3)

Attachment 4: Preliminary estimation of dilution capacity for water quality leading to future water resource management in Doke Hta Waddy River (Case Study 4)

ATTACHMENT 1 POLLUTION LOAD ANALYSIS IN THE PILOT AREA OF YANGON (CASE STUDY 1)

A1. CASE STUDY 1: POLLUTION LOAD ANALYSIS IN IN THE PILOT AREA OF YANGON

A1.1 Outline of Case Study 1

Table A1-1 shows the outline of the Case Study 1: Pollution load analysis in the pilot area of Yangon. The objective of the Case Study 1 is to identify key pollution sources to be controlled in the pilot area in Yangon City. The results of the pollution load analysis become essential information to make strategies for water environment management in Hlaing River basin in the future.

Table A1-1 Outline of Case Study 1 (Pollution Load Analysis in the Pilot Area of Yangon)

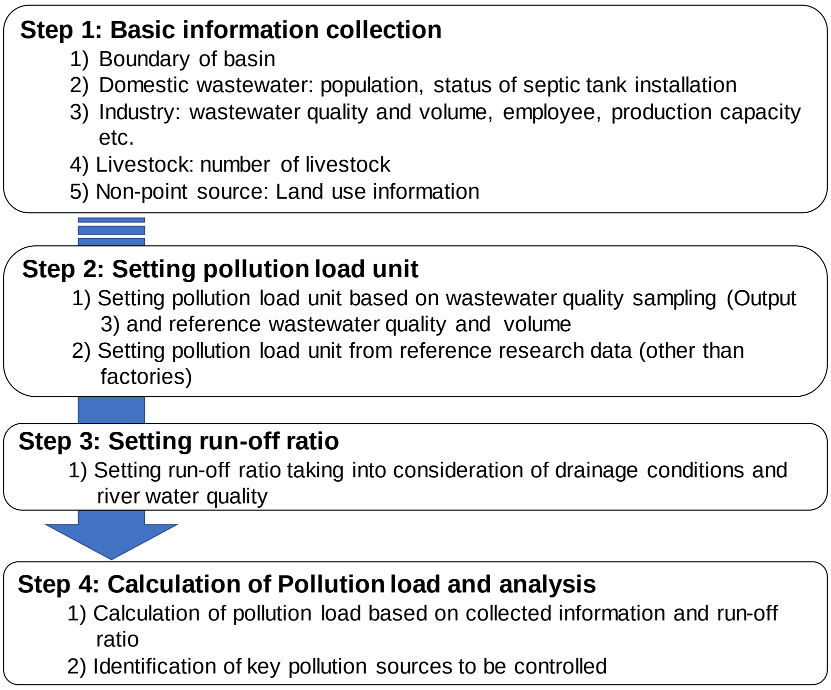
Item	Description
Target Level and Area	**[Target level]** Regional Level (Yangon) **[Target Area]** Hlaing River Basin, Yangon
Objective	To identify key pollution sources to be controlled in the pilot area in Yangon City
Methodology	Sectoral pollution loads are estimated based on available information and unit of pollution load in order to prioritize sectors required to control wastewater.
Expected outcome	The results of the pollution load analysis with prioritized sectors required to control wastewater can be a basic information to make a certain strategy for water environment management to conserve water uses in Hlaing River basin in future.
Target Decision Maker	Mayor and Committee Member of YCDC/Yangon Region Government

Source: JET

A1.2 Procedures and conditions of pollution load analysis

(1) *Procedures of Pollution Load Analysis*

Figure A1-1 shows procedures of pollution load analysis. There are four steps in analysis of pollution load.

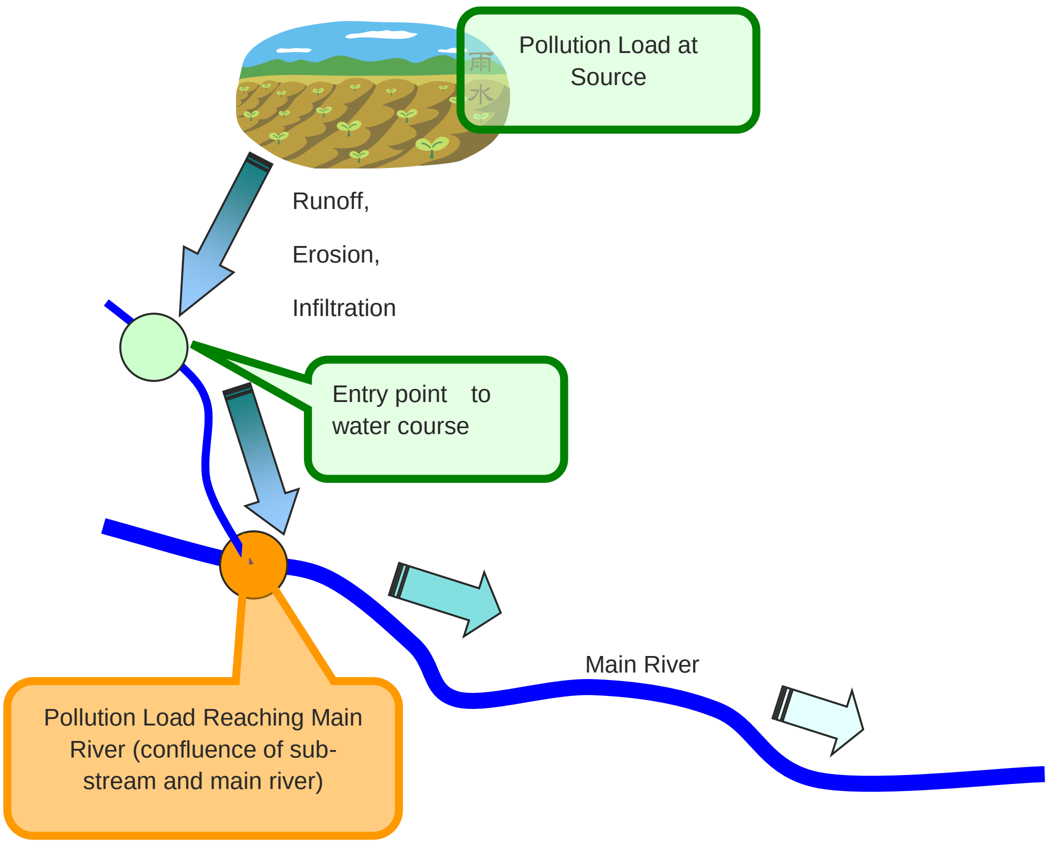


Source: JET

Figure A1-1   Procedures of Pollution Load Analysis

(2) *Type of pollution load*

Pollution load is categorized into two types, one is pollution load at source and the other is pollution load reaching main river. The term “reaching main river” means that pollutant is transported from the source to the point of interest such as the confluence of sub-stream and main river as shown in Figure A1-1.

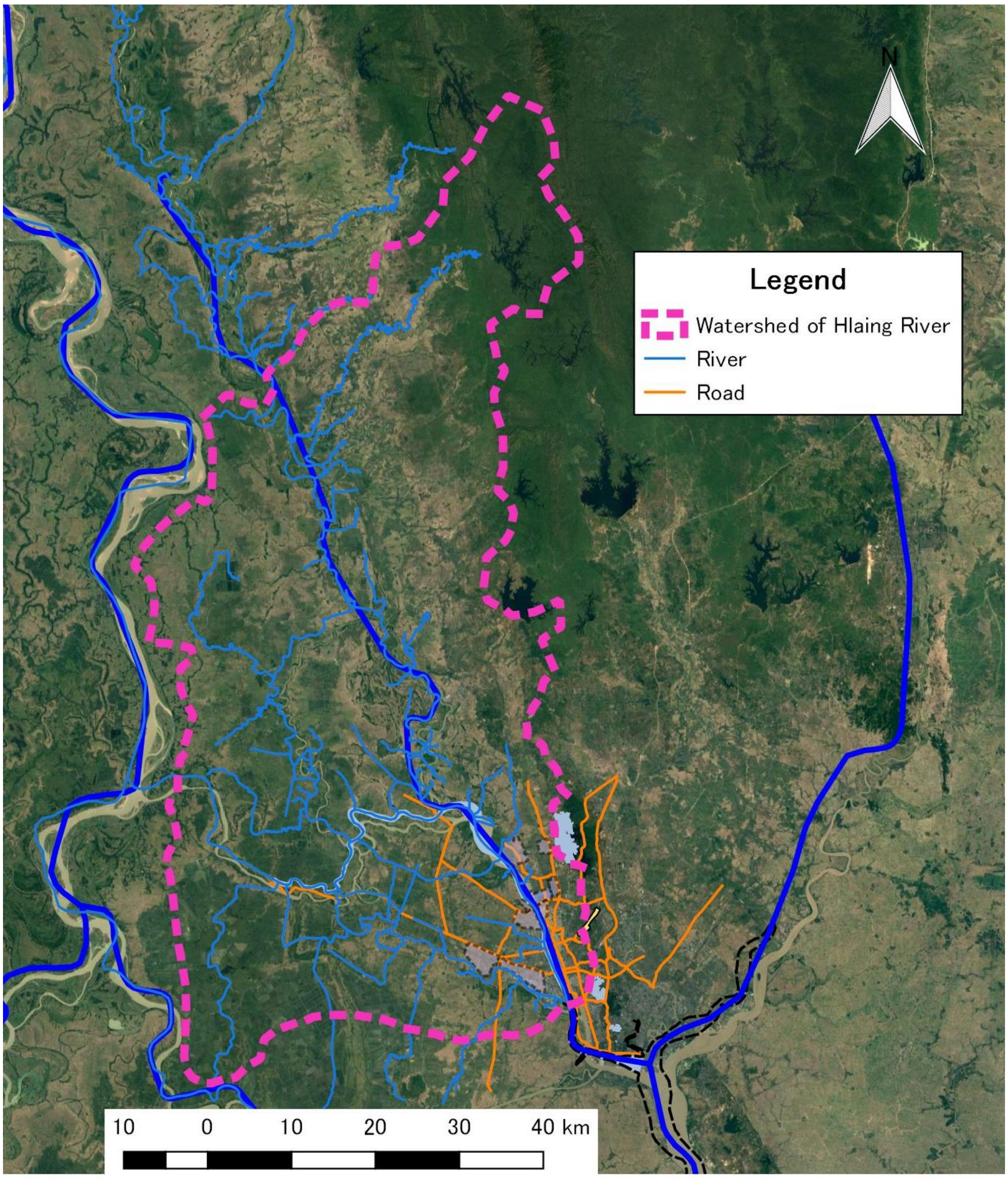


Source: JET

Figure A1-2 Relation between Pollution Load at Source and Exported Pollution Load

(3) *Target Areas of Pollution Load Analysis*

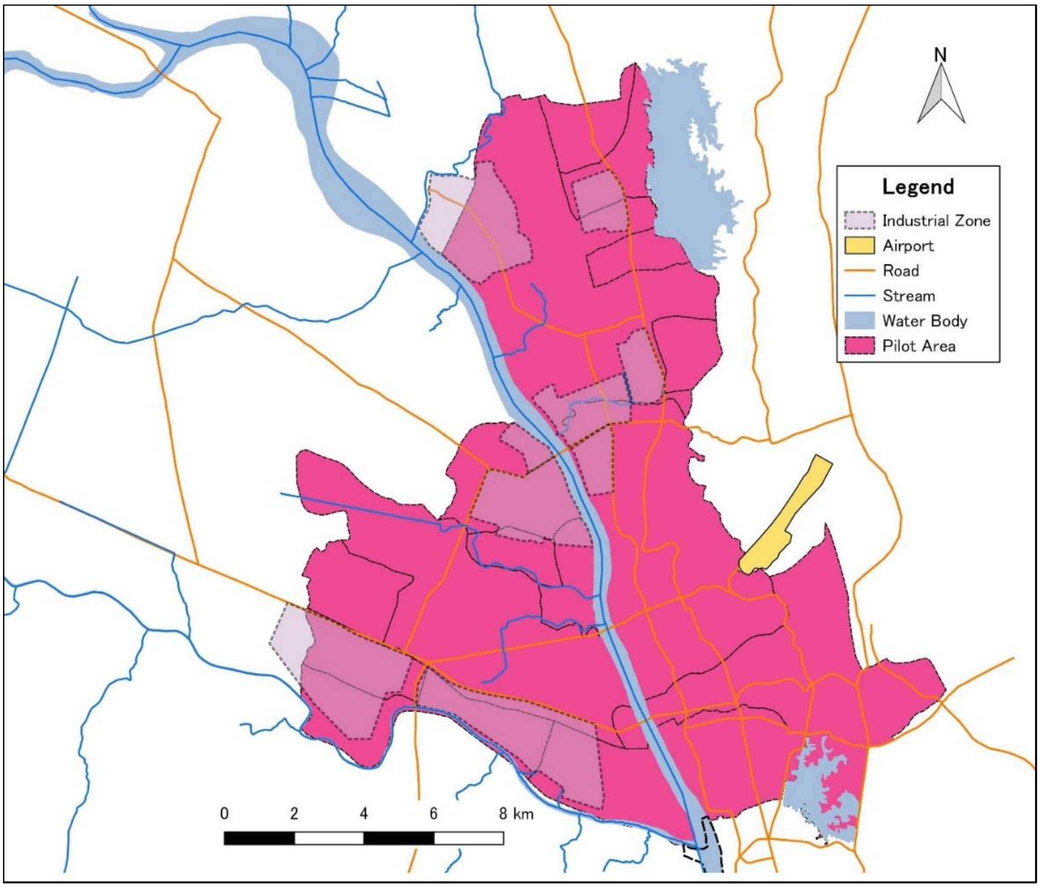
Figure A1-3 and Figure A1-4 show target areas of the pollution load analysis. One is the whole basin of the Hlaing River and the other one is the pilot area of the Hlaing River (Hlaing River basin in Yangon City including Hlaing Tharya, Mayangone, Insein, Hlaing, and Shwepyithar townships).



Source: JET based on dataset prepared by MIMU

Figure A1-3 Target Area for Pollution Load Analysis

(The whole area of Hlaing River basin)



Source: JET based on dataset prepared by MIMU

Figure A1-4 Target Area for Pollution Load Analysis

(Pilot area of Hlaing River basin)

(4) *Basic information for pollution load analysis*

Table A1-2 and Table A1-3 show basic information of the industry sector and other sectors for pollution load analysis. Industrial information is from DISI and others are from various sources, such as population census and statistic books.

Table A1-2 Basic Information for Pollution Load Analysis (Industry Sector)

No.	DISI Category	Detailed Categories	Nine Target Sectors (for EMP)	Number of Employee
1	Food and Beverages	Distillery	(Distillery)	555
		Beverage/Dairy	(Food & Beverages)	1,170
		Rice/Noodle	(Food & Beverages)	1,013
		Fish/Meat/Cold Store/Sea Food	(Food & Beverages)	3,082
		Sugar	(Sugar)	0
		Oil (Sesame)	(Food & Beverages)	26

No.	DISI Category	Detailed Categories	Nine Target Sectors (for EMP)	Number of Employee
		Snack/Wheat/Bean	(Food & Beverages)	3,878
		Others	(Food & Beverages)	3,100
2	Clothing	Textile	(Textile/ Dyeing)	44,893
		Dyeing w/treatment	(Textile/ Dyeing)	1,220
		Dyeing wo/treatment	(Textile/ Dyeing)	0
		Other Clothing	N/A	10,333
3	Accommodation	-	N/A	3,454
4	Domestic Materials	Chemical (Detergent/Drug)	N/A	561
		Other Domestic Material	N/A	7,483
5	Household Materials	Paper/Cardboard	(Paper/ Pulp)	1,137
		Other Household Materials	N/A	219
6	Literature and Art	-	N/A	62
7	Raw Material	Leather	(Leather)	21
		Pesticide/ Fertilizer	(Pesticide/ Fertilizer)	293
		Cement	(Cement)	0
		Other Raw Material	N/A	662
8	Minerals	Iron/ Alminum/ Zinc	(Metal Smelting)	796
		Other Minerals	N/A	336
9	Agricultural Equipment/Machinery	-	N/A	58
10	Industrial Equipment/ Machinery	-	N/A	162
11	Transportation Vehicles Manufacturing	-	N/A	714
12	Electricity	-	N/A	1,781
13	General Mechanics	-	N/A	3,139
			Total	**90,148**

Source: JET from DISI

Table A1-3 Basic Information for Pollution Load Analysis (Other than Industry Sector)

Item	Description	Whole of the Hlaing River Basin	Pilot Area of Hlaing River in Yangon City (5 townships)
1. Catchment area	Total Area	3,195 km^2	207 km^2
2. Domestic	Urban population	2,278,707	1,695,096
	Rural population/ squatter	623,611	40,000
3. Livestock	No. of Cow/ buffalo	308,000	18,000
	No. of Pig	150,000	9,000
	No. Poultry	3,150,000	186,000
4. Non-point	Urban	10%	48%
	Agriculture	78%	29%
	Others	12%	23%

Source: JET based on various information sources

(5) *Pollution load unit*

Table A1-4 and Table A1-5 show unit pollution load of industrial sector and other sectors for pollution load analysis. Industrial pollution load units are categorized into two types; i) wastewater generated from production process (e.g. food and beverage, dyeing, paper) and ii) wastewater generated from only toilet and office wastewater in factories (e.g. garment factory, simple assembling, and storage). As for pollution load for T-N and T-P, only the case of Taung Tha Man Lake in Mandalay basin was examined impacts of different pollution sources on the eutrophication of the lake.

The unit pollution loads for different industrial sub-sectors were estimated from the pollution source survey of the project. However, if unit pollution loads were not available for some industrial sub-sectors, data from industrial zones in Vietnam were referred to. Moreover, the results of surveys of wastewater from industrial factories in Japan (Ministry of Environment of Japan, 2017) were also consulted to check reliability of wastewater data in Myanmar. At the end, only T-N concentration from distillery was refereed from the inlet water quality survey result in Japan instead of T-N concentration in Myanmar.

Table A1-4 Unit Pollution Loads (Industry Sector)

Unit: g/day/employee

DISI Category	Detailed Categories	BOD	T-N*	T-P*	Information Source
Food and Beverages	Distillery	15,112	240.8	23.93	Result of Pollution Source Survey- Myanmar PSS (BOD and T-P) and Ministry of Environment Japan (T-N)
	Beverage/Dairy	1,853	56	19	Data from industrial zones in Vietnam
	Rice/Noodle	1,853	56	19	Data from industrial zones in Vietnam
	Fish/Meat/Cold Store/Sea Food	2,250	150.0	46.50	Data from industrial zones in Vietnam
	Sugar	461	5.1	0.96	Myanmar PSS
	Oil (Sesame)	260	7.5	4.57	Myanmar PSS
Clothing	Dyeing w/treatment	8	2.6	0.39	Myanmar PSS
	Dyeing wo/treatment	49	2.6	0.39	Myanmar PSS
Domestic Materials	Chemical (Detergent/Drug)	358	29.9	1.19	Myanmar PSS
Household Materials	Paper/Cardboard	1,010	6	4	Myanmar PSS
Raw Material	Leather	1,250	12.6	4.88	Myanmar PSS
	Pesticide/ Fertilizer	133	149.3	1.49	Data from industrial zones in Vietnam
Other general industries (only domestic wastewater)	-	18	5.1	0.96	Data from industrial zones in Vietnam

Note: T-N and T-P are applied in the case of Taung Tha Man Lake in Mandalay
Source: JET from various information sources

Aside from unit pollution loads of industrial sector in Japan, information from JICA sewerage master plan in Yangon, Ministry of Land, Infrastructure, Transport and Tourism of Japan (2015) and BASIN/PLOAD model of USEPA (2001) was also used to set the unit pollution load for different pollution sources.

Table A1-5 Pollution Load Unit (Other than Industry)

Item	Description	Unit	BOD	T-N*	T-P*	Information source
1. Domestic	Urban (with collection of black water by septic tank trucks)	g/person/day	27	2	0.2	JICA sewerage master plan in Yangon
	Rural population/ squatter (without septic tank)	g/person/day	40	10	1	
3. Livestock	Cow/ buffalo	g/head/day	640	290	50	Ministry of Land, Infrastructure, Transport and Tourism of Japan (2015)
	Pig	g/head/day	200	40	25	
	Poultry	g/head/day	2.8	1.91	0.27	
4. Non-point	Urban	kg/ha/year	56	9	2.2	BASIN/PLOAD model of USEPA (2001)
	Agriculture	kg/ha/year	9	11	3.4	
	Others	kg/ha/year	2.2	0.75	0.1	

Note: T-N and T-P are applied in the case of Taung Tha Man Lake in Mandalay
Source: JET based on various information sources

(6) *Run-off Ratio*

A run-off ratio is percentage of discharged pollution load which reaches a mainstream of river from a pollution source. If pollution load from a pollution source is directly discharged to a mainstream of river, its run-off ratio is 1. This means that all the pollution load reaches the mainstream. On the other hand, if pollution load from a pollution source is indirectly discharged to a mainstream of river, e.g. through a tributary, channel, drainage, etc., the pollution load is often reduced before reaching the mainstream due to self-purification process. As a result, its run-off ratio is below 1. Table A1-6 summarizes the run-off ratios set for different sectors and areas through a calibration process using the surface water quality monitoring data and the river flow rate.

Table A1-6 Run-off Effect of each Sector

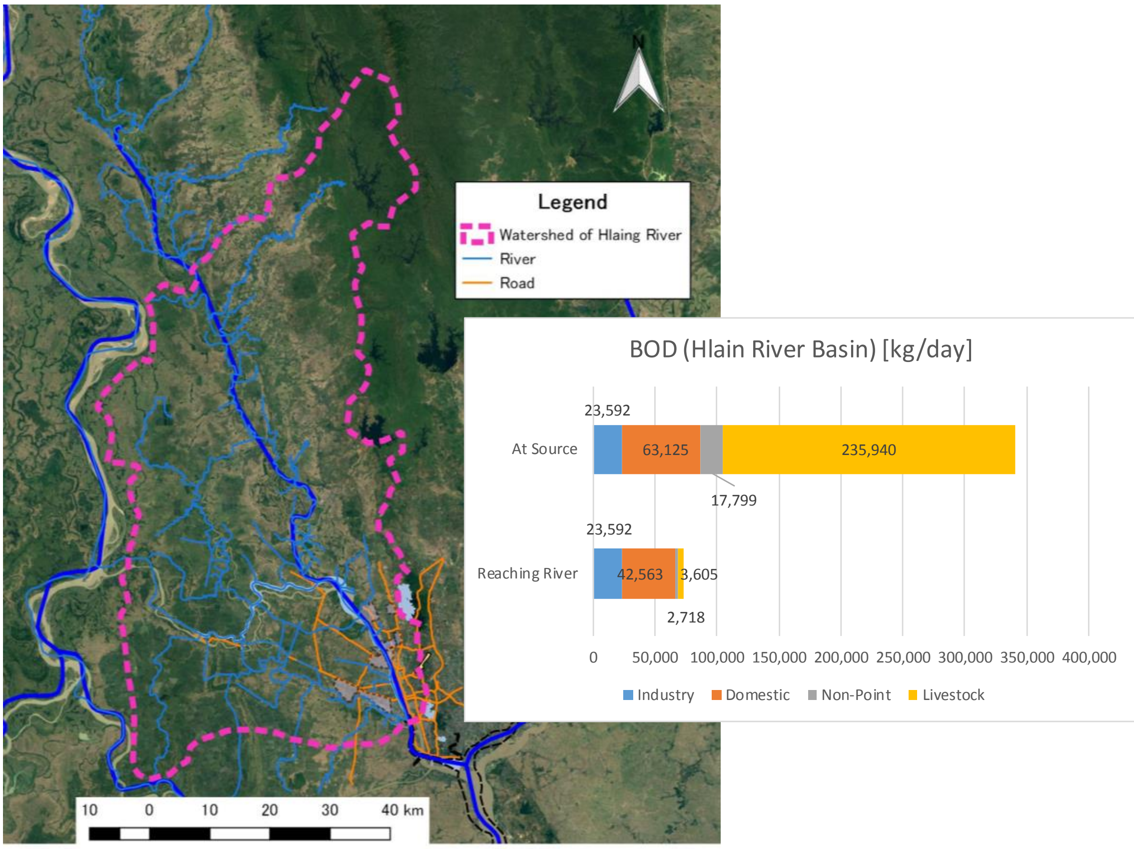
Sector	Description	BOD	T-N*	T-P*
1. Domestic	Urban area	0.8	0.8	0.8
	Urban area (squatter along rivers)	1.0	1.0	1.0
	Rural population/ squatter (without septic tank)	0.2	0.2	0.2
2. Industry	-	1.0	1.0	1.0
3. Livestock	Urban area	0.05	0.05	0.05
	Rural area	0.01	0.01	0.01
4. Non-point	Urban area	0.6	1.0	1.0
	Rural area	0.1	1.0	1.0

Note: T-N and T-P are applied in the case of Taung Tha Man Lake in Mandalay
Source: JET

A1.3 Results of pollution load analysis

(1) *Whole area of Hlaing River basin*

The results of the pollution load analysis in the whole area of the Hlaing River basin is summarized in Figure A1-5. In this analysis, pollution loads from industrial, domestic and non-point sources, such as agricultural fields, were estimated using the results of the pollution source survey as well as unit pollution load for different pollution sources established in different countries. According to the results, 340,000 kg/day of BOD pollution load is generated in the basin and 72,000 kg/day of BOD is reaching the Hlaing River. Among 72,000 kg/day of pollution load reaching the river, 59% is from domestic wastewater, 33% is from industries, 4% is from livestock, and 5% is from non-point sources. The ratio of pollution load reaching the river is around 20% only due to natural attenuation in the upstream of the basin, especially in the rural areas.

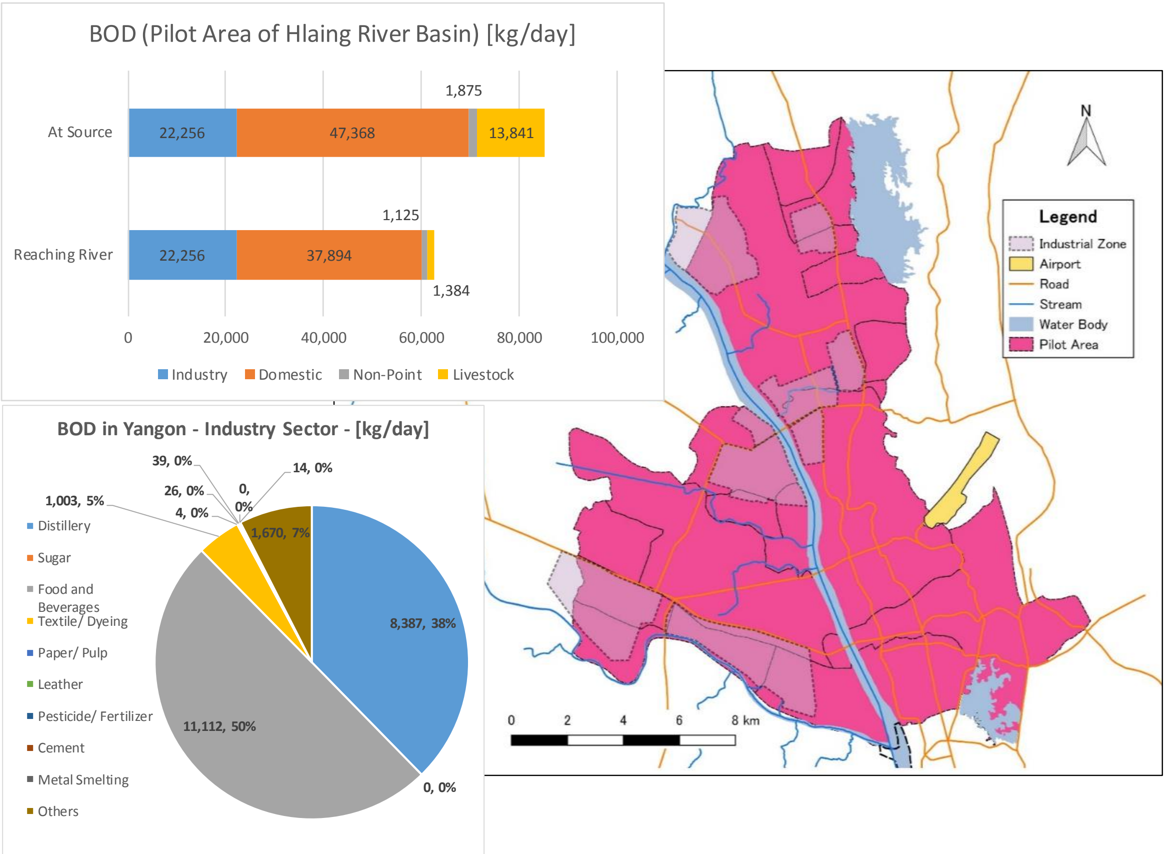


Source: JET based on dataset prepared by MIMU

Figure A1-5 Estimated Pollution Load in the Hlaing River basin

(2) *Pilot area of Hlaing River basin*

The results of the pollution load analysis in the pilot area of Yangon is summarized in Figure A1-6. According to the results, 85,000 kg/day of BOD pollution load is generated in the townships of Yangon City (Hlaingtharya, Mayangone, Insein, Hlaing, Shwepyithar townships) in the Hlaing River basin, and 63,000 kg/day of generated BOD reaches the Hlaing River and the Pan Hlaing River. Among 63,000 kg/day of pollution load reaching the rivers, 60% is from domestic wastewater, 36% is from industries, and 4% is from livestock and non-point sources. Evidently, sewage from domestic sources is the main source of BOD load but the contribution of industrial sources is also significant. The major types of industries which generate large pollution load are distillery, food and beverage, and textile, and these three industries generate 93% of BOD pollution load from industrial sources.



Source: JET based on dataset prepared by MIMU

Figure A1-6 Estimated Pollution Load in the Pilot Area of Yangon (Upper Left: Pollution Load Generated at Source and Reaching Rivers by Sector, Lower Left: Industrial Pollution Load by Industries)

ATTACHMENT 2: POLLUTION LOAD ANALYSIS IN THE PILOT AREA OF MANDALAY (CASE STUDY 2)

A2. CASE STUDY 2: POLLUTION LOAD ANALYSIS IN THE PILOT AREA OF MANDALAY

A2.1 Outline of Case Study 2

Table A2-1 shows the outline of the Case Study 2: Pollution load analysis in the pilot area of Mandalay. The objective of the Case Study 2 is also to identify key pollution sources to be controlled in the pilot area in the Doke Hta Waddy River basin and the catchment area of Taung Tha Man Lake. The results of the pollution load analysis become essential information to make certain strategies for water environment management in Doke Hta Waddy River basin and the catchment area of Taung Tha Man Lake in the future.

Table A2-1 Outline of Case Study 2 (Pollution Load Analysis in the Pilot Area of Mandalay)

Item	Description
Target Level and Area	**[Target level]** Regional Level (Mandalay) **[Target Area]** Doke Hta Waddy River basin and the catchment area of Taung Tha Man Lake
Objective	To identify key pollution sources to be controlled in the Doke Hta Waddy River basin and the catchment of Taung Tha Man Lake
Methodology	Sectoral pollution loads are estimated based on the existing available information and unit of pollution load to set prioritize sectors required to control wastewater.
Expected outcome	The results of the pollution load analysis with prioritized sectors required to control wastewater can be a basic information to make a certain strategy for water environment management to conserve water uses in the Doke Hta Waddy River and the Taung Tha Man Lake.
Target Decision Maker	Mayor and Committee Member of MCDC/ Mandalay Region Government

Source: JET

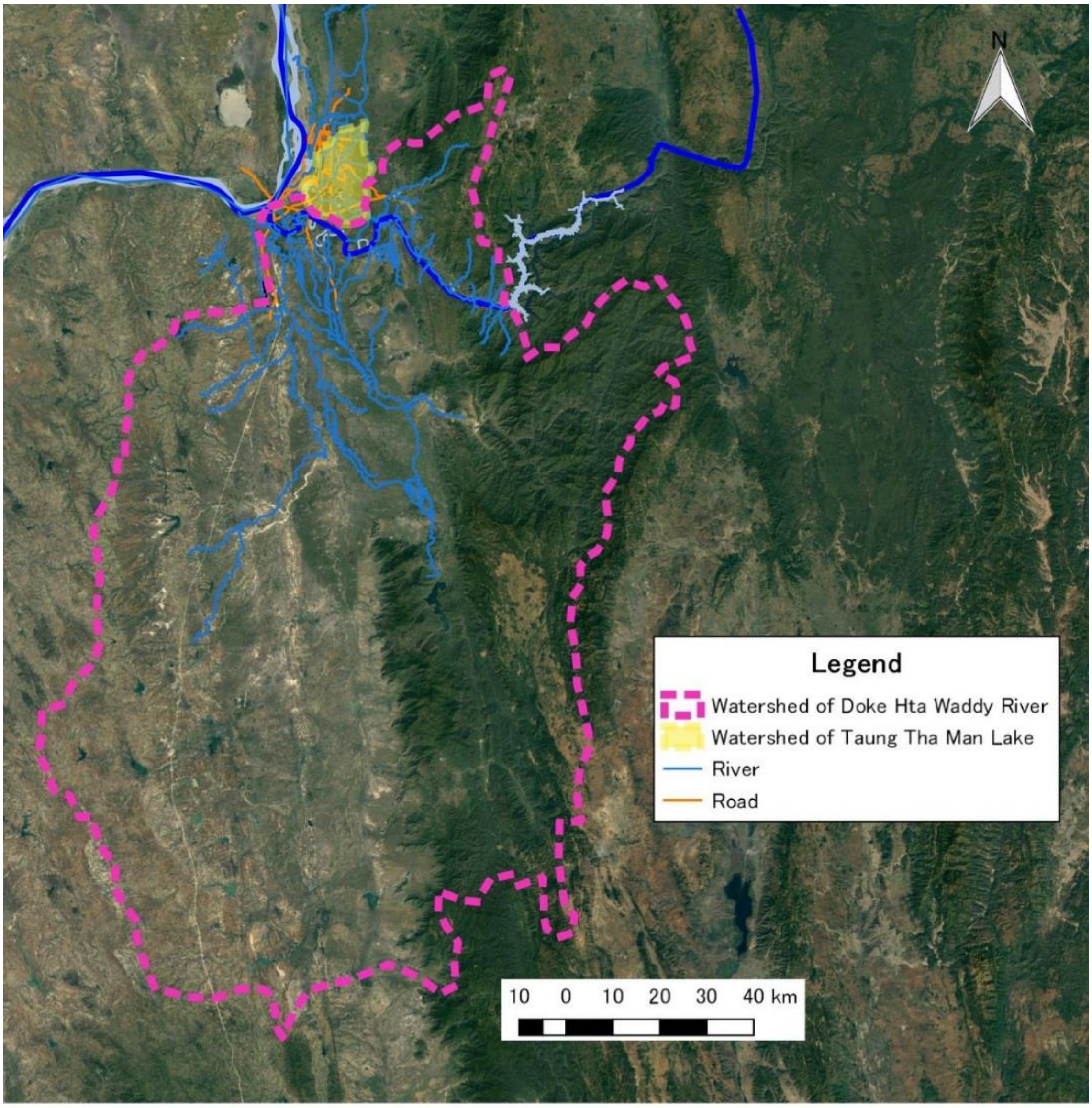
A2.2 Conditions of pollution load analysis

(1) *Procedures of Pollution Load Analysis*

Procedures of pollution load analysis is the same in Yangon as shown in Figure A1-1.

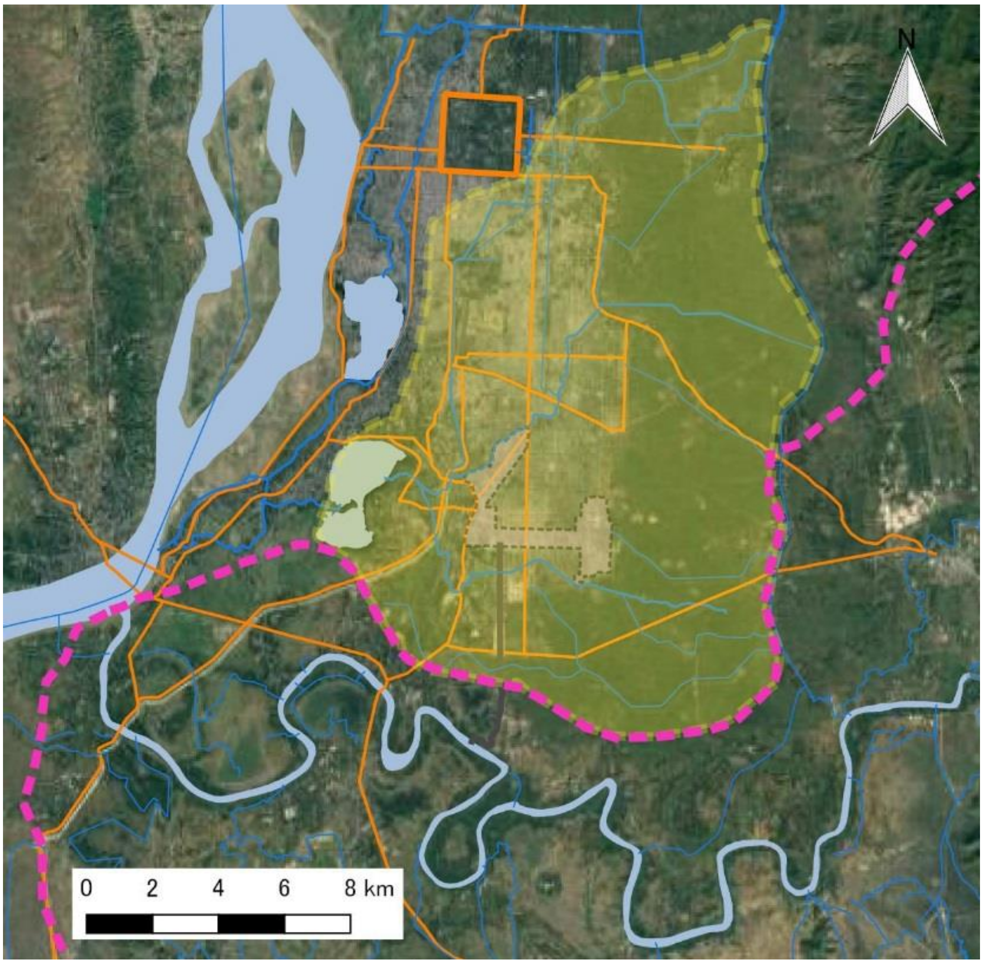
(2) *Target Areas of Pollution Load Analysis*

Figure A2-1 and Figure A2-2 show the target areas of pollution load analysis in Mandalay. One is the whole basin of the Doke Hta Waddy River and the other one is the catchment of Taung Tha Man Lake.



Source: JET based on dataset prepared by MIMU

Figure A2-1 Target Area for Pollution Load Analysis (Whole Basin of Doke Hta Waddy River)



Source: JET based on dataset prepared by MIMU

Figure A2-2 Target Area for Pollution Load Analysis
(Catchment of Taung Tha Man Lake)

(3) *Basic information for pollution load analysis*

Table A2-2 and Table A2-3 show the basic information of industry sector and other sectors for pollution load analysis. Industrial information is from DISI and others are from various sources, such as population census and statistic books.

Table A2-2 Basic Information for Pollution Load Analysis (Industry Sector)

No.	DISI Category	Detailed Categories	Nine Target Sectors (for EMP)	Number of Employee
1	Food and Beverages	Distillery	(Distillery)	297
		Beverage/Dairy	(Food & Beverages)	276
		Rice/Noodle	(Food & Beverages)	22
		Fish/Meat/Cold Store/Sea Food	(Food & Beverages)	5
		Sugar	(Sugar)	193
		Oil (Sesame)	(Food & Beverages)	502

No.	DISI Category	Detailed Categories	Nine Target Sectors (for EMP)	Number of Employee
		Snack/Wheat/Bean	(Food & Beverages)	1,576
		Others	(Food & Beverages)	1,019
2	Clothing	Textile	(Textile/ Dyeing)	288
		Dyeing w/treatment	(Textile/ Dyeing)	0
		Dyeing wo/treatment	(Textile/ Dyeing)	1,160
		Other Clothing	N/A	441
3	Accommodation	-	N/A	2,105
4	Domestic Materials	Chemical (Detergent/Drug)	N/A	579
		Other Domestic Material	N/A	1,343
5	Household Materials	Paper/Cardboard	(Paper/ Pulp)	246
		Other Household Materials	N/A	0
6	Literature and Art	-	N/A	72
7	Raw Material	Leather	(Leather)	161
		Pesticide/ Fertilizer	(Pesticide/ Fertilizer)	27
		Cement	(Cement)	0
		Other Raw Material	N/A	447
8	Minerals	Iron/ Alminum/ Zinc	(Metal Smelting)	948
		Other Minerals	N/A	809
9	Agricultural Equipment/Machinery	-	N/A	77
10	Industrial Equipment/ Machinery	-	N/A	3
11	Transportation Vehicles Manufacturing	-	N/A	858
12	Electricity	-	N/A	78
13	General Mechanics	-	N/A	2,618
			Total	**16,150**

Source: JET from DISI

Table A2-3 Basic Information for Pollution Load Analysis (Other than Industry)

Item	Description	Whole of the Doke Hta Waddy River	Catchment of Taung Tha Man Lake
1. Catchment area	Total Area	17,098 km^2	227 km^2
2. Domestic	Urban population	0	812,269
	Rural population/ squatter	2,310,477	13,000
3. Livestock	No. of Cow/ buffalo	971,000	25,000
	No. of Pig	170,000	4,000
	No. Poultry	2,194,000	55,000
4. Non-point	Urban	6%	26%
	Agriculture	53%	45%
	Others	41%	29%

Source: JET based on various information sources

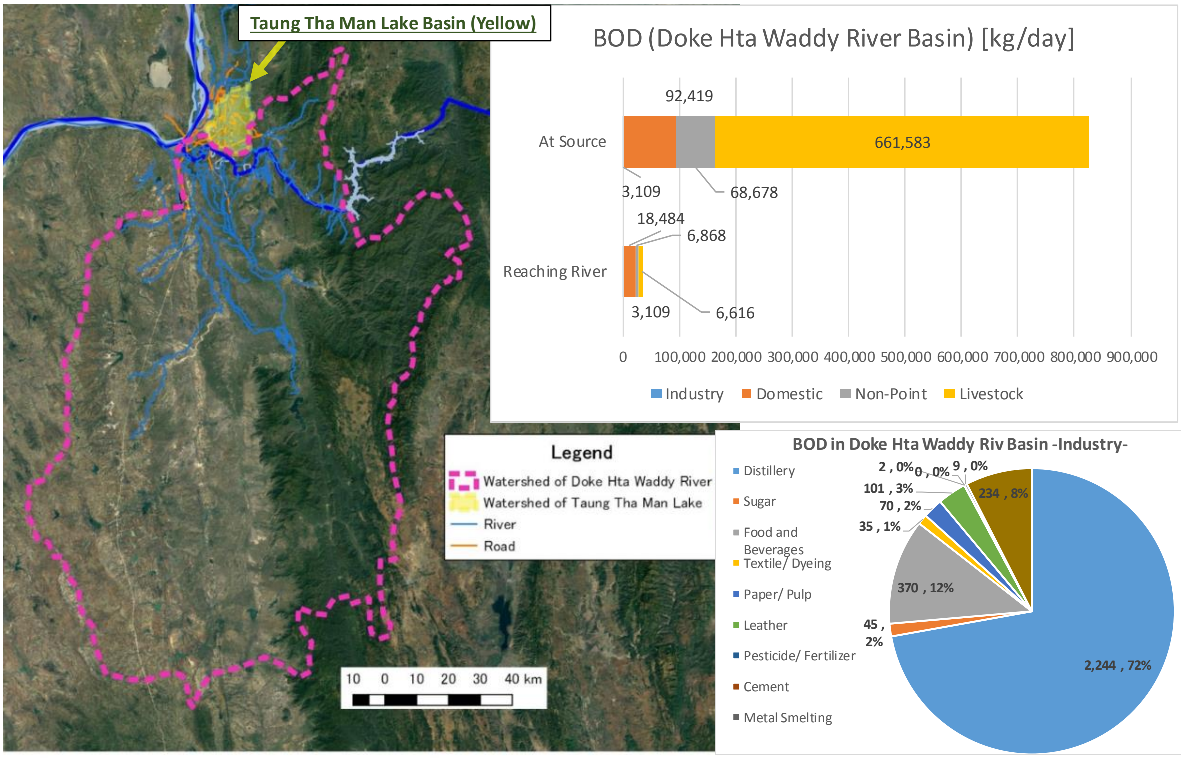
(4) *Pollution load unit and Run-Off Ratio*

Pollution load unit and run-off ratio are same in Yangon.

A2.3 Results of Pollution Load Analysis

(1) *Doke Hta Waddy River basin*

The results of pollution load analysis in Doke Hta Waddy River basin (the basin from the outlet of Yeywa dam to before the confluence of Ayeyawaddy River with 17,000km^2) are summarized in Figure A2-3. 825,000 kg/day of BOD pollution load is generated in the basin and 35,000 kg/day of BOD is reaching Doke Hta Waddy River. Among 35,000 kg/day of pollution load reaching the river, 53% is from domestic wastewater, 9%[10] is from industries, 19% is from livestock, and 19% is from non-point sources. The ratio of pollution load reaching the river is less than 10% only due to natural attenuation in the basin, especially in the rural areas. The major types of industries which generate large pollution load are distillery and food and beverage, and these two industrial sectors are responsible for 84% of the BOD pollution load.



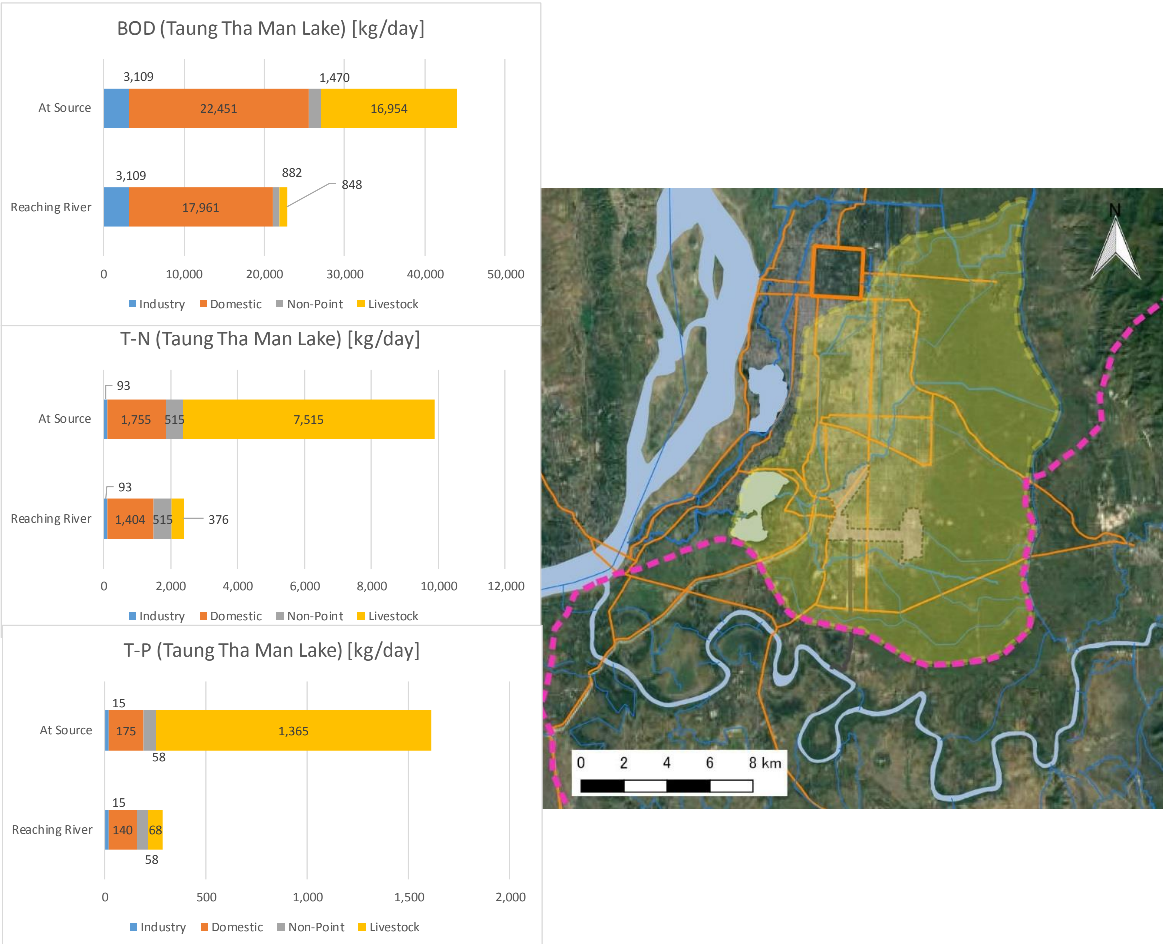
Source: JET based on dataset prepared by MIMU

Figure A2-3 Estimated Pollution Load in Doke Hta Waddy River Basin (Upper Right: Pollution Load at Source and reaching to Rivers by Sector, Lower Right: Industrial Pollution Load by Industries)

[10] Industrial wastewater from Pyi Gyi Tagon Industrial Zone is discharges in two directions: discharge to the Doke Hta Waddy River through 10-inch pipeline and discharge to Taung Tha Man Lake through creeks. The amount of each wastewater discharge is fifty and fifty.

(2) *Taung Tha Man Lake basin*

The results of BOD, T-N, and T-P pollution load analysis in Taung Tha Man Lake basin are summarized in Figure A2-4. BOD pollution loads generated at source and reaching the lake are 44,000 kg/day (at source) and 23,000 kg/day (to the lake), respectively. Among the 23,000 kg/day of pollution load reaching the lake, 79% is from domestic wastewater, 13% is from industries, 4% is from livestock, and 4% is from non-point sources. As for T-N and T-P pollution loads related to eutrophication, 10,000 kg/day of T-N is generated at source while 2,400 kg/day is reaching the lake. As for T-P, 1,600 kg/day is generated at source and 300 kg/day is reaching the lake. Among the T-N and T-P pollution loads reaching the lake, 59% of T-N pollution load (50% of T-P pollution load) is from domestic wastewater, 4% of T-N (5% of T-P) is from industries, 16% of T-N (24% of T-P) is from livestock, and 16% of T-N (21% of T-P) is from non-point sources. The major pollution source of T-N and T-P is from domestic wastewater as well as BOD pollution load, whereas the second and third largest pollution load are from livestock and non-point sources. These ratios are relatively high compared with BOD pollution load.



Source: JET based on dataset prepared by MIMU

Figure A2-4 Estimated Pollution Load in Taung Tha Man Lake Basin (BOD, T-N, and T-P Pollution Load at Source and reaching to Rivers by Sector)

ATTACHMENT 3: INSTALLATION OF CENTRALIZED WASTEWATER TREATMENT SYSTEM IN HLAING THAR YAR INDUSTRIAL ZONES (CASE STUDY 3)

A3. Case Study 3: Installation of Centralized Wastewater Treatment System in Hlaing Thar Yar Industrial Zones

A3.1 Outline of Case Study 3

Table A3-1 shows the outline of the Case Study 3: Pollution load analysis in the pilot area of Mandalay. The objective of the Case Study 3 is to examine installation of a centralized industrial wastewater treatment system in Hlaing Thar Yar Industrial Zone as an effective tool for water environmental management. The results are used to identify issues to promote PPP scheme for construction of a centralized industrial wastewater treatment plant, such as financial feasibility, operation and maintenance, fee collection, and securing land. The lessons learnt from this case study can also be utilized for installation of a treatment plant in other industrial zones.

Table A3-1 Outline of Case Study 3 (Installation of Centralized Wastewater Treatment System in Hlaing Tharyar IZ)

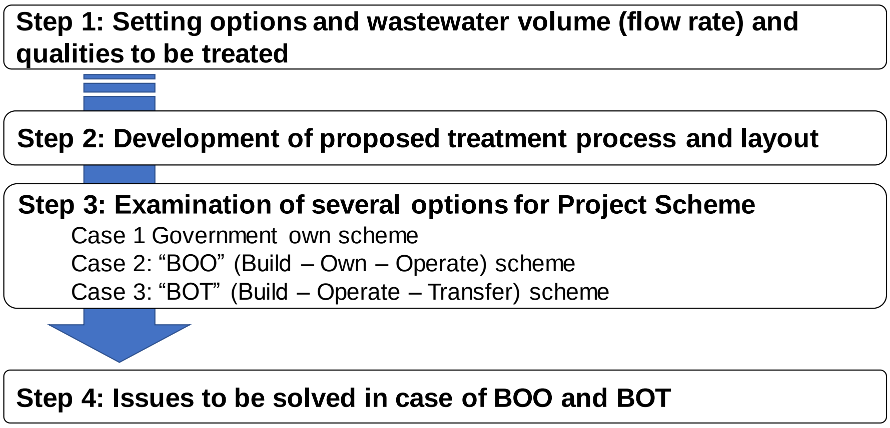
Item	Description
Target Level and Area	**[Target level]** Regional Level (Yangon) **[Target Area]** Hlaing Thar Yar Industrial Zones
Objective	To examine installation of a centralized industrial wastewater treatment system in the Industrial Zone as an effective tool for water environmental management
Methodology	As the case study, Hlaing Thar Yar Industrial Zones No.1 to No.4 are selected and an examination is carried out including a possibility of installation of centralized wastewater treatment plant and identification of issues to promote PPP scheme for construction such centralized industrial wastewater plant.
Expected outcome	The results of the examination can identify issues to promote PPP scheme for construction of the centralized industrial wastewater treatment plant such as financial feasibility, operation and maintenance, fee collection, securing land. The lessons and learned of the case study can be also utilized to other existing industrial zones to install the treatment plant.
Target Decision Maker	Industrial Zone Steering Committee of Yangon Region Government

Source: JET

A3.2 Procedures and conditions of examination of dilution capacity

(1) *Procedures of examination of installation of centralized wastewater treatment system in Hlaing Thar Yar IZ*

Figure A3-1 shows the procedures of examination of installation of centralized wastewater treatment system in Hlaing Thar Yar IZ, which have four steps. This report shows the summary of the examination. Please see the “Options for Wastewater Treatment in Hlaing Thar Yar IZ in October 2017” in the “Materials from Seminars and Workshops (Appendix 14)” in detail.



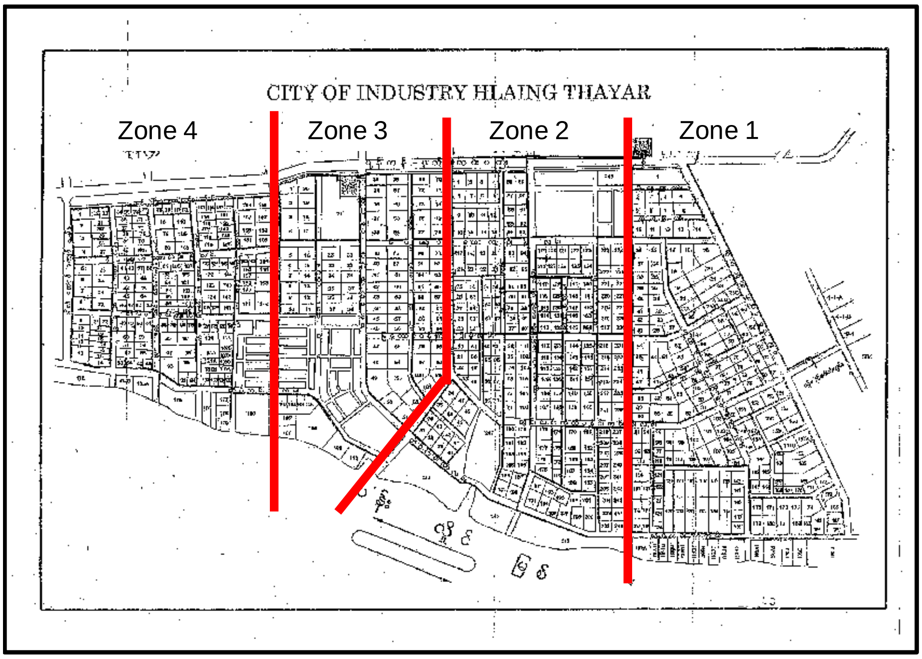
Source: JET

Figure A3-1 Procedures of Examination of Installation of Centralized Wastewater Treatment System in Hlaing Tharyar IZ

(2) *Setting options for Examination*

Figure A3-2 shows the plot map of Hlaing Tharyar IZ (No.1~4). Two options were examined as follows:

- Option 1: Installation of a centralized wastewater treatment system for Zone 1
- Option 2: Installation of a centralized wastewater treatment system for Zones 1, 2, 3 and 4



Source: JET

Figure A3-2 Plot Map of Hlaing Tharyar IZ (No.1~4)

(3) *Setting assumed wastewater volume and quality*

In this examination, certain assumptions were made to set wastewater volume and quality because most of the factories in the area have of no water and wastewater meters, and there were no reliable data on flow. Similarly, available water quality data were too scarce at the time of the case study.

Table A3-2 and Table A3-3 show the summary of the assumed wastewater volumes and qualities in Option 1 and Option 2. Compared with pollution load analysis, volumes of wastewater and concentrations of wastewater in some sectors are relatively high to make the estimates on the safer side.

Table A3-2 Summary of Assumed Wastewater Volume and Qualities (Option 1)

No	Kind of industry	Design flowrate	Calculated flowrate	COD	s-COD	BOD	SS	TN	TP
		m3/d	m3/d	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	Zone 1	**8,300**	**6,581**	**1,899**	**1,031**	**836**	**881**	**65.6**	**7.1**
1	Domestic		1083	405	182	225	667	64.1	12.0
2	Garment		1616	1,300	1,040	260	61	150	5.0
3	Dyeing			2,500	2,000	1,000	200	130	10.0
4	Ice storage		145	2,000	900	1,500	500	100	31.0
5	Chemical								
	Painting		871	3,000	540	600	2,000	50	2.0
	Fertilizer			355	160	178	463	200	2.0
6	Paper								
	Paper mill		697	5,500	3,614	3,000	3,000	9.0	2.0
	Without paper mill		621	500	300	300	450	1.0	0.1
7	Food		1548	1,880	1,034	1,176	510	35.6	11.8

Design flowrate = Calculated flowrate/0.8 (0.8 = Occupancy rate)

Source: JET (Kobelco-Supreme)

Table A3-3 Summary of Assumed Wastewater Volume and Qualities (Option 2)

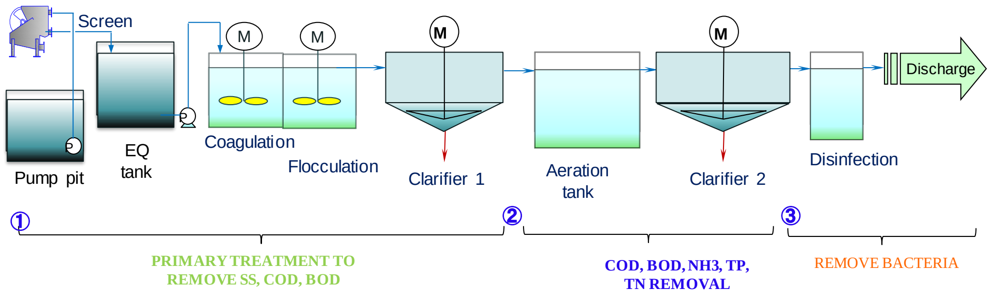
No	kind of industry	Design flowrate	Calculated flowrate	COD	s-COD	BOD	SS	TN	TP
		m3/d	m3/d	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	Zone 1 +2+3+4	**43,300**	**34,614**	**1,973**	**1,209**	**931**	**719**	**83.1**	**9.6**
1	Domestic		5,468	405	182	225	667	64.1	12.0
2	Garment		8,062	1,300	1,040	260	61	150	5.0
3	Dyeing		4,325	2,500	2,000	1,000	200	130	10.0
4	Ice storage		2,670	2,000	900	1,500	500	100	31.0
5	Chemical								
	Painting		2,038	3,000	540	600	2,000	50	2.0
	Fertilizer		415	355	160	178	463	200	2.0
6	Paper								
	Paper mill		3,362	5,500	3,614	3,000	3,000	9.0	2.0
	Without paper mill		621	500	300	300	450	1.0	0.1
7	Food		7,650	1,880	1,034	1,176	510	35.6	11.8

Design flowrate = Calculated flowrate/0.8 (0.8 = Occupancy rate)

Source: JET (Kobelco-Supreme)

A3.3 Development of proposed treatment process and layout

Figure A3-3 shows the proposed treatment process of the centralized wastewater treatment system. The target values of wastewater treatment were set based on National Environmental Quality (Emission) Guidelines in Myanmar (2015, MONREC). The required treatment capacity and the land area are 11,200 m^2 with 83,00 m^3 for Option 1, and 50,000 m^2 with 43,300 m^3 (Option 2).



Parameter	Unit	Inlet ①			Outlet ④
COD	mg/l	1780 - 1800			< 250
BOD	mg/l	700 - 800			< 50
SS	mg/l	600 - 720			< 50
NH3-N	mg/l	80 - 95			< 10
TP	mg/l	6.5 - 9			< 2
Coliform	MPN/100 ml				< 400

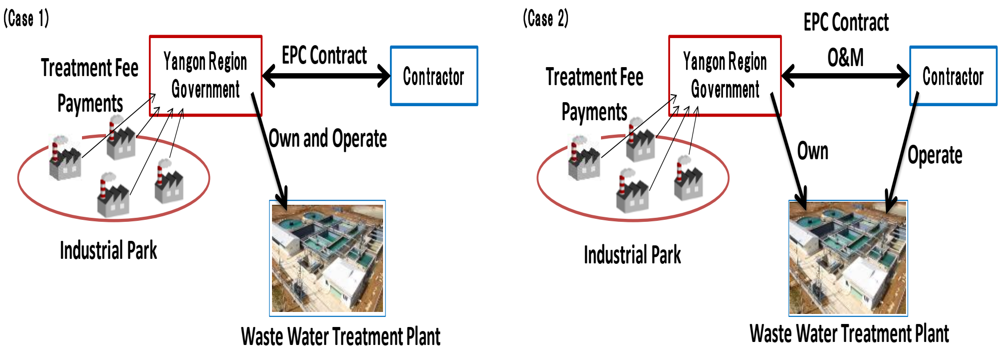
Source: JET (Kobelco-Supreme)

Figure A3-3 Proposed Treatment Process

A3.4 Examination of Options for Project Scheme

(1) *Case 1: Government own scheme*

Figure A3-4 shows the option of a government-owned scheme. The financing for project will be arranged by Yangon Region Government. In principle, the contractor carries out the works under Engineering-Procurement-Construction (EPC) Contract (Case 1). If necessary, the Government and the contractor may enter into Operation & Maimane (O&M) Contact in addition to the EPC Contract (Case 2).

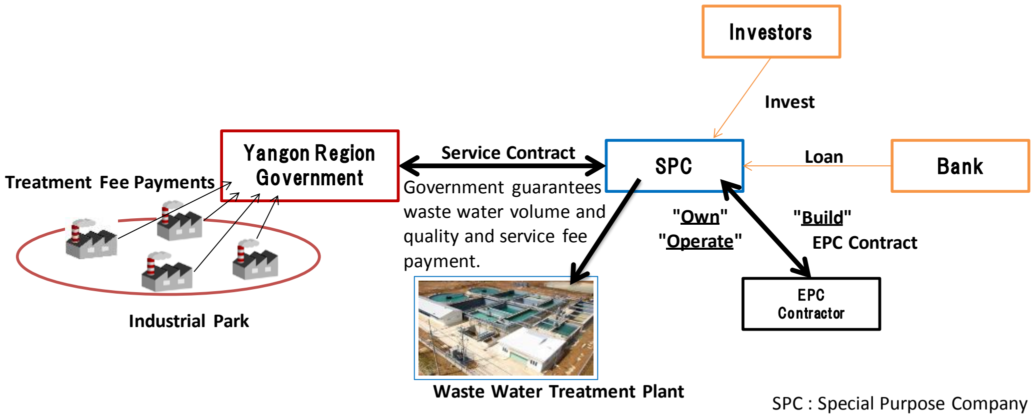


Source: JET (Kobelco-Supreme)

Figure A3-4 Case 1: Government Own Scheme

(2) *Case 2: "BOO" (Build – Own – Operate) scheme*

Figure A3-5 shows the BOO (Build – Own – Operate) scheme. The financing for the project will be arranged by an Investor that sets up Special Purpose Company (SPC). A SPC builds and owns the wastewater treatment plant, and provides the Government with services of treatment of wastewater.

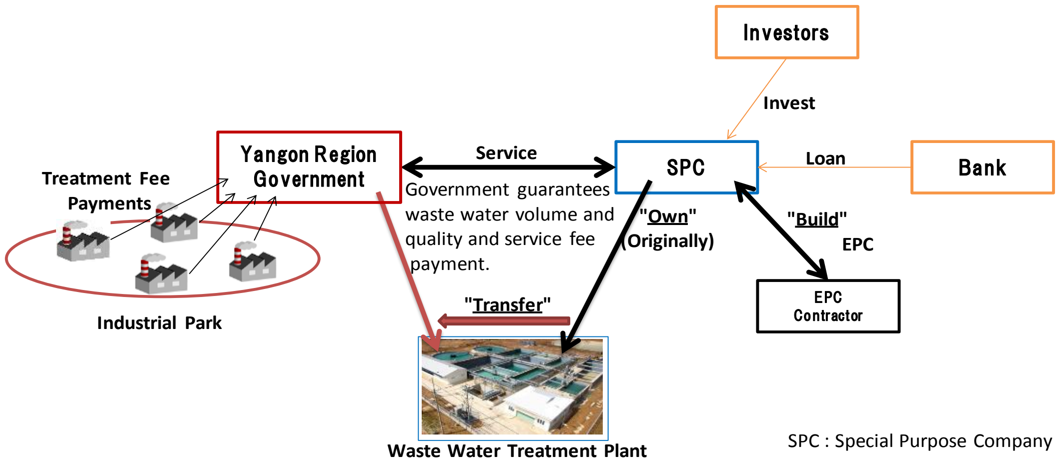


Source: JET (Kobelco-Supreme)

Figure A3-5 Case 2: BOO (Build – Own – Operate) Scheme

(3) *Case 3: "BOT" (Build – Operate – Transfer) scheme*

Figure A3-6 shows the BOT (Build – Operate – Transfer) scheme. The basic conditions such as financing, contract scheme, etc. are the same as BOO. In BOT, the ownership of the wastewater treatment plant will be transferred after reasonable return of investment has been obtained by the investors, which is the difference from BOO.



Source: JET (Kobelco-Supreme)

Figure A3-6 Case 3: BOT (Build – Operate – Transfer) Scheme

(4) *Comparison of each scheme*

Table A3-4 compares the results among proposed options for project scheme. There are many differences between the government-owned scheme and private company owned schemes (BOO and BOT).

Table A3-4 Comparison of Proposed Options for Project Scheme

	Government Owned	Private Company Owned	
		BOO (Build-Own-Operate)	BOT (Build-Operate-Transfer)
Arrangement of Funds - CAPEX - OPEX	Government (Yangon Region Government)	SPC	
Payment by Government	- For Construction of Plant to EPC Contractor (Payment at the time of constrction) - For Operation and Maintenance (O&M) to Cotractor if it is outsourced.	- For Waste Water Treatment Service to SPC (Payment over the period of Waste Water Treatment Service)	
Source of Fund for Payment by Government	Own fund for construction of Plant (= Tax revenue or Loan) * Fund for construction of Plant and O&M will be collected from factories in the industrial zone (Tenants) over the period of plant operation.	Fee collected from factories in the industrial zone (Tenants) * It is recommended to set the Government's fee charged to Tenants higher than the fee paid to SPC in order to cover expenses of Government.	
Ownership of Waste Water Treatment Plant	Yangon Region Government	SPC	- Originally, SPC owns plant. - After reasonable return of investment has been obtained by Investors, ownership is transferred to Yangon Region Government.
Summary of role of Government	- Arrangement of fund - Operation and Maintenance of Plant - Colletion of fees from Tenants - Arrangement of land - Arrangement of resettlement (if required)	- Payment of waste water treatment service fee - Guarantee of waste water volume and quality - Collection of fee from Tenants - Arrangement of land - Arrangement of resettlement (if required)	

Source: JET (Kobelco-Supreme)

A3.5 Identified issues to be solved

The results of the examinations identified major issues in establishing a centralized wastewater treatment facility, such as:

- Organization of a company responsible for overall management of an IZ
- Scheme for construction and operation of a centralized wastewater treatment facility (public project, BOO, BOT, etc.)
- Financing of investment cost
- How to estimate quantity and quality of wastewater from each factory
- How to secure land to construct the treatment facility and auxiliary facilities
- How to recover cost from factories and guarantee for minimum flow rate

Many IZs in Myanmar are facing similar issues in provision of other utilities/infrastructure services, such as water supply, electricity and road. Moreover, many IZs do not have clear organizational structure for management. Thus, establishing the management structure may be the first step before establishing centralized wastewater treatment.

ATTACHMENT 4: PRELIMINARY ESTIMATION OF DILUTION CAPACITY FOR WATER QUALITY IN DOKE HTA WADDY RIVER (CASE STUDY 4)

A4. CASE STUDY 4: PRELIMINARY ESTIMATION OF DILUTION CAPACITY IN DOKE HTA WADDY RIVER

A4.1 Outline of Case Study 4

Table A4-1 shows the outline of the Case Study 4: Preliminary Estimation of Dilution Capacity for Water Quality in the Doke Hta Waddy River. The objective of the Case Study 4 is to examine dilution capacity of water quality in the Doke Hta Waddy River, which is relevant to future water resources management. The results becomes a basic information to develop strategies for water environment management in Doke Hta Waddy River basin in the future, including coordination among the water users.

Table A4-1 Outline of Case Study 4 (Preliminary Estimation of Dilution Capacity for Water Quality leading to future water resource management in Doke Hta Waddy River)

Item	Description
Target Level and Area	**[Target level]** Regional Level (Mandalay) **[Target Area]** Doke Hta Waddy River
Objective	To examine dilution capacity for water quality in Doke Hta Waddy River, and to consider available water resource taking into account any future development along the target river such as a new hydropower plant upstream of Yeywa dam, a small weir with hydropower function, and irrigation development.
Methodology	Water quality in the current and future are estimated based on existing water quality data and water volume information especially water discharge from hydropower dam and water intakes for irrigation. Based on the existing information dilution capacity for water quality in Doke Hta Waddy River will be estimated as preliminary examination.
Expected Outcome	The results of estimation of dilution capacity for Doke Hta Waddy water quality can be utilized for coordination of water resource management among water users such as MCDC, Irrigation Department and Fishery Department of MOALI, Electricity Power Generation Enterprise of Ministry of Electricity and Energy, Directorate Water Resources and Improvement of River System of Ministry of Transport and Communication.
Target Decision Maker	Mayor and Committee Member of MCDC, Mandalay Regional Government

Source: JET

A4.2 Procedures and conditions of examination of dilution capacity

(1) *Procedures of examination of dilution capacity*

Figure A4-1 shows the procedures of examination of dilution capacity, which have four steps.

Step 1: Basic information collection
1) Water use of Doke Hta Waddy River (Current and Future)
2) Water quality of Doke Hta Waddy River (Output 2)
3) Wastewater quality and volume from 10-inchi pipeline (Current and Future)

Step 2: Setting water balance of Doke Hta Waddy River

Step 3: Setting cases of examination of dilution capacity
Case 0: Current dilution capacity
Case 1: BOD concentration at downstream of the 10-inchi pipeline in case of increasing water use in the upstream in future (before operation of Centralized WWTP)
Case 2: Case 1 + after operation of Centralized WWTP

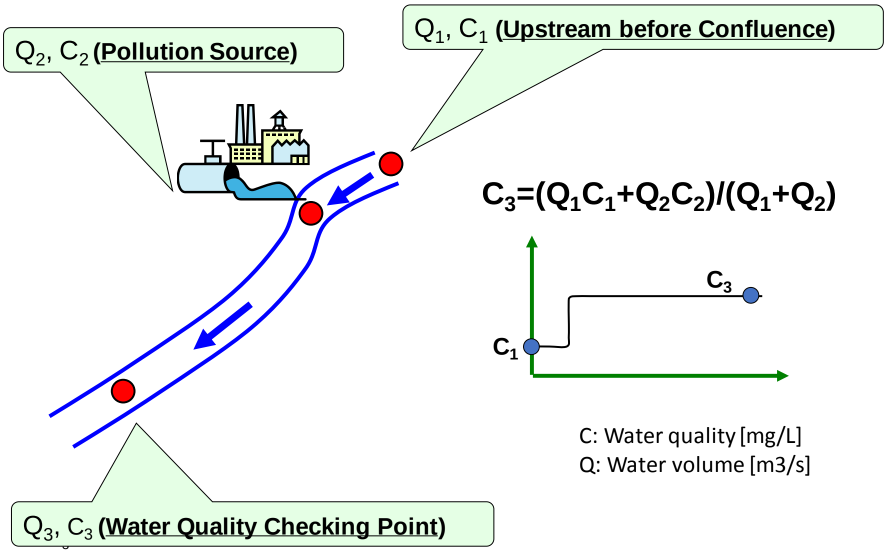
Step 4: Calculation of dilution capacity
1) Estimation BOD at downstream point of each case

Source: JET

Figure A4-1 Procedures of Dilution Capacity

(2) *Methodology of calculation of dilution capacity*

Figure A4-2 shows the image of calculation of downstream water quality based on the water quality and the water volume from the upstream, and those from the wastewater discharge point. The methodology of calculation is called “mass balance method”.



Source: JET

Figure A4-2 Calculation Methodology of Dilution Capacity (Mas Balance Method)

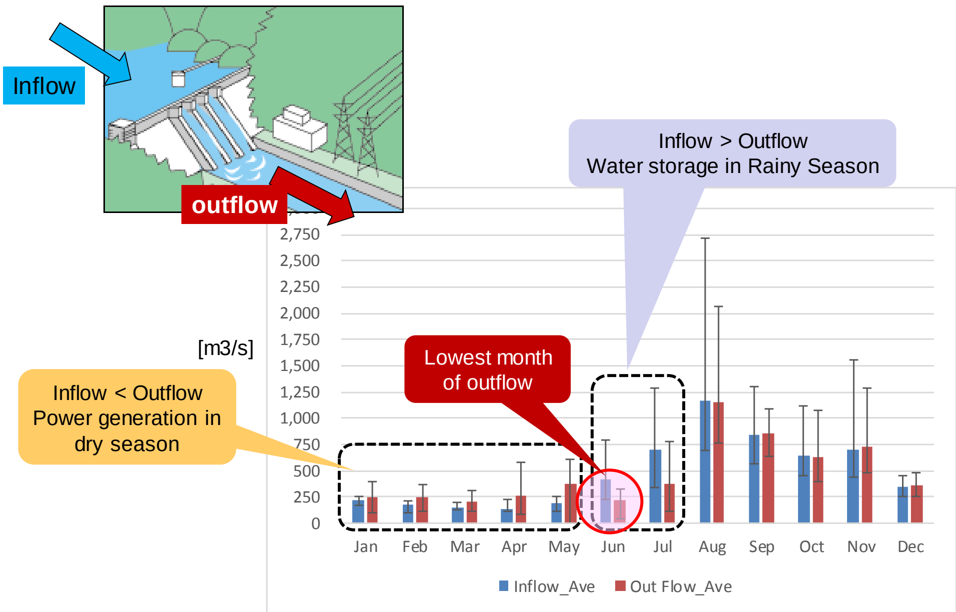
(3) *Basic information for examination of dilution capacity*

Table A4-2 shows the basic information used to examine the dilution capacity, namely the water use, water quality (BOD), and wastewater quality and volume from the 10-inch pipeline. At present, the most important factor of water quality at downstream of the 10-inchi pipeline is the discharge from Yeywa dam. Figure A4-3 shows the inflow and outflow rates of Yeywa dam in 2016. From January to May in 2016, the outflow is larger than the inflow because of power generation by water stored in the dry season. From July to August in 2016, the outflow is smaller than the inflow because of the storage of water in the beginning of rainy season. The lowest monthly average outflow was 200m^3/day in July 2016.

Table A4-2 Basic Information for Examination of Dilution Capacity (Existing Condition)

No.	Category	Items	Amount	Source
1	Water use	Discharge from Yeywa dam	200 m^3/s at the average of lowest month (Jul)	EPGE of MOEE
		Intake for irrigation	10 m^3/s as the maximum volume	Irrigation Department of Mandalay Region
2	Water quality	BOD Water quality at the upstream of 10-inch pipeline	4.7 mg/L	Results of 5th Water Quality in the latest dry season (Output 2)
3	Wastewater quality and volume from 10-inch pipeline	Design capacity of wastewater	2,500 m^3/day (0.03 m^3/s)	Data from MCDC
		Design BOD wastewater quality (inlet)	6,500 mg/L	
		Design BOD wastewater quality (outlet)	50 mg/L	

Source: JET summarizes based on various information source

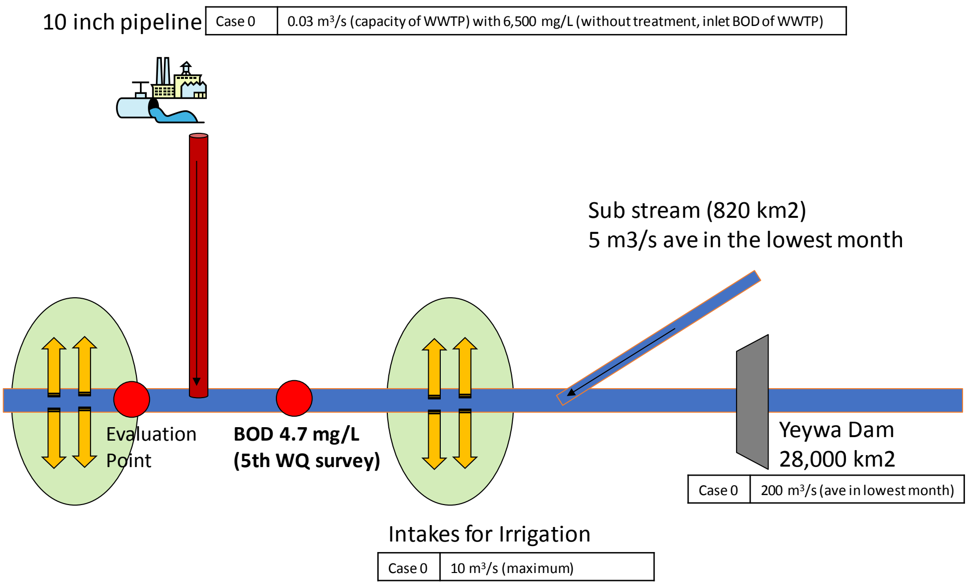


Source: JET based on EPGE of MOEE

Figure A4-3 Monthly Average Water Volume of Inflow and Outflow of Yeywa Dam in 2016

A4.3 Setting water balance

Figure A4-4 shows the image of the current water balance in the Doke Hta Waddy River. There is one main sub stream in the upstream of the river. The water volume from the sub stream was set in proportion to the area of the basin (Yeywa dam: 200m^3/s from 28,000 km^2 and sub stream: 5 m^3/s from 820 km^2).



Source: JET

Figure A4-4 Current Water Balance

A4.4 Setting cases for examination of dilution capacity

For examination of dilution capacity, the following three cases were set to understand impact of reduction of the water flow from the upstream area, and the effect of installation of the centralized wastewater treatment plant.

- Case 0: Current dilution capacity
- Case 1: Increased water use in the upstream in the future without operation of the centralized WWTP
- Case 2: Case 1 + after operation of Centralized WWTP

MCDC has a plan to withdraw water from the Doke Hta Waddy River for drinking water supply at a point upstream of the outlet of the 10-inch-pipeline. Meanwhile, new hydropower development projects such as upper Yeywa dam project and Deedoke hydropower project, are planned in addition to the Yeywa dam development. If these hydropower projects and other industrial and urban developments would take place in the future, the water quality of the Doke Hta Waddy River may deteriorate due to reduced water volume from the dams and increased industrial pollution. Table 4-3 shows conditions of cases for examination of dilution capacity.

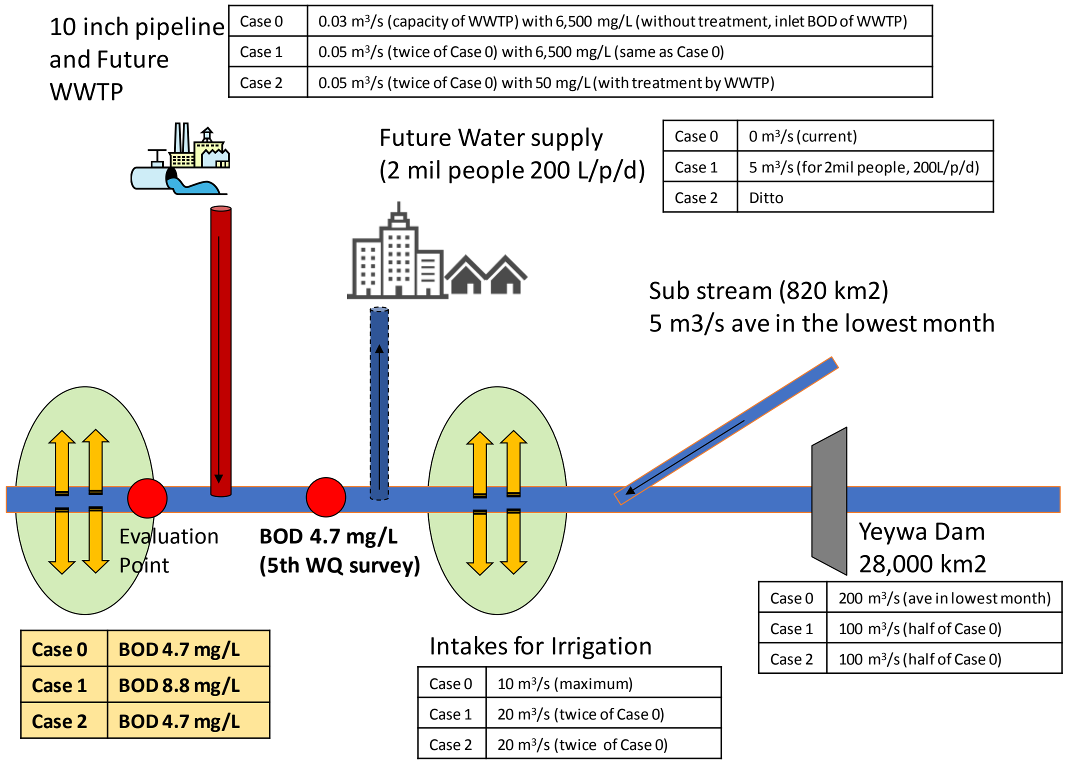
Table A4-3 Conditions of Cases for Examination of Dilution Capacity

No.	Category	Items	Case 0	Case 1	Case 2	Note
1	Water use	Discharge from Yeywa dam	200 m^3/s at the average of lowest month (Jul)	100 m^3/s (half of Case 0)	100 m^3/s (half of Case 0)	Assumption in case of development other hydropower dam
		Intake for irrigation	10 m^3/s as the maximum volume	20 m^3/s as (twice of Case 0)	20 m^3/s as (twice of Case 0)	Assumption in case of development more irrigation
		Public water supply for Mandalay City	N/A	5 m3/s	5 m3/s	For 2 million people (200L/person/day)
2	Water quality	BOD Water quality at the upstream of 10-inch pipeline	4.7 mg/L	4.7 mg/L	4.7 mg/L	Results of 5th Water Quality in the latest dry season (Output 2)
3	Wastewater quality and volume from 10-inch pipeline	Design capacity of wastewater	2,500 m^3/day (0.03 m^3/s)	5,000 m^3/day (0.05 m^3/s)	5,000 m^3/day (0.05 m^3/s)	Assumption in case of development more irrigation
		Design BOD wastewater quality (inlet)	6,500 mg/L	6,500 mg/L	6,500 mg/L	Data from MCDC
		Design BOD wastewater quality (outlet)	6,500 mg/L	6,500 mg/L	50 mg/L	Data from MCDC

Source: JET summarizes based on various information source

A4.5 Results of examination of dilution capacity

Figure A4-5 summarizes the result of the study. Compared with the current situation (Case 0), BOD concentration in the downstream of the 10-inch pipeline could double if the river flow rate decreases due to the operation of the dam(s) and use of more water for irrigation and domestic water supply, and if the industrial wastewater discharge from 10-inch pipeline increased without centralized wastewater treatment (Case 1). If the operation of the centralized wastewater treatment plant started, the water quality in the downstream would remain at the current level, even if the river flow decreased (Case 2). Thus, it was confirmed that the water quality of the river will be affected by the change in the flow and change in pollution load from Pyi Gyi Tagon IZ with/ without the centralized WWTP.



Source: JET

Figure A4-5 Results of Preliminary Examination of Dilution Capacity in Doke Hta Waddy River