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

PROJECT FOR IMPROVEMENT OF WATER SUPPLY MANAGEMENT OF YCDC

FINAL COMPLETION REPORT (MAIN REPORT)

JUNE 2021

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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GE
JR
21-020

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List of Abbreviations

Abbreviation	Full Name
AAS	Atomic absorption spectrophotometer
AC	Advisory Committee
ACE	Assistant Chief Engineer
ACH	Aluminum Chloro-hydrate
AE	Assistant Engineer
CA	Capacity Assessment
CD	Capacity Development
CE	Chief Engineer
C/P	Counterpart
CSM	Customer service management
Daw	Ms.
DMA	District Metered Area
DYCE	Deputy Chief Engineer
EDWS	Engineering Department of Water and Sanitation (Present WRAWSA)
EE	Executive Engineer
FY	Fiscal year
GOM	Government of Myanmar
HDPE	High Density Polyethylene Pipe
HRD	Human Resource Development
IWA	International Water Association
JE	Junior Engineer
JICA	Japan International Cooperation Agency
JPY	Japanese Yen
MGD	Million Gallons per Day
MJJS	Myanmar Japan Joint Seminar
MKPI	Management Key Performance Indicators
MNDWQS	Management Key Performance Indicators
M/P	Water Supply System Master Plan in the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City
MTP	Mid-term Management Plan
NRW	Non-Revenue Water
O&M	Operation and Maintenance
Off-JT	Off-the-Job Training
OJT	On-the-Job Training
PAC	Poly Aluminum Chloride
PCM	Project Cycle Management
PDCA Cycle	Plan-Do-Check-Action Cycle
PDM	Project Design matrix
PO	Plan of Operation
PPP	Public Private Partnership
PIs	Performance Indicators
PS	Pumping Station
RSGM	Regulations, Standards, Guidelines and Manuals
S/C	Steering Committee
SOP	Standard Operation Procedure
SR	Service Reservoir
SS	Suspended Solid
TFT	Task Force Team

Abbreviation	Full Name
TOT	Training of Trainers
T/S	Township
U	Mr.
WA	Working Authority
WRAWSA	Water Resource and Water Supply Authority (Former EDWS)
WTP	Water Treatment Plant
YCDC	Yangon City Development Committee
YESC	Yangon Electricity Supply Corporation
YRG	Yangon Region Government

Name of Places

Aungtagon and Barlar	North Okkalapa
Bahan	Phugyi
Gyobyu	Pazundaung
Hlaingtharyar	Pywbwesu
Hlawga	Shwedagon
Insein	Shwepyithar
Inya Lake	South Okkalapa
Kokkine	Tarmwe
Kokkowa	Thaephyu
Kyauktada	Thaketa
Kyeemyindaing	Thingangyun
Lagunbyin	Yangonpauk
Ngamoeyeik	Yankin
Mayangone	Yegu
Mingalardon	
Nyaunghnapin	

1. Outline of the Project

1.1. Background

Yangon city has a population of approximately 5.21 million (the National Census 2014) and is Myanmar's national center of economy, business, and communication. The water supply system in Yangon has a long history, which is in existence since 1842 and currently provides water from 4 reservoirs and a number of wells. The responsible organization of water supply in Yangon is Water Resources and Water Supply Authority (WRAWSA) under Yangon City Development Committee (YCDC). WRAWSA was reorganized from Engineering Department (Water and Sanitation) (EDWS) in April 2020.

The water supply service ratio in Yangon city was only 37 % in 2011 with an average daily service duration of only 9.2 hours although the service duration in the central part of the city was 24 hours. On the other hand, staged development of waterworks facility has become urgent to meet the rapid increase of water demand due to rapid population increase and commercial / industrial development. Moreover, two-third of the approximately 90 % of distributed water, which comes from reservoirs is distributed directly without any treatment. In addition, treatment process at the water treatment plant is insufficient, and disinfection (chlorination) at the city's Yegu pumping station is irregular. Non-revenue water (NRW) ratio in Yangon city is estimated to be 66%, and the revenues collected for water services is very low because of low rate of water tariff (e. g. metered rate: about 8 JPY/m^3, flat rate: about 170JPY/month). Measures for controlling NRW by YCDC are limited to only reactive measures to frequent breakdown of facilities and equipment and disrupted water supply and the expansion of water supply and replacement of the old facilities have not been sufficiently accomplished.

Under the above circumstances, Japan International Cooperation Agency (JICA) assisted YCDC to prepare Water Vision and Master Plan of Water Supply System (M/P) with the target year of 2040 through the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City from 2012 to 2014. Based on the M/P, and in response to the request from the Government of Myanmar, Japanese ODA Loan Project "Greater Yangon Water Supply System Improvement Project" was announced to be implemented by the Government of Japan in December 2013. The above project aims to supply water in the eastern area of Yangon city and Thilawa Special Economic Zone (SEZ) and to install disinfection facilities in Yangon city.

On the other hand, WRAWSA does not have sufficient capacity to manage the waterworks since YCDC does not have a planning section and lacks stipulated plans, standards and standard operating procedures (SOP), based on which the waterworks are managed. Besides quantitative performance evaluation of the waterworks using performance indicators (PIs) is not made and implementation of improvement measures based on PIs is also not carried out, financial management is insufficient to ensure adequate revenue, and human resource development, public relations, customer services and other waterworks management components are also insufficient. Furthermore, there are many issues related to NRW management and water quality management mentioned above. Issues related to these organizational capacities and improvement plans are analyzed in the M/P. It is necessary to develop capacity of YCDC together with the provision of water supply facilities through JICA loans in order to ensure sustained water supply services. JICA dispatched a long-term expert team from the Waterworks Bureau, Fukuoka City as "Yangon City Water Supply Management Advisors" since 2015. As a successor, JICA is dispatching an expert of "Yangon City Water Supply and Sanitation Advisors". However, in addition to policy advice by individual experts, focused capacity building and strengthening of practical skills are necessary to cope with wide-ranging issues mentioned above. Under this background, YCDC requested technical cooperation related to capacity development from Japan. JICA decided to implement 'The Project for Improvement of Water Supply Management of YCDC' (hereinafter, the Project) and dispatched the project experts (hereinafter, the Expert) in July 2015.

1.2. Outline of the Project

The outline on the Project is shown below:

(1) Name	The Project for Improvement of Water Supply Management of YCDC
(2) Overall goal	Water supply services provided by YCDC are enhanced.
(3) Project purpose	Capacity of YCDC on the management of water supply service is improved.
(4) Outputs	1. Capacity of YCDC on institutional management of water supply utility is improved. 2. Capacity of YCDC on NRW management is improved. 3. Capacity of YCDC on water quality management is improved.
(5) Project target area	Greater Yangon Area
(6) Implementing Organization	Water Resource and Water Supply Authority (WRAWSA), Yangon City Development Committee (YCDC)

1.3. Project Purpose

The aim of the Project is to achieve the project purpose by achieving the expected outputs through implementation of operations (activities) with regard to "The Project for Improvement of Water Supply Management of YCDC" based on the Record and Discussions (R/D) related to the Project.

1.4. Project Design Matrix and Plan of Operation

1.4.1. Revision of PDM

The final project design matrix (PDM) (version 5) of the Project and the history of revisions are given in Appendix 1.

(1) History of revision of PDM

1) 1st amendment of R/D

The 1st revision of PDM was agreed in the 1st Joint Coordinating Committee (JCC) meeting held on 29th Jan. 2016 and the 1st R/D was agreed on 30th Mar. 2016. The major modifications are as follows. In addition, the equipment to be procured were decided as shown in 2.1.2.

a. Additional activity for establishing new divisions/sections
b. Additional activity for Performance Indicators (PI) monitoring
c. Additional activity of water quality management (water treatment)
d. Additional activity of water quality improvement of reservoir water quality through on-the-job training (OJT)
e. Addition of indicators of additional activities
f. Decision of equipment to be procured

2) 2nd amendment of R/D

The 2nd revision of PDM was agreed in the 3rd JCC meeting held on 1st Feb 2017 and the 2nd R/D was agreed on 5th May 2017. The major modifications are additional activities as follows. In addition, the equipment to be procured were added as shown in 2.1.2.

- Assistance to establish Customer Service Division
- Assistance for preparation of draft water supply regulation
- Construction of NRW management training yard
- Technical assistance to NRW management pilot project in North Okkalapa T/S that is implemented by YCDC.

3) 3rd amendment of R/D

The 3rd revision of PDM was agreed in the 5th JCC meeting held on 26th Feb 2018 and the 3rd R/D was agreed on 19th Sept 2018. The major modifications included modification of the objectively verified indicators (OBIs) of PDM and setting up of the indicator values. The concept of the review is that the OBIs system was reestablished by examining the path to achieve the overall goal by creating the impact from the achievement of the project goal. The indicators after the modification are shown below.

Narrative Summary	**Objectively Verifiable Indicator (after revision)**
[Overall Goal] Water supply services provided by YCDC are enhanced.	1. The management key performance indicators (MKPIs) are improved compared to the data at the Project commencement. 2. NRW is decreased from OO % to OO % in the water supply area of YCDC 3. The compliance ratio in terms of turbidity to meet the water quality standard is increased from OO% to OO%. The compliance ratio is increased from OO% to OO% in terms of residual chlorine (>0.2 mg/l).
[Project Purpose]	
Capacity of YCDC on the management of water supply service is improved.	1. Steering Committees (S/C) are organized, and improvement actions are implemented.
	2. Mid-term management plan is approved by EDWS.
	3. The implementation of mid-term management plan is monitored based on MKPIs.
	4. The NRW ratio is grasped in the water supply service area of YCDC and monitored.
	5. Plan for NRW reduction is approved by EDWS.
	6. Water quality is grasped in the water supply service area of YCDC and monitored.
	7. Plan for improvement of water quality is approved by EDWS.
[Outputs]	
1. Capacity of YCDC on institutional management of water supply utility is improved.	1-1 Plan for improvement of water bill collection is approved by EDWS.
	1-2 Plan for human resources development is approved by EDWS.
	1-3 Drafts of regulations, standards, and guidelines for water supply services in Yangon is approved by EDWS.
	1-4 New organization structure is approved by Mayor.
	1-5 2 Full time staff members in Planning Section can give direction of PDCA cycle to EDWS staff.
2. Capacity of YCDC on NRW management is improved.	2-1 Manuals and training materials on NRW management are utilized by YCDC staff.
	2-2 Information of customers and pipes for the pilot areas is compiled and updated
	2-3 The number of trainers for NRW management becomes 8.
	2-4 EDWS staff participates in training based on training plan for NRW management.
	2-5 NRW ratio is decreased to 25% in the pilot area.
3. Capacity of YCDC on water quality management is improved.	3-1 Manuals and training materials on water quality management are fully utilized by YCDC staff.
	3-2 Result of the water quality test by the central laboratory and on-site mini laboratory is recorded and monitored periodically.
	3-3 The number of trainers for water quality management becomes 4.
	3-4 EDWS staff participate in training based on training plan for water quality management.
	3-5 The turbidity of treated water in pilot sand filter in Nyaunghnapin water treatment plant is controlled to less than 1 NTU.
	3-6 The operation and maintenance system of Lagunbyin water treatment plant is prepared.
	3-7 The operation and maintenance system of chlorination facilities is prepared.

Note: EDWS indicates WRAWSA.

4) 4th amendment of R/D

The 4th R/D was agreed on 3rd July 2020. Due to the COVID-19 pandemic, some project activities were suspended. The project period was extended to achieve the project purposes after the project team resumed activities in Myanmar. The extension period was set to half a year, and the project period was set to December 2020. In addition, support activities to respond to the COVID-19 pandemic were added.

5) 5th amendment of R/D

The 5th R/D was agreed on 30th December 2020. The project period was extended once in the 4th revised R/D, but the project activity was still suspended, and the project period was extended for the second time. The extension period was set to half a year, and the project period was set to June 2021.

(2) Addition of activities

1) PDM Ver.1

The following activities were added in PDM Ver.1.

a. Additional activities for establishing new division and section.
- "1-1 Prepare overall organizational change plan" was added to restructure the existing YCDC-EDWS organization. For the achievement indicator of this activity, "1-4 New organization structure is approved by Mayor" was added.
- Establishment of "Planning Section" and "NRW Management Unit (Section)" was proposed in the existing PDM. Based on the result of the baseline survey, establishment of following division and section was proposed.
  - Customer Service Division
  - Water Treatment Section

Detailed activities (subject)

1-3 Establish Customer Service Division

1-3-1 Establish the Customer Service Division in Department of Water and Sanitation

1-3-2 Define the division of duties of the Customer Service Division

3-1 Establish Water Treatment Section

3-1-1 Establish Water Treatment Section in Department of Water and Sanitation

3-1-2 Define the division of duties of the Water Treatment Section

3-1-3 Hold a series of seminar for basic water treatment technology with study tours

b. Additional activities for PI monitoring
- Water distribution volume is an important PI for waterworks management. However, YCDC had not monitored water distribution volume. Therefore, flow-monitoring system is to be installed to monitor water distribution volume.
- At present, office work in T/S office and branch office of WRAWSA depends on handwritten documents and manual calculation. To improve an efficiency of PI data collection, personal computer (PC) is to be installed and computerized database to be established in each T/S office and branch office necessarily.
- PI data is to be efficiently collected.

Detailed activity (subject)

1-3-4 Install transmission flow meter and data logger and collect flow data

1-3-5 Procure equipment (computers, printers, etc.) for computerized data management system in local offices and conduct training

1-3-6 Collect data required for setting PIs

c. Additional activity of water quality management (water treatment)
- In the initial PDM, OJT in the pilot water treatment plant (Nyaunghnapin water treatment plant (WTP)) including SOPs and operation manual development was planned. However, through the baseline survey, it was found that diagnostic survey of function of WTP and development of WTP performance improvement plan are necessary before establishing SOPs and operation manuals.
- Diagnosis survey and improvement of WTP performance are implemented by YCDC. These activities are included in "3-5 Conduct OJT on water quality management at the pilot treatment plants and disinfection facility".

- In the implementation of these activities, a feasible improvement plan will be prepared based on the financial ability and technical capacity of YCDC.

Detailed activity (subject)

3-5-1 Procure water quality analysis and water quality management equipment
3-5-3 Diagnose treatment performance of Nyaunghnapin water treatment plant
3-5-4 Develop improvement measures of function of Nyaunghnapin water treatment plant through pilot basin
3-5-5 Prepare an improvement plan of Nyaunghnapin water treatment plant

d. Additional activity of water quality improvement of reservoir water quality through OJT

- In the initial PDM, improvement of water quality of raw water from reservoirs was not included. However, through the baseline survey, it was found that suspended solids (SS) and small aquatic life in non-treated water from reservoir deteriorate tap water quality and cause malfunction of consumer water meter.
- Thus, to reply to the request of YCDC to add an OJT activity of water quality improvement of reservoir water, i) Water quality monitoring of reservoir water and ii) Technical assistance to establish water quality improvement plan were added.

Detailed activity (subject)

3-6 Conduct OJT on improvement of water quality supplied from storage reservoirs
3-6-1 Review water quality problems in reservoir water
3-6-2 Research water quality improvement measure of reservoir suppled water

e. Additional indicators

"Indicator 4: New organization structure is approved by Mayor" was added as indicator of "Output1: Capacity of YCDC on the institutional management of water supply utility is improved".

2) PDM Ver.2

The following activities are added in PDM Ver.2.

a. The Project supports the establishment of the operation system of EDWS on customer service to guide and train T/S. The Project also supports that the Head Office of EDWS provides guidance for improvement of operation in T/S. A survey on e-government system, which is newly installed, will be carried out and an improvement plan will be developed.

1-3 Establish the Customer Service Division
1-3-3 Establish operation system of the Customer Service Division

b. The Project supports to develop the preliminary draft of Water Supply Regulation, to implement a trial operation, and to formulate the draft with modification and addition based on the evaluation results of trial run.

1-5 Formulate regulations, standards and guidelines
1-5-3 Draft water supply regulation and run a trial

c. The Project supports pilot project activities of North Okkalapa T/S for NRW management which will be implemented by YCDC.

2-3 Develop a model on the management of physical loss (leakage, overflow) and human resources development
2-3-2 Conduct trainings of trainers
2-4 Develop a model on the management of commercial loss (meter fault, miss reading of meter, illegal connection) and human resources development
2-4-2 Conduct trainings of trainers

d. The Project supports the construction of a training yard which will be a center of technology transfer and accumulation of knowledge in mid- and long-term. The purpose is to systematically and continuously provide an opportunity to train many staff members in all related sections including T/S.

2-5 Develop training yard for NRW management

3) PDM Ver.4

In response to the COVID-19 pandemic, the activities including support for public awareness activities carried out by JICA Myanmar Office were added.

1-10 Conduct support activities in response to the COVID-19 emergency

1.4.2. Additional Activities in Japan

In response to the COVID-19 pandemic and the infection spread in Myanmar, all consultant experts left Myanmar for this project work at the end of 17th March 2020. After that, remote work was carried out in Japan until the Project was completed by transferring the remaining foreign man-months to domestic man-months and adding man-months for new activities. The following activities were added as domestic works to realize project outputs and sustain effects.

Table 1-1: Additional domestic works to realize project outputs and sustain effects

No.	Output	Additional Activities
1	1	Create teaching materials for water supply business management basic course (technology transfer product)
2	1	Create PPP teaching materials (technology transfer deliverable)
3	1	Create a future vision (draft) for the Customer Service Section
4	1	Create educational activity teaching materials (technology transfer deliverable)
5	overall	Create technical materials compiling advisory committee seminars (technology transfer deliverable)
6	overall	Create records of project activities
7	1	Create a water tariff setting guidebook
8	1	Assist the improvement and implementation of water supply regulation (draft)
9	1	Support the implementation of the future vision (draft) of the Customer Service Section
10	1	Assist public awareness and information dissemination activities including the new coronavirus during the extended project period
11	2	Create online training materials on non-revenue water management
12	3	Continue to provide operational guidance for chlorine disinfection facilities
13	3	Continue to provide operational guidance for the Lagunbyin WTP
14	3	Prepare a research treatise to be submitted to the academic society
15	overall	Continue to hold remote meetings and create monthly reports
16	overall	Continue to provide guidance on deepening each activity

1.4.3. Plan of Activity

The final version of plan of activity (PO) is shown below.

PO Activity No.			Schedule						
			Term 1		Term 2				
			2015	2016	2017	2018	2019	2020	2021
Output 1: Capacity of YCDC on Institutional management is improved.									
1-1		Prepare overall new organization structure							
1-2		Establish Planning Section							
	1-2-1	Establish the Planning Section in Department of Water and Sanitation							
	1-2-2	Define the division of duties of the Planning Section							
1-3		Establish Customer Service Division							
	1-3-1	Establish the Customer Service Division in Department of Water and Sanitation							
	1-3-2	Define the division of duties of the Customer Service Division							
	1-3-3	Establish operation system of the Customer Service Division							
1-4		Develop and Monitor Performance Indicators (PIs)							
	1-4-1	Review the current method of calculation and monitoring of performance data							
	1-4-2	Conduct training of trainers on the calculation and monitoring of Performance Indicators.							
	1-4-3	Identify the necessary and available Performance Indicators to be monitored							
	1-4-4	Install transmission flow meter and data logger and collect flow data							
	1-4-5	Procure equipment (computers, printers, software, etc.) in local offices and conduct training							
	1-4-6	Collect data required for setting PIs							
	1-4-7	Develop calculation method, manuals and monitoring system of Performance Indicators							
	1-4-8	Calculate Performance Indicators							
	1-4-9	Update and monitor the Performance Indicators periodically							
1-5		Formulate regulations, standards and guidelines							
	1-5-1	Review the existing rules, regulations, standards and guidelines							
	1-5-2	Identify regulation, standards and guidelines to be modified and/or newly formulated							
	1-5-3	Draft water supply regulation and run a trial							
	1-5-4	Draft necessary regulation, standards and guidelines, which can be prepared by YCDC							
1-6		Enhance understanding on financial management							
	1-6-1	Analyze the current financial management system							
	1-6-2	Implement training on financial management for the sustainable operation of water supply service in consideration of future development plans							
	1-6-3	Conduct OJT on development of asset ledger							
1-7		Strengthen Public Relations							
	1-7-1	Analyze the effective public relations on water service of YCDC							
	1-7-2	Conduct awareness raising of YCDC staff							
	1-7-3	Conduct OJT on the public relations activities							
1-8		Strengthen human resources development							
	1-8-1	Review the existing human resources development system							
	1-8-2	Identify necessary improvement on structure and materials of the trainings							
	1-8-3	Conduct trainings of trainers for planning and organizing the trainings							
	1-8-4	Develop 5-year and 10-year human resources development plans							
	1-8-5	Launch priority activities as a part of implementing the 5-year human resources development plan							
1-9		Develop and support implementation of the institutional management plans							
	1-9-1	Develop 5-year and 10-year institutional management plans							
	1-9-2	Launch priority activities as a part of implementing the 5-year institutional management plan							
1-10		Conduct the support activities in response to the COVID-19 emergency							

: Main activities ▪▪▪▪ : Monitoring or minor activities

Red: Added activities

Figure 1-1: PO of Output 1: Capacity of YCDC on institutional management of water supply utility is improved

PO Activity No.		Schedule						
		Term 1		Term 2				
		2015	2016	2017	2018	2019	2020	2021
Output 2. Capacity of YCDC on NRW management is improved.								
2-1	Establish NRW Management Unit							
2-1-1	Establish NRW Management Unit							
2-1-2	Define the division of duties of NRW Management Unit							
2-2	Collect and compile information of NRW							
2-2-1	Collect information of NRW and implement a baseline survey							
2-2-2	Compile information of pipes for establishment of GIS							
2-2-3	Compile customer information into database							
2-2-4	Formulate Standard Operation Procedure (SOP) of the above information management							
2-3	Develop a model on the management of physical loss (leakage, over flow) and human resources development							
2-3-1	Review current situation and develop phased countermeasures							
2-3-2	Conduct trainings of trainers							
	Conduct trainings of trainers through implementation of Non-revenue water (NRW) pilot project in North Okkalapa							
2-3-3	Prepare training plan and training materials by the trainers							
2-3-4	Formulate manuals on physical loss							
2-3-5	Conduct Off-JT by the trainers							
2-3-6	Select a pilot areas for NRW management activities							
2-3-7	Prepare action plan and procurement of equipment (leakage survey and repair) for the countermeasure to be taken for physical loss in the pilot area							
2-3-8	Set up DMAs at the pilot area (Including procure materials and construct DMA)							
2-3-9	Conduct the countermeasures against physical loss in the pilot area							
2-3-10	Evaluate cost-benefit of countermeasures against physical loss of the pilot area and formulate the optimal model of activities							
2-3-11	Implement OJT by the trainers							
2-3-12	Verify the manuals on physical loss							
2-4	Develop a model on the management of commercial (non-physical) loss (meter fault, miss reading of meter, illegal connection) and human resources development							
2-4-1	Review current situation and develop phased countermeasures							
2-4-2	Conduct trainings of trainers							
	Conduct trainings of trainers through implementation of Non-revenue water (NRW) pilot project in North Okkalapa							
2-4-3	Prepare training plan and training materials by the trainers							
2-4-4	Formulate manuals on commercial loss							
2-4-5	Conduct Off-JT by the trainers							
2-4-6	Prepare action plan and procurement of equipment for the countermeasures to be taken for commercial loss in the selected pilot area							
2-4-7	Conduct the countermeasures against commercial loss in the pilot area							
2-4-8	Evaluate cost-benefit of countermeasures against physical loss in the pilot area and formulate the optimal model of activities							
2-4-9	Implement OJT by the trainers in the pilot area							
2-4-10	Verify the manuals on commercial loss							
2-5	Develop training yard for NRW management							
2-5-1	Prepare training plan for training yard							
2-5-2	Design training yard							
2-5-3	Prepare equipment and materials for training yard							
2-5-4	Construct training yard							
2-5-5	Prepare training manuals and materials for training yard and conduct trainings of the trainers in training yard							
2-5-6	Conduct Off-JT by the trainers in training yard							
2-6	Develop and support implementation of the NRW management plans							
2-6-1	Develop 5-year and 10-year NRW management plans							
2-6-2	Launch priority activities as a part of implementing the 5-year NRW management plan							

━ : Main activities　　■ ■ ■ ■ : Monitoring or minor activities

Red: Added activities

Figure 1-2: PO of Output 2: Capacity of YCDC on NRW management is improved

PO Activity No.		Schedule: Term 1 (2015–2016), Term 2 (2017–2021)
Output 3. Capacity of YCDC on water quality management is improved.		
3-1	Establish Water Treatment Section	
3-1-1	Establish the Water Treatment Section in Department of Water and Sanitation	
3-1-2	Define the division of duties of the Water Treatment Section	
3-1-3	Hold a series of seminar for basic water treatment technology with study tours in treatment facilities	
3-2	Review current situation and formulate phased countermeasures	
3-3	Conduct training of trainers on water quality management	
3-3-1	Conduct training of trainers on the water quality management	
3-3-2	Prepare the training plan and training manuals by the trainers	
3-3-3	Conduct Off-JT by the trainers	
3-4	Develop SOP for water quality management	
3-4-1	Develop SOP on water quality test and monitoring	
3-4-2	Develop SOP on operation and maintenance of water treatment plant & disinfection facility	
3-5	Conduct OJT on water quality management at the pilot treatment plants and disinfection facilities	
3-5-1	Procure water quality analysis and water quality management equipment	
3-5-2	Conduct OJT on water quality test and monitoring	
3-5-3	Diagnose function of treatment processes of Nyaunghnapin water treatment plant	
3-5-4	Develop improvement measures of function of Nyaunghnapin water treatment plant through pilot basin	
3-5-5	Prepare an improvement plan of Nyaunghnapin water treatment plant	
3-5-6	Conduct OJT on operation and maintenance of water treatment plant & disinfection facility	
3-5-7	Verify SOP for water quality management	
3-6	Conduct OJT on improvement of water quality supplied from reservoirs	
3-6-1	Review water quality problems in reservoir water	
3-6-2	Research water quality improvement measure of reservoir suppled water	
3-7	Develop and support implementation of the water quality management plans	
3-7-1	Develop 5-year and 10-year water quality management plans	
3-7-2	Launch priority activities as a part of implementing 5-year water quality management plan	
Common Activities		
Preparation of Work Plan Phase 1 (Draft) and Monitoring Sheet Ver.1 and Discussion		
Preparation of Work Plan Phase 2 (Draft) and Monitoring Sheet Ver.4 and Discussion		
Baseline Survey (Implementation of Capacity Assessment)		
Confirmation of Work Plan and Monitoring Sheet Ver.1		
Preparation of Monitoring Sheet Ver.2～Ver.10		
Study of training in Japan and third country and implementation		
Study of materials to be procured and their procurement		
Preparation of project progress report		
End line survey		
Preparation of project completion report		
Kick-off Meeting, Joint Coordinating Committee (JCC) Meetings		Kick-off, JCC1, JCC2, JCC3, JCC4, JCC5, JCC6, JCC7, JCC8, JCC9

▬ : Main activities ▪▪▪▪ : Monitoring or minor activities

Red: Added activities

Figure 1-3: PO of Output 3: Capacity of YCDC on water quality management is improved, and Common Activities

1.5. Outline of Achievement of the Project Outputs and Purpose

The Project is to strengthen the capacity necessary for the execution of the master plan (M/P) formulated through the "the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City" and the execution of various projects such as ODA loans based on the M/P. The contents of the Project were prepared based on the feasibility study of YCDC's capacity development plan conducted in the project above. The Project covered a wide range of contents from the basic level and established the foundation for an organization to realize modernized water supply services.

The main points of the outputs and purpose of the Project achieved and the outline of each achievement by output and project purpose are shown in the tables below. The responsible organizations for achievement of the project purpose and overall goal were established, the standard operation procedure (SOP) was set up, the technical and management abilities were improved, and the trainers who can teach the achieved outputs to the staff were developed in achievement of the outputs of the Project. The implementation system of the Plan-Do-Check-Action (PDCA) cycle, including a system for planning, monitoring, and improvement for applying these output elements to water supply service improvement, was established (achievement of the project purpose). By continuing to practice this cycle, it is expected that improvement of the service (achievement of the overall goal) will be realized. The path (concept) to achieve the overall goal is shown in the figure below.

Table 1-2: The main points of the outputs and project purpose achieved in the Project

Item	Achievement
Outputs	• Responsible organizations for achievement of the project purpose and the overall goal were established and started activities. • An internal business process for improvement has been formed (Creation of SOP and establishment of operation system, planning process, etc.) • Training instructors with leadership and technical skills were developed. • The ability to continuously develop human resources has been developed. • Technical skills and management skills for instructing business improvement are being developed.
Project purpose	• Mid-term action plans with goals were created. • The monitoring system has been put into operation and monitoring of indicators to achieve the targets started. • An official system for taking improvement actions (Steering Committees: S/C) were established to create the driving force for practice of PDCA cycle. • Plans were approved and being monitored, and an independent PDCA improvement cycle was formed, and its operation was started.

Table 1-3: Outline of Outputs and Project Purpose achieved in the Project

<table>
<tr><th rowspan="2">Item</th><th colspan="3">Outputs achieved</th></tr>
<tr><th>Institutional management capacity</th><th>NRW management capacity</th><th>Water quality management capacity</th></tr>
<tr><td rowspan="2">• Responsible organizations are established</td><td colspan="3">A new organization structure for WRAWSA was submitted to the Mayor and the operation of the new organization was started.</td></tr>
<tr><td>Planning Section, Customer Service Division, and Human Resource Development Section were established.</td><td>NRW Management Section was established.</td><td>Water Treatment Section was established.</td></tr>
<tr><td>• Internal business process for improvement is established
• The ability to continuously develop human resources has been developed.
• Technical and management abilities to guide improvement actions were being developed.</td><td>- An improvement plan of billing and collection was approved in WRAWSA.
- A human resource management plan was prepared and reviewed by the top management of WRAWSA for approval.
- SOPs for all sections and offices in WRAWSA were created, approved, and/or started in use.
- The draft Water Supply Regulation was reviewed by the top management of WRAWSA.</td><td>- The customer data and pipeline data in the pilot area were developed and updated.
- The NRW ratio in the pilot area was reduced to about 5%.
- SOPs of NRW management were started to use by staff.</td><td>- Turbidity of treated water in pilot filter of Nyaunghnapin water treatment plant has been controlled below 1 NTU.
- Operation and maintenance system of Lagunbyin water treatment plant was established.
- Water quality analysis data in the central water quality laboratory and mini laboratories have been recorded and monitored.
- SOPs of water quality management has been utilized by the staff.</td></tr>
<tr><td>• Trainers with leadership and/or technical capacity were developed.</td><td>- 2 full time staff members in Planning Section can give direction of PDCA cycle to WRAWSA staff.
- Trainings started by Human Resource Development Section.</td><td>- At least 8 trainers for NRW management were developed.
- WRAWSA staff has participated in training based on training plan for NRW management.</td><td>- At least 4 trainers for water quality management were developed.
- WRAWSA staff has participated in training based on SOPs created.</td></tr>
<tr><th rowspan="2">Item</th><th colspan="3">Project Purpose</th></tr>
<tr><th colspan="3">Management capacity of water supply service by YCDC</th></tr>
<tr><td>• Mid-term action plans were created.</td><td>Mid-term management plan was approved in WRAWSA.</td><td>NRW management plan of YCDC was approved by WRAWSA. The detailed plan is under preparation.</td><td>Draft water quality management plan was created.</td></tr>
<tr><td>• Monitoring system is in operation.</td><td>The implementation of mid-term management plan is periodically monitored based on management key performance indicators (MKPIs).</td><td>The NRW ratio is grasped in the water supply service area of YCDC and monitored.</td><td>Water quality is grasped in the water supply service area of YCDC and monitored.</td></tr>
<tr><td rowspan="2">• An official system for taking improvement actions was established.</td><td colspan="3">S/Cs are organized, and improvement actions has been implemented.</td></tr>
<tr><td>S/C2</td><td>S/C1</td><td>S/C2 and S/C3</td></tr>
</table>

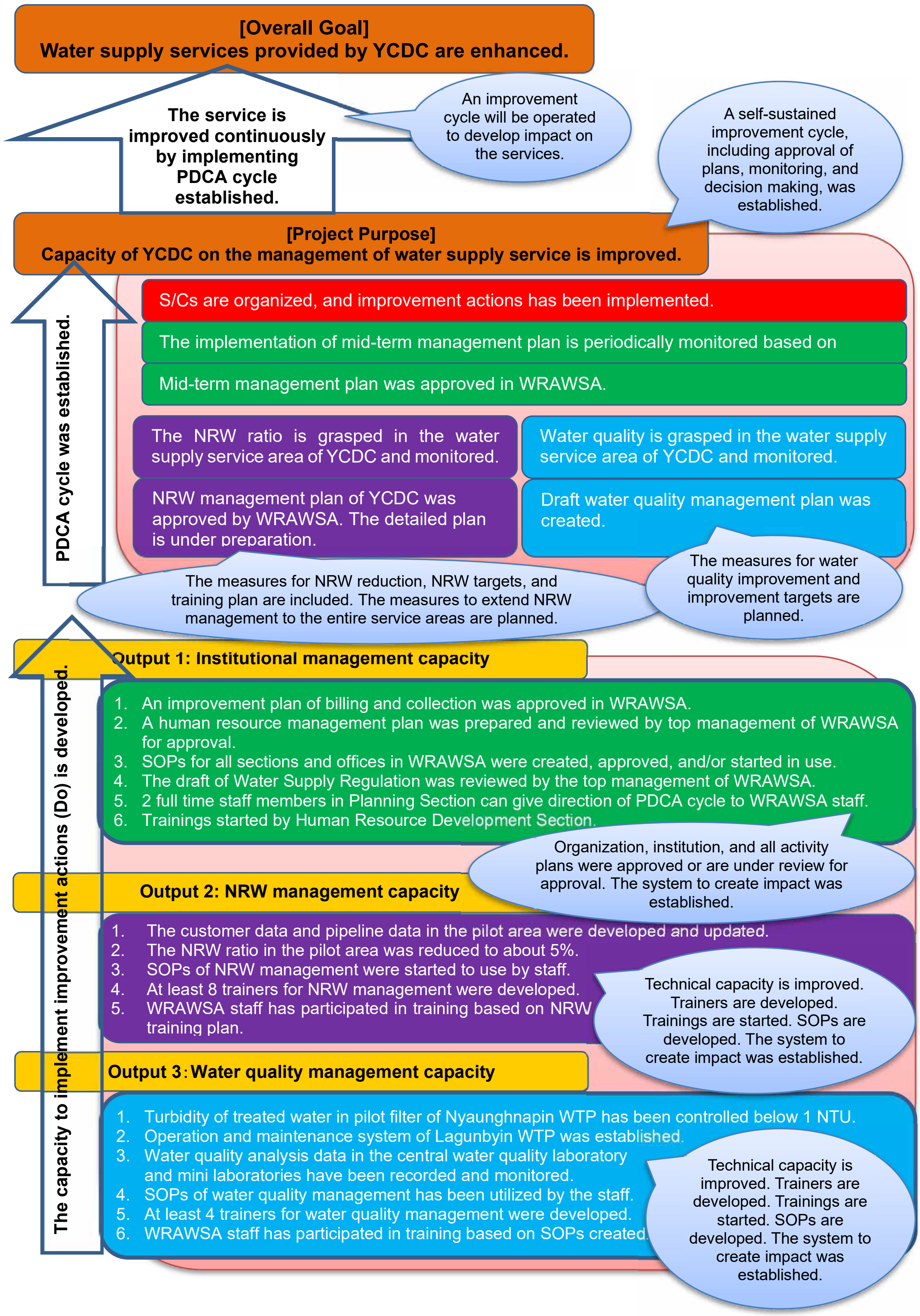


Figure 1-4: Path (Concept) to achieve Overall Goal in the Project

2. Activity in the Project

2.1. Input

2.1.1. Input of experts and counterparts

(1) Japanese side

1) Consultant experts

The planned and actual inputs of consultant experts in Term 1 and Term 2 are shown below. The remaining man-month (M/M) in Term 1 was transferred to Term 2. In Term 2, 2.6 M/M, which was taken from M/M for domestic preparation work of the Expert was transferred to the expert of Customer Service/Tariff Collection from the other experts in August 2018 as additional activity regarding development of customer database management system was required. In addition, total 4.6 M/M was added to the experts of NRW management (physical loss, non-physical loss) in January 2020 to handle the delay in the delivery of pilot project equipment and changes in the OJT schedule. These changes are reflected in the tables below.

Table 2-1: Input of consultant experts in Term 1 (Planned and actual inputs) (from June 2015 to March 2017)

Title	Name	(1) Planed input		(1) Actual input		Difference (1) – (2)	
		Date	M/M	Date	Date	M/M	Date
Myanmar (Field work)							
1. Chief Adviser / Water Supply Operation	Hirotaka SATO	255	8.50	256	8.53	1	-0.03
2. Deputy Chief /Planning / Monitoring	Atsuo ONO	240	8.00	231	7.70	9	0.30
3. Financial / Business Management	Yoji MATSUI	255	8.50	255	8.50	0	0.00
4. NRW Management (Physical Loss)	Akihiro OKADA	360	12.00	269	8.97	91	3.03
5. NRW Management (Non-Physical Loss)	Tadashi AKANUMA	345	11.50	292	9.73	53	1.76
6. GIS	Shinsuke KISHIDA	150	5.00	150	5.00	0	0.00
7. O&M of Water Supply Facilities	Katsuhiko TERASHIMA	240	18.00	240	8.00	0	0.00
8. Water Quality Management	Yasuhiko MORITA	210	7.00	214	7.13	-4	-0.13
9. Assistant for Water Supply Operation	Shoko YAMADA	90	3.00	90	3.00	0	0.00
10. Design and supervision for flow meter chamber	Motochika KAMIOKA	90	3.00	82	2.73	0	0
11. Coordination / Assistant to Planning and Monitoring	Hsumon WIN	90	3.00	90	3.00	0	0
	Sub-total (Myanmar)	**2,325**	**77.50**	**2,169**	**72.29**	**156**	**5.20**
Japan (Domestic work)							
1. Chief Adviser / Water Supply Operation	Hirotaka SATO	15	0.75	15	1.00	0	0.00
2. Deputy Chief /Planning / Monitoring	Atsuo ONO	15	0.75	18	0.95	-3	-0.15
3. Financial / Business Management	Yoji MATSUI	10	0.50	10	0.65	0	0.00
4. NRW Management (Physical Loss)	Akihiro OKADA	10	0.50	10	0.45	0	0.00
5. Water Quality Management	Yasuhiko MORITA	10	0.50	10	0.35	0	0.00
	Sub-total (Japan)	**60**	**3.00**	**63**	**3.15**	**-3**	**-0.15**
	Total	**2,385**	**80.50**	**2,232**	**75.44**	**153**	**5.05**

Table 2-2: Input of consultant experts in Term 2 (Planned and actual performance)
(from June 2017 to May 2021)

Title	Name	(1) Planed input		(2) Actual input		Difference (1) – (2)	
		Date	M/M	Date	M/M	Date	M/M
Myanmar (Field work)							
Chief Adviser / Water Supply Operation	Hirotaka SATO	256	8.53	256	8.53	0	0
Deputy Chief /Planning / Monitoring	Atsuo ONO	338	11.27	338	11.27	0	0
Financial / Business Management	Yoji MATSUI	293	9.77	293	9.77	0	0
Customer service / Tariff collection	Yutaka SAITO (Toshio KANOU from Jan.2019)	172	5.73	172	5.73	0	0
NRW Management (Physical Loss)	Akihiro OKADA	500	16.67	500	16.67	0	0
NRW Management (Non-Physical Loss)	Tadashi AKANUMA	580	19.33	580	19.33	0	0
GIS	Shinsuke KISHIDA	142	4.73	142	4.73	0	0
O&M of Water Supply Facilities	Katsuhiko TERASHIMA	361	12.03	361	12.03	0	0
Water Quality Management	Yasuhiko MORITA	333	11.1	333	11.1	0	0
Assistant for Water Supply Operation	Shoko YAMADA	189	6.3	189	6.3	0	0
Design and supervision for flow meter chamber	Motochika KAMIOKA	8	0.27	8	0.27	0	0
Coordination / Assistant to Planning and Monitoring	Hsumon WIN Mayu SHIDO (after Apr. 2018) Yusaku KUDO (after Oct 2020)	97	3.23	97	3.23	0	0
	Subtotal (Myanmar)	**3,269**	**108.96**	**3,269**	**108.96**	**0**	**0**
Japan (Domestic work)							
Chief Adviser / Water Supply Operation	Hirotaka SATO	100.4	5.0	104.5	5.22	-4.09	-0.20
Deputy Chief /Planning / Monitoring	Atsuo ONO	93.0	4.7	88.2	4.41	4.80	0.24
Financial / Business Management	Yoji MATSUI	83.6	4.2	83.6	4.18	0.00	0.00
Customer service / Tariff collection	Toshio KANOU	48.4	2.4	48.4	2.42	0.00	0.00
NRW Management (Physical Loss)	Akihiro OKADA	81.6	4.1	81.7	4.09	-0.10	-0.01
NRW Management (Non-Physical Loss)	Tadashi AKANUMA	52.8	2.6	52.7	2.64	0.10	0.00
GIS	Shinsuke KISHIDA	18.0	0.9	18.0	0.90	0.00	0.00
O&M of Water Supply Facilities	Katsuhiko TERASHIMA	61.4	3.1	61.4	3.07	0.00	0.00
Water Quality Management	Yasuhiko MORITA	51.0	2.6	43.5	2.18	7.50	0.37
Assistant for Water Supply Operation	Shoko YAMADA	36.0	1.8	25.0	1.25	11.00	0.55
PPP	Kenichiro FUKUDA	40.0	2.0	40.0	2.00	0.00	0.00
Coordination / Assistant to Planning and Monitoring	Yosaku KUDO	0.0	0.0	11.0	0.55	-11.00	-0.55
	Subtotal (Japan)	**666.2**	**33.3**	**658.0**	**32.91**	**8.21**	**0.40**
	Total	**3,935.2**	**142.3**	**3,927.0**	**141.87**	**8.21**	**0.40**

Note: As of May 2021.

2) JICA employed long-term expert (Mina Yariuchi)

Title: Deputy Chief Adviser / Institutional Capacity Development / Human Resources Management

- Year 2015: 6.00 M/M (Dispatch by short trip)
- Year 2016: 10.70M/M (Long- term dispatch)
- Year 2017: 12.00 M/M (Long- term dispatch)
- Year 2018: 12.00 M/M (Long- term dispatch)
- Year 2019: 12:00 M/M (Long- term dispatch)
- Year 2020: 8:81 M/M (Long- term dispatch)
- Total: 61.51 MM

(2) Myanmar side

1) Counterpart (hereinafter, the C/P)

In August 2015, the C/P of YCDC was assigned. Since then, several changes in the C/P have been made. The latest list of the C/P is shown in the table below.

Table 2-3: List of counterparts

Name of Counterparts		Full time	Part time	Section	Remarks
Output 1-1: Planning (11 persons)					
1	U Zaw Min		v	Planning Sec.	
2	U Than Han		v	Planning Sec.	
3	Daw Khin San Win		v	Planning Sec.	
4	Daw Khaing Khaing Soe	v		Planning Sec.	
5	Daw Naw Ellinar		v	Yegu PS	
6	U Tun Tun Hlaing		v	Pipe 1 Sec.	
7	Daw Sandar Myint Lwin	v		Planning Sec.	
8	Daw Kyawt Kay Khine	v		Planning Sec.	
9	Daw Soe Yu New	v		Planning Sec.	
10	Daw Aye Aye Kyu		v	Pipe 1 Sec.	
11	Daw Khin Eindra Htun		v	M&E Sec.	
Output 1-2: RSGM (WG - 3.1) (14 persons)					
1	Daw Thwe Naing Oo		v	DYCE	
2	Daw Thin Thin Soe		v	ACE, Supporting Sec.	
3	U Than Han		v	ACE, Reservoir Sec.	
4	U Zaw Min		v	EE, Planning Sec.	
5	Daw Yu Yu Hla Baw		v	EE, NRW Management Sec.	
6	U Tin Win Aung		v	EE, House Connection Sec.	
7	U Tint Zaw		v	AE, Pipe 1 Sec.	
8	U Aung Ko Oo		v	AE, Pipe 2 Sec.	
9	U Chit Ko Ko		v	EE, West District Officer	
10	U Thant Zin Oo		v	EE, South District Officer	
11	U Nay Lin		v	EE, Head of four Pipe Sec.	
12	U Kyaw Kyaw Oo		v	EE, North District Officer	
13	Daw Su Myat Bo Bo		v	Estimate Sec.	New staff in 2018. Not nominated but involved extensively.
14	Daw Seint Swe Zin		v	Estimate Sec.	
Output 1-2: RSGM (Sub Group A under WG 3.1) (4 Person)					
1	U Tin Win Aung		v	House Connection Sec.	Member of WG 3-1
2	Daw Mar Mar Aye		v	Deputy District Officer (N)	
3	Daw Ye Mon		v	House Connection Sec.	
4	Daw Thin Thin Cho		v	Supporting Sec.	
Output 1-2: RSGM (Sub Group B under WG 3.1) (3 Person)					
1	Daw Aye Aye Mar		v	ACE, CS & Computer Sec.	
2	Daw Khin Khin Htwe		v	Finance Sec.	
3	Daw Nimar Zin		v	Tamwe T/S officer	

Name of Counterparts		Full time	Part time	Section	Remarks
Output 1-3：Finance (11 persons)					
1	Daw Khin Khin Htwe	v		Finance Sec.	
2	Daw Thin Thin Yee	v		Finance Sec.	
3	Daw May Thet Kyaw	v		Finance Sec.	
4	Daw Hnin Mya Khine	v		Finance Sec.	
5	Daw Ohnmar Soe	v		Finance Sec.	
6	Daw Hla Hla Htwe	v		Finance Sec.	Not nominated but involved extensively
7	Daw Zarni Hlaing	v		Finance Sec.	Not nominated but involved a lot.
8	U Khant Sithu	v		Finance Sec.	New Staff
9	U Zayyar Tun	v		Finance Sec.	New Staff
10	D Yin Min Thu	v		Finance Sec.	New Staff
11	Daw Thazin Wai Phyo Khine	v		Finance Sec.	New Staff
Output 1-4：Human resource development (8 persons)					
1	U Kyaw Kyaw Oo		v	EE, East District Officer	
2	Daw Swe Swe Win	v		EE, HRD Sec.	
3	Daw Su Nandar Lin		v	AE, Research Sec.	
4	U Aung Moe Kyaw		v	E&M Sec., Reservoir Division	
5	Daw Khin Zin Mar Myint	v		HRD Sec.	
6	Daw Wine Htet Htet Aung	v		HRD Sec.	**New Staff in 2018**
7	Ms. Nyo Nyo Htun Kyaw	v		HRD Section	
8	Daw May Htoo Aung		v	Office Sec., Reservoir Division	
Output 1-5：Customer service (10 persons)					
1	Daw Aye Aye Mar	v		Customer Service Mngt Sec.	
2	Daw Khin Htay Win	v		Customer Service Mngt Sec.	
3	Daw Win Pa Pa Soe	v		Customer Service Mngt Sec.	
4	Daw Aye Aye Moe		v	Finance Sec.	
5	Daw Sanda Htay		v	Finance Sec.	
6	Daw Wah Wah Aung		v	Computer Sec.	
7	Daw Thel Su Hsu Wai	v		Customer Service Mngt Sec.	**New Staff in 2018**
8	Daw Hnin Lae Lae Win	v		Customer Service Mngt Sec.	New Staff in 2018
9	Daw Mi Mi Lay Maung	v		Customer Service Mngt Sec.	New Staff in 2019
10	Daw Saw Yu Nandar	v		Customer Service Mngt Sec.	New Staff in 2019
Output 1-6：PR (5 persons)					
1	Daw Thin Thin Soe		v	ACE, Supporting Sec.	
2	Daw Ohmar Aung		v	House Connection Sec.	
3	Daw Nwe Ni Win		v	Supporting Sec.	
4	U Htay Naing		v	Deputy District Officer (East)	
5	Daw Thandar Htwe		v	House Connection Sec.	
Output 2：NRW (16 persons)					
1	Daw Aye Pa Pa Nyo		v	ACE, Leader	
2	Daw Yu Yu Hla Baw	v		NRW Management Sec.	
3	U Aung Min Oo	v		NRW Management Sec.	
4	U Myo Thant Htun	v		NRW Management Sec.	
5	U Yan Naing Tun	v		NRW Management Sec.	
6	Daw Win Sandar Oo	v		NRW Management Sec.	
7	Daw Htwe Htwe Nu	v		NRW Management Sec.	
8	Daw Win Maw	v		NRW Management Sec.	
9	U Kaung Zaw Htet	v		NRW Management Sec.	
10	U Phyo Han Kyaw	v		NRW Management Sec.	
11	Daw Yu Khin Khin Kyaw	v		NRW Management Sec.	
12	Daw Htet Wai Hnin	v		NRW Management Sec.	
13	Daw Su May Thea Hlaing	v		NRW Management Sec.	

Name of Counterparts		Full time	Part time	Section	Remarks
14	Daw Phyu Phyu Myint Myat	v		NRW Management Sec.	
15	Daw Zin Mar Htwe	v		NRW Management Sec.	
16	U Aung Hlaing Phyo	v		NRW Management Sec.	
Output 2：Yankin NRW Pilot Project (5 persons)					
1	U Myo Thant Htun	v		SAE, NRW Management Sec. (Field manager)	
2	U Phyo Han kyaw	v		Flat (NRW Management Sec.)	
3	U Kaung Zaw Htet	v		Flat (NRW Management Sec.)	
4	Daw Zin New Oo	v		Skill W - 5 (Tamwe T/S)	
5	U Sithu Win	v		WA (Pazundaung T/S)	
Remarks: New counterpart was assigned for NRW management of pilot project in Yankin in January 2019. Initially, full-time staff of NRW Management Section was supposed to be assigned, but eight staff members were selected from T/S offices in the South District and two staff members were selected from the NRW Management Section, based on the view that it would be difficult to select all project members from NRW Management Section. In total, 10 staff members and a field manager (SAE rank) were assigned to the pilot project. However, since then, several counterparts have left the pilot project.					
Output 3：Water quality management and water treatment (14 persons)					
1	U Myint Zaw Than			CE, Leader	
2	U Zaw Oo	v		WTP	
3	U Zaw Win Aung		v	Water Treatment Sec.	
4	Daw Ei Khaing Mon	v		Water Quality Monitoring Sec.	
5	Daw Thidar Su Su Khin	v		WTP	Not nominated but involved extensively.
6	Daw May Thawdar Oo	v		WTP (Dy Supv:)	
7	Daw Thet Htet Myat		v	WTP	
8	U Thit Lwin	v		WTP	
9	U Phone Thet Naing		v	Hlawga Reservoir	
10	Daw May Zin Oo	v		Water Quality Monitoring Sec.	
11	Daw Nwe Nwe Zin	v		Water Quality Monitoring Sec.	
12	U Zin Min Latt		v	Water Treatment Sec.	
13	Daw Aye Aye Thu Zar	v		Water Quality Monitoring Sec.	
14	Daw Tinzar Lwin	v		Water Treatment Sec.	
Transmission and Distribution Management Team					
1.Water Demand Estimation Team					
1	U Tin Win Aung	v		EE, House Connection Sec.	Leader
2	U Kyaw Kyaw Oo	v		EE, East District	Member
3	U Chit Ko Ko	v		EE, West District	Member
4	U Thant Zin Oo	v		EE, South District	Member
5	U Nay Lin	v		EE, Transmission Pipe Sec. Head	Member
2.EPANET Hydraulic Modeling Team					
1	U Zaw Win Aung	v		EE, GIS Sec.	Leader
2	U Ye Zay Ya	v		Flat, GIS Sec.	Member
3	Daw May Myat Mon	v		Flat, GIS Sec.	Member
4	Daw Aye Myat Thu	v		Flat, GIS Sec.	Member
3.Transmission Flow System Analysis Team					
1	U Tint Zaw	v		AE, Pipe Sec. 1	Leader
2	U Aung Ko Oo	v		AE, Pipe Sec. 2	Member
3	U Than Win	v		SAE, Pipe Sec. 3	Member
4	U Aung Ko Ko Tin	v		SAE, Pipe Sec. 4	Member
4.NRW Estimation Team					
1	Daw Yu Yu Hla Baw	v		EE, NRW Sec.	Leader
2	Daw Mi Mi Khine	v		AE, NRW Sec.	Member
3	U Aung Min Oo	v		SAE, NRW Sec.	Member
4	U Yan Naing Tun	v		SAE, NRW Sec.	Member

Note: RSGM; Rules, standards, guidelines, and manuals

2.1.2. Procurement of Equipment

(1) Japanese side

Based on the baseline survey, procurement of following equipment was decided in the 1st JCC in Term 1. Purpose of use, major equipment, supplier, and status are shown below. The equipment includes the procurement both by JICA (Head office and Myanmar office) and by the consultant. The details are given in Appendix 5.

1) Flow monitoring system (Term 2)
2) Equipment for electric data and PI (Term 1)
3) NRW management (leakage repair and detection, DMA construction) (Term 1 and Term 2)
4) Water quality monitoring (Term 1)
5) Water quality management (Term 2)
6) NRW training yard (Term 2)
7) Reference books (Term 1). Note: procured by the JICA long-term expert.

Table 2-4: Summary of procured equipment

No.	Equipment	Purpose	Contents	Procured from and by	Status
1	Flow monitoring system	• Obtain water distribution volume • Utilize water flow data for NRW management • Establish effective water distribution plan	- Ultra-sonic flow meter (21 nos.) - Remote Terminal Unit (RTU) (9 nos.) - Communication equipment and S/CADA software (1 nos.) - Gases monitor (1 nos.)	Japan JICA Head office	- Procurement was completed. - The 1st to 5th dispatches of contractor's experts was completed. - One more trip for final inspection is remaining.
	Equipment for electric data and PIs	• Prepare computerized database in T/S offices and water supply facility offices • Effective data collection for PI calculation	• Computer (72 nos.) • Printer • Copy machine • MS-Office • Training textbook	Myanmar JICA Myanmar office	Completed
2	NRW management (leakage repair and detection and DMA construction)	• Implement NRW management (DMA construction in pilot project, practice and training of NRW management)	• Internal pipe survey camera • Detection equipment • Leakage repair • DMA construction materials	Japan JICA Head office	Completed
			• Excavator	Myanmar JICA Myanmar office	Completed
3	Water quality monitoring	• Improve water treatment process • Water quality monitoring in reservoir, and consider water treatment of reservoir water	• Jar tester • Sieving test equipment • Grass ware • Textbook	Japan Consultants	Completed
4	Water quality management (Term 2)	• Implement experiment for improvement of the function of WTP	• Potable ultrasonic flow meter • Desiccator • Dry oven • etc.	Japan Consultants	Completed
5	Training yard for NRW management (Term 2)	• Acquire the basic techniques necessary for maintenance work of pipelines such as correct pipeline joining technology through	• Pipe materials • Drilling machine for pipe • Repair materials for leakage	Japan JICA Head office	Completed

No.	Equipment	Purpose	Contents	Procured from and by	Status
		practical skills in the training yard.			
6	Reference books	• Reference books required for each output team • The books are stored in the library of HRD Section for lending	• Manuals and texts of AWWA (52 books)	JICA long-term expert	Completed

(2) Myanmar side
The status of YCDC responsible items of the Project is shown in the table below.

Table 2-5: Status of YCDC responsible items

Item	Status
Flow monitoring	
Design of flowmeter chamber (Assisted by the Expert)	• Field survey with the Expert completed. • Design work of chambers and kiosks completed.
Construction of flowmeter chamber (Assisted by the Expert)	• The construction completed.
Antitheft security system (Installation of guard fence)	• Data transmission device was installed in the kiosk and the existing building. • Ultra-sonic sensor on the above-ground pipeline was protected using steel box with lock.
Installation of flow monitoring system	• Under guideline of the contractor, the equipment was installed in kiosks, etc.
Periodical data collection of water flow. Data analysis and periodical reporting.	• Flow monitoring system was launched in September 2019 and monitoring is on-going.
Water quality management equipment	
Prepare installation space of water quality analysis equipment in the YCDC central laboratory	• All analysis equipment was installed in the central laboratory and is currently operational.
Installation of mini laboratories in WTP, reservoir and pumping station.	• Mini laboratories were installed in Reservoir (Phugyi, Hlawga and Gyobyu), Yegu pumping station, and Nyaunghnapin WTP. • Equipment for water quality test (pH, Turbidity and Color) was installed and its usage started in mini laboratories. • Sieving test equipment was installed in Nyaunghnapin WTP laboratory.
Flow monitoring equipment in WTP, experimental equipment for water treatment improvement (Term2)	• Flow meter was delivered and stored in the warehouse. • Desiccator and automatic oven were delivered to YCDC and its usage started.
Procurement of reagent (additional procurement after installation of equipment)	• YCDC have their own procurement system for HACH reagent, and procurement of reagent is carried out by the C/P.
Securing enough numbers of the C/P	• 12 staff members are currently engaged in water quality test in the central laboratory according to the monitoring plan. • The C/P has highly educated background about chemical and water quality monitoring and is well equipped with basic knowledge on water quality analysis.
Daily maintenance of water quality monitoring equipment	• SOP is developed for operation and maintenance of analysis equipment. • Periodical maintenance is continued.
Rehabilitation of Nyaunghnapin WTP by a pilot project for water quality improvement	• The rehabilitation works of sedimentation and filtration basins are completed. • Application of this improved experience to the other basins is underway.
Construction of experiment facility for reservoir for water quality improvement	• The experimental facility in Hlawga and Gyobyu reservoirs was installed, and experiment continued. • The full-scale demonstration plant is under consideration.

Item	Status
NRW management equipment	
Procurement of equipment and material in purview of YCDC	• In the 1st phase pilot project, Japanese equipment and materials were used to learn ideal installation method of pipe network. Therefore, procurement by YCDC was not necessary. • The 2nd phase pilot project was implemented by YCDC. The 3rd phase was implemented by YCDC under the guidance of the Trainers developed in the 1st phase. In 2nd and 3rd phase pilot projects, all materials were procured by YCDC.
Preparation of stocking place for equipment and materials	• Equipment for planning and designing (e.g., surveying equipment) was stored in YCDC Head Office building at implementation stage. • Excavator is stored in Yegu pumping station. • Equipment and materials for pilot project was completed by JICA and was stored in pilot project office and other neighboring YCDC land. • Finally, all equipment and materials are stored in NRW training yard in Yegu.
Civil work for DMA construction (excavation, pipe laying, backfill and recovery)	• Pilot project was completed, and the civil works were provided by YCDC.
Application and obtaining of permit approval for civil work	• Application and the response were taken in parallel with construction work.
Construction of training yard (building, civil works)	• Competed in January 2020 by YCDC.
PI data collection (computerization)	
Delivery and installation of PC etc. (items procured from Japan)	• Delivery and installation completed. The equipment is currently in use.
Prepare PC installation space	• Training room was prepared in front of GIS Section office and PC was installed. • For T/S office and other branch office, PC was installed.
Procurement of consumable supplies	• Consumable supplies (paper, ink, etc.) are procured by YCDC.
Current expense for training	• Current expense for training (e.g., white board, power cable, daily allowance, etc.) was made by YCDC.
Update of anti-virus software	• Anti-virus software is updated by YCDC.
Antitheft	• In YCDC Head office building, PC training room and GIS Section office room are separated and locked every day. To enter PC training room, approval by GIS Section is necessary. • The offices are locked in other branch offices and T/S offices.
Prohibition of usage in different purpose of use	• Rules for the training room was prepared and posted on the wall.

(3) Other major responsible works of YCDC

1) Computerized customer database management system

WRAWSA decided to develop its own customer database management and bill collection system. The C/P presented a development plan of the system, based on which the development work was outsourced to a private IT vendor, and efforts are underway. All system development costs were borne by YCDC.

2) Training Center for NRW Management

The Expert proposed the construction of NRW training yard. Based on YCDC's own initiative, a training building was planned adjacent to the yard and was constructed as an integrated Training Center for NRW Management. YCDC carried out the design and construction of the structure of the training yard and the design and construction of the training building.

2.1.3. Other Input

(1) Project office space and equipment

The office space equipped with furniture, air condition and light has been provided for the Expert in the building of YCDC Head office.

(2) Necessary data and information for the Project activity

Necessary data and information for the Project activity have been provided timely. For instance, these include existing regulations, standards, guidelines, and manuals (RSGM) of WRAWSA, financial data, information on billing and collection, specifications and drawings on water supply facilities, data on water flow, pipeline information, water quality monitoring data, staffing data, and job description.

(3) Other expense related to the Project activities

The total expense borne by Myanmar side for the Project activities in Term 1 and Term 2 is shown below.

Table 2-6: Expense borne by Myanmar side for the Project activities in Term 1 and Term 2

No.	Items	Cost (kyat)	Yen equivalent (JPY)
1	Equipment and construction costs for flow meter chambers and kiosk including cost for safety measures on construction site	368,965,173	26,806,796
2	Reagents costs on water quality test for water quality equipment	524,370,205	39,238,622
3	Operation and maintenance costs of the PCs provided for monitoring PIs Updating costs by anti-virus for the above provided PCs	50,108,620	3,749,628
4	NRW pilot project (including equipment, machine, labor, materials, etc.)	725,943,716	54,322,368
	NRW training yard construction (including equipment, machine, labor, materials, etc.)	458,703,060	34,324,750
5	Nyaunghnapin WTP improvement pilot project	41,000,000	3,068,030
6	Reservoir water treatment for pilot project	15,000,000	1,122,450
7	Tax, commission fee etc. of delivery and registration for the equipment procured and transmitted from the Japanese side.	2,401,358	179,694
8	Electricity cost of project offices, equipment provided and construction of flow meter chambers	60,877,886	4,555,492
9	Development of customer database and billing software	164,476,178	12,307,752
Total		2,411,846,196	179,675,582

Note: The cost of item 2 includes all expenditures for reagents from the Project commencement.

2.2. Activities Based on the Plan of Operation (PO)

2.2.1. Output 1: Capacity of YCDC on institutional management of water supply utility is improved

1-1 Prepare overall new organization structure

(1) Future image of WRAWSA

The Water Vision of YCDC and the master plan of water supply system (2014) mention a future image of YCDC in 2040. To realize the Water Vision and the master plan, and to incarnate the improvement targets on the business operation of WRAWSA, 1) ideal situation in the future, and 2) achievement at the end of the Project were discussed and decided (Annex 3.A). A content of this future image was confirmed as the goal to be accomplished as an entire organization by presenting it by the C/P in the 1st Myanmar-Japan Joint Seminar (MJJS). Mid- and long-term target of each section is shown below. In addition, a strategic map of future image by four perspectives (i.e., learning and growth of organization, operation process (internal process), customer and finance) was established as shown below.

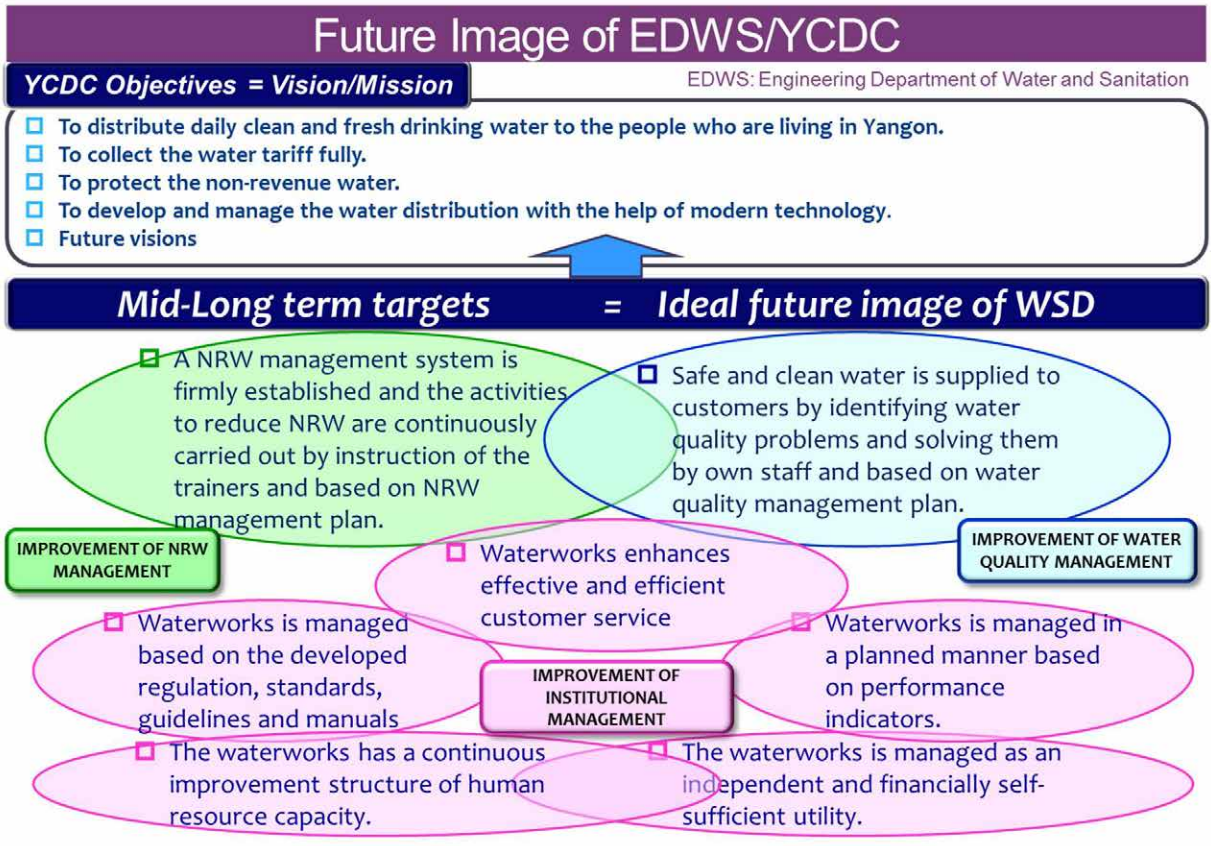


Figure 2-1: Future image of WRAWSA and Mid- and long-term targets

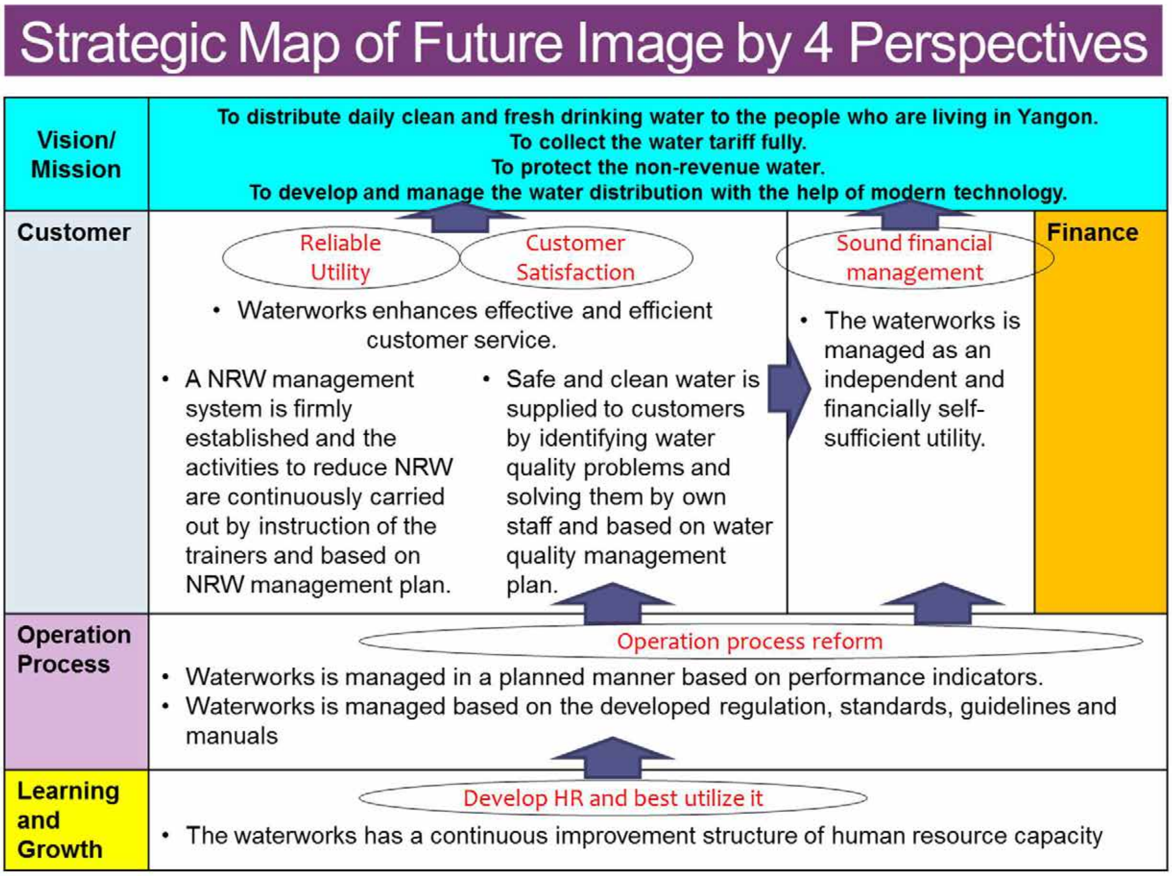


Figure 2-2: Strategic map of future image

(2) Proposal for overall new organization structure of WRAWSA by the Expert

Immediately after launching the Project, it was realized that the existing institutional system of WRAWSA /YCDC was not developed enough to achieve their mission of water services and an overall institutional reorganization was necessary. Hence, the Expert prepared the draft of an overall institutional reorganization plan of WRAWSA (Annex 3.B) through discussion with the C/P and proposed it to WRAWSA. The reorganization plan was approved in the 1st JCC. Accordingly, WRAWSA launched the necessary procedure for the approval of the plan by the Mayor and Committee Members of YCDC and submitted it to them. The proposed reorganization plan has been taken into practice in some sections such as Planning Section, Public Relation Section, Customer Service Management Section, Non-Revenue Water Management Section, and Water Treatment Section. The CE in WRAWSA issued the order for establishment of these sections and for staff appointment. Accordingly, these sections started their daily activities. Furthermore, the reorganization plan was studied/reviewed together with the C/P and revised again in June 2017.

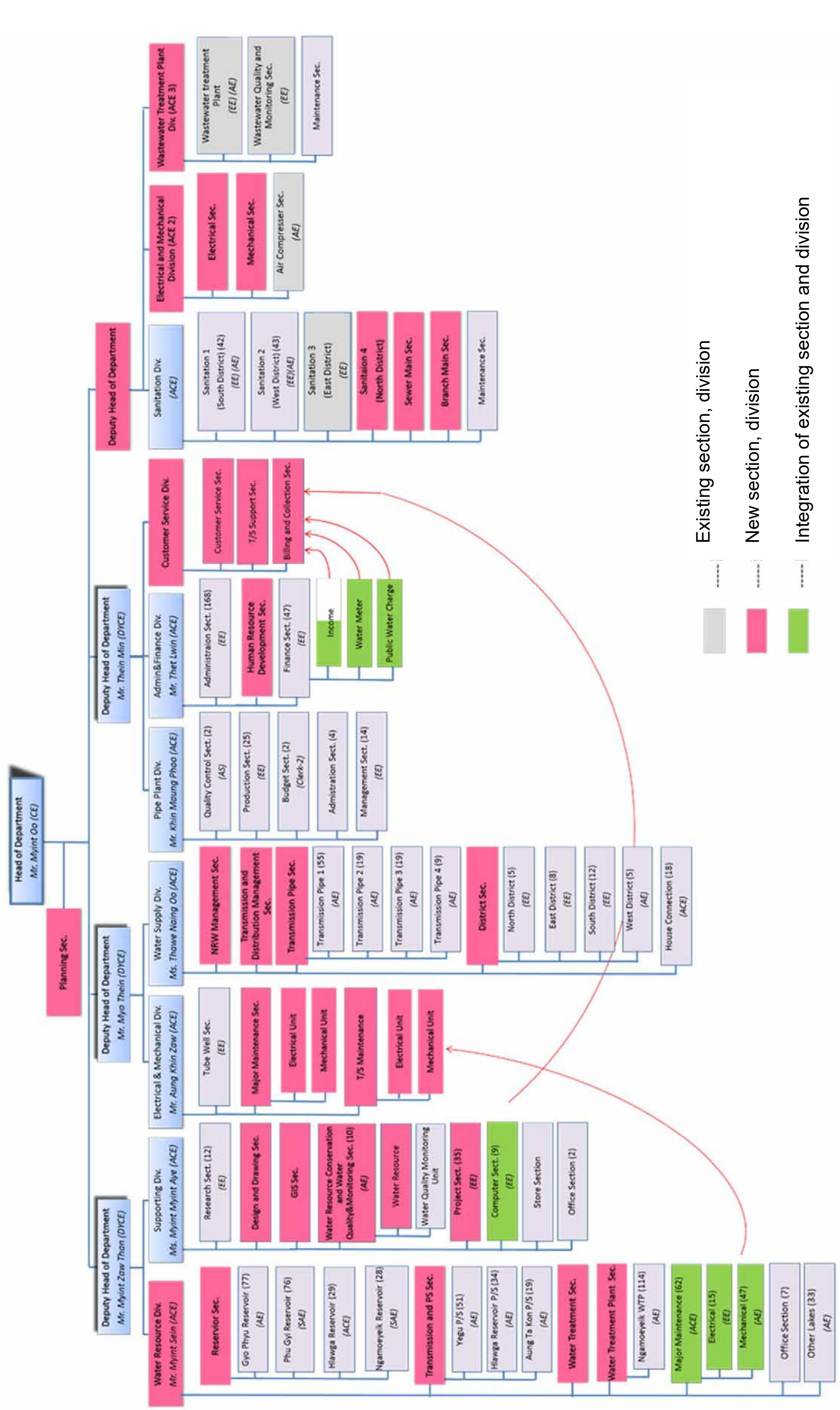
The summary and the organogram of the proposal of institutional reorganization are shown below. It is expected that new sections/divisions that have not been organized will be considered when the WRAWSA is reorganized into Authority.

Table 2-7: Summary of the proposed institutional reorganization

New Sections and New DYCE	Remarks	Organized
Deputy Head of Department	New establishment to manage the Division of Sanitation, Electrical and mechanical, Wastewater treatment plant	O
Water Resource Division	Renamed	
Water Treatment Sec.	New establishment	O
Water Treatment Plant Sec.	Renamed	
Design and Drawing Sec.	Renamed	O
GIS Sec.	New establishment	O
Water Resource Conservation and Water Quality and Monitoring Sec.	New establishment and integration	
Water Resource Sec.	New establishment	
NRW Management Sec.	New establishment	O
Transmission and Distribution Management Sec.	New establishment	O
Planning Sec.	New establishment	O
Human Resource Development Sec.	New establishment	O
Customer Service Division	New establishment, Re-arrangement	O
Customer Service Management Sec.	New establishment, Re-organization	O
Public Relation Sec.	New establishment	○

Source: Report on Institutional Reorganization of EDWS (WRAWSA), Rev. in June 2017.

Note: Refer to the report for the detail proposals.



Source: Report on Institutional Reorganization of EDWS(WRAWSA)

Figure 2-3: Proposed institutional reorganization of WRAWSA

(3) Proposal for organizational reform of overall YCDC structure by YCDC

After the change of the political governance scheme of YCDC in April 2016, a draft of new orientation of the organizational reform was under consideration by the top management of YCDC including Mayor, the committee members, and a consulting firm in Singapore. Although an official announcement was not made, the DYCE of WRAWSA made a presentation on main features of YCDC's organizational reform in Asia-Pacific Water Summit in December 2017. The main features explained in the Seminar are shown below.

- YCDC will be restructured into 7 Authorities and 3 sections (Security & Disciplinary, Administration & Management, Public Relations & Information) under Mayor and committee members.
- 7 Authorities
  - ✧ Urban Planning Authority
  - ✧ Building Control Authority
  - ✧ Roads and Bridges Authority
  - ✧ Storm Water and Wastewater Management Authority
  - ✧ Waterworks Authority
  - ✧ Public Health and Markets management Authority
  - ✧ Environmental Management Authority
- EDWS will be divided into 2 parts: Waterworks and Wastewater management

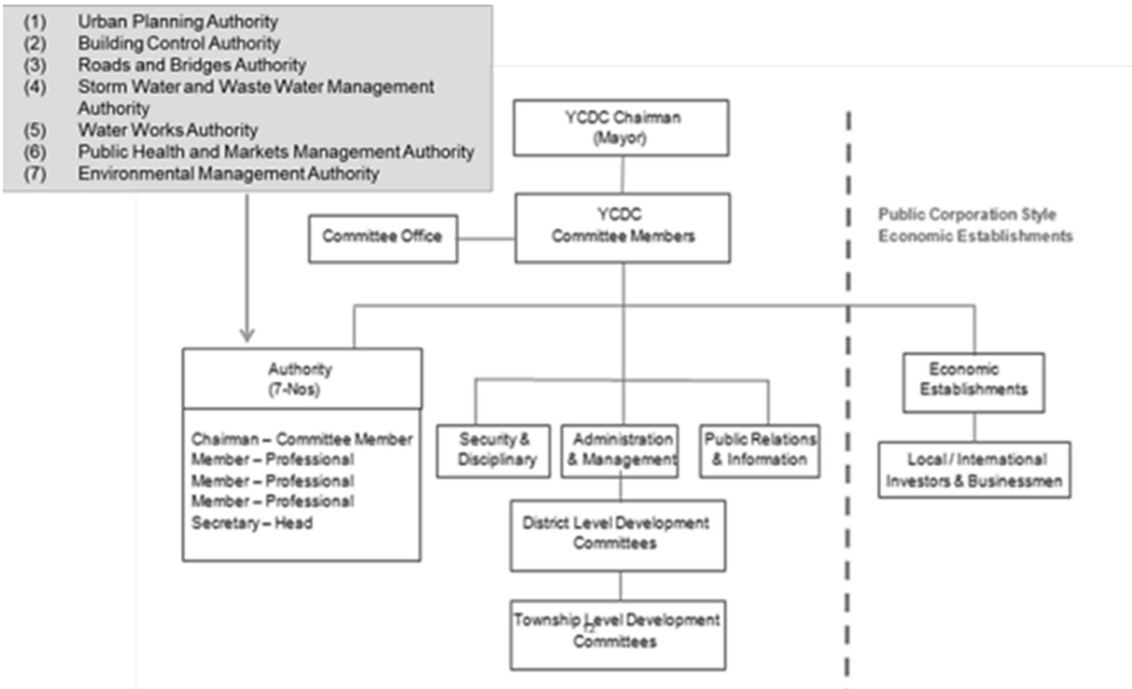


Figure 2-4: Proposal of new organizational system of YCDC

In June 2018, the new YCDC Law was promulgated by the chief minister of the regional government. The new Law mentioned the contents of organizational reform of YCDC. The new organizational structure has not yet been officially announced. The structure has been considered by the regional government and the top management of YCDC. At present, the idea of corporatization is also on the table together with the style of public enterprise. The substantive contents and the concrete picture of the new organizational style is not yet indicated. However, the CE mentioned about new organization of WRAWSA that there is no substantial change and only the name of the organization changes.

(4) Management Improvement Plan of WRAWSA (EDWS)

The Management Improvement Plan of WRAWSA was prepared by the C/P through a comparative study based on the third country training in Phnom Penh Water Supply Authority (PPWSA) and Metropolitan Waterworks Authority (MWA) in Bangkok. The contents of plan are shown below. The plan is given in Annex CD1.

Chapter 1 Introduction Chapter 2 Current Conditions of EDWS/YCDC Chapter 3 Summary of Current Issues and Contents to be studied Chapter 4 Study on MWA/PPWSA System Chapter 5 Comparative Study (YCDC vs. MWA/PPWSA) Chapter 6 Proposal for Improvement of EDWS 6.1 Institutional Governance and Organization Structure of Water Utility 6.2 Planning System 6.3 Human Resource Development 6.4 Corporate Accounting 6.5 Standard, Guideline, Manual and SOP 6.6 Actions for problem solving Chapter 7 Executive Summary

1-2 Establish the Planning Section

1-2-1 Establish the Planning Section

In order to establish Planning Section in WRAWSA, the Expert made a proposal for the implementation system, roles, and scale of staffing of new Planning Section after due discussion with the counterpart members. As a result, an order on establishment of Planning Section was issued by the CE on 12th August 2016, and the establishment was officially approved. The members of Planning Section originally appointed by an official order are shown below.

Table 2-8: Member composition of Planning Section (as of August 2016)

Name	Class	Position
1. U Zaw Min	EE	Leader
2. Daw Yu Yu Hla Baw	AE	Member
3. Daw Khin San Win	AE	Member
4. Daw Khine Khine Soe	SAE	Member
5. Daw Khin Than Oo	SAE	Member
6. Daw Naw Ellin Dar	SAE	Member
7. U Tun Tun Hlaing	SAE	Member

In April 2018, eleven (11) new members of Planning Section were appointed after the revision since it was found that some appointed members were transferred and/or others had limited participation in the planning activities. Out of eleven members, one member was promoted to ACE in FY2018/19 and another member started studying in the University of Tokyo in Japan under the JICA overseas scholarship program. Therefore, the members who substantially participated in the activities were approximately 4-5 members. To implement the proposed duties and responsibilities of Planning Section, an additional allocation of full-time members with rich experience is required.

It is expected that the official member of Planning Section will be determined by the top management again as a result of the on-going institutional reorganization of WRAWSA. The current members appointed by an official order are shown below.

Table 2-9: Member composition of Planning Section (as of April 2018)

Name	Full-time	Part-time	Remarks
U Zaw Min		O	
U Than Han		O	
Daw Khin San Win,		O	
Daw Khaing Khaing Soe	O		Study in Japan
Daw Naw Ellinar		O	

Name	Full-time	Part-time	Remarks
U Tun Tun Hlaing		O	
Daw Sandar Myint Lwin	O		
Daw Kyawt Kay Khine	O		
Daw Soe Yu New	O		
Daw Aye Aye Kyu		O	
Daw Khin Eindra Htun		O	

1-2-2 Define the division of duties of the Planning Section

(1) Division of duties of the Planning Section

In Term 1, the Expert collected information on organizational composition, and duties and responsibilities of Planning Section in Tokyo Metropolitan Waterworks Bureau and Fukuoka City Waterworks Bureau in cooperation with Advisory Committee members of the Project. Based on the information, the Expert proposed the division of duties of the Planning Section, and it was approved by WRAWSA. The organizational composition and the main division of duties are shown below.

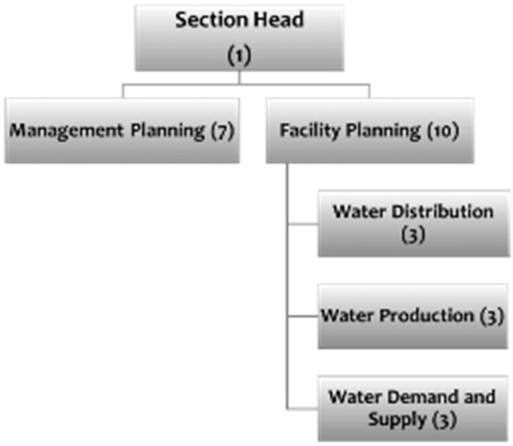


Figure 2-5: Proposed organization structure of Planning Sec.

Table 2-10: Division of duties of Planning Section

Item	Division of duties of Planning Section
Overall	• Formulating overall vision, policy, and strategy of WRAWSA • Making comprehensive management plan and development of operation • Periodic Monitoring and evaluating the performance of WRAWSA's waterworks • Providing timely feedback to the management class of the operational areas • Enhancing the continuous improvement of WRAWSA's waterworks from a comprehensive viewpoint • Preparing guidelines • Maintaining a database on key operating indicators for computation of trends and performance history
Management Planning (7) Note: including one unit leader	• Formulating overall management plan (non-technical) of waterworks • Identifying problematic areas in the operations • Study, analysis, and data collection on management plan • Overall coordination with other sections and units • Continuous assessment of the management plans and playing a leading role in strengthening/ developing improvement program • Developing and implementing performance bench marking systems comparable to good international standards. • Preparing and issuing guidelines of Admin. & Finance • Preparing non- technical database system
Facility Planning (8) (Water demand and supply :2) (Production :3) (Distribution :3) Note: including one unit	• Preparing water supply plan and demand plan • Preparing development plan of reservoir, intake, conveyance, production, and transmission facilities • Preparing development plan of distribution facilities • Overall coordination with other sections and units • Control of technologies introduced • Evaluation of materials (pipe, accessories, etc.) and water supply technologies

Item	Division of duties of Planning Section
leader	• Preparation of technical guidelines and standards • Study and research on water supply technologies • Safety measure of construction • Control of technologies to be adopted

Note: The number in brackets is the proposed number of staff.

The staff number of Planning Section was assumed to be 17 persons in the proposal as shown in the table above. Out of the total number, 11 members were already assigned by the order in April 2018. Afterwards, it was acknowledged that the following challenges emerged for the appointed members through implementing the regular activities.

- Within the appointed middle class staff, one staff is a part-time assignment serving concurrently with other tasks. Thus, it is not easy for her to specialize in the duties of Planning Section. Also, she attended a long-term training course held by Fukuoka City from June to December 2019, and she was absent from work during that period.
- Another middle-class staff has studied in the University of Tokyo by utilizing the JICA overseas scholarship program in the period of September 2018 - August 2020. She was absent for a long time.
- 4-5 members including three (3) young full-time staff members were engaged in the planning activities. Currently, this period could be considered as the transition period toward the final organization set-up and 17 staff members are not required now. Due to the small number of staff, the implementation of duties and responsibilities described above is limited to some extent. The allocation of additional full-time staff members is expected to make Planning Section fully functional in management planning and facility planning.

Within the defined duties and responsibilities of planning and monitoring, the following activities are presently underway through the practice of PI setting and data collection and development of Mid-term Management Plan.

- Periodical monitoring of the WRAWSA performance on water supply service
- Developing and implementing performance bench marking systems comparable to good international standards
- Studying, analysis and data collection on management plan
- Developing an overall management plan
- Preparation of estimation for water demand and supply volume
- Management of technical guideline and standards
- Overall coordination with other sections and units.

In FY2016/2017, Planning Section arranged the PI data collection, selected fifteen (15) Management KPIs for the top management and set up the target values. In the preparation of Mid-term Management Plan, Planning Section requested the relevant sections for their activity proposal and promote their submission.

In FY2018/19, Planning Section freshly carried out the activities of “planning of overall management plan (non-technical) of waterworks” and “identifying problematic areas in the operations” and developed the Mid-term Management Plan. The details are described in 1-9.

In FY2019/20, the main activities were collection, correction, and arrangement of data of FY2016/17-FY2018/19. After completion of data arrangement of FY2018/19, Planning Section estimated the actual values of MKPIs for FY2018/19 after December 2019. The work of performance monitoring and the comparison with the past value for analysis were carried out.

In terms of development of Rules, Standards, Guidelines, and Manuals (RSGM), Planning Section and the other relevant counterparts are responsible for the coordination and arrangement of related activities.

The additional tasks for Planning Section which were decided in S/C3 in March 2019 are as follows.

1) Coordination of approval for prepared RSGM in S/C2 and S/C3
   - Each relevant section asks the approval process of RSGM to Planning Section
   - Planning Section organizes S/C for the approval
   - Planning Section keeps all approved plans and RSGMs
2) Implementation of RSGM and regular monitoring
   - Planning Section prepares monitoring items and establishes a monitoring team
   - Planning Section implements monitoring and reports the results to the CE of WRAWSA in S/C
   - Planning Section keeps the monitoring results and enhances the implementation of the countermeasures for improvement if necessary

(2) Progress of activity of the Planning Section and challenges

There was no section with the function of planning in WRAWSA and no mid-and long-term management plans at the commencement of the Project in 2015. Also, the status of water supply services was neither sufficiently and systematically understood nor comprehensive. WRAWSA did not understand the quantity and the quality of water service provided by themselves. In this connection, the progress and the improvement in terms of planning can be seen in the following points at the end of the Project considering the activities that have been undertaken by Planning Section. They are shown together with the challenges as below.

1) Visualization of the performance of water supply service

The performance of water supply service is visualized quantitively and objectively by development and implementation of benchmarking system through introduction of PIs data sheets. The importance of PIs data system and the benchmarking system has been well acknowledged within WRARSA and repeatedly emphasized by the CE. The recording of data by the relevant staffs and the submission of records to Planning Section are operated as a regular procedure of WRAWSA.

Remaining challenge is that the accuracy of the data from T/S shall be improved further and the frequency of checking and modification by the Planning Section shall be minimized.

2) Periodical monitoring of the performance of water supply service

The performance has been periodically understood and PIs datasheets is monitored not only by ad-hoc basis but regularly. As the staff of Planning Section still spend a long time to finalize the collected data due to the abovementioned challenges regarding accuracy of data, the remaining challenge is to compile the data in the timely manner through the optimization of the datasheets and continuous improvement of data collection system.

3) Development of overall management plan on water supply service

The performance of water supply service could be understood by introduction of benchmarking system in the Project. Based on the data of this system, we were able to lay the foundation for the planned development of activities by deciding mid-term priority policies, creating a management plan, and setting targets. In addition, a plan of water demand and supply was revised by the C/P as a significant work through the process of development of a management plan.

A remaining challenge is to continuously establish the second mid-term management plan for FY2021/22-FY2025/26. When the plan will be prepared, the top management of WRAWSA needs to allocate their budget by emphasizing more on the priority activities than the first management plan according to the mid-term priority policies, which may contribute to establishing a more effective management plan on water supply service for achievement of the decided targets.

4) Monitoring of the management plan

After the establishment of a mid-term management plan, the understanding on the progress status and the achievement status has been improved through the performance monitoring of the first year and the comparison of the performance indicators at the beginning with those at the selected fiscal year.

Remaining challenge is to make continuous monitoring and annual performance evaluation as regular activities of WRAWSA, for which a timely collection and compilation of data could be an important element.

5) Central management of project information

Now Planning Section can centrally manage information of both donor projects and WRAWSA's own projects and works. The importance of the Planning Section has been enhanced as the Planning Section which can grasp an overall picture of all projects and works in WRAWSA by collecting the scattered project information with their initiative, which was previously made by each assigned section such as NRW Management Section that implements projects or works. The operation of collection system, however, is not sufficient although a central collection system was established in Planning Section. Remining challenge is to appoint a head of the section from the officials higher than ACE level and to strengthen their authorizing power.

The opportunity of consultation from the top management of WRAWSA has been increased. However, the coordination of projects and allocation of resources are mainly done by the CE and the DYCE. Therefore, it is expected to strengthen the function that Planning Section undertakes as a part of its roles and to make an advice and recommendation to them from a viewpoint of mid- and long-term management.

6) Management of technical guidelines, standard operation procedure (SOP), etc.

It was decided that Planning Section takes a role to centrally manage the information of technical guidelines, SOPs, etc. Now final data of all SOPs created in the Project is managed by Planning Section. On the other hand, many of the guidelines and manuals were developed towards the end of the Project. Therefore, Planning Section needs an initiative to compile and manage final documents.

From a mid- and long-term perspective, it is expected that more full-time staff members are to be assigned to Planning Section and the staffing plan mentioned in the previous section shall be fulfilled. In addition to the responsibilities and roles implemented in the project activities, it is desirable that Planning Section shall cover all responsibilities and roles prescribed in the previous section.

1-3 Establish Customer Service Division

1-3-1 Establish Customer Service Division in WRAWSA

(1) Background of setting up the Customer Service Division as an additional activity

Meter reading, billing and collection works performed at Township (T/S) offices were inefficient, and the works at each T/S were not uniform, which was not fair or equitable to customers. However, WRAWSA did not have a section/division in Head Office responsible for supervising T/S office works or leading their improvement. Therefore, at the 1st JCC meeting, it was proposed and approved to add "Establish Customer Service Division" as a new activity of the Project. In addition, as strengthening public relations was one of the activities from the beginning of the Project, the establishment of Public Relations Section (PR Section) within Customer Service Division was also approved at the 1st JCC meeting.

(2) Background of the establishment of the Customer Service Division

Since it was decided to set up Customer Service Division at the 1st JCC, eight counterparts were assigned in May 2016 to examine the organizational structure and its duties and responsibilities.

The 2nd JCC meeting, held in August 2016, focused on reorganizing WRAWSA. After that, Customer

Service Division also started its operation on 23rd August 2016 with two-sections; Customer Service Management Section (CSM Section) and PR Section.

(3) Structure of Customer Service Division
As shown in the figure below, Customer Service Division is composed of two sections, CSM Section and PR Section, and those are further divided into sub-sections.

(4) Structure of Customer Service Division
Under the Deputy Director as an officer in charge, CSM Section had 8 members and PR Section had 6 members, with a total of 15 people. However, all staff assigned were part-time staff, who also served concurrently in other divisions. In addition, at the beginning of the establishment, since it was a new division, it had a weak voice, and it was difficult to maintain active works.

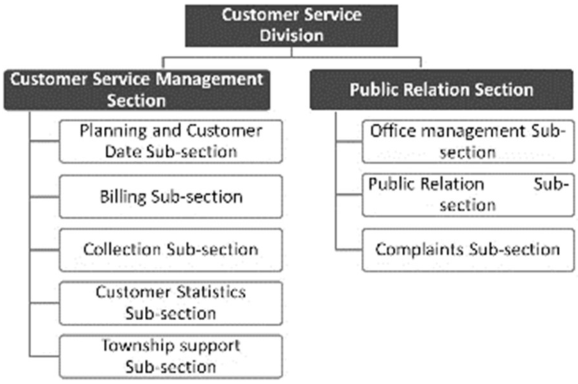


Figure 2-6: Organization of Customer Service Division

(5) Reorganization to strengthen leadership
In order to strengthen the leadership as a head office, the Expert requested the YCDC side to accelerate the reorganization. The reorganization including the appointment of full-time staff was implemented in August 2017. As a result, the head of CSM Section, who is concurrently the head of Computer Section was assigned. Computer Section is closely related to the work of the T/S office, and Customer Service Division was strengthened to 12 members including full-time staff and section head. Moreover, two new staff members were assigned as full-time staff members in March 2018, and the total members of the section thus became 14.

Photo 2-1: Kick-off meeting of Customer Service Division

Currently, CSM Section consists of 7 members, engaging in the main activities such as creating work manuals. In the future, it is desirable to allocate personnel who are familiar with T/S work in order to supplement the lack of practical knowledge of the present staff and to enhance their activities and performance.

1-3-2 Define the division of duties of the Customer Service Division

(1) Duties of Customer Service Division
The division of duties of CSM Section and PR Section was discussed and confirmed as below after analyzing the current situation of WRAWSA and taking reference to those sections in Tokyo Metropolitan Office and Fukuoka City.

Table 2-11: Duties of Customer Service Division

Customer Service Management Section
(1) Planning and Customer Data sub-section • to plan a new work process to improve billing and collection work

• to make manual for billing and collection, and improve it • to lead introducing e-Government water tariff billing system (2) Billing sub-section • transfer of all the computer section's work (3) Collection sub-section • transfer a part of the Finance Section's work such as confirmation of tariff revenue (4) Customer Statistics sub-section • to make statistics of tariff such as customer number, consumption volume, tariff billing, revenue, non-payment • to make monthly report and annual report regarding water tariff (5) Township Support sub-section • to support T/S when new work process is introduced • to support T/S when difficult events happened • to conduct and implement training course for billing and collection work of T/S
Public Relation Section
(1) Office Management Sub-Section • Overall office management of public relations • Overall management of customer service works (2) Public Relation Sub-Section • Planning, research, coordination for improvement of customer satisfaction • Public relations and information disclosure on water supply, sewerage and sanitation (3) Complaints Management Sub-Section • Overall management of customer complaints • Prepare the report of received complaints

(2) Tackle various issues of Customer Service Division

Customer Service Division started its activities to tackle various issues related to its duties as below.

1) Guidance for optimizing and increasing efficiency of billing collection works

In order to improve meter reading and tariff collection work of T/S office, the members of CSM Section examined how to optimize and improve the efficiency of those works prior to providing guidance to T/S office. They studied the proposals and case studies presented by the Expert at seminars and section meetings, third-country training for the C/P, and recommendations by Advisory Committee members. As a result, the staff members gradually recognized the issues faced with WRAWSA and become aware of the need of improving work efficiency, and fairness in customer service.

Replacing defective meters is one of the most urgent issues in Yangon. The initial and replacement cost of water meter are the customer's own burden. Through those studies, the staff could get to share the concept that this system is a problem for the customer in terms of temporary increase of financial burden and fairness. The case of Japan was introduced where these costs are included in the monthly water bill, and the staff recognized that WRAWSA needs to review the water tariff system.

WRAWSA has managed information on paper and has just begun computerization. Through a series of guidance, the staff members well recognized that it is essential to use computers and information systems to collect and analyze customer complaints and statistical information.

2) Guidance for work improvement from Customer Service Division to T/S

CSM Section conducted a survey on the schedule and administrative process related to meter reading and tariff collection operations targeting some T/Ss to establish unified operation process. As a result of the survey, some T/Ss were found to differ from other offices. Therefore, it was decided to compile a proper work schedule and workflow as Standard Operation Procedure (SOP) and distribute it to each T/S for guidance.

- Target operations: meter reading, non-payment management, new connection procedure

3) Survey of existing customer data system and e-Government System

Customer data, meter reading data, and billing/collection data are managed almost manually using standard forms (called YAPA Form 1 to YAPA Form 8) in the office work at T/S and head office. Filling out these forms and checking them takes enormous time, is quite inefficient, and lacks accuracy. To solve these problems, YCDC decided to develop a customer management and tariff collection data system.

To realize more accurate customer management with the tariff collection data system, a survey was conducted firstly on the billing data system and e-Government System currently operated by WRAWSA.

[Existing billing data system]
Currently, the customer data system of WRAWSA is operated only in Computer Section in head office, and it is a simple system outputting each customer's bill and accumulated consumption/billing data only. It is not a system for customer service that can be immediately used for various applications and inquiries from customers.

[Survey on possible utilization of e-Government System of YCDC]
If various functions envisaged by WRAWSA for the improvement of customer service are added to the current e-Government System, it may require a large system change such as a major change in the database (DB) and a significant addition of functions. This may cause bugs and degrade the performance of e-Government system. Furthermore, it was considered that it is difficult to improve and change the system in the future since e-Government System is not managed by WRAWSA.

4) Creating a data system improvement plan
As a result of a survey by the Expert (in 2017), it was concluded that the expansion of the e-Government System of YCDC for the water supply work was difficult and suggested to develop a new system of own billing system with WRAWSA budget. A plan for outsourcing development work to an IT vendor company in Myanmar was formulated, and proposed to the CE and the DYCE2 on 7 November 2017, and the proposal was accepted. In response to this, the C/P announced its own system improvement plan at the 5th JCC on 26 February 2018.

At the same time, it was decided to consider preparing a simple system to create the standard forms (YAPA 1 to 8) by utilizing the data extracted from the existing system and manage tariff collection using Excel.

● Improvement Plan (5th JCC Meeting Material. "Proposal for new customer database")

functions	2017-18 FY current , near future	2018-19 FY -1st phase	2019-20 FY -2nd phase
1 Customer database	Customer info. should be shared more timely.	Customer data migration in all T/S	SQL server
2 Meter reading management Yapa-1 etc.	Water consumption should be managed by excel in T/S.	Development of functions (Pilot T/S)	Spread to other T/S
3 New Billing & Collection function New connection, Data search, Yapa-3	The system is existed Foxpro		Re-Development of functions
4 Tariff collection management Yapa-2, 4 - 8	Collected and outstanding bills are managed by hand working in T/S.		Development of functions (Pilot T/S)
+ Smart functions Complaints, Statistic	Continuous Progress after 2nd Phase		

Figure 2-7: Creating a system improvement plan

(3) Proposal for the priority of issues
Customer Service Division has promoted the development of a customer management and tariff

collection data system and implementing it. However, other issues such as creation of work manuals, standardization, and improvement of the efficiency of work, and instructions to T/Ss were delayed.

To promote these delayed issues, a seminar was held and discussed with the Section about prioritized issues (on 6 and 7 December 2018). In this seminar, the Expert gave lectures to the CE and other executives on the role of CSM Section, function of each office, and cooperation among them, so that WRAWSA could deepen the recognition of the division’s role. In addition, for the preparation of work manuals, workshops were held so as to introduce the structure of manuals and discuss the issues and solutions in Yangon.

At the same time, the Expert proposed the following three points as priority issues to tackle in the second term.

1) Create work manuals
2) Hold regular meetings together with T/S officers and CSM Section
3) Collect statistical data on meter reading, billing and tariff collection and staff data of each T/S for the preparation of annual report

The priority issues proposed to tackle at the seminar are shown below.

Figure 2-8: Customer Service Division's priority

1-3-3 Establish operation system of Customer Service Division

(1) Development of customer management and billing/collection data system

The development process of the "customer management and billing/collection data system" can be roughly divided into two phases. In the first phase (October 2018-September 2019), development would be focused on the function of customer information search/inquiry/ new registration, meter reading, and billing. In the second phase (scheduled to start after October 2019), the function of tariff collection work, non-payment management work, statistical work, etc. would be developed. In line with this plan, the development work was outsourced to a private IT vendor and was implemented accordingly.

In addition, the financial resource for it was allocated from the budget for non-revenue water management project in WRAWSA, and the contract amount was MMK15 million (about JPY1.2 million) annually (only the first phase).

In the first phase, the new system was introduced after development, operation was verified, and errors in a pilot T/S (1 site) were corrected and would be gradually expanded to other T/S.

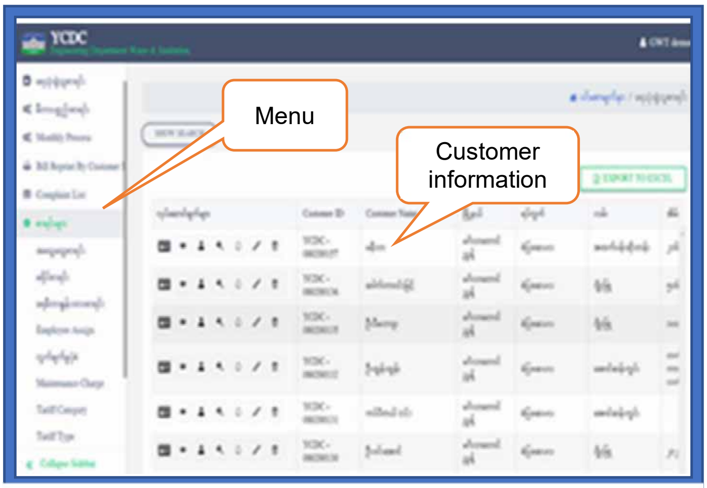


Figure 2-9: Customer list screen

In 2019, the development planned in the first phase, such as functions related to search/inquiry/new registration of customer information, meter reading work, and billing work, was almost completed as planned. From August 2019, trials started at 6 pilot T/Ss such as Kyauktada, Botahtaung, Pabendan, Lathar, Lanmadaw and Pazundan.

After that, there was a situation that water tariff system would be reviewed and altered in near future. Since it might require changing the specifications of the system, the trial was suspended, and the reconstruction was carried out. Then, from February 2020, trials were restarted at 6 pilot T/Ss.

(2) Improvement of billing/collection work

Kyauktada T/S has been trying to improve the work that manages the meter reading results and the tariff collection by utilizing Excel for the existing customer management database, while the new customer management and billing/collection data system was being developed.

Photo 2-2: Training for operation of data processing of meter reading and bill collection by Excel

After promoting the utilization of Excel, the accuracy and work efficiency were improved. In addition, it also contributed greatly to the improvement of work efficiency in the management of the collected money.

Utilizing Excel for meter reading data management was positioned as a transitional computerization until the release of the first phase of new data system. Also, utilizing it for the tariff collection management was transitional until the system release of the second phase. In addition, utilization of Excel was also expected to be effective as training of T/S staff for computer operation and as accumulation of original data to migrate to the new system. Regarding this activity, 14 staff members (CSM Section, Computer Section, Kyauktada T/S) were given training on Excel operation on the meter reading and tariff collection management on 3 December 2018. Follow-up training was also conducted on 27 February 2019.

Trials application started only at Kyauktada T/S. In 2019, trials were expanded to 6 other T/S, and further expansion has been planned. Also, the Expert responded to the requests of the C/P and improved the application of Excel for more convenient use from time to time.

(3) Strengthening of CSM Section as a headquarters

To strengthen CSM Section, along with the development of customer management and billing/collection data system, the three priority issues were steadily implemented as below.

1) Create work manual

Photo 2-3: Seminar for work manuals

In order to standardize operations of tasks at T/S, CMS Section members discussed to create a work manual by utilizing the knowledge acquired in the investigation of work schedules and work procedures at each T/S, which was conducted by CSM Section, and the training in the third countries.

In 2018, the Expert gave a lecture again about the role of CSM Section and the function of cooperation within the water supply utility, including the executives such as the CE. At the same time, seminars and workshops were held to create work manuals.

In addition, for the creation of the work manual, the Expert also held a seminar on the specific preparation procedure. Furthermore, the Expert delivered detailed lectures based on the work manual of Tokyo Metropolitan Government to staff of the CSM Section in 2019 to promote the creation of a work manual for meter reading and tariff collection work.

The work manual was almost completed, and it was shown to each T/S for trial and feedback for the purpose of correction or amendment.

Table 2-12: Structure of manual, SOP, etc.

Classification	Name	Content	Remarks
Work manual	Meter reading manual	Meter reading work outline, Field work, Water amount increase/decrease investigation, Meter abnormality investigation, Water leakage response, Customer response	Completed
	Tariff collection manual	Customer information survey, Notification, Response to non-payment, Collection cycle	Completed
Standard operating procedures (SOP)	Tariff collection processing standard 1	Basic policy, Processing standard	Completed
	Tariff collection processing standard 2	New connection procedure, Issue of water connection permit, Meter reading, Stop tap fee, Water fee payment method, Unpaid tariff collection procedure, etc.	Completed
Standard operation procedure for customer data management (SOP)	Customer management and tariff collection system operation procedure	Operation of customer management / charge collection system (customer information search, data input/correction/ deletion, material creation, etc.)	Completed

The work manual also serves as a tool for supporting and instructing the T/S by Customer Service Division in the future. It is expected that the CSM Section will be able to demonstrate leadership by effectively utilizing this to improve the work of T/S and related sections of the headquarters, and toward efficient and appropriate business operation in WRAWSA.

2) Establishment of T/S Officers' Meeting

Aiming at strengthening CSM Section, the establishment of a T/S officers' association has been promoted to ensure efficient and well-organized relation between the headquarters and T/S. So far, several seminars have been held for T/S officers, its deputy officers, district officers and its deputy officers regarding their significance and roles.

From 2018, the T/S officers' meeting organized by Customer Service Division has been held regularly twice a month. It was hoped that this would continue and that information sharing and opinion exchange would be activated for business improvement and efficient and appropriate business operation.

3) Collecting statistical data

Collecting statistical data on tariff collection is very important for preparing annual reports, proper business operation and business improvement, and utilizing various types of information in business plans. Therefore, the Expert have provided guidance on the types and contents of data to be collected, effective use of statistical information, etc. by introducing cases in Tokyo.

At present, YCDC has developed its own customer management and billing/collection data system, which would be a database of basic customer information, water usage, and tariff information. In the future, various types of information will be accumulated and enriched by the new data system.

By development of an organized statistical data system which is planned for the second phase, basic useful data (such as the number of connections by customer category, consumption, and billed amount) will be created from monthly meter reading, tariff collection, etc. In addition to this, it is planned to include reasons why a meter is not read or estimated, and non-payment data, etc., by which it is possible to grasp the situation of customers and the actual condition of water use more accurately and minutely. Based on this, Customer Service Division can identify problems to promote reliable and accurate billing and collection of water tariff and use it to support and improve the T/S's works. Also, in the end, this will lead to reduction of non-revenue water.

(4) Future Vision of Customer Service Management Section (draft)

1) Creating a future vision (draft) for the CSM Section

After Customer Service Division was established, the organization with the duties of office work has been developed, a "customer management and tariff collection system" has been developed, operations related to meter reading and tariff collection have been unified, and work manuals have been created. These efforts have just taken a step towards modernizing customer service. From now on, it is required to further develop these efforts and aim at improving the efficiency and quality of operations, reducing non-revenue water, and improving customer service.

In the "Future Vision of CSM Section (draft)", as an example, the future image of the CSM Section's goals and efforts toward the modernization of collection work and customer service is shown. The final goal of the "Future Vision of CSM Section ", and the image and main activities of the CSM Section toward this goal are given as follows. In addition, based on this, it is expected that it will be further refined as a guidepost of CSM Section.

<< Goal >>

Improvement of management capacity	**Reduction of NRW**	**Improvement of customer satisfaction**

<< The image and main activities of the Customer Service Management Section >>

Image of the CSM Section	Main Activities
1. Working on the operation of the modernized tariff collection system and further improvement	Elimination of manual work for meter reading and revenue collection data management
	Introduction of online networking system
	Improvement of meter reading work such as introduction of smart meter reading
2. Improving the leadership of the CSM Section	Promotion and enhancement of work manuals
	Preparation and utilization of statistical data
	Support and guidance for T/S
3. Various improvements in the tariff collection operations	Promotion of bimonthly meter reading
	Outsourcing of work to the private sector
	Consolidation of T/Ss
4. Further improvement of customer service	Information provision, reception and PR using the Internet
	Diversification of payment methods
	Establishment of call center

<< **Image of future vision of Customer Service Management Section** >>

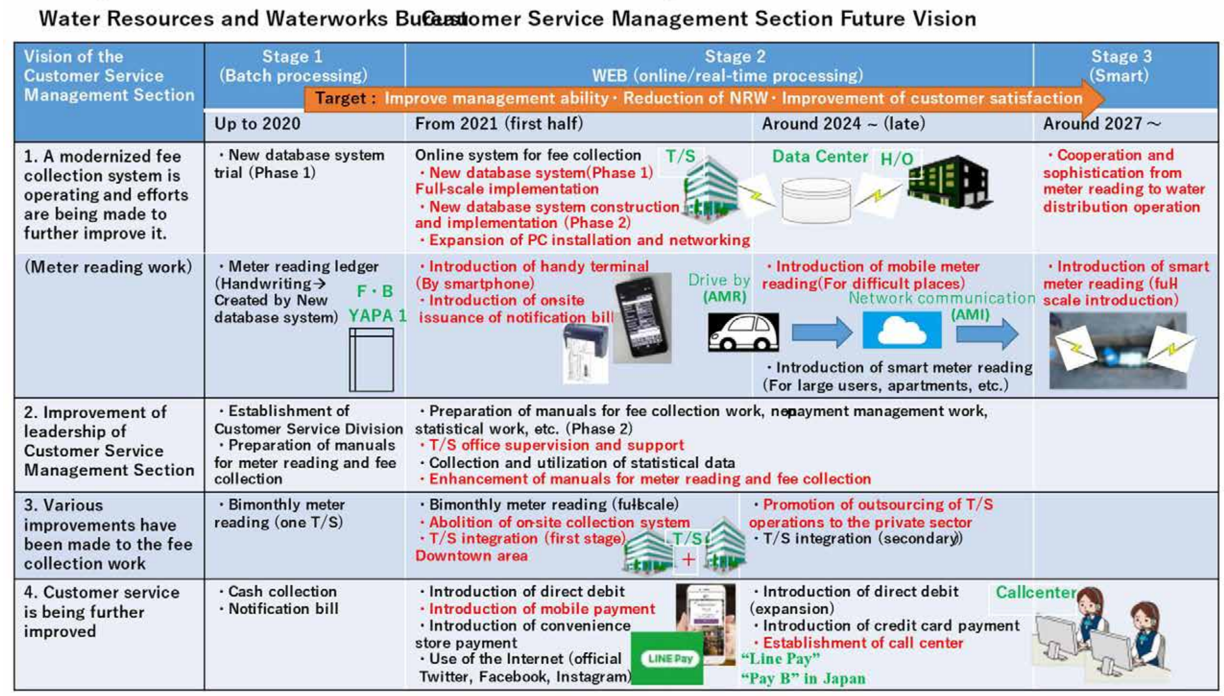


Figure 2-10: Image of future vision of Customer Service Management Section

2) Activities to realize the "Future Vision of CSM Section"

As an immediate schedule for the realization of the "Future Vision of the CSM Section", the Expert prepared a more detailed schedule for the various initiatives scheduled for [Stage 2 (development of online system) 2021 to first half year in 2023] (Figure 2-11). Then, to move forward, the following activities were undertaken, including a detailed explanation to the C/P of Future Vision of the CSM Section (draft) in December 2021.

(Support for implementation of high-priority activities)

- Created and explained study materials for formulating improvement policies for meter reading operations such as the introduction of smart meters. After exchange of opinions, it was confirmed that the C/P would continue to work on improving meter reading operations from various directions.
- Created and explained study materials for drafting improvement policy for tariff payment method. After exchange of opinions, it was confirmed that the C/P will work towards diversification of payment methods.

(Support for improving the leadership of the CSM Section)

- For the supervision and support of the T/S offices, the format of the monthly report (unread, unpaid information, etc.) was examined.
- As an effort to create and revise the manual and guidelines, a draft "Meter reading work (site survey work) guideline" was created as a concrete example of a manual for the enhancement of the meter reading work.

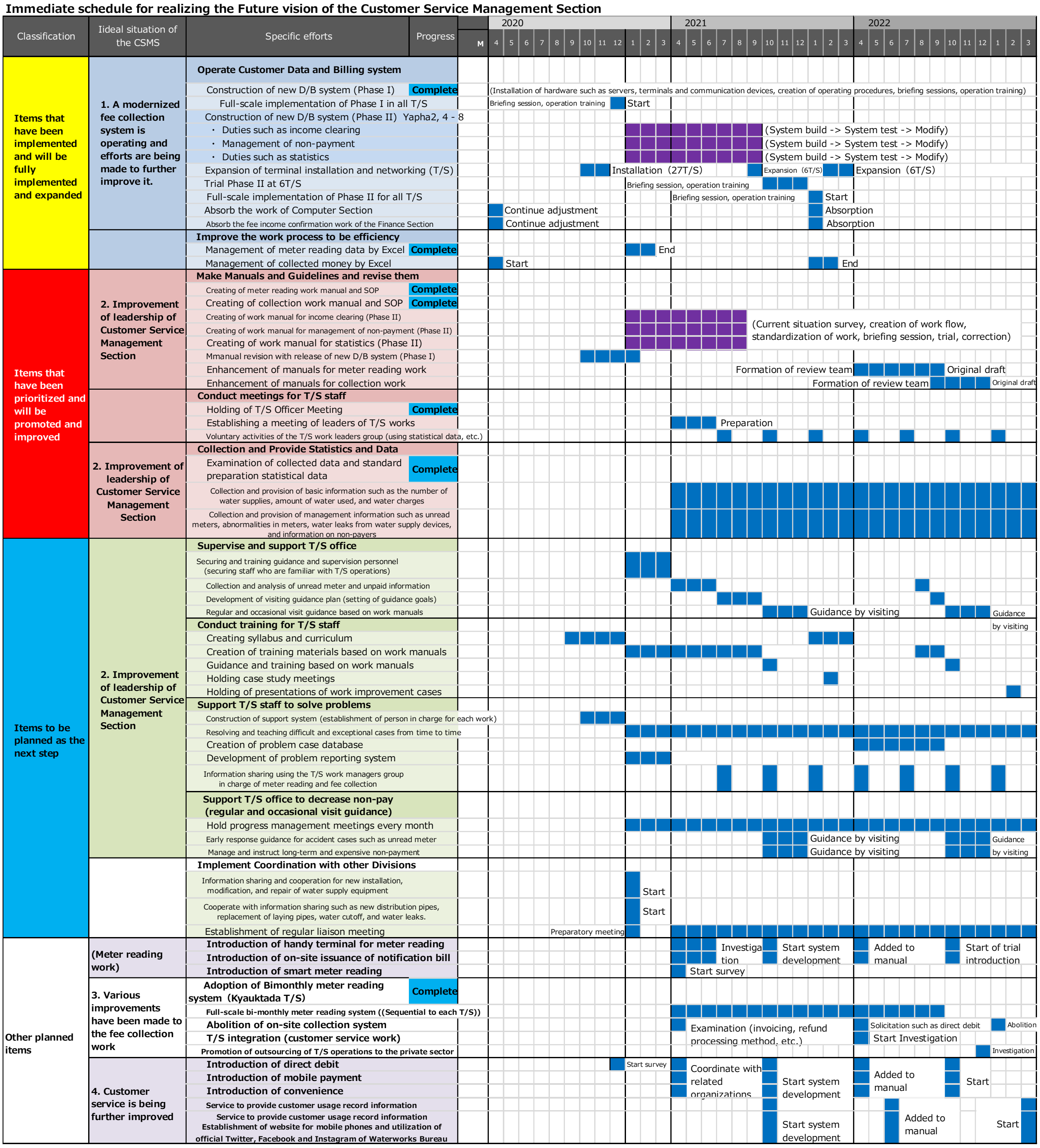


Figure 2-11: Immediate schedule for realizing future vision of Customer Service Management Section

1-4 Develop and Monitor Performance Indicators (PIs)

1-4-1 Review the current method of calculation and monitoring of performance data

The current method of calculation and monitoring of performance data on waterworks and the existing data of PIs obtained by WRAWSA was confirmed through PCM workshop and a baseline survey. The C/P made a research on reporting system including reporting frequency, reporting persons etc. As a result, it was understood that water volume supplied, water volume stored in reservoir and power supply status were reported, but it was also acknowledged that PIs data indicating current water services was not sufficiently collected or reported. For instance, the data information indicated in the table below was fragmentally reported, however the basic data to understand the status of waterworks such as water supply volume, NRW ratio, collection ratio, unit cost and average revenue was not yet collected and calculated. Hence, it was confirmed again that it was difficult to understand accurately the current status of waterworks of YCDC. The existing PIs, data and its reporting system are shown below.

Table 2-13: Existing indicators and data

	Existing	
	Data	Monitoring Data
Reservoir	Storage Capacity of each reservoir	Water level and depth
	Storage curve	Precipitation
		Pump operation hour (PS)
		Electrical Breakdown records (PS)
WTP	Back washing time	ACH Dosing rate
		Electricity Power Consumption
		Water Quality
		-Turbidity (raw, treated), PH, temp., Alkalinity
Pumping		Operation Hours
		Electricity Consumption
		Flow - inflow, out flow
		Pump and Mortor
		-Ampere meter reading
		-voltage reading
		-frequency
		Transformer
		-temperature
		-voltage (inlet, outlet)
		Pressure
Service Reservoir	Storage capacity	Water level
	Age	Valve Control
Underground Water		Pumping Hours
		Electricity Consumption
		Ground Water Quality (three times per year)
		-15 parameters
Distribution	Pipe size	Pressure (some pts)
	Pipe length	Leakage repair record of main transmission pipe
	Pipe materials	

Source: JICA Project Team (PCM workshop, Baseline Survey)

Table 2-14: Reporting System of Existing Data

No	Facilities	Data	daily	weekly	monthly	Submission processess				
						ACE	DYCE	CE	C/O	R/G
1	Reservoir	water level	√		√					→
		precipitation	√		√					→
		storage capacity	√		√					→
		electricity shortage		√	√					→
		Operating Hours		√	√					→
		water supplied amount		√						→
2	WTP	ACH dosing rate	√		√			→		
		water supplied amount		√						→
		electricity shortage	√							→
		Operating Hours	√							→
3	Pumping Station	electric consumption	√					→		
		Operating Hours	√							→
		electricity shortage	√							→
4	M & E Section	Maintenance Records			√			→		
		New Installation			√			→		
		water supplied amount	√							→
5	Service Reservoir	Water level			√			→		
6	Water supply	Maintenance Records on transmission lines		√				→		
		patrol records on transmission lines		√				→		
7	Customer service	Numbers of customers							→	
		water quality parameter						→		

Source: JICA Project Team (PCM workshop, Baseline Survey)

1-4-2 Conduct training of trainers on the calculation and monitoring of Performance Indicators.
Training for monitoring PIs was comprehensively carried out after the PIs setting activity in 1-4-8. The Expert gave trainings on the purpose of data collection, collection methods, meaning of PIs, composition of data sheet, data input method, and data collection system to the staff members of Planning Section based on the manual for "Water Service Monitoring by PIs -Data Preparation and Data Entry (Annex 1)." Before the Project commencement, WRAWSA had a practice to collect the relevant data in a piece meal manner and made a report. It was, however, a new concept for the counterparts to collect and compile PIs comprehensively and regularly. Hence, the Expert had to repeatedly explain its purpose, collection methods, meaning and date entry methods and its practice to deepen the C/P understanding. In Term 1, two mid-level staff members of Planning Section, who were expected to play a core role in future, were primarily provided trainings as trainers to T/S and District offices, and other relevant sections.

Photo 2-4: Training for Trainers (TOT) on PIs data collection

In Term 2, the training of trainers on the arrangement of PIs data, definition PIs, calculation method of PIs, preparation of charts and its analysis has been continuously given to the C/P.

Three young staff members were newly appointed to Planning Section in 2018, the training of trainers was carried out for the new members in addition to the two trainers at the middle class trained in Term 1. Same as Term 1, the Expert carried out training on the basic topics such as the purpose of data collection and collection methods, meaning of PIs, composition of data sheet and data input method for the C/P and data collection system.

Regarding PIs data sheet, the new staff members could check data input by T/S staff and its appropriateness and give guidance to the T/S staff, especially on the sheet of "distribution and NRW", "sales sub-format sheet" and "customer connection and consumption sheet" input which is the responsibility of T/S office. The young staff members made presentation and gave guidance to the data entry officer of all T/S offices at the PIs data entry seminar in held in December 2019 (also described in 1-4-7).

1-4-3 Identify the important and available Performance Indicators to be monitored

To monitor the performance on water services of WRAWSA, the Expert and the C/P selected PIs for monthly monitoring purpose. After installation of the equipment to be procured in the Project, PIs that can be collected using the equipment were also included in the data sheet.

In the Project, PIs data sheets were developed by categorizing water supply services into 7 areas as shown in the table below. PIs such as flow volumes etc. which would be monitored after installation of the equipment were also included in the data sheet. It is assumed that the management status of water supply service can be understood by monitoring PIs in the seven areas every month. Among those basic PIs, 60 Key Performance Indicators (KPIs) were selected. In addition, 15 KPIs were identified as Management KPIs (MKPIs) for an important essence of all KPIs, which should be monitored by the top management of WRAWSA. The details are shown below.

Table 2-15: Composition of PIs and its target area

Area	Composition sheet
1. Water Supply Service	・Water Supply Service
2. Production and Transmission	・Production (Reservoir, WTP, Underground)) ・Water Flow Measurement ・Transmission System
3. Distribution	・Distribution and NRW
4. Water Quality	・Water Quality Summary ・Water Quality (Monthly) ・Water Quality (Weekly) ・Water Quality (Nyaughnapin)
5. Sales and Collection	・Sales and Collection (Summary) ・Sales and Collection (Data)
6. Finance	・Finance (Summary) ・Finance
7. Admin & HRD	・Administration and Human Resource ・Human Resource Development (Sub-sheet)

Table 2-16: KPIs of WRAWSA YCDC

Key Performance Indicators (KPI)

Summary Sheet

Sq.N	Symbol	Indicators	Unit	Jan	Dec	Total	Average
1. Water Supply Service							
1	S1	Service population	'000 inhabitants				
2	S2	Total connections	Nb.				
3	S28	Service coverage rate	%				
4	D5-1	Average hours of water supply per day	hr/day				
5	C23	Unit (average) water consumption per connection per day	L/conn/d				
6	Q7-2	Compliance ratio of monthly water test at tap water in TS (turbidity)	%				
7	Q7-5	Compliance ratio of monthly water test for tube well (TDS)	%				
8	C25-2	Average tariff per connection (billed connection)	Kyat/conn				
9	C26	Unit (Average) tariff per unit water consumption	Kyat/m^3				
2. Production & Transmission							
10	PT4-1	Daily average total production (untreated)	m3/day				
11	PT4-2	Daily average total production (treated)	m3/day				
12	PT4-3	Daily average total production (groundwater)	m3/day				
13	PT4-4	Daily average total production	m3/day				
14	PT4-5	Percentage of actual production (surface water) of total capacity	%				
15	PT4-6	Achievement ratio of water production of the planned production	%				
	Nyaghnapin WTP						
16	P4-1	Achievement ratio of WTP water production of the planned product	%				
17	P4-2	Operation ratio of WTP water production	%				
18	P4-3	Production efficiency (balance between inflow and outflow)	%				
19	P4-4	Transmission efficiency (transmitted water / produced water)	%				
20	P4-5	Overall production-transmission efficiency (transmitted water / raw water volume)	%				
21	P4-7	Alum sulfate consumption per unit treated water volume (m3)	g/m3				
3. Distribution & NRW							
22	D3-3	The number of leakage repaired (distribution network)	Nb./month				
23	D3-6	The number of pipe breaks (distribution network)	Nb./month				
24	D9	NRW	%				
25	D12	Operating metering level	%				
26	D14	The number of repaired pipe breaks per 1,000 connections	Nb./ 1,000 conn.				
4. Water Quality							
27	Q7-1	Compliance ratio of monthly water test in water facilities (turbidity)	%				
28	Q7-2	Compliance ratio of monthly water test at tap water in TS (turbidity)	%				
29	Q7-5	Compliance ratio of monthly water test for tube well (TDS)	%				
5. Sales & Collection							
30	C4-1	Number of connections -Metered (end of the month)	Nb.				
31	C4-3	Number of total connections (Metered+Flat) (end of the month)	Nb.				
32	C5-3	Number of bills delivered (Metered+Flat)	Nb.				
33	C6-3	Amount of bills delivered (Metered+Flat)	Kyat/month				
34	C7-3	Number of bills collected (Metered+Flat)	Nb.				
35	C8-3	Amount of bills collected (Metered+Flat)	Kyat/month				
36	C9-3	Number of bills outstanding (Metered+Flat)	Nb.				
37	C10-3	Amount of bills outstanding (Metered+Flat)	Kyat/month				
38	C12	Number of new connection	Nb.				
39	C15-1	Metering ratio (by total connection)	%				
40	C15-3	Operating metering ratio (by total connection)	%				
41	C16	Billing ratio in number	%				
42	C17-2	Collection ratio in amount	%				
	C18-2	Outstanding ratio in amount	%				
44	C19-2	Daily average water consumption (metered)	m3/d(MGD)				
45	C23	Collection period of account receivable (Outstanding bill amount)	days				
46	C24	Service coverage rate	%				
6. Finance							
47	F1	Total operating revenue for water	Kyat/month				
48	F2	Total operational expenses for water	Kyat/month				
49	F3	Accounts receivable	Kyat//month				
50	F4	Financial balance	Kyat/month				
51	F5	Operating ratio (Operating cost coverage)	%				
52	F8	Average revenue per m3 produced	Kyat/m3 water produced				
53	F9	Average revenue per m3 sold	Kyat/m3 water sold				
54	F10	Average revenue per connection	Kyat/month/conn				
55	F11	Unit operational cost for water produced	Kyat/m3 water produced				
56	F12	Unit operational cost for water sold	Kyat/m3 water sold				
7. Administration & Human Resource							
57	H8	Training period*number of trainee/Total staff	Person*day				
58	H9	Ratio of trainers to trainees	Person				
59	H10	Ratio of practice sessions	%				
60	H11	Total staffs number/1000 connections	person				

Prepared by:
Date:

Checked by:
Date:

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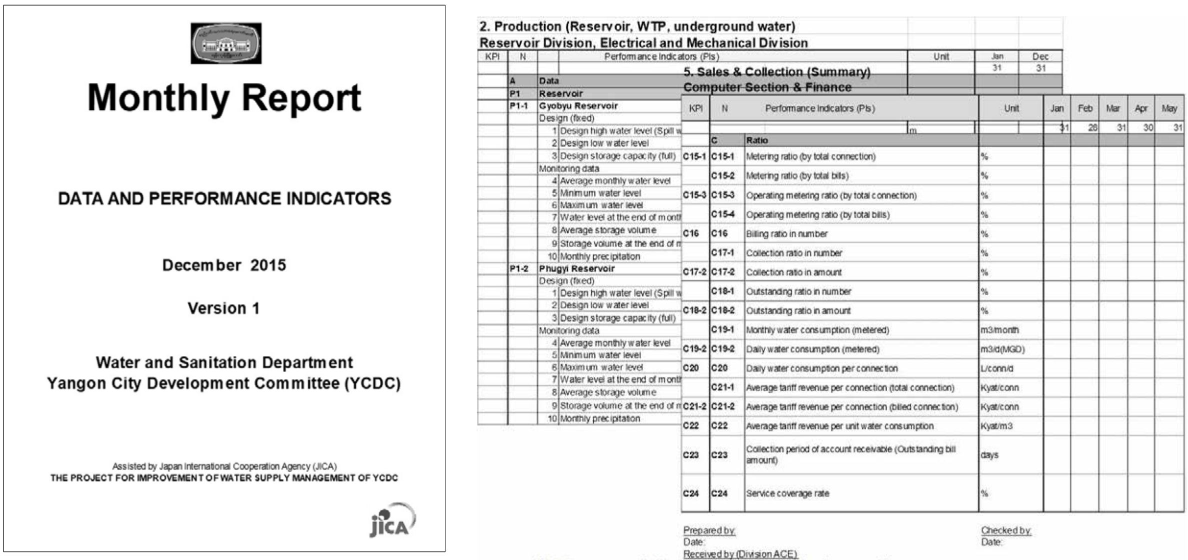
Date:


Monthly Report

DATA AND PERFORMANCE INDICATORS

December 2015

Version 1

Water and Sanitation Department
Yangon City Development Committee (YCDC)

Assisted by Japan International Cooperation Agency (JICA)
THE PROJECT FOR IMPROVEMENT OF WATER SUPPLY MANAGEMENT OF YCDC

2. Production (Reservoir, WTP, underground water)
Reservoir Division, Electrical and Mechanical Division

5. Sales & Collection (Summary)
Computer Section & Finance

KPI	N	Performance Indicators (PIs)	Unit	Jan	Feb	Mar	Apr	May
				31	28	31	30	31
	C	Ratio						
C15-1	C15-1	Metering ratio (by total connection)	%					
	C15-2	Metering ratio (by total bills)	%					
C15-3	C15-3	Operating metering ratio (by total connection)	%					
	C15-4	Operating metering ratio (by total bills)	%					
C16	C16	Billing ratio in number	%					
	C17-1	Collection ratio in number	%					
C17-2	C17-2	Collection ratio in amount	%					
	C18-1	Outstanding ratio in number	%					
C18-2	C18-2	Outstanding ratio in amount	%					
	C19-1	Monthly water consumption (metered)	m3/month					
C19-2	C19-2	Daily water consumption (metered)	m3/d(MGD)					
C20	C20	Daily water consumption per connection	L/conn/d					
	C21-1	Average tariff revenue per connection (total connection)	Kyat/conn					
C21-2	C21-2	Average tariff revenue per connection (billed connection)	Kyat/conn					
C22	C22	Average tariff revenue per unit water consumption	Kyat/m3					
C23	C23	Collection period of account receivable (Outstanding bill amount)	days					
C24	C24	Service coverage rate	%					

Prepared by: Date:
Checked by: Date:
Received by (Division ACE) Date:

Figure 2-12: Cover page of PI monthly report and data sheet

1-4-4 Install transmission flow meter and data logger and collect flow data

(1) Purpose of installation of flow monitoring system

Installation of flow monitoring system was decided in the 1st JCC. Purposes of this flow monitoring system are shown below:

- To understand the water volume of transmission and distribution, which is the most basic data needed for water supply management.
- To utilize flow data for NRW management.
- To develop an efficient water transmission and distribution management plan to ensure equitable water transmission and distribution.

(2) Configuration of flow monitoring system

For this purpose, following major flow monitoring data were collected. Detailed location of monitoring points is shown in Appendix 7.I.

- Treated water
- Flow volume of trunk water transmission (outflow of reservoirs, outflow of transmission pumping stations (PS))
- Flow volume of trunk water distribution (inflow/outflow of trunk water distribution PSs and service reservoirs (SR))

Note: Nyaunghnapin WTP had been equipped with 2 existing flow meters. Data from these existing flow meters were also incorporated into this monitoring system.

Overview of flow monitoring system is as follows:

- Installation of 21 flow meters. Flowmeters were installed in underground flowmeter chambers for underground piping and in steel boxes for above ground piping.
- Installation of data transmission equipment in 9 locations. Data transmission equipment was installed in newly constructed kiosk or in existing structure.
- Installation of central data collection system in WRAWSA head office.

The following activities were carried out as part of the training for the C/P.

- A field survey was conducted based on the existing pipeline drawing to identify the necessary flow monitoring points.
- The installation point of flowmeter was determined based on the required distance from the deformed pipe, valve, reservoir and pump.

(3) Design and construction of flowmeter chamber and kiosk

With JICA Expert's guidance, the C/P designed and constructed flowmeter chambers and kiosks in which flowmeter and transmission device are installed. The following is a summary of the expert's guidance.

- Decide specifications of flowmeter chamber and kiosk, and support designing.
- Instructed a construction supervision of flowmeter chambers and kiosks including safety management.
- Instructed a waterproofing work of flowmeter chambers – an outer bitumen coating and an inner epoxy coating.
- Instructed a safety management in flowmeter chamber using gas detector.
- Construction inspection was conducted at the site with the C/P, and the C/P compiled an inspection report and submitted to the DYCE.

(4) Implementation of installation work

Installation of flow meter and OJT were implemented by the contractors. Installation of flow meters and sensors was carried out by Kantou Bussan Co., Ltd. / Tokyo Keiki Inc., and installation of data collection/transmission system and data browsing software was carried out by Delairco Japan KK. Contractor's dispatch and construction details are as follows:

Table 2-17: Constructor's dispatch and construction details

No.	Contractor	Dispatch period	Construction details
1st	Delairco	Feb. 18 - Mar.2 2019	• Installation of Field data transmission unit and Central data collection system
2nd	Kantou Bussan	May 5 - Jul.1st	• Installation of flow meter and operation check • OJT (1st)
3rd	Delairco	Jul. 7 -Jul.15	• Installation of Data collection system and Central data collection system • Improvement of UPS battery (Gyobyu reservoir site) and Power supply unit (Nyaunghnapin WTP site) • Final inspection • OJT (2nd)
4th	Delairco	Aug. 18 - Aug.25	• Installation of interface (IF) unit • Re-inspection • OJT (3rd)
5th	Kantou Bussan Delairco	Oct.21-Nov.2 Oct.27-Nov.2	• Maintenance by Tokyo keiki and Delairco • OJT (4th)

(5) OJT

OJT was carried out by contractor in parallel with the installation work. Date and contents of OJT is shown in the table below.

Table 2-18: Date and contents of OJT

No.	Date and Instructor	Venue	Trainee	Contents	Number of trainees
1	Jun. 28 2019 Tokyo Keiki	Yegu PS	WRAWSA HQ: Electric section and Pipeline3 section Staff of flow meter: Yegu PS, Hlawga PS, Pywbwesu PS, Gyobyu Reservoir and Nyaunghnapin WTP	O & M of flowmeter model UFL-30 Workshop in Yegu PS kiosk	12
2	Jul. 13 Delairco	Yegu PS	WRAWSA HQ: Electric section Staff of flow meter: Yegu PS, Hlawga PS, Pywbwesu PS,	O&M of data logger Workshop in Yegu PS kiosk	18

No.	Date and Instructor	Venue	Trainee	Contents	Number of trainees
			Gyobyu Reservoir, Phugyi Reservoir and Nyaunghnapin WTP		
3	Jul. 15 Delairco	WRAWSA HQ Central data room	WRAWSA HQ: Electric section, Computer section, Customer section, GIS section and Design section	Operation of data collection system (1st) Operation of data collection system	6
4	Aug. 23 Delairco	WRAWSA HQ Central data room	WRAWSA HQ: Electric section, Customer section, GIS section and Design section Staff of flow meter: Yegu PS Assistant of JICA long-term expert	Operation of data collection system (2nd) Operation of data collection system (reporting function and error report)	9
5	Oct. 30 Tokyo Keiki Delairco	Yegu PS	WRAWSA HQ: Electric section Staff of flow meter: Yegu PS	Maintenance of flow meter kiosk O&M of flow meter, RTU (data collection and communication equipment) and power supply system	6
6	Nov. 11 Delairco	WRAWSA HQ Central data room	WRAWSA HQ: Electric section, Customer section, GIS section and Design section Staff of flow meter: Yegu PS and Hlawga PS	Operation of data collection system (3rd) Operation of data collection system (reporting function and error report)	11


Workshop in Yegu PS


Workshop in WRAWSA HQ Central data room


Workshop in Yegu PS


Workshop in WRAWSA HQ Central data room
Nov. 1

Photo 2-5: Implementation of OJT for Flow monitoring system

(6) Current situation

Flow monitoring system excluding flowmeters in Yegu No.9, No.12 and Nyaunghnapin No.2 (existing) is operated, and flow data is being monitored. Based on the flow data acquired in this system, the citywide non-revenue water (NRW) ratio was calculated in November 2019. Estimated NRW ratio was 63%.

1-4-5 Procure equipment (computers, printers, software, etc.) in local offices and conduct training

The recording of existing data of WRAWSA was largely carried out by manual recording and manual writing. As a result, calculation and analysis of the data were not accurate. Therefore, personal computers (PC) were procured in the Project and provided to the required sections to support PIs data input and calculation, preparation of report and improvement of work efficiency. The details of procured PC equipment and its allocation are shown below.

Table 2-19: Detail of PCs equipment and its allocation

1st Procurement

No	Section	PC (desktop, UPS)	Printer & consumables	MS-Office software	Anti-virus software	USB	Copy machine & consumables
1	Township office(33)	33	33	33	33	33	
2	District office (4)	4	4	4	4	4	
3	Gyobyu Reservoir	1	1	1	1	1	
4	Phugyi Reservoir	1	1	1	1	1	
5	Hlawga Reservoir	1	1	1	1	1	
6	Nyaunghnapin WTP	1	1	1	1	1	
7	Yegu PS	1	1	1	1	1	
8	Pywbwesu PS	1	1	1	1	1	
9	NRW Sec.	1	1	1	1	1	
10	Customer Service Sec.	1	1	1	1	1	
11	Planning Sec.	1	1	1	1	1	
12	HRD Sec.	1	1	1	1	1	
13	AID Compound	1	1	1	1	1	
14	Store Sec.	1	1	1	1	1	
15	HQ (computer room)	10		10	10		
16	JICA Project office						1
	Total	59	49	59	59	49	1

2nd Procurement

No	Section Name	PC (Laptop)	PC (desktop, UPS)	Printer & consumables	MS-Office software	Anti-virus software
1	WQ Monitoring Sec.	1			1	1
2	HRD Section	1			1	1
3	Planning Sec.	1			1	1
4	Finance Sec.		1		1	1
5	Research Sec.	1			1	1
6	Electrical Sec.		1	1	1	1
7	NRW Sec.	2			2	2
8	South District		1		1	1
9	Lagunbyin WTP	1			1	1
10	Customer service division	1	2		3	3
	Total	8	5	1	13	13

1-4-6 Collect data required for setting PIs

Prior to setting up PIs, the necessary existing data was collected and PIs for water services were studied based on the result of PCM workshop and a baseline survey in Term 1 described in 1-4-1.

1-4-7 Develop calculation method, manuals and monitoring system of Performance Indicators

(1) Activity in Term 1

In Term 1, Expert Team collected information and understood the status of waterworks of YCDC. Planning Section decided to collect and compile the data sheets comprehensively. After establishing the regular and appropriate data collection, Planning Section would prepare a report regularly and submit to the top management of WRAWSA. For the first step, the Project put a priority on data collection and date entry, and its submission to Planning Section. The conceptual chart of PIs data collection is shown in the figure below.

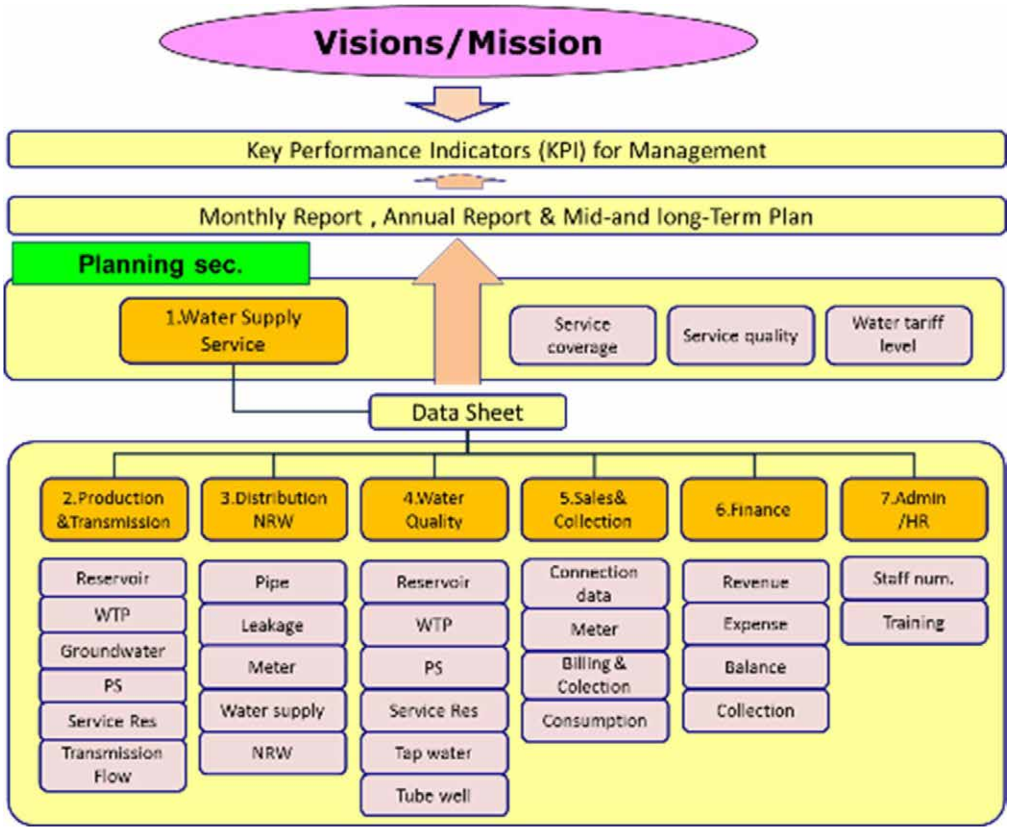


Figure 2-13: PIs data collection system (conceptual chart)

In parallel to the activities of “1-4-8 PIs Setting”, “PIs monitoring manual” was prepared. It includes the definition of PIs, meaning, formula, data entry methods etc. Afterwards, Expert and Planning Section carried out a training to the C/P, key staff of the relevant sections, data entry operators of T/S and district offices based on the manual. In the training, attention was especially paid to the point that the C/P of Planning Section provided training as trainers as much as possible. Main trainings provided are shown in the table below. In addition, separate guidance apart from the following training were also carried out.

Table 2-20: List of training provided on PIs data entry

Month / Year	Target	Number of Trainees	Contents
Jul./2016	T/S office District office Reservoir Div., Water Quality Sec., Finance Sec., Admin & HRD Sec., Groundwater Sec.	100	**Data Entry Training (Basic Data)** Based on datasheet between January and March 2016, training and guidance were carried out aiming at 1) improvement of its accuracy, 2) securing data quality by using unique definition, source and calculation methods. In the training, the Expert unified the definition,

Month / Year	Target	Number of Trainees	Contents
			source, and calculation method, and provided a guidance on appropriate data entry method. The Expert and the C/P answered the inquiries from T/S and the relevant sections and modified a part of datasheet according to the practical use. Afterwards, T/S office and the relevant sections modified data again and submitted to Planning Sec..
Sep./2016	T/S office District office Reservoir Div., Water Quality Sec., Finance Sec., Admin & HRD Sec., Groundwater Sec.	199	**Data Entry Training (Ratio part)** Training and guidance were provided aiming 1) to deepen understandings of meaning of PIs and data entry method, 2) to understand the indicators for ratio calculation and calculate in practice, 3) utilize the function of MS Excel and optimize the datasheet. This training was done by using computers provided by the Project.
Dec./2016	District office	10	**Follow-up Training** Training and guidance were carried out aiming 1) to explain the revised datasheet, 2) CD of appropriate data management from T/S offices.
Jan./2017	T/S office	61	**Follow-up Training** Follow-up training and guidance was provided aiming at minimizing mistake of data entry and improvement of data quality.

(2) Activity in Term 2

In Term 2, the activities were continuously done to strengthen data collection and monitoring. In concrete term, the optimization of activities of 1) modification of PIs data sheet, 2) change of the sections in charge of data entry, were implemented to collect the data efficiently and accurately.

In FY2017/18, a sub-format of “sales sheet” was prepared and newly added in the PI data sheet, in order to reduce data entry mistake and to enhance T/S members’ understanding on billing and collection. The sub-format sheet was prepared by Planning Section and Computer Section together to avoid data entry mistakes and wrong indications due to poor understanding of data to be entered and to improve accuracy of data entry. The sub-format was developed in accordance with collection ledger in T/S. In the excel sheet format, calculation formulas were input in advance and locked to prevent format change. A training on data entry in the format was carried out by two key trainers of Planning Section and follow-up guidance on the format was carried out.

In FY 2018/19, as the results of continuous guidance, T/S offices were able to submit more accurate PIs datasheet to Planning Section. In addition, two counterparts of Planning Section were able to confirm the datasheet as received and to make instruction of modification and/or correction on time.

In FY2019/20, the new staff members of Planning Section became responsible for PIs data collection, correction, and arrangement under the supervision of the C/P at the middle class. During the absence of the C/P (mid-level staff) due to a long-term training in Japan and overseas study, the Expert has provided OJT for PIs data collection and confirmation continuously to new staff members. In particular, mutual collaboration between the C/P and T/S officers happened on data confirmation and modification for the datasheet of “distribution and NRW sheet”, “sale sub-format sheet” as a supplementary sheet of “sales sheet”, and “customer connection and consumption sheet”. The young staff members were enabled to communicate with the T/S officers and make an individual guidance to them. “PIs Datasheet Entry Seminar” was held on 23rd December 2019 for the purpose of reduction of mistakes, where the young staff members provided a guidance to the T/S officials as a trainer. The actual training list is shown in the table below.

Table 2-21: Training on PIs data entry

Year / Date	Target	Number of Trainees	Contents
29 Aug. 2017	All township office Reservoir Div., Water Quality Sec., Finance Sec., Admin &HRD Sec., Groundwater Sec.	34	**Data Entry Training for Sub-format** A sub-format for Sales as been installed in PIs data sheets. Training was carried out by the C/P as trainers aiming at explaining data entry method. 1) to understand the collection and the outstanding amount against the billing amount easier than an existing format, 2) to transfer the data from collection ledger at T/S in an easier way.
Aug. to Dec. 2017	All township office Reservoir Div., Water Quality Sec., Finance Sec., Admin &HRD Sec., Groundwater Sec.	Many	**Data Entry Consultation and Guidance for Sub-format** Guidance was provided to T/S on intermittent basis. This training was done by using computers installed by the Project.
4 to 22 Dec. 2017	Township office District office	24	**Follow-up Training Data Entry Consultation and Guidance for Sub-format** Confirmation and guidance were provided for mistake and inappropriate data.
Apr. 2018 – Mar. 2020	Township office District office	-	**Guidance to the Staff Members of Township** It is difficult to count the number of trainees by the Planning C/P due to the irregular visits of township staff and the different frequency depending on township.
23rd Dec. 2019	All T/S offices PIs Datasheet Data Entry Seminar	Approx. 50	Explaining on PIs definition, entry method, a partial modification point of PIs datasheet of "Distribution and NRW", "Sales Sub-format", and "Customer Connection and Consumption" and making guidance. The C/P both at middle and young classes of Planning Section carried out training by using the Excel sheet and conducting Q&A session

In parallel with "1-4-8 Setting PIs", the Expert explained the definition, the meaning and the formula of 15 MKPIs selected in Term 2, and its data entry method to the C/P of Planning Section. Afterwards, the calculation of MKPIs in the Mid-term Management Plan was practiced by using the data of FY2016/17. In January 2020, the C/P and the Expert estimated the PI values in MKPIs based on the data of FY 2018/19. The estimated tentative value is shown in 1-4-9, although the inappropriate data in each datasheet needs to be continuously checked.

1-4-8 Calculate Performance Indicators

The necessary PIs for monitoring water services of YCDC were set up. In the process of setting up, datasheets in 7 major areas were prepared to monitor overall waterworks in a balanced manner. Each datasheet consists of basic data and ratio data parts. In addition, 60 key performance indicators (KPIs) were selected. The number of KPIs by area is shown below.

Table 2-22: KPIs and its number

Area	The number of KPIs
Water supply service	9
Production and transmission	12
Distribution	5
Water quality	3
Sales ad collection	17
Finance	10
Admin & HRD	4
Total	60

In Term 2, 15 indicators as Management Key Performance Indicators (MKPIs) out of KPIs were selected. MKPIs are significant indicators which should be monitored by the top management. Also, MKPIs enable the top management to understand the periodical transition of performance of the utility and utilized for setting of targets for mid-term plan. These data can be compared with the performance of other water utilities. MKPIs are shown below.

Table 2-23: Management key performance indicators (MKPIs) of YCDC

No.	Serial No.	Indicator	Unit
1	S1	Service population	'000 inhabitants
2	S2	Total connections	Nb.
3	S28	Service coverage rate	%
4	PT4-4	Daily average total production	m^3/day
5	D9	NRW	%
6	D13	The number of repaired pipe breaks per pipe length	Nb./ km
7	Q7-1	Compliance ratio of monthly water test in water facilities (turbidity)	%
8	Q7-2	Compliance ratio of monthly water test at tap water in T/S (Residual chlorine)	%
9	C15-3	Operating metering ratio (by total connection)	%
10	C17-2	Collection ratio in amount	%
11	F5	Operating ratio (Operating cost coverage)	%
12	F9	Average revenue per m^3 sold	Kyat/m^3 water sold
13	F12	Unit operational cost for water sold	Kyat/m^3 water sold
14	H8	Training period*number of trainee/Total staff	Person*day
15	H11	Total staff number/1000 connections	person/1000 conn.

1-4-9 Update and monitor the Performance Indicators periodically

(1) Challenges emerged in Term 1

Data collection of PIs from the relevant sections was launched in January 2016. Meanwhile, the following challenges emerged after data collection was started. The Expert and the C/P dealt with these challenges by organizing retraining.

- ✓ Input data itself was not appropriate in the datasheet by each section
  - Misuse of unit
  - Figure was extraordinarily too large or too small
  - Inputting data in wrong cells
  - Pasting data out of alignment inappropriately
  - Inputting comma inappropriately, thereby MS Excel does not acknowledge the figures
  - Inputting not only figure but also text in cells, thereby MS Excel does not acknowledge the figure
- ✓ District officers did not transfer the data of township offices into the summary sheet accurately in some cases
- ✓ Officers both in District office and T/S office misunderstood the meaning of PIs

(2) Modification and addition of PIs data sheet and change of data collection system

In Term 2, the following actions were undertaken to implement more efficient and accurate data entry by modifying the data sheet installed and by adding supplementary sheets.

- As mentioned in 1-4-7, after "Sales" sheet was reviewed, "Sales sub-format", which the T/S staff could easily understand, was created and installed. Computer Section and Planning Section initiated installation of "Sale sub-format", which was created based on the existing format used in T/S office, because mistakes and incorrection occurred frequently when the T/S staff members transferred the data into PIs data sheet.
- It was decided to change the procedure of data entry and submission to one single format, so that each T/S office submits only "Sale sub-format" sheet which includes information on billing, collection and outstanding to Planning Section. Planning Section copies the information to "Sales" sheet of PIs data sheet and compile it.
- Same as the above, "Meter connection and consumption sub-format" sheet was newly installed. We

adopted the new modified method that T/S summarize the information on water meter connection and consumption in that sheet which were entered in “Sales” sheet, because it was more understandable for T/S staffs.

- In terms of “Water quality monitoring” sheet, “quarterly” and “mini-lab” sheets were newly installed. Based on the actual water sampling/analysis situation, the existing indicators of “Summary”, “Monthly”, and “Weekly” sheets were modified.
- The definition of the existing indicators of “Distribution and NRW” sheet was made clear and modified. New indicators were added in that sheet. For instance, an average number of persons in the household was originally set up as 5 persons per household, however the disparity can be seen between T/S. To estimate more accurate number, the estimation method was changed by calculating average number of persons in the household by each T/S, based on population data and the number of households.
- Hence, the average number of persons in household was added as a new indicator in the “Distribution and NRW” sheet. In addition, another modification point was to adopt a system that Planning Section estimated the average value and population served to avoid making a calculation mistake by the T/S side.
- In other PIs datasheets, the necessary modification and addition were carried out through discussion with relevant sections. The indicators which were difficult to monitor were deleted.

Also, the data collection system was continuously revised and changed from the original according to the installation of new sub-sheets. In the current institutional hierarchy of YCDC, district offices are positioned above T/S offices. However, as the staffing and the capacity of the district offices were limited, it was evaluated that original collection system was a bit too early to apply. As a result, the datasheets prepared by T/S are submitted directly to Planning Section under the current flow.

(3) Main activities in each fiscal year

As the activities in FY2017, the PI data for FY2016 and FY2017 was mostly collected by Planning Section. This information was confirmed and analyzed by Planning Section. While it appeared that information on the population served and the number of connections submitted by T/S necessarily did not reflect the real situation, the reasons were the different definition and rules among T/S, and the registered number of households and population was not the same as the number of current residential households and people. Hence, an additional survey on the abovementioned items were made by NRW Management Section in FY2018.

As the activities in FY2018, the value of MKPIs as of September 2018 was calculated based on the PIs data sheet information of FY2016 and FY2017 in the process of preparation of Mid-term Management Plan. Out of MKPIs, production volume and NRW ratio was estimated after installation of flow meters procured by JICA. Population served and the number of connections was modified after the additional survey by NRW Management Section. In the Mid-term Management Plan, it was aimed at grasping these target values.

The indicator values set up in Mid-term Management Plan in September 2018 is shown in the table below.

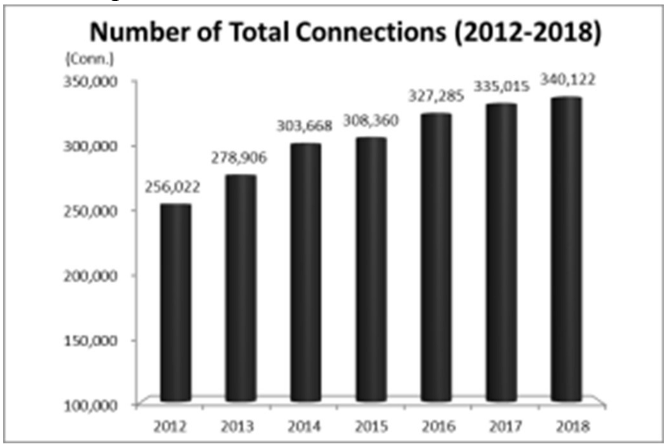


Figure 2-14: Trend of water connection number

Table 2-24: Management KPIs for FY2016/17 (tentative)

No.	Serial no.	Indicator	Unit	FY2016/17 Actual	Status
1. Water Supply Service					
1	S1	Service population	‘000 inhabitants	1,392	Tentative
2	S2	Total connections	Nb.	327,285	Tentative
3	S28	Service coverage rate	%	30.1	Tentative
2. Production & Transmission					
4	PT4-4	Daily average total production	m^3/day	761,255	Tentative
3. Distribution & NRW					
5	D9	NRW	%	–	After flow meter installation
6	D13	The number of repaired pipe breaks per pipe length	Nb./ km	0.28	
4. Water Quality					
7	Q7-1	Compliance ratio of monthly water test in water facilities (turbidity)	%	69.0	
8	Q7-2	Compliance ratio of monthly water test at tap water in T/S (Residual chlorine)	%	–	After chlorination
5. Sales & Collection					
9	C15-3	Operating metering ratio (by total connection)	%	–	After survey
10	C17-2	Collection ratio in amount	%	72.7	
6. Finance					
11	F5	Operating ratio (Operating cost coverage)	%	63.7	
12	F9	Average revenue per m^3 sold	Kyat/m^3 water sold	98	Estimation
13	F12	Unit operational cost for water sold	Kyat/m^3 water sold	173	Estimation
7. Administration & Human Resource					
14	H8	Training period*number of trainee/Total staff	Person*day	2.9	
15	H11	Total staff number/1000 connections	person/ 1000 conn.	7.4	


Training on Estimation of MKPIs


Practical Training by Excel Sheet

Photo 2-6: Training on Estimation of MKPIs

As activities in FY2018/19, the C/P of Planning Section and the Expert continued collecting and confirming the inappropriateness of the PIs datasheet of FY2017/18 and FY2018/19 submitted by the relevant sections. Although the inappropriateness of the PIs datasheet has been improving gradually especially in “Distribution and NRW sheet”, “Sales Sub-format sheet”, “Customer Connection and Consumption sheet”, the correction points can be still seen in the sheet submitted, such as entry mistake, inappropriate data input by misunderstanding, unit mistake, and digit mistake. Under such situation, the C/P of Planning Section took time for communication and modification to all 33 T/S offices. It was observed that the data entry practice was not sufficiently succeeded over to the new T/S staff due to the staff transfer in WRAWSA, so we planned and implemented “PIs Datasheet Entry Seminar” again targeting the data operators in the T/Ss and the district offices. The outline of the seminar is shown below.

Table 2-25: PIs Datasheet Entry Seminar

Date:	23rd December 2019
Participant targeted:	Data operators for data entry in T/S and District office
Number of participants:	Approximately 50
Contents:	Main purpose was to reduce inappropriateness of data entry in PIs data sheet, which is responsibility of T/S offices, by explaining and deepening their understanding on data items, data definition/ meaning, input method, partial modification on input data. “Distribution and NRW sheet” • To discuss and optimize data entry to reduce data entry mistake and calculation mistake as follows. ① to calculate average number of persons in household by Planning Section based on township data ② to confirm on the definition of distribution pipe being followed as to not by distribution pipe diameter but by categorised distribution pipe ③ to carry out indication of all leakage events identified through control, as contrary to counting only large leakage events (modification of PI’s expression) ④ to make the data entry on “number of water meter”, which should be sum of “number of meter functional” and “number of meters malfunctional” “Sales Sub-format sheet” • to explain the matrix table indicating billed amount, collection amount and outstanding amount every month • to explain and to make data entry on “outstanding amount” which should be difference between “billed amount” and “collection amount”, and its confirmation method

1-5 Formulating Regulations, Standards, Guidelines and Manuals

1-5-1 Reviewing the existing rules, regulations, standards, and guidelines

The existing regulations, standards, guidelines and manuals (RSGM) were confirmed by PCM workshop and a baseline survey. In the baseline survey, table of contents and topics of major existing RSGM were arranged and compiled as a report. The existing RSGM identified in Term 1 are shown in the table below.

Table 2-26: Existing laws, regulations, guidelines and manuals

No.	Title	Issued by	Detailed document
1	YCDC Law (2013) (2014 updated) (2016 2nd updated)	YCDC	Yes
2	YCDC Regulations related to water and sanitation (1999, December-17)	YCDC	
3	New YCDC Regulation related to water and sanitation (under drafting)	YCDC	
4	Analysis of rate for Roads, bridges, buildings, electrical, airfield, research, laboratory, water supply	Ministry of Construction	Yes

No.	Title	Issued by	Detailed document
	and sanitation (2014)		
5	Guidelines for water and sanitation (1996)	Ministry of Construction	Yes
6	Reinforced concrete design by Professor U Nyi Hla Ngae	Yangon Technological University	Yes
7	Guidelines for High-rise building construction projects (Sanitary)	Committee for Quality Control of High-Rise Building	
8	Guidelines for civil engineers (Including material standards) (2001)	Ministry of Construction	Yes
9	National drinking water quality standard Myanmar by Ministry of Health (2014)	Ministry of Health	Yes
10	Myanmar National Water Policy (2015)	NWRC	

1-5-2 Identify regulation, standards and guidelines to be modified and/or newly formulated

The necessary RSGM for new creation or revision were identified and arranged with counterparts in workshops such as PCM workshop, T/S and district office's workshop and Myanmar-Japan Joint Seminar workshop. Through these workshops, the RSGM which needs new preparation and revision was identified and arranged as below respectively.

(1) PCM Workshop

At the beginning of the Project, the necessary RSGM were listed up after discussion with the assigned counterparts. The rules listed-up are shown below.

Table 2-27: Necessary regulations, standards, guidelines and manuals (RSGM)

Area	Items
Design	Design criteria on water supply system
Design	Material standards
Facility Renewal	Guideline on replacement of old pipeline into new pipeline
Facility Renewal	Manual on replacement of water meter and pump
O&M	O&M guideline on reservoir, pipeline, mechanical and electric equipment
O&M	Guideline on regular inspection of submersible pump, transmission pump and motor
Construction	Guideline on construction project management
Construction	Guideline on safety management
Water Quality	Guideline on chlorine disinfection
Customer Management	Revision of customer service agreement
Revenue Collection	Guideline on water tariff collection
Environmental Conservation	Guideline on strengthening / enforcement of environmental conservation of intake area

(2) Workshop for T/S and district offices

The participants of PCM workshop above largely consisted of the staff of head office. This workshop was held to have field offices' understanding and identification of needs on-site. Prior to the workshop, Expert listed up the necessary RSGM, then participants considered additional ones and prioritized them in the workshop. Outline and summary of the workshop are shown below.

Date:	20 Dec 2016
Participant:	Head/ or deputy head of 4 district offices,7 township offices
Purpose:	To identify the needs of T/S and district offices on the rules To understand the priority from the viewpoint of T/S and district offices
Method：	− Distribution of the list − Consideration of additional list − Prioritization of the necessary rules by 3 group discussion

Table 2-28: Necessary regulations, standards, guidelines and manuals (field offices' workshop)

Priority	Area	Items	Score
1	Billing & collection	Manual on billing operation	19
2	Billing & collection	Manual on collection operation	18
2	Billing & collection	Manual for meter reading and recording	18
2	Water meter & service pipe	Design standard for service pipe and water meter	18
5	Billing & collection	Rules for ownership of water meter and service pipe and customer's responsibility	17
6	Billing & collection	Rule for FOC	16
7	Transmission & Distribution	Design standard for transmission and distribution facilities	12
7	Water meter & service pipe	Maintenance and management manual on water meter	12
9	Water meter & service pipe	Standard drawing on service pipe installation	10
10	Transmission & Distribution	Standard drawing on transmission and distribution pipeline installation	8

The development needs of manuals/rules on billing and collection were high according to the opinions of field offices. With the need of technical side, the results show the high needs in the following items: 1) design criteria and standard drawing on water meter and service pipe, 2) operation and maintenance (O&M), 3) design criteria and standard drawings on transmission and distribution pipeline. Overall, high needs were identified with regards to development of design of pipeline, standard drawing for construction and O&M.

(3) Myanmar – Japan Joint Seminar (MJJS)
The main purpose of the Joint Seminar was to consider the necessary plans and RSGM which support the actions of YCDC/WRAWSA to achieve the ideal state in future. In the seminar, Advisory Committee members presented the plan and the RSGM as samples of Japan, and YCDC/WRAWSA had discussion on the necessary plans and RSGM based on the Japanese cases.

Participants placed priority on the list of necessary regulations, standards, guidelines, and manuals according to the degree of importance between A-C. As a result, high importance was placed on many items. Meanwhile, enough time could not be secured to deepen the discussion due to variety of participants' background. In most of the items, many participants wanted to develop them within the short-term considering its importance. Hence, when the C/P translates development of these RSGM into practice, the feasibility of development priority should be re-considered.

Table 2-29: Necessary regulations, standards, guidelines and manuals identified in MJJS

No.	Items	Importance (A /B/ C) *	Target within
1	Water Supply Ordinance	A	1 year
2	Manual on billing operation	A	1 year
3	Manual on collection operation	A	1 year
4	Manual for meter reading and recording	A	1 year
5	Rules for ownership of water meter and service pipe and customer's responsibility	A, B, C	1 year
6	Rule for outstanding bill	A, B	1 year
7	Rule for illegal connection	A	1 year
8	Rule for FOC	A, B	1 year
9	Rule for VIP	A	1 year
10	Rule for Fire hydrant	A, B	1-2 years
11	Enforcement of fine on NRW in customer's territory	A	1 year
12	Design standard for service pipe and water meter	A, B	1-3 years
13	General specification on water meter	B	1 year

No.	Items	Importance (A /B/ C) *	Target within
14	General specification on service pipes	B	3 years
15	Manual for water meter installation	A	1 years
16	Manual for service pipe installation	A	1 year
17	Standard drawing on water meter installation	A, B	1 year
18	Standard drawing on service pipe installation	B	1 year
19	Maintenance and management manual on water meter	A, B	3 years
20	Design standard for transmission and distribution facilities	A, B	1-3 years
21	General specification on transmission & distribution pipes	A, B	1-3 years
22	Manual for transmission and distribution pipe installation	A, B	1-3 years
23	Standard drawing on transmission and distribution pipeline installation	A, B	1-3 years
24	Maintenance and management manual on pipeline (transmission, distribution)	A, C	1-3 years
25	Inspection of pipeline (transmission, distribution)	A, B, C	1-3 years
26	Design standard for pump and valve equipment	A, B	1-3 years
27	Manual for pump & valve installation	A, B	3 years
28	Valve maintenance/replacement manual	A	1 year
29	Pump maintenance/replacement manual	A	1 year
30	Inspection of pump & valve	A	1 year

Note: *Multiple answers applicable

1-5-3 Draft water supply regulation and run a trial

(1) Background for drafting water supply regulation as additional activity of the Project

This activity was put in the scope of Project from the Term 2 that started in June 2017.

Water supply business should be executed based on laws, regulations, or rules. Especially duties/responsibilities and rights/authorities between customers and water supplier shall be clearly defined by those rules. In Yangon city there existed the YCDC Law and the YCDC Regulation which defined the role of WRAWSA, however, those provisions of rules were not enough to manage the water supply services provided by YCDC in a stable manner. In the Union Government level, there was no such law defining water supply services.

Consequently, the situation was such that laws and regulations regarding water supply services were not properly arranged in Myanmar and in Yangon city. This was recognized in Term 1 of the Project and the new activity was added to it. Under the condition that no union level law exists and no prompt action of making such law was expected, YCDC Law and/or YCDC Regulation should define more proper and overall rule of water supply services in Yangon city. Besides, it should be the principal rule for water supply services which might stand as the foundation of affiliated standards, guidelines, manuals, and SOPs. These rules were expected to be created in the Project.

According to the background mentioned above, YCDC members of the JCC proposed new activities at the 3rd JCC meeting held in February 2017 and the minutes including this matter were signed on 5th of May 2017 by both sides, and an activity to draft water supply regulation started as a new activity of Term 2 of the Project.

In Japan, every municipal water supply utility has “Water Supply Ordinance” whose characteristic is different from that of YCDC water supply regulation. “Ordinance” is municipal law of Japan’s local government system, whereas “Regulations” in Myanmar’s legal system are like “enforcing regulations” in Japan which do not create new rights or obligations of citizen. In Yangon city, YCDC Law stipulated the activities of water supply, and “Regulation” might stipulate enforcing articles of YCDC Law.

(2) Organizing new committee/groups for drafting regulation

1) Establishing “Steering Committee” and “Working Group”

To draft the water supply regulation, a working group (WG) responsible for the activities was needed to be established and its members needed to have broad knowledge and experience of each division/section's role or responsibilities.

In the meantime, the Steering Committees 3 (S/C3) were established at the Term 1 of the Project to promote the performance of the Project through involving the executive class of WRAWSA. Among three of them, S/C3 was in charge of creating RSGM and was to supervise WG for drafting regulation.

The members of S/C3 were assigned on 10th July 2017 and the members of WG were nominated by consulting the DYCE and ACEs of S/C3 members and decided by the CE in the middle of October 2017.

Table 2-30: Name list of Working Group for Drafting Regulation

1	Daw Thwe Naing Oo (ACE)	Water Supply Division
2	Daw Thin Thin Soe (ACE)	Supporting Division
3	U Tin Win Aung (EE)	House Connection Section
4	Daw Yu Yu Hla Baw (EE)	NRW, Research Section
5	U Zaw Min (EE)	Lagunpbyin Project
6	U Kyaw Kyaw Oo (EE)	District Officer (East)
7	U Chit Ko Ko (EE)	District Officer (West)
8	U Thant Zin Oo (EE)	District Officer (South)
9	U Nay Lin (EE)	District Officer (North)
10	U Than Han (EE)	Lagunpyin Project
11	U Tint Zaw (EE)	Pipe 1
12	U Aung Ko Oo (EE)	Pipe 2

2) Set-up of Sub-groups

In S/C3 meeting held on 26th June 2018, previous year's activities were reported and shared by WG members. On that occasion, the Expert requested to establish sub-groups to enhance studying different aspects of water supply regulation such as service installation and billing/collection of water tariff. Sub-group A was set up to treat service connection issues and Sub-group B to handle billing/collection issues of water tariff. Both sub-groups had 4 members as follows.

- ✧ Sub-group A (Service connection issues): U Tin Win Aung (House Connection Section), Daw Ye Mon (House connection section), Daw Thin Thin Cho (North District), Daw Mar Mar Aye (Thingangyun T/S)
- ✧ Sub-group B (Billing and collection issues): Daw Aye Aye Mar (Computer Section), Daw Khin Khin Htwe (Finance Section), Daw Moe Moe Khine (Finance Section), Daw Ni Mar Zin (Tarmwe T/S)

(3) Activities at the beginning

1) Activities before establishment of WG

Before adding these activities to the scope of the Project, the C/P members of Planning and RSGM investigated what kind of RSGM related to water supply had been enacted including the YCDC Regulation, and the team reported the result at the end of Term 1. According to the report, since there was a lack of water supply law at national level, only YCDC Law and YCDC Regulation stipulated water supply services in Yangon city. However, both YCDC Law and Regulation only defined Department's roles and activities, but they did not include overall duties/responsibilities and rights/authorities between customers and water supplier which were found in the regulation of water supply services in Japan and in most countries.

Photo 2-7: Kick-off meeting of S/C 3 and WG for Regulation (CE and three DYCEs attended)

2) Start of WG and its Kick-off Meeting

In the middle of October 2017, the members of WG for Water Supply Regulation were assigned and the WG started its activities. Following the assignment of members, the Kick-off meeting was planned to be held. Key members of WG, Ms. Thwe Naing Oo (ACE), Ms. Thin Thin Soe (ACE), Ms. Yu Yu Hla Baw, Ms. Yamin and Mr. Thein Min (Deputy chair of S/C3/DYCE3), got together and discussed the contents and agenda of the Kick-off meeting.

On 20th October 2017, the Kick-of meeting of WG and S/C3 for water supply regulation were held together. All executives of WRAWSA, the CE, the DYCE-1,2,3 and all members of S/C3 attended the meeting. Ms. Khain Khain Soe of Planning Section did her role as MC. Agenda of the meeting were as follows:

1. Presentation on activities of S/C3 by Ms. Thin Thin Soe (ACE)
2. Presentation on activities of WG Water Supply Regulation by Ms. Yu Yu Hla Baw (Research Section)
3. Presentation on Japan's law and regulation of water supply services by Mr. Yoji Matsui (JICA Expert)

At the meeting, activities of WG were discussed and agreed as follows:

- To review the existing laws/regulations relating to water supply in Yangon city
- To study other countries' cases
  - Japan's case (Waterworks Law, Tokyo's Water Supply Ordinance)
  - Other countries' case
- To draw the draft of YCDC's Water Supply Regulation
- To submit the draft to S/C3
- To amend the draft according to suggestions by S/C3
- To re-submit the amended draft to S/C3

Schedule of WG was agreed as follows:

- Select member October 2017
- Kick-off meeting October 2017
- Review October 2017 – September 2018
- Study October 2017 – September 2018
- Draw draft by WG January 2018 – December 2018
- Discuss in WRAWSA (S/C 3) April 2018 – December 2018
- Discuss with CM/YCDC September 2018 – December 2018
- Trail run January 2019 – December 2019
- Adjustment April 2019 – September 2020
- Discuss with YRG October 2019 – December 2019

3) Review and study of other countries' regulations and discussing table of contents of regulation

At the start of WG, members reviewed the existing YCDC Regulation and studying other countries' regulations. As for overseas cases, Tokyo, Faisalabad (Pakistan) and Kenya's model regulation were studied. JICA Expert was familiar with Tokyo's case, and other two cases were selected because its detail provisions might be useful to study and compare with YCDC's.

On 6th March 2018, WG members conducted a workshop to discuss on the table of contents to draft regulation of YCDC after presentations of the results of comparison study on YCDC and other countries' regulations.

Photo 2-8: On 6th March 2018, WG members for Regulation conducted a workshop to discuss Water Supply Regulation. Ms. Thwe Naing Oo (ACE) presided over it.

The workshop started with presentations of "comparison of regulations in Myanmar, Tokyo, Kenya and Faisalabad (Pakistan)" by Ms. Khine Su Wai and Ms. Hsu Myat Bo Bo who were new staff of YCDC. They compared each provisions of regulation dividing them into category by category (chapter by chapter).

After that, they discussed on the table of contents but failed to identify missing contents or additional contents to the existing YCDC Regulation. Yet, they reached a tentative conclusion that the regulation should be chaptered into following five items:

(1) General
(2) Water Supply
(3) Service Installation
(4) Water Tariff
(5) Prohibitions and Penalties

4) Training in Japan and seminar with Advisory Committee members in YCDC

i) Training in Japan

In the end of January 2018, the training course on "Overall utility management of waterworks in Japan" was conducted with the support of Bureau of Waterworks, Tokyo Metropolitan Government. Among nine participants of WRAWSA, following three persons represented "Regulation Team".

- U Pyi Soe (EE) (Reservoir Section)
- Daw Khin Than Oo (SAE) (House Connection Section)
- Daw Yamin (SAE) (Research Section)

Program relating to regulation were as follows.

26th January 2018 (Friday), 13:00-16:00

Topics	Lecturer	Affiliation/Position
Water administration and the relevant Laws and regulations (13:00-13:30 Presentation by the C/P)	Mr. Yoshiaki Asaka	Assistant Director, Water Supply Division, Ministry of Health, Labor and Welfare

29th January 2018 (Monday), 9:00-10:15 and 10:30-11:15

Water Supply Ordinance (Water Service Installation) (9:00-9:30 Presentation by the C/P)	Mr. Keisuke Takemoto	Assistant Director, Management Section, Construction Division, Bureau of Waterworks, TMG
	Mr. Makoto Aoki	Assistant Director for Service Installation, Water Supply Division, Bureau of Waterworks, TMG
Water Supply Ordinance (Tariff, Billing and Collection)	Mr. Kenichiro Sata	Assistant Director, Billing & Collection Section, Customer Service Division, Bureau of Waterworks, TMG

ii) Seminar with Advisory Committee members in YCDC

In late February 2018, Advisory Committee members for Output 1 of the Project visited YCDC and participated in seminar/ workshop. Regarding regulation, Mr. Naoki Hamanaka, Waterworks Bureau of TMG was responsible and participated in the Seminar on "Water supply ordinance/regulation" on 21st February 2018, at 13:00-16:00 at meeting room No. 3.

Items of agenda of the seminar are as follows:

1. Presentation on "RSGM in YCDC" by Ms. Yamin (WRAWSA)
2. Presentation on "Tokyo's Water Supply Ordinance" by Mr. Naoki Hamanaka"
3. Question and Answer

Photo 2-9: On 21st February 2018 WG and Mr. Naoki Hamanaka discussed Water Supply Regulation at WRAWSA's meeting room No.3

In the seminar, it was expected that some issues regarding missing provisions on the YCDC Regulation comparing it to Tokyo's Ordinance would be discussed between the C/P and Advisory Committee member. However, Q&A session was lengthy which did not allow time to move to the topic of missing provisions in YCDC Regulation.

5) Start of Sub-group activities

On 10th August 2018, the first Sub-group A & B meeting was held jointly. The Expert for NRW explained structure of Japan's ordinance of municipal water supply and had a brainstorming session to collect idea from members on water supply regulation.

On 31st August 2018, the second meeting was held jointly and the Expert for Management shared information regarding previous activities of WG such as result of research on overseas regulations and Japan's Water Supply Law and Tokyo's ordinance.

(4) Stepwise preparation of the draft of YCDC Water Supply Regulation

1) Preparing the outline of the 1st draft

On 5th September 2018, Sub-group B meeting was held. The Expert made a presentation on specific issues related to preparing the draft of regulation on water tariff billing and collection. Contents of it were extracted from the new YCDC Law, the existing Regulation, brainstorming results, and other documents. At the meeting, the outline of Regulation was also presented, and it was utilized and improved by WG members to prepare the 1st draft.

On 7th September 2018, Sub-group A meeting was held following the same process of the previous meeting of Sub-group B. The Expert made a presentation relating to the regulation of service installation which was made by extracting materials from the new YCDC Law, the existing Regulation, brochure of WRAWSA, web-site contents of YCDC, etc. The outline of draft regulation was submitted by the Expert to promote this activity.

2) The 1st draft prepared by WG members

By October 2018, group members of WG and Sub-group A & B had made the 1st draft following the outline prepared by the Expert. Translation of the outline from English into Burmese and the 1st draft in

Burmese to English was required and made by the assistant to the Expert.

Regarding laws or regulations, translation is not easy because of its technical terms and those meanings which differ among languages. The Expert made comments in English and the C/P discussed at the meeting in Myanmar and revised the draft in their language. It took rather much time for the first translation of the draft.

3) Comments on the 1st draft by the Expert

After translation of the 1st draft was accomplished, the Expert reviewed it and made overall comments which included proposal of reorganizing chapters, and some major issues but not detail of each article. A meeting was held on 12th December 2018 to explain his intention and he requested to proceed to make the 2nd draft with reference to his comments. The Expert of NRW also gave comments on it in January 2019.

4) Drafting 2nd version

After comments of the Expert, the member started drafting the 2nd version. However, the comments were not clearly understood by the members and again a meeting of WG3 and Sub-group A & B was held on 5th March 2019 where the Expert explained again comments of the 1st draft and made review for the preparation of the 2nd version.

5) The 3rd Draft to the 4th Draft

In April 2019, WG members completed the 2nd draft. The Expert made comments on it and explained at the workshop held on 7th June 2019. Then, the 3rd draft was completed after considering the Expert's comments at the end of August 2019. And again, the Expert's comments for the 3rd draft were given. Before October 2019, the 4th draft was made considering those comments.

6) Workshop with Advisory Committee members

To discuss about the 4th draft and disseminate it, a seminar/workshop with Advisory Committee member of Fukuoka City was held on 23rd October 2019. This seminar/workshop focused on the water supply regulation and its schedule and agenda is shown below. Through this event, the contents of the draft were profoundly understood and WRAWSA members shared proceedings of this activities.

Table 2-31: Workshop program: Towards the finalization of Water Supply Regulation

<table>
<tr><th>Session</th><th>Agenda</th><th>Name</th></tr>
<tr><td colspan="2">Introduction of Water Supply Regulation</td><td>ACE Thin Thin Soe</td></tr>
<tr><td rowspan="3">Session A
Service connection and water meter</td><td>• Presentation by AC member</td><td>Mr. Kenzo Watanabe</td></tr>
<tr><td>• Presentation by WRAWSA</td><td>EE Mar Mar Aye</td></tr>
<tr><td>• Discussion and Opinion Exchange</td><td></td></tr>
<tr><td rowspan="3">Session B
Tariff billing and collection</td><td>• Presentation by AC member</td><td>Mr. Kenzo Watanabe</td></tr>
<tr><td>• Presentation by WRAWSA</td><td>EE Aye Aye Mar</td></tr>
<tr><td>• Discussion and Opinion Exchange</td><td></td></tr>
<tr><td rowspan="2">Session C
Other issues in Regulation</td><td>• Presentation by WRAWSA</td><td>EE Yu Yu Hla Baw</td></tr>
<tr><td>• Discussion and Opinion Exchange</td><td></td></tr>
<tr><td colspan="2">Summarization of Discussion Results and Preparation of Report</td><td>Each C/P group</td></tr>
<tr><td colspan="2">Wrap-up meeting and Further Discussion</td><td>C/P group and the Expert</td></tr>
</table>

7) Review by the Legal Advisor of WRAWSA and check by management staff of WRAWSA as trial run

The legal adviser for WRAWSA had reviewed the draft since December 2019 and the management members of WRAWSA checked it as if it was enacted. It was thought to be finalized after final revision of draft by WG with the comments from the management members.

8) Activity during extended project term after outbreak of COVID-19

The Expert could not visit Yangon after March 2020, and the C/P had suffered limited working hours such as working in shifts to prevent infection of COVID 19. Accordingly, the activity was relied on web-meeting between the Expert and the C/P. Several sub-meetings had been implemented with the C/P since August 2020 through which some revision points were discussed, and reference materials had been tried to be compiled putting together related laws, regulations, policies, or SOPs into each article of the Regulation. The intention of preparation of reference materials was to promote profound understanding on the Regulation of the C/P. However, due to political instability which started in February 2021, this activity was stopped. Consequently, the final draft was not confirmed by the CE or S/C3 in the Project, and the preparation of reference materials did not progress sufficiently.

(5) Outline of the Water Supply Regulation (Draft) and its characteristics

The outline of the draft regulation is shown below.

1) Outline of the Draft of Water Supply Regulation

Chapter 1 Terms and Definition

Chapter 2 Water Resources --- YCDC's right on management of reservoirs and surrounding area, authority of coordinating rainwater and ground water, and others.

Chapter 3 Water Supply Works --- YCDC's right on management of water supply works such as laying water pipe, its responsibility to manage the work conforming to water quality standards and facility standards, ant others.

Chapter 4 House Connection --- application and approval of house connection, standard of design and material, owner's responsibility, and others.

Chapter 5 Water Meter --- ownership of meter, installation standard of meter, customer's responsibility, and others.

Chapter 6 Water Tariff and Billing --- YCDC's right to collect tariff, customer & owner's responsibility, non-payment & disconnection, and others.

Chapter 7 Prohibition --- illegal connection, damages for meter and water facilities, and others.

Chapter 8 General --- delegate tasks to relevant department or others

2) Characteristics of the Regulation

Its characteristics are figured out below after looking back on the project activities.

a. Some basic requirements of Japan's Water Supply Law were incorporated into the Regulation; for example, it stipulates that operations be carried out in accordance with facility standards as well as water quality standards. The obligation to supply water at all times and the obligation to respond to water supply applications, which are stipulated in the Water Supply Law of Japan, are considered premature and have not been adopted.
b. With reference to the water supply ordinance established by Japanese water supply utilities, relationships with water supply customers that have not been clearly defined so far were established. For example, it clarifies the relationship with water supply customers regarding application of house connection and installation of service pipes and clarifies the relationship with water supply customers regarding tariff rates and their collection.
c. An article of water resource management was also included in the Regulation with confirming to the new YCDC Law 2018. Japan's Water Supply Law and ordinances does not provide for articles related to the conservation of water resources, but the article for water resource management were included in the Regulation because water resources management were indicated by the organization name of Water Resource and Water Supply Authority created under the new YCDC law.

(6) Looking back the main point of activities

In Myanmar, water supply has not been managed nor operated based on national water supply laws, which is much different from Japan or other country's system. The Expert could not find any law system in Myanmar which could provide a good example for YCDC. Therefore, Japan's water supply regulations and laws were used as a reference, and it was devised to incorporate the contents of Japan's water supply regulations and laws into the YCDC's regulations system.

The most important notion in the activity was to make clear the relation between the utility and the customer on water tariff billing/collection and house connection/water supply equipment and to stipulate them in the draft Water Supply Regulation. The Expert realized that this notion was clearly understood by the C/P from the contents of the completed draft Water Supply Regulation.

Reference: Amendment of the YCDC Law and new 2018 YCDC Law was enacted
The new YCDC Law was enacted on 28 June 2018.
According to local newspapers, Ms. Aung San Suu Kyi, directed to revise the YCDC Law after she visited.

It included a drastic organizational restructuring; however, its articles regarding water supply work did not change mostly. Basically, new YCDC Law defined obligations of 7 Authorities and 3 Departments and gave them authority to implement their work. Principally the characteristics of the YCDC Law did not change from the former one.

According to the new YCDC Law, the existing Engineering Department (Water Supply and Sanitation) was separated, and water supply function formed "Water Resource and Water Supply Authority" and sanitation function formed "Drainage and Wastewater Management Authority". Authority was expected to manage more autonomously which might provide positive influence on YCDC.

YCDC Regulations was enacted under former YCDC Law. It was said such regulations had been reviewed under new 2018 YCDC Law by each Authority and Department. The Draft of YCDC Water Supply Regulation was expected to be enacted soon in line with this trend.

1-5-4 Draft necessary regulations, standards and guidelines, which can be prepared by YCDC (e.g. design, construction and material standards for distribution pipes, service pipes and meters, tariff collection manuals, guidelines of tariff setting)

(1) Prepared regulation, standards and guidelines in the project
The following regulation, standards and guidelines are finally prepared through the project activities.

No	Title	Annex
1	Manual for Monitoring Performance Indicators (PIs)	1
2	Water Supply Regulation (draft)	2.A
3	Water Tariff Setting Guidebook	2.B
4	Fixed Asset Management and Accounting	2.C
5	Customer Management Manual (draft)	2.D
6	Guidelines and Manuals for Non-Revenue Water (NRW) Management	5.B
7	SOP for Pipeline Drawing Management	4.
8	Operation Manuals for Customer Data Management System	Burmese language only
9	SOP for NRW Management	5.A
10	SOP for Water Quality Test and Monitoring	6.A
11	SOP for Operation and Maintenance of WTP and Disinfection Facilities	6.B
12	SOPs for All Sections (English and Burmese)	2.E (list only)

The activities on the prepared regulation, standards and guideline are also described in each relevant section of the project output. With regard to No.12 in the table above, the activity outline SOPs for All Sections is mentioned in the following section.

(2) Development of SOPs
1) Launching preparation of Standard Operation Procedures (SOPs)
Reservoir Division initiated and launched the preparation of SOPs prior to other sections. By appreciating its achievement, Steering Committee No.3 (S/C3) decided on 12th March 2019 that all sections should prepare SOPs. Afterwards, SOP meeting was held on 29th March 2019. The outline of the meeting is shown as follows.

Date:	29th March 2019
Purpose:	• Kick-off meeting to implement the preparation of SOP in all sections based on the advanced preparation of SOPs in Reservoir Division. • Enhancement and finalization of SOPs preparation in all sections
Participants:	Approximately 70 consisting of CE, DYCE and mainly head of the sections
Contents:	1) To explain purpose, structure, format, and notable points for preparation of SOPs. Mr. Zaw Win Aung, head of Water Treatment Section explained the preparation methods based on the SOP documents prepared by the Section. 2) To present the draft of SOPs by Yegu Pumping Station, HRD section, Thingangyun T/S Office and to make comments on questions and discuss improvement. 3) To emphasize the necessity of SOP, points to be noted, and demarcation of the succeeding works by the CE.

CE provided instructions on the preparation of SOP in all sections

Thingangyun T/S officer presented the first draft

Photo 2-10: SOP Meetings

2) SOP meeting held

After the kick-off meeting, the WRAWSA side mainly took an initiative and organized the SOP meetings continuously. The officer in Yegu P/S, who prepared the SOP in advance, played a moderator, and the meetings enhanced the preparation of SOP in 33 sections. Each section developed the draft, made a presentation in SOP meetings, and modified the contents according to comments and advice from the top management such as ACE, EE and the participants. In addition, the Expert provided advice in the meeting and/or in individual occasion and supported the preparation. The SOP meetings were held between April and November 2019 mostly every week unless other meetings were overlapped. These landmark activities were rooted due to the increased counterpart ownership. The schedule and the participants of SOP meetings until 9th December 2019 is shown below.

Table 2-32: Schedule and participants of SOP meetings

No.	Date	Participants Number
1.	29/3 /2019	68
2.	5/4/2019	52
3.	10/5/2019	75
4.	24/5/2019	66
5.	31/5/2019	50
6.	7/6/2019	30
7.	14/6/2019	45
8.	21/6/2019	41
9.	28/6/2019	48
10.	5/7/2019	49
11.	12/7/2019	39
12.	26/7/2019	46
13.	2/8/2019	40

No.	Date	Participants Number
14.	9/8/2019	51
15.	16/8/2019	46
16.	23/8/2019	47
17.	23/8/2019	47
18.	30/8/2019	45
19.	6/9/2019	37
20.	13/9/2019	64
21.	20/9/2019	34
22.	27/9/2019	27
23.	4/10/2019	35
24.	18/10/2019	33
25.	1/11/2019	27
26.	15/11/2019	28

3) Preparation status of SOPs

As of 20th November 2019, the preparation status was: 1) 14 Applied, 2) 6 Completed, waiting the approval from the CE, 3) 11 Finished, 4) 1 Drafted, 5) 1 Under preparation. The status of progress is shown in the table below.

Table 2-33: Progress of SOP preparation by section (As of the end of March 2020)

Sr.No	Facility Name/Section	Preparation Status	Remarks
1	Yegu	Applied	
2	Yegu P/S -1	Applied	
3	Yegu P/S -2	Applied	
4	Electro Chlorination Plant	Applied	
5	SCADA System	Applied	
6	Hlawgar Reservoir	Completed	MS
7	Hlawgar PumpingStation	Completed	MS
8	HRD Section	Applied	
9	Computer Section	Applied	
10	Water Quality Section	Applied	
11	Mini Labs	Applied	
12	Pipe Sections	Applied	
13	Gyophyu Reservoir	Finished	
14	Phugyi Reservoir	Finished	
15	Nyaungnapin WTP	Finished	
16	Lagunpyin WTP	Drafted	
17	AungTagon Water Supply	Finished	
18	GIS Section	Finished	
19	Major Maintenance Section	Completed	MS
20	Customer Service Section	Completed	MS
21	M & E section (AID)	Completed	MS
22	Other Reservoirs	Applied	
23	Finance Section	Finished	
24	Design Section	Finished	
25	NRW Section	Finished	
26	Main Store	Finished	
27	Planning Section(PI)	Finished	
28	Planning Section(Mid-term Plan)	Under preparation	
29	Estimate & Drawing section	Applied	
30	Admin Section	Finished	
31	District Offices	Applied	
32	House Connection	Completed	MS
33	PR Section	Applied	

[Note]

MS (Minutes Sheet): under application to the CE, Finished: Finished drafting in the responsible section, but need checking, Completed: draft is finalized and waiting for the CE's approval, Applied: Approval is done and under application in the relevant section

These SOPs are mainly utilized as manuals. The preparation of necessary RSGM for YCDC was launched since Term 2. The RSGM except for Water Supply Regulation were primarily prepared by the activities in each relevant output.

1-6 Enhance Understanding on Financial Management

1-6-1 Analyze the present Financial Management system

(1) Survey the present financial management system in water supply sector

WRAWSA does not have independent and autonomous power to manage its organization, which is much different from Japan or other countries. Its accounting (budget) is a part of the general account (budget) of YCDC whose system is government accounting but not corporate accounting. In this regard, some weak points are listed below comparing with ideal management of water supply organization. To overcome these issues and improve water supply system in the aspect of financial management, the Project picked up the activity of analysis of the present financial management system.

- It is difficult to calculate the cost of water supply. Accordingly, it is not easy to fix water tariff rate to get full cost recovery principle or sustainable cost recovery principle. In Myanmar, democratic society and market economy have been penetrating rapidly and rights of citizen has been awakened, too. Citizens may request reasonable tariff setting based on the principle, sooner or later.
- It is difficult to enhance staff members for efforts to reduce costs because of lack of cost-consciousness.
- It is difficult to enhance staff members' efforts to improve customer service because of lack of consciousness that customer's tariff is the financial basis of WRAWSA.
- It is difficult to provide motivation to staff members because they cannot know financial position of WRAWSA.

It is not an easy task to understand such financial management system in a country clearly, in which law and regulation, historical change, political position, practical power balance, etc. have been mixed up. In Myanmar, particularly, the socialist government and military regime had reigned long time and democratic government started not long ago. Then, still many English colonial laws and regulations have been effective. Transparent government system has not been materialized because most public service officers were used to keeping their information undisclosed, and they hesitate to share information among themselves and with the public. Therefore, information gained through the Project was not sufficient for the Expert to grasp the present system. A couple of NGOs and international organizations have been trying to organize systematic information collection program regarding local government system of Myanmar such as annual budget of each state/region which has been expected to be provided to the public.

(2) Financial management system of water supply in YCDC

Management system of water supply depends on the local government institutional and governance system when it is owned and operated by municipal entity like Yangon city. In Yangon city, municipal activities including water supply works are done by YCDC and it is essential to understand YCDC system in a broader perspective to find the way how to improve water supply management system.

In this respect, clear and comprehensive report/information about local government system were searched over the internet websites and in meetings with the C/P. However, the C/P did not have enough information on financial matter and could not clearly explain the process in YRG or Union Government's system. They seemed to have limited information on such matters. Then, especially regarding information on Union government's system, the data or facts on website was helpful.

According to the information the Expert learned, YCDC's financial system (accounting and budget system) is under Yangon Region Government system which was under the Union Government. It seemed important decisions are made by the Union Government even if there is not any legal basis. In any cases, to introduce autonomous water supply system in YCDC, these institutional and governance background shall be considered. The following list shows reference materials about the local government system available websites.

(*1) "(Local Governance Mapping) The state of local governance: Trends in Yangon", UNDP Myanmar, 2015

(*2) "(Local Governance Mapping) The state of local governance: Trends in Myanmar –A Synthesis of people's perspectives across all States and Regions", UNDP Myanmar, 2015

(*3) "(Local Governance Mapping) Mapping the state of local governance in Myanmar: Background and methodology", UNDP Myanmar, 2015

(*4) "State and Region Public Finance in Myanmar", Giles Dickenson-Jones, S Kanay De and Andrea Smurra, Myanmar Development Resource Institute's Center for Economic and Social Development (MDRI-CESD), International Growth Centre (IGC) and The Asia Foundation, Sep 2015

(*5) "State and Region Financing, Planning and Budgeting in Myanmar – What are the procedures and what are the outcomes? －", Roger Shotton, Zin Wint Yee and Khin Pwint Oo, Renaissance Institute and The Asia Foundation, Dec 2016

(*6) "Local government system in Myanmar" in Japanese, CLAIR: Council of Local Authorities for International Relation, Japan, Oct 2014

(*7) "Local government system in ASEAN " in Japanese, CLAIR: Council of Local Authorities for International Relation, Japan, Feb 2004

(3) Financial Section's organization structure and its job description

According to the official documents of WRAWSA Financial Section's responsibilities are following. It is equivalent to 1. Accounting sub-section, 2. Expenditure sub-section, 3. Income sub-section and 4. Budget sub-section that are familiar in water utility of Japan

1. To keep account tables
2. To analyze and check the expenditure account and disburse money
3. To receive the money in accordance with the Financial Regulations to implement the estimate budget and transfer the received money into the bank.
4. To analyze income situation within a financial year and make estimation and calculation in advance to manage the revenue and the sector in which it will be invested.

Financial Section of WRAWSA is regarded as "Division" and has three sub-sections in reality.

- Expenditure (Budget) sub-Section	12 staff
- Water Tariff sub-Section	25 staff
* Metered customer's tariff revenue	7 staff
* Flat rate customer's tariff revenue	5 staff
* Government's customer's tariff revenue	6 staff
* Foreign customer's tariff revenue	7 staff
- Income sub-Section	7 staff
- Total	45 staff members

Total number of staff members in Financial Section is 45 including division head. More than a half of the members are working for Water Tariff sub-Section and staff members who are working for financial management is rather small in number.

(4) Organizational issues relating to Financial Section

The former name of water supply department in YCDC was "EDWS: Engineering Department (Water and Sanitation)", which is an engineering department but not an independent management entity. Its head was called as CE (Chief Engineer)", deputy head as DYCE (Deputy Chief Engineer), and division head as ACE (Assistant Chief Engineer). All executives of the department were engineer, and financial section, whose staff are not engineer, may feel difficult to control budget/expenditure because of power balance.

As for the tendency of counterpart's ability, there was a lack of practical knowledge such as tariff setting and corporate financial management because it is not an independent and corporate accounting body. In addition, as mentioned above, since a large number of personnel are assigned to management work of water charge collection, the allocation of personnel to financial management of water supply business is insufficient. They needed more knowledge or actual experience of utility financial management.

For example, the C/P was not familiar with "capital threshold" which relates to fixed assets accounting. However, according to the reference document (*5) of the previous page, it is said that capital threshold is set on 1 million Kyat and they may have learned it. Unfortunately, they could connect that to asset accounting.

As mentioned above, half of the total staff members are working for Water Tariff sub-Section and the number of staff members who are working for financial management is rather small. Any important financial decision of WRAWASA have not been made by WRAWSA but by top management of YCDC. Now the financial situation of water supply sector in YCDC has been getting more complicated, to which Financial Section should respond by enhancing its function. Water tariff confirmation work shall be transferred to newly established Customer Service Division, which was established under the initiative of the Project and is described on "1-3 Establishment of Customer Service Division".

(5) Financial situation of water supply of YCDC

Information about finance is essential to judge the situation of management of water supply. WRAWSA organized such information according to the progress of the Project together with PI arrangement. Also sharing this information among WRAWSA management members was enhanced and the finance C/P were pushed to make presentation at a regular meeting of the Project. Financial information was also indispensable for international/foreign aid organization and that of WRAWSA was requested often. The organized information has been useful for such cases; however, it has not been publicized for the citizen yet.

After the financial year of 2011-2012, the following financial statement data was arranged to show the situation of water supply sector in YCDC. In the year of 2011, the new government started under the general election implemented according to the new constitution of Myanmar 2008 and local government system started under State/Region system. The data is available after 2011/2012.

According to the graph relating Opex shown below, the revenue was almost able to cover Opex in 2011 and 2012. However, the cost of electricity has increased, and the deficit of revenue is by 30-40% to cover Opex. Costs of Salary, Maintenance, or Goods & Services have been almost stable, but Electricity cost has increased year by year in the portion of Opex. Electricity rate was raised on the 1st of July 2018, which put the heavy burden on WRAWSA financial situation in 2019-2020 and afterwards.

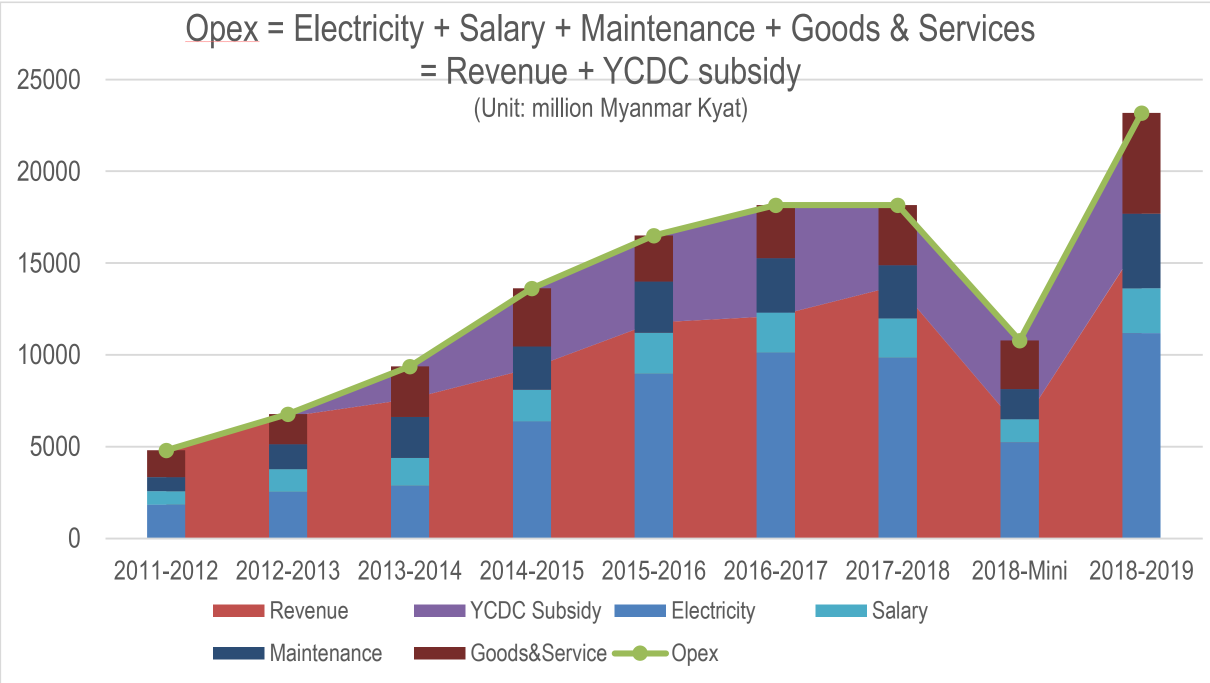


Figure 2-15: Current expenditure/income balance

Regarding the balance of income and total expenditure, that is total of Opex and Capex, the deficit was covered by YCDC subsidy which has been 3-5 times of the revenue. The government accounting system does not have a concept of depreciation and adopts cash-basis accounting. Therefore, to cover the full cost including depreciation cost, tariff should be raised 3-5 times.

At the expanding stage of a city like the current Yangon, huge capital costs are needed to expand its facilities and hard work is required to obtain financial resources in the water supply business. In YCDC, construction works of Lagunbyin WTP or Kokkowa WTP have been financed by JICA loan, whose repayment from 2025 will cause a big burden to WRAWSA financial situation.

YCDC subsidy is not acknowledged as subsidy by YCDC officials because WRAWSA account is included in the YCDC general account and is not an independent/separate account, even though it covers costs of water supply. The amount of YCDC subsidy has fluctuated year by year considerably, that means other departments' understanding and cooperation is necessary to transfer enough subsidy from other departments' revenue to WRAWSA, and to implement planned investment systematically. WRAWSA started reviewing the current water tariff system considering the on-going big projects which cost a lot. For sustainable water utility management, YCDC should think about long-term strategy on tariff policy and subsidy system.

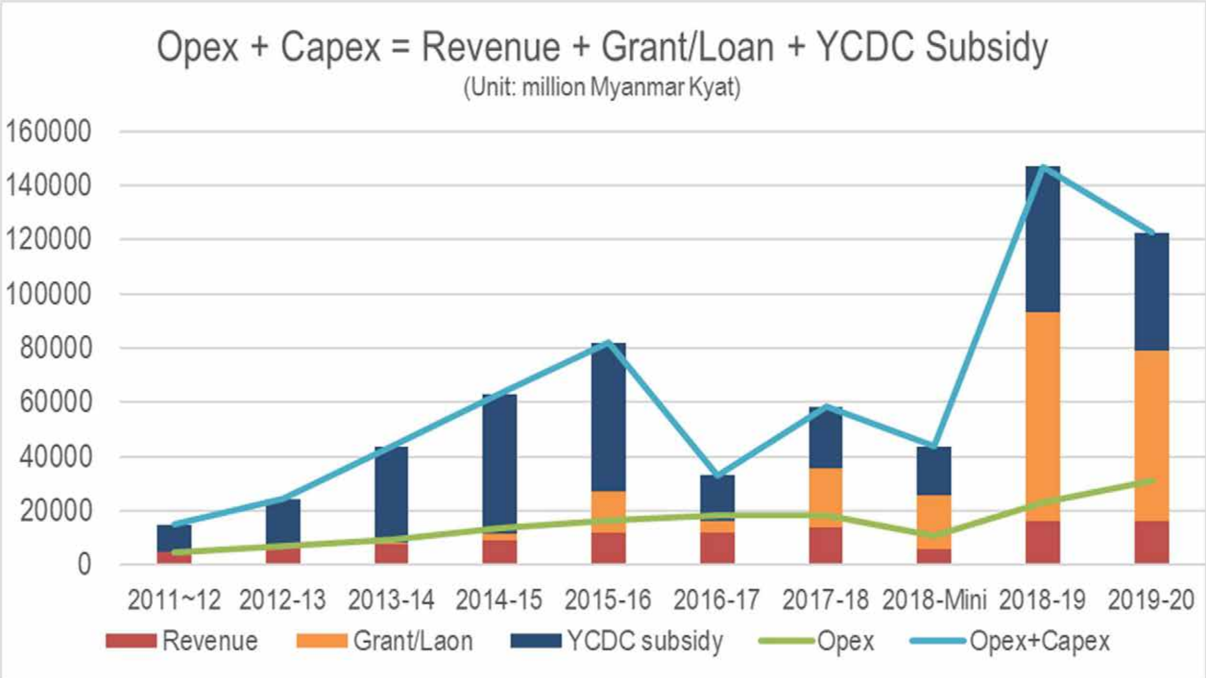


Figure 2-16: Financial balance

Table 2-34: Current income

(Unit: thousand Myanmar Kyat))

Account Items	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018 (Apr-Sep)	2018-2019	2019-2020
	Result	Result	Result	Result	Result	Result	Result	Result (6 month)	Result	Result
Current Revenue										
02 Water Charges										
01 Departmental Water Charges	1,081.913	1,073.245	1,110.961	1,608.373	1,696.523	1,619.549	1,676.536	806.461	1,686,403	1,720,567
02 Public Water Charges	3,300.490	5,272.007	5,973.024	6,906.423	8,496.946	9,288.345	10,425.070	4,579.873	12,682,056	12,127,194
03 Water Connection	185.760	144.605	217.758	296.317	535.506	415.684	455.818	236.249	763,179	864.060
03 Rental										
02 Sales of Water Meters	16.188	53.944	129.999							
03 Rental of Shops and Sites	44.321	29.877	80.165	65.075	68.065	64.491	76.126	37.167	77,209	134,261
04 Licenses										
01 Plumber Licenses Fees	1.344	1.684	1.277	1.396	1.257	1.216	1.096			
05 Miscellaneous										
02 Road Crossing Charges (Ngamoyeik Tall Gate)		21	51	16	153	123	68			
99- Other Revenue	79.103	64.868	85.379	130.192	222.477	166.088	108.221	63.775	79,461	399,275
Minus-50 Restore revenues????										
Sale of old Equipment										
Total	4,709.119	6,640.251	7,598.614	9,007.792	11,020.927	11,555.496	12,742.935	5,723.525	15,288,308	15,245,267
Capital Income										
Sale of Water Meter (capital Income)				280.002	731.830	548.847	1029.856	266.081	973,483	740,755
Sale of old Equipment									23,450	
Grand Total	4,709,119	6,640.251	7,598.614	9,287.794	11,752.757	12,104.343	13,772.791	5,989.606	16,285,241	15,986,022

Table 2-35: Current expenditure

Account Items	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018 (Apr-Sep)	2018-2019	2019-2020
	Result	Result	Result	Result	Result	Result	Result	Result (6 month)	Result	Result
3(700)Engineering Department (Water and Sanitation)										
01 Salary and Allowance	740.806	1,251.612	1,512.472	1,729.182	2,232.784	2,186.036	2,146.349	1,245.591	2,436,421	2,017,903
01 Salary	740.806	805.683	1,079.335	1,313.608	2,232.604	2,186.036	2,146.349	1,245.591	2,436,421	2,017,903
02 Allowance Salary		445.929	433.137	415.574	180					
02 Travel Expenses						32	32	60	311	88
01 Domestic Travel						32	32	60	311	88
03 Good, Service and Labor Social Costs	3,311.283	4,175.329	5,630.554	9,552.040	11,474.070	13,006.122	13,111.495	7,878.014	16,684,830	24,330,700
01 Labor Charges	393.202	699.968	951.328	1,055.149	1,191.500	1,406.689	1,448.377	940.436	2,002,263	1,920,495
02 Tax							1.031	432	60,578	9,288
03 Hiring Fee and Production Cost	500	500	500			6.000			27,911	33,221
04 Transportation/Shipping	5.487	27.424	26.651	27.944	30.149	10.750	15.991	20.938	18,115	20,731

Account Items	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018 (Apr-Sep)	2018-2019	2019-2020
	Result	Result	Result	Result	Result	Result	Result	Result (6 month)	Result	Result
05 Office Facilities	2.000	3.000	3.500	8.098	5.099	15.000	22.000	10.000	24,000	44,353
06 Petrol & Lubricant	119.709	114.605	120.863	72.392	45.402	33.352	49.948	18.862	116,128	95,550
07 Telephone, Telegram and Postage Stamp	2.357	2.656	2.246	1.428	0.715	1.128	0.771	0.200	3,363	7,260
08 Electricity Charges	1,832.309	2,528.121	2,864.923	6,374.300	8,964.176	10,111.090	9,838.343	5,238.663	11,187,781	18,227,168
09 Books, Journal & Newspaper	50	50	50	50			30	43	100	100
12 Uniform	1.000	1.000	1.000					400	820	
13 Operating Material	900.699	746.733	1,603.493	1,942.713	1,192.407	1,380.983	1,688.340	1,621.167	3,191,404	3,914,064
20 Printing & Publishing	53.970	51.272	56.000	69.966	44.622	38.327	46.228	26.453	49,993	58,000
21 Advertising Cost						2.803	436	420	2,374	470
04 Maintenance Costs	758.049	1,350.027	2,234.205	2,342.592	(2,789.176) 2,567,379 221,797	(2,961.187) 2,667,435 293,752	(2,885.816) 2,730,783 155,033	(1,644.198) 1,452,115 192,083	(4,051,439) 3,613,172 438,267	4,567,675
01 Machine Equipment	155.540	149.768	239.759	289.939	(142.889) 139,752 3,137	(149.549) 122,767 26,782	(237.231) 232,686 4,545	(137.906) 118,882 19,024	(300,859) 284,256 16,603	314,697
02 Building	33.890	229.140	339.933	339.701	(337.486) 322,652 14,834	(314.111) 314,111 -	(199.947) 195,773 4,174	(183.496) 159,393 24,103	(524,130) 491,025 33,105	395,793
03 Roads	4.830	15.976	58.940	59.998	(94.643) 94,643 -	(147.185) 135,289 11,896	(85.813) 84,312 1,501	(144.521) 141,826 2,695	(399,560) 399,560 -	382,184
04 Motor and Vehicle	18.669	34.579	19.919	18.078	19.277	19.447	24.639	25.000	48,999	49,402
05 Vessels	4.483	5.000	9.934	8.927	2.598	2.800	2.993	1.269	2,886	11,836
09 Others	540.637	915.564	1,565.720	1,625.949	(2,192.283) 1,988,457 203,826	(2,328.095) 2,073,021 255,074	(2,335.193) 2,190,380 144,813	(1,147.683) 1,001,422 146,261	(2,625,015) 2,236,456 388,559	3,282,273
10 Bridges								4.323	149,993	131,490
05 Education & Social Expenditure							6.297	3.000	7,000	1,967
06 Education/Training							6.297	3.000	7,000	1,967
06 Reception Cost	199						300	2.000	4,479	89,649
02 Cost of Reception	199						300	2.000	4,479	89,694
Loan Interest (JICA Loan)					22	543	830	1.370		7,215
Grand Total	4,810.337	6,776.968	9,377.231	13,623.814	16,496.052	18,153.920	18,151,119	10,774.233	23,184,480	31,007,982

Note: At three lines, first line, second and third lines indicate total in parentheses, water supply account, and sanitation account, respectively.

Table 2-36: Capital expenditure

Account Items	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018 (Apr-Sep)	2018-2019	2019-2020
	Result	Result	Result	Result	Result	Result	Result	Result (6 month)	Result	Result
Extention of Water Supply Pipes	132.143	98.132	189.892	2,243.162	5,145.622	1,276.842	3,625.675	549.950	3,799,823	825,034
Water Supply	8,617.087	16,272.985	32,153.366	38,859.761	56,054.609	11,862.727	32,139.145	30,628.555	106,973,654	83,648,325
Ngamoeyeik - Hlawga		14,724.410	13,299.149	11,570.567	31,765.697	3,986.657	2,764.357	4,030.044	7,678,038	7,740,774
Ngamoeyeik - Hlawga (YCDC)	7,511.578	14,724.410	12,664.795	9,185.459	19,226.554	2,814.332	2,764.357	4,030.044	7,678,038	7,740,774
Ngamoeyeik - Hlawga (ODA Grants)			634.354	2,385.108	12,539.143	1,172.325				
Water Supply from Nagamoeyeik - Chaung	195.000									
Lagunbyin Water Supply			12,833.692	22,328.192	15,913.266	6,580.207	26,403.501	22,115.544	82,810,011	57,793,126
Lagunbyin Water Supply (MaSo) (YCDC)			12,833.692	22,328.192	13,097.930	3,554.435	4,740.744	3,422.466	14,977,304	4,537,859
Lagunbyin Water Supply (MaSo) (ODA Loan)					2,815.336	3,025.773	21,662.757	18,693.078	67,832,707	53,255,267
Water Supply for new Township	143.063	201.949	3,350.015	930.431	282.418	203.696	202.434	1,177.540	2,532,915	4,937,017
Lakes and Tube Wells	491.423	1,096.721	2,555.875	3,527.219	5,230.509	821.277	2,629.333	1,915.734	2,167,926	1,143,958
Hlawga -Yangon (Aungtagon)	276.023	249.905	114.635	4.931	80.135					
Kokkowa River Water Supply				498.421	2,782.584	270.890	139.520	1,389.693	11,784,764	12,033,450
Kokkowa River Water Supply (YCDC)				498.421	2,782.584	270.890	139.520	538.848	2,532,690	2,112,590
Kokkowa River Water Supply (ODA)								850.845	9,252,073	9,920,860
Yangon Water Supply										
Sufficient Water Supplies	954.651	956.345	1,843.461	7,949.869	4,013.300	1,725.337	3,343.852	1,575.739	9,729,028	6,238,021
Sufficient Water Supply for Downtown	648.42	637.039	732.350	4,922.310	2,989.767	510.321	3,343.852	1,575.739	9,729,028	6,238,021
Water Service for Upgrading	18.57	19.310	784.121	3,027.559	1,023.533	1,215.015	-			
Production of Water Pipes (Pipe Plant)	287.661	299.996	326.990				-			
Construction of Water Staff???							713.304		1,869,450	764,310
Buildings						-	36,098	-	631,409	31,192
Office Equipment/Vehicle						1,223	-	1,474	11,000	22,000
Expansion/Alternative Investment						-	15,700	55,405	194,000	330,000
(Sewerage Waste Disposal)	351.663	199.918	166.695	240.960	208.318	55.014	388.861	267.591	622,459	-
(Wastewater Treatment Plant)	15.715	58.499	48.824	68.531	39.471			-	-	-
Grand Total	10,071.259	17,585.879	34,402.238	49,362.283	65,213,531 (65,461.320)	14,866,080 (14,921.094)	39,858,074 (40,246.935)	32,811,123 (33,078.714)	123,208,364 (123,830,823)	92,129,882 -

Note: At the bottom line of columns of 2015-2016 to 2018-2019, first and second lines indicate water supply account only and total of water supply and sanitation account in parentheses, respectively.

(6) Decision process of budget or water tariff rate in YCDC

Budget of WRAWSA is included in the general budget of YCDC. Decision process of YCDC is described in following diagram. After 2011, under new 2008 Constitution, YCDC's budget is a part of Yangon Region Government's budget, however, some WRAWSA officials said YCDC is almost financially independent from YRG. Also, after decentralization following establishment of state/region government, the Union Government's influence on Yangon Region Government's budget is described in the diagram but actual process of subsidy system by Union Government is complicated and is not clearly understood.

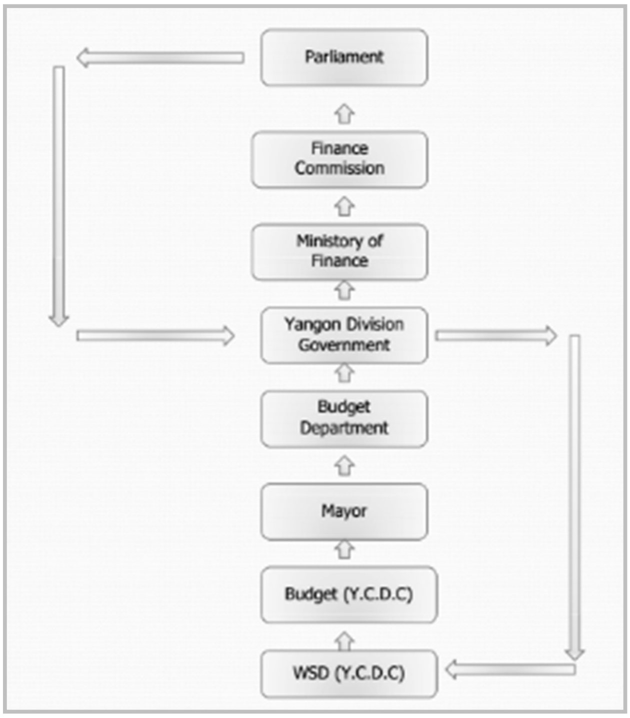


Figure 2-17: Budget process for YCDC

It is said that decision process of water tariff rate is the same as budget process, that is, YRG has the authority to decide, but the Union Government shall approve it. During the project, the basis for such authority was not confirmed in laws or regulations. After 2011, the government system had changed but it seemed the law system had not been yet properly arranged, and it was managed based on practical reason. Such system shall be clearly described in law or regulation.

In Myanmar, the government system is still in transition and reform of the system has been often implemented. According to the reference document (*5) of the previous item 1-6-1 (2), budget process between Union government and Region/State Government (R/SG) was improved in FY 2016/17, before which Union Government provided subsidies to compensate the deficit of Region/State budget plan. After that, Union Government provides subsidies according to some standards, but not the balance (deficit) of budget. Year by year, the financial relation between the Union and state/region has been reorganized and improved, and to grasp such information is not easy at the present Myanmar's publication circumstances.

(7) Changing the government's financial year

The Union Government decided to change the financial calendar at the cabinet meeting in September 2017. The existing financial calendar starting on 1st April changed to the new financial calendar starting on 1st October. The Union parliament approved it at the end of October 2017. The change of financial calendar was introduced with effect from FY 2018-2019 starting from 1st October 2018.

For transitional period to the new 2018-2019 financial year, six-month budget starting from 2018 April to September (called mini-budget period) was implemented. The schedule of government budget process, including YCDC, was drastically changed according to the change of financial year in Myanmar.

There were mainly two reasons for the amendment:

i) The start of the financial year would not be hindered by the new year holidays in April when most works pile up and are delayed
ii) The rainy season which starts in late May and continues for about 4 months prevents construction works. The new period of the budget year would help construction work to get eight consecutive months (October – May) as the new period starts after the rainy season.

They said the same financial year is adopted in other countries such as USA, Thailand, and Laos. In YCDC, WRAWSA submitted three kinds of six-month budget estimation: April-September 2018, October 2018- March 2019 and April-September 2019, to Yangon Regional Government to cope with the amendment of fiscal year.

(8) Corporate Accounting System in Myanmar

WRAWSA's budget and account is a part of the YCDC's general budget and account. That means Yangon's water supply is managed as "government accounting system" not as "corporate accounting system", and moreover, it is not managed as an independent account. However, in the Project, autonomous and self-sufficient system which requires corporate accounting system was adopted as future image of the utility management system. To adopt corporate account, the C/P should be familiar with the local corporate accounting standards. The C/P was able to collect text series of Myanmar Accounting Standard (MAS) which he showed them on 8th March 2018 which the Expert had recognized the existence of such standards since the start of the Project. The series were written in Myanmar language which would be useful for the C/P to promote understanding of corporate accounting system to make SOP of fixed asset management and accounting.

Photo 2-11: (Left) The series of "Myanmar Financial Report Standards for Small and Medium Enterprises". (Right) The series of Myanmar Accounting Standards.

Study visits to Yangon Electricity Supply Corporation (YESC), which was corporatized from state enterprise to corporation in April 2015 was very useful to get important information on fixed asset accounting. However, standards or guidelines for "public enterprise accounting system", which might have been in existence in Myanmar, could not be confirmed. After three visits to YESC, the C/P was convinced that it should be the first priority to learn the local accounting system, especially the system for state enterprises, when WRAWSA would introduce corporate accounting system.

(9) Water tariff raise in Mandalay city

In Mandalay, the second largest city in Myanmar, the water tariff rates were raised by Mandalay City Development Committee (MCDC) in April 2017. The C/P learnt that the rise ratio of water tariffs by MCDC was rather high and unit prices got higher than Yangon city.

In MCDC, the water supply works is operated by EDWS, similar as in YCDC, and tariff is collected by the Tax and Revenue Department. Accordingly, the Tax and Revenue Department is in charge of water tariff rate revision. They looked little concerned that water rate is designed considering management of water supply system. The structure of rate table is the same as previous one. In YCDC, water tariff of flat rate is collected by the Administration Department which is similar to that in MCDC.

MCDC explained this tariff raise would contribute to improve the financial situation by increasing revenue, although full costs were not covered, and they made efforts to shorten the cycle of works of meter reading, billing, and collecting.

Table 2-37: Transition of water tariff rate in Mandalay City

Category	Unit price (Kyat/m3)			Ratio	Price in YCDC
	2008 →	2015 →	2017	2017/2015	(2020)
Domestic	55	85	200	2.35	88
Commercial (Medium)	77	110	260	2.36	110
Commercial (Factory)		440	660	1.5	--
FE (Commercial)	490	880	1,100	1.25	880

(10) Budget of the Union Government and middle and long-term national plans
The Union Government of Myanmar decided to change the financial year from October 2018. Consequently, mid and long-term term national plans of Union Government were reviewed. The mid-term plan of 2016-2020 was revised as 3-year plan (2018-2019 to 2020-2021), and long-term plan has not been revised.

In Myanmar, the new government that was established in 2011, after the general election based on the new 2008 Constitution, prepared the 20 years National Comprehensive Development Plan for 2011-2030, which is segmented by 5 year in middle term plans such as 2011-2015, 2016-2020. The national plan aims to promote capital investment systematically. However, the detail of plan has not been publicized.

In WRAWSA, the first mid-term management plan was developed with support of the Project. The mid-term plan was set with the same term as the revised national mid-term plan. The relation of planning periods of government plans and the Water Supply Master Plan are shown below together with the developed mid-term plan.

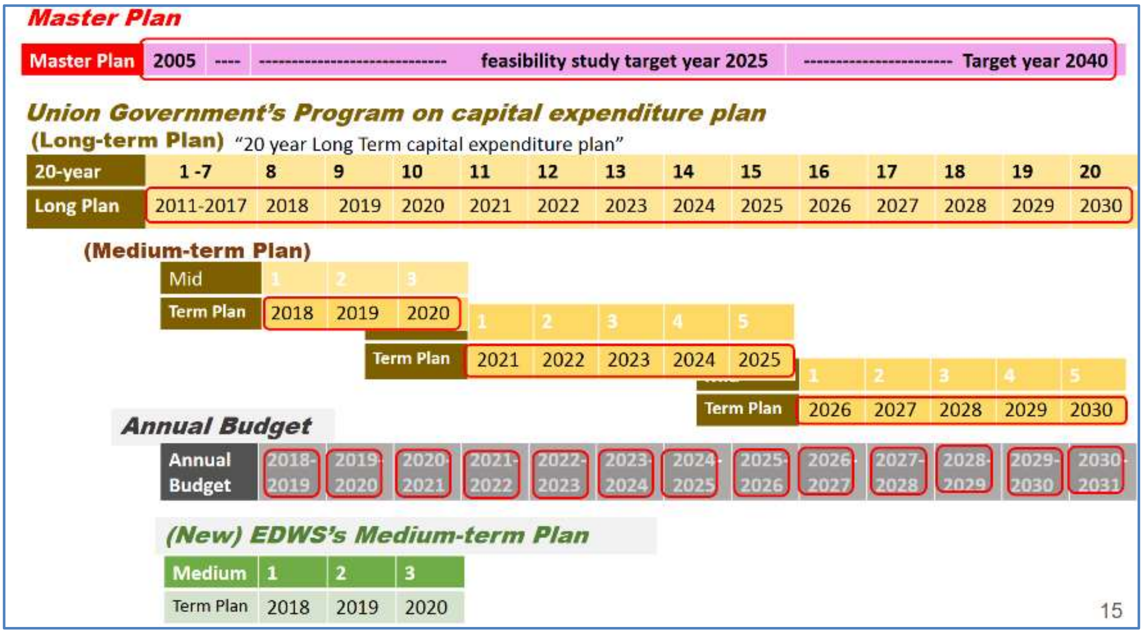


Figure 2-18: Relevant plans and its planning period

(11) Establishment of Authority by new YCDC Law (2018) and its impact to financial system
According to the new YCDC Law enacted on 28 June 2018, EDWS (current WRAWSA) was separated into two authorities: water supply and sanitation. "Water Resource and Water Supply Authority" which was organized for water supply and sanitation was moved to a different authority.

According to the new YCDC Law, the board of directors consists of 5 members. One was appointed from the 11 committee members as a chairperson, three were appointed from external experts, and a departmental head was appointed as the secretary. After election for new YCDC committee members, which was held on 31st March 2019, Mr. Sein Ohn, YCDC No. 9 committee member was appointed as the chairperson of WRAWSA and other three external experts were appointed as follows.

1. Daw Than Than Soe: ex-officer, Ministry of Construction (Civil Engineer)
2. U Soe Than: ex-officer, Ministry of Agriculture, Livestock and Irrigation (Civil Engineer)
3. Daw Aye Zin Soe: ex-Law adviser for YCDC (Lawyer)

The Project visioned WRAWSA as an independent and autonomous water supply entity in YCDC. However, after establishing Authority, no announcement was made on any change of budget, accounting, or financial system.

During drafting new YCDC Law, it was said the Authority might have the function of regulator, and water supply might be operated by a corporation which would be established under YCDC's 100% share (according to the presentation made by Ms. Hlaing Maw Oo, the Secretary of YCDC at JICA Yokohama Forum held in August 2018). Final version of YCDC Law did not have such contents, but executive members of YCDC still have the intention that Authority shall have the role of regulator in the future.

1-6-2 Implement training on financial management for the sustainable operation of water supply service in consideration of future development plans (e.g. general financial management, accounting, asset management, budget regulation, tariff setting, PPP, etc.)

(1) Training subject to establishing sustainable financial management of water supply

In YCDC water supply is managed as governmental "public works" style which is same as road/river management, not as an autonomous entity or as public utilities like in Japan or in most other countries.

The concept of financial management is effective in autonomous entity, especially in corporate style entity. Accordingly, training of financial management should be implemented towards the preparation of autonomous management and utility style management.

At the beginning of the Project, subjects of training were assumed as (i) Financial management, (ii) Asset accounting, (iii) Budget system, (iv) Corporate accounting, (v) Tariff setting, and (vi) PPP. However, the subjects were changed to (i) Financial management of water supply utility, (ii) Corporate accounting, (iii) Asset accounting, (iv) Tariff setting, and (v) PPP based on the reasons mentioned above.

Individual activities are explained below. They can be categorized as: seminar or workshop by the Expert at periodical meetings, team meetings with the C/P, third-country training, training in Japan, and seminar/workshop with JICA Advisory-committee members. In addition, the C/P made presentations and lectures at seminar/workshop and in-house training courses which were effective to review gained knowledge or information.

(2) The basis of financial management: to enhance understanding on water utility management

1) Seminar by the Expert

As mentioned in the previous paragraph, the first target was to enhance the understanding of autonomous and financially self-sufficient water utility whose costs should be recovered by water tariff revenues. In this regard, two series of presentation by the Expert at Weekly Meeting had been implemented and the concept of autonomous water utility was highlighted. Consequently, the importance of autonomous management was understood by YCDC at JCC meeting held in January 2016. The future vision of Financial team was described as "The waterworks is managed as an independent and financially self-sufficient utility."

Topics of two series of the Expert's presentation at Weekly Meeting are as follows.

(a) Sustainable management and organization in water supply 1st on 17th August 2015 "Why independent and self-sufficient" 2nd on 24th August 2015 "How independent and self-sufficient in other water utilities" 3rd on 31st August 2015 "How water supply in Yangon city be independent and self-sufficient"
(b) Seminar series on basics of water supply utilities 1st on 30th November 2015 "Characteristics of water supply utilities" 2nd 8th December 2015 "Regulation for water supply utilities" 3rd 14th December 2015 "Asset management and accounting for water supply utilities" 4th 21st December 2015 "Rate making of water tariff"

Another seminar was conducted to enhance the understanding of the big financial burden under the growing demand and development like in the present Yangon situation. Also, as capital expenditure and its financial resources are relating these issues closely, the Expert explained experience of Tokyo on how to cope with the situation.

(a) Tokyo's experience at the time of rapid economic growth
In Tokyo, the demand for water had increased enormously according to the rapid economic growth and concentration of population to the capital. The Tokyo Metropolitan Government had struggled to cope with it by constructing a lot of facilities and obtaining financial resources to cover it. Following seminar was conducted by the Expert, the theme of which would be useful to think about the near future of Yangon city's situation.
Theme: "How to cope with accumulated burden of capital expenditure -Experience in Tokyo and messages", on 31st May 2016.

(b) Mini seminar on capital accounting
Water utility is a typical capital-intensive industry, and capital accounting is crucial to judge financial condition. In YCDC, accounting is kept in government system, and accordingly consciousness of capital expenditures was not enough to compare with operating expenditure considering the sustainable management of autonomous and self-sufficient utility.

Photo 2-12: Mini seminars on capital accounting

Theme of each mini seminar:
1st: 2nd October 2017 "Capital expenditure on Budget plan and relation to P/L and B/S statements"
2nd: 3rd October 2017 "Capital expenditures and water tariff setting"
3rd: 13th October 2017 "Capital expenditures and financial plan"
4th: 19th October 2017 "Capital expenditures and profits and "cost of service""

2) Training in Japan
In the end of January 2018, the training course on "overall utility management of waterworks in Japan" was conducted with the support of Bureau of Waterworks, Tokyo Metropolitan Government. Among the nine participants of WRAWSA, following three persons represented "Finance Team".
- Daw May Oo Lwin (EE) (Finance Section)
- Daw Khin Khin Htwe (AE) (Finance Section)
- Daw May Thet Kyaw (Accountant 3) (Finance Section)

Topics relating to financial management are as follows. The topics requested to enhance understanding of utility management included autonomous and self-sufficient management, short/middle/long term planned management, and water tariff setting for the YCDC's future water raise. In this occasion, two counterparts made presentations to explain YCDC's situation that provided them a good opportunity to review and compile their knowledge learned through the Project.

25th January 2018 (Thursday), 13:30-14:45and 14:55-15:40

Topics	Lecturer	Affiliation/ Position
Financial autonomy (13:30～14:00 Presentation by the C/P)	Mr. Satoshi Takano	Assistant Director, Finance and Budget Section, General Affairs Division, Bureau of Waterworks, TMG
Waterworks and utility management (14:55～15:10 Presentation by the C/P)	Mr. Motoki Inomata	Deputy Director, Finance and Budget Section, General Affairs Division, Bureau of Waterworks, TMG

3) Seminar with Advisory Committee member in YCDC
On 23rd February 2018, at 10:00 – 12:00, a workshop was held with attendance of the C/P and Mr. Takayuki Takahashi, Advisory Committee members for Output 1 (Finance) from Tokyo Waterworks Bureau, at the meeting room No. 3 of WRAWSA.

The purpose of the workshop was to understand the role of Financial Section in water utility when WRAWSA would become an autonomous and self-sufficient utility as similar as Tokyo Waterworks Bureau. WRAWSA would be an authority according to the draft of new YCDC Law which would be financially independent from the general account. For this shift this workshop might be useful to change the mindset of staff towards independent utility.

Photo 2-13: Seminar with Advisory Committee member in YCDC

At the Workshop, the C/P made presentation on YCDC's situation and then Mr. Takahashi explained the role of financial section and its relating sections such as cashier section, tariff billing/collection section in Tokyo Waterworks Bureau. He stressed that the financial section should lead utility management by estimating annual budget, examining expenditure plan, developing financial plan, and creating water tariff rate setting, as well as to raise such mindset as cost-consciousness and balance of equity and efficiency in water utility.

4) Delivery of lecture by the C/P on in-house training courses

The C/P conducted practice sessions of trainers on financial subject that they had learned through the Project activities. Those in-house training courses were conducted not only for new staff but also for T/S officers and Deputy T/S officers. The accumulated number of attendees increased gradually, and they might have understood the basics of financial management in water utility.

(3) Enhance understanding on corporate accounting

1) The present financial accounting system of WRAWSA and corporate accounting in Myanmar

In WRAWSA, water supply account is managed as government style and included in YCDC's general accounting system, which is not an independent accounting system. Even though it is a governmental system, operating income/expenditure and capital income/expenditure are separated like corporate accounting. That is an advantage for understanding of corporate accounting.

Regarding corporate accounting, general knowledge of it was shared with the C/P and they did not necessarily learn its basics. The target of the Project was to make quasi-P/L and B/S for water supply utility and to provide public enterprise grounding as basic understanding.

These days in Japan, there are a lot of such cases as shifting from government account to corporate account in sewerage works. In such cases the biggest issues are to establish asset accounting and calculate depreciation costs which government accounts do not have. This process takes a lot of time and needs complicated works to acquire accurate figures of each facility. Because of such complicated works, usually a consultant firm is hired while introducing corporate accounting.

According to the C/P, IFRS (International Financial Reporting Standards) was adopted as Myanmar's corporate accounting standards, but difference in standards between private company and "state enterprise" was not acknowledged among the C/P and public officers.

To find the appropriate accounting style for YCDC water supply entity, it was useful to learn accounting system of Japan's local public enterprise, MWA in Bangkok and PPWSA in Phnom Penh. Also, the study visit to Yangon Electricity Supply Corporation (YESC) was conducted to learn its accounting system as corporatized state enterprise. Study visits to YESC were very fruitful for getting its P/L, B/S and asset accounting information. Following YESC style, WRAWSA made format of P/L, B/S, although figures were not filled (blank).

To introduce corporate accounting system for water supply of YCDC, accounting process, accounting ledger/slips should be independent from general account, which means WRAWSA should have independent accounting, which is impossible to establish soon under the present situation. Consequently, the Project targeted to enhance understanding of management such as financial accounting of autonomous water utility.

2) Seminar/training to enhance understanding on corporate accounting

In order to enhance understanding of corporate accounting, several presentations were implemented as following, some of which also overlaps with that of previous section.

a. Expert's seminar
- ✓ 3rd seminar of "Basics of water supply utilities" on 14th December 2015 which is titled" Asset management and accounting for water supply utilities"

b. Seminar with Advisory Committee members
- ✓ 1st MJJS (MJJS: Myanmar Japan Joint Seminar) (Jan 2016)
  Advisory Committee member, Mr. Naganuma made a presentation on "Public enterprise accounting of water utility in Tokyo"
- ✓ 2nd MJJS (Jan 2017)
  - Again, Mr. Naganuma made a presentation on "Plans and rules for financial management"
- ✓ The counterpart's (Daw Moe Khaing) made a presentation on "The waterworks is managed as an independent and financially self-sufficient utility."

c. Third country training
- ✓ MWA, Bangkok (Thailand)
- ✓ PPWSA, Phnom Penh (Cambodia)

d. Study visit to YESC

e. C/P's lectures on in-house training courses such as the new staff training and the T/S officer training

(4) Enhance understanding on water tariff rate setting

1) The present situation about water tariff setting process in YCDC

In Myanmar, no process, method nor rule on water tariff has been set for utility. In YCDC, theory or standards for tariff setting were also not found. According to the C/P's explanation, water tariff was set through the same process of annual YCDC budget, and they did not know who made the draft of tariff rate plan at the last tariff revision. In the previous chapter, the latest MCDC tariff revision events were summarized, and it was supposed that members of EDWS in MCDC were not much involved in tariff revision process.

In near future huge investment for expansion of facilities should invite water tariff raise in YCDC. On the other hand, under the condition of democratic society and market economy progressing rapidly, the Myanmar public would be getting aware of rights for public services. Accordingly, water tariff raise process should be requested for more transparent and theoretical explanation. The executives in YCDC have acknowledged this situation and they understood the importance of water rate setting practice. Especially the second phase of JICA Loan which was discussed in 2015-16 made them more sensitive for financial situation of YCDC.

2) Activities to enhance understanding on water tariff rate setting

The key principle of water tariff setting is globally accepted. It is almost the same in Japan and other countries, although water utility is a domestic industry. At the Project, to learn such common principle was the first step to start because no basic understanding existed among the C/P. A trial and error process was applied to attract interest of the C/P and YCDC executives. Ultimately, it was understood that practical experience was more attractive for the C/P than to learn theory.

(a) The Expert' seminar on water tariff setting process

On 21st December 2015, the Expert made a presentation at a weekly workshop on "Basics of water supply utilities (4) Rate making of water tariff".

(b) Seminar with Advisory Committee member and third-country training

In January 2016 and January 2017, the Advisory Committee member in charge of finance visited YCDC and held a seminar. In his lectures, the vital role of water tariff in utility management was explained and stressed upon.

In November 2016, Daw Moe Moe Khaing of the C/P attended the third country training at MWA, Bangkok. She was much impressed with the difference of water tariff system between YCDC and MWA by the lecture provided, and she seemed to be awakened by the practice and principle of water tariff setting.

(c) Expert's mini-seminar series

A mini seminar was held on 12th, 16th and 19th August 2016 for the C/P of Finance Team about detail of water tariff setting process. During that time, the C/P were not assigned to such jobs and the seminar's theme was not directly connected to their pressing job. Thus, the contents might have been understood superficially.

(d) Presentation by the C/P

In order to enhance active and better understanding, the C/P was requested to make presentation summarizing expert's presentation at mini seminar. On 5th December 2016, the C/P presented "Progress Report: Progress of Tariff Setting Study". However, it appeared that deeper understanding was needed, and some practical exercise such as compiling guidelines in Myanmar language was suggested to set the target of the Project. It was deemed useful not only for YCDC but also for other utilities in Myanmar.

(e) Training in Japan

At the training in Tokyo, the history on water tariff revision of Tokyo Waterworks Bureau was presented as follows.

26th January 2018 (Friday), 10:40 - 11:40

Topic	Lecturer	Affiliation/Position
History of Tokyo Waterworks in the rapid economic growth period - Securing financial sources, background of water tariff raise --	Mr. Yoichi Ichimura	Assistant Director, Finance and Budget Section, General Affairs Division, Bureau of Waterworks, TMG

(f) Workshop on drafting table of contents of the Guideline for water tariff setting in YCDC

i) Date/Time: 7th March 2018, 10:00 - 12:00

ii) Participants: The Finance Section C/P, 8 persons

iii) Purpose:

To review information and knowledge of tariff setting that the C/P obtained so far in the Project and to make the table of contents which will guide YCDC when water tariff raise is discussed in a few years.

Photo 2-14: C/P for Finance discussed to make manual of Water Tariff Setting for YCDC

iv) Main points:

At the workshop, a tentative table of contents was proposed by the Expert as follows. It was expected to be arranged if the guidelines would be compiled as a recommendation style to the executives of YCDC. The C/P were requested further study to make a table of contents on this subject.

a) Background

- Present tariff in Yangon
- Comparison of water tariff (Mandalay, Tokyo/Bangkok/Phnom Penh)
- Electricity tariff

- Key points learned from other countries' guidelines (JWWA, AWWA, AfDB)

b) Proposed guidelines for the next water tariff revision in YCDC

- Process
- Principle
- Revenue requirements
- Tariff structure

(g) Exercise of tariff setting in WRAWSA

1) To cooperate to make a financial plan

The C/P of Planning Section were developing the mid-term plan and the Finance Section's C/P cooperated to make financial plan which was included in the mid-term plan. It was a great opportunity for them to learn how to make financial plan through actual process. They made progress on developing guidelines gradually from what they learned.

2) Exercise to calculate water tariff raise by financial plan on the mid-term plan

On 14 December 2018, at the half monthly meeting, the C/P made a presentation regarding tariff setting. Although some figures such as depreciation costs were not given, it seemed they have learnt a part of process. It was a good opportunity for them to understand the process because the mid-term plan was made over all divisions involved and approved by the CE. The difference between full cost recovery and sustainable cost recovery was emphasized to show the alternatives as follows.

Table 2-38: Results of water tariff rate setting exercise

Type	Hike rate (-times)	Hike rate (%)	Domestic	Total Increase	Remark
Type 1	2.41	142 %	88 Kyat/m3	213 Kyat	Full Cost
Type 2	1.73	72 %		152 Kyat	50% Subsidy for YCDC Capital Cost
Type 3	1.045	4.5 %		92 Kyat	Full Subsidy for YCDC Capital Cost

(h) Seminar again for executives of WRAWSA

On 8th March 2019, the Expert conducted a seminar again especially for executives of WRAWSA. They were impressed with the last presentation by the C/P on tariff setting exercise results in December 2018. Also, they seemed to think about an actual tariff raise in near future, and more than 30 members attended it including the DYCE1 and 2.

(i) Establishment of taskforce for water tariff review

Meanwhile, the CE showed an intention to review the present water tariff system in June 2019, and he issued an order on 10 July 2019 to establish a taskforce to review water tariff of YCDC. Until that time, tariff setting lectures/seminars were looked upon as impractical activities. After that, however, they became real and useful ones.

Powerful management members who were not the C/P until that time were included in the taskforce and they lead the team. The C/P of the Financial Section were also appointed as members, followed leaders' activities, and provided financial data. Also, it was a good opportunity for the C/P to learn the process and summarize it as guidelines which is one of the targets of the Project.

No	Name	Position	Member
1	Daw Htwe Naing Oo	ACE	Chair
2	Daw Thin Thin Soe	ACE	Deputy Chair
3	Daw Aye Aye Mar	EE (Computer)	Staff
4	U Soe Kyaing	EE (Elect & Mech)	Staff
5	U Zaw Win Aung	EE (GIS)	Staff
6	Daw Thin Thin Yi	Finance	Staff
7	Daw May Htet Kyaw	Finance	Staff

8	Daw Hnin Mya Khine	Finance	Staff
9	Daw Aye Myat Thu	GIS	Staff
10	Daw Ei Ei Nyein	GIS	Staff

On the document of the CE's order, WRAWSA's cost recovery strategy was defined to cover O&M cost at the 1st step, to cover debt services at the 2nd step, and to set the final target to cover full costs. To define such strategy was one of the progresses for setting theoretical tariff system which was one of the outputs of the Project.

After establishing the water tariff review taskforce, seminars and workshops were conducted and members were trying to make a rough draft of new water tariff rate system. A member of the taskforce team made presentation on the draft tariff rate system at NRW training course in January 2020, which indicated that an own initiative to set tariff rate system has been started although the draft tariff rate system is still under reviewing.

At the end of the Project, it seemed that WRAWSA was consulting Yangon Region Government, which has the authority to decide the rate revision, on revision of water tariff rate system, but the details have not been disclosed.

(j) Mayor's statement at press conference

From the summer of 2019, the Mayor has repeatedly stated that they have not intended raising the water tariff rate for the time being, but the water tariff revenue has not been able to cover the water supply cost. After announcement of introduction of PPP, the Mayor and city executives made several statements on water supply, in which they referred to the same statement the Mayor made. These statements are considered to be the result of presentations at project seminars, which have repeatedly pointed out that it is necessary to set prices that can cover costs. In addition, these statements are also due to the increased interest of citizens in utility bills due to the increase in electricity prices on July 1, 2019, and the prospect of a general election in November 2020. After that, detail actions on PPP were expected, but the Project ended due to Covid-19 pandemic and political instability in Myanmar since February 2021.

(k) The activity of compiling "Water Tariff Setting Guidebook in YCDC"

After discussing the table of contents of "Water Tariff Setting Guideline" which is summarized at previous item of (f), the C/P continued to prepare it according to the TOC. As the Project term was extended, the C/P and the Expert held web-meetings several times and improved the subject matter of it. Its title was changed to Guidebook from Guideline because it would provide reference not normative rule. In Myanmar there is not any manual or reference on water tariff setting in Myanmar language, thus it would be a first basic reference brochure in their language.

(5) Enhance understanding on Public-Private Participation (PPP)

At the start of the Project in 2015 some executive members of WRAWSA were interested in PPP but most of staff members were not. However, the situation changed drastically. The actual PPP project was announced by YCDC on 27th August 2019 which intended to invite private companies to manage water delivery to customer with less loss in a water supply zone of Yangon city. The Project was said to be supported strongly by Yangon Region Chief Minister.

Like neighboring countries, PPP system could likely be introduced in Myanmar in near future, and in the Project some seminars/training had been conducted to enhance understanding of PPP. Although the PPP project was announced, the concern was that the facilities or management system of YCDC were not organized properly to introduce and implement PPP project effectively. The following activities were implemented to enhance understanding on PPP.

1) Seminars about PPP

(a) The Expert made presentation at a monthly meeting held on 14th June 2016. The topic was "PPP – Introduction- How to involve private sector". The Expert explained the basic information and global trend of PPP.

(b) The Expert conducted mini-seminars on detail of PPP and outsourcing for the C/P of Finance Team on 26th August and 2nd September 2016.

In YCDC area, a NRW project which is financed by Japan's Ministry of Foreign Affairs aiming to make PPP contract has been carried out. Also, the Manila Water implemented a NRW pilot project and tried to find opportunity to make PPP contract. Through both projects, PPP scheme would be the next target for private sector to seek for.

(c) Third country training in Bangkok
At the third country training in Bangkok, the trainee team of WRAWSA visited PWA (Provincial Waterworks Authority) which has experienced several projects of PPP but MWA had no experience of PPP. Some PWA's cases indicated that construction of water treatment plant by private finance caused serious problems for water utility such as imbalance between price of bulk water supply and retail water tariff rate. They understood these experience/cases suggested that detailed consideration is required in introducing PPP scheme.

(d) Training in Japan
At the training in Japan, "Cooperation with private sector" in Tokyo Waterworks Bureau was presented relating to PPP as follows.

25th January 2018 (Thursday), 15:50-16:50

Topic	Lecturer	Affiliation/ Position
Cooperation with private sector	Mr. Motoki Inomata	Deputy Director, Finance and Budget Section, General Affairs Division, Bureau of Waterworks, TMG

2) PPP and reorganization of YCDC in water supply
(a) New YCDC Law 2018 and PPP
In June 2018, the new YCDC Law was enacted. The Bill before passing through YRG parliament had a scheme of private companies owned by YCDC who would operate municipal works such as water supply. This can be referred to the ppresentation material of YCDC Secretary Daw Hlaing Maw Oo at JICA Yokohama Forum in August 2017. Although the scheme was not materialized, the Chief Minister of Yangon Region Government and YCDC executives still had the intention of utilizing private companies for water supply works. Because of their basic idea that "YCDC should act as a regulator and private companies act as an operator in the future", they seemed to initiate the PPP project in August 2019. In addition, the Secretary sometimes made a statement about the change of business to the private sector and YCDC to the regulatory body.

On the other hand, at the end of October 2017, the information about the group management scheme of Tokyo Metropolitan Government with subsidiary companies (TSS, PUC, and TGS) was requested by DYC1 in WRAWSA. This management method provided a different idea in examining the reorganization of YCDC under the new YCDC Law. The information was also explained to the C/P at the training in Tokyo.

(b) Presentation to Mayor and Chief Minister
On 28th March 2019, a presentation was delivered to the Mayor, Mr. Maung Maung Soe to explain the ideal future image of water supply organization under the new YCDC Law, in which the information was provided that the priority of reorganization shall be placed on establishment of autonomous entity or introduction of PPP project. At the same time, Fukuoka City, the sister city of Yangon, dispatched its staff to Yangon and explained that autonomous water supply entity should be in the first step, which is the same idea of the Expert. On 22nd May 2019, the same kind of presentation was delivered by the Expert to Chief Minister of Yangon Region Government, Mr. Pyo Min Thein. These presentation materials of the Expert are given in Annex CD9.

(c) Announcement of PPP project

On 27 August 2019, YCDC announced to request Expression of Interest (EoI) for the development of Zoning Water Distribution System, and relevant documents were distributed from the next day. Until 28th October, about 20 companies submitted EoI according to unofficial information. International Financial Corporation (IFC), one of World Bank group joined to evaluate the EoI. Due to concerns about the outcome of the PPP scheme, the activities aiming at examining PPP options and strengthening PPP capacity of WRAWSA were added to the scope of the Project as an additional work in the latter half of 2020.

The Government of the Republic of the Union of Myanmar
Yangon Region Government
Yangon City Development Committee (YCDC)

Request for Expression of Interest (EOI)

1. Applications/ Proposals for Expression of Interest (EOI) are invited from interested companies (local, international or joint venture) to carry out the works for the Project for the development of Zoning Water Distribution System (the Project) in Yangon City according to the master plan under Public-Private Partnership (PPP).
2. A complete set of the EOI documents may be purchased by the interested companies from the date of 28th August, 2019 at the address below during office hours:

   Water Resources and Water Supply Authority Office
   Yangon City Development Committee
   12-Storeyed New Office Building
   No. 390, Merchant Road, Botahtaung Township, Yangon, Myanmar.
3. Applications for EOI shall be delivered in sealed envelopes to the above address not later than 15:00 hours(local time) on 28th October, 2019 by hand. The EOI documents submitted later than the designated time and date will not be considered.
4. After the evaluation of EOIs, the Tender Committee will invite Proposal Bids from the Applicants that have been prequalified.
5. For further information, please contact Phone: +959-8627-992.

Tender Committee
Yangon City Development Committee

YCDC announced Request for Expression of Interest (27 August 2017)

(d) Seminar on PPP by the Expert

On 13 September 2019, the Expert conducted a seminar, in which the Expert explained the points to be considered in implementing PPP and expressed concerns about this PPP project. The Expert emphasized that this PPP project was similar to the NRW project in Mayangon T/S funded by the Japanese Government and the project in Insein T/S implemented by Manila Water, and WRAWSA needed more detailed study with a clear image of the project to be implemented.

(e) Progress of YCDC's PPP project after announced in August 2017

After YCDC received EoI from interested companies, YCDC requested IFC to conduct a pre-feasibility study (pre-F/S) on this PPP project. Then, Castalia, a consultant for IFC, submitted the study report on management of WRAWSA in May 2020 and the pre-F/S report on PPP options in August 2020. On the other hand, it was decided to include the activities to review the contents of the studies on PPP in the Project as well, and the activities were accordingly implemented, since it was expected that there are many challenges in commercializing this PPP project, which will be not easy to realize.

1-6-3 Conduct OJT on development of asset ledger

Water utility is a capital-intensive industry like electricity utility which operates and maintains huge facilities, and, consequently, fixed asset management and accounting are vital for sustainable management of water utility. In recent days, aged infrastructure is a big issue globally and asset-management is highlighted in terms of how to cope with the issue on efficient repairment or replacement. Asset management shall be made based on the accurate assessment of fixed asset. In addition, the water utility has a large proportion of costs related to fixed assets in total costs. Understanding it and appropriate management is very important in terms of financial management.

According to the corporate accounting, fixed asset list is arranged, and depreciation is calculated, and relating costs are shown in financial statement. However, government accounting is applied to WRAWSA. The assets have not been properly replaced or repaired, nor depreciation costs of water supply have been calculated.

Under these conditions, the Project assisted the activities to establish fixed asset management system through OJT and seminars to enhance understanding of important role of fixed assets and to establish its management and accounting system in WRAWSA.

(1) Enhancement of understanding on asset accounting

1) Seminars by the Expert and Advisory Committee members

On 14th December 2015, the Expert made presentation on "basics of water supply utilities (3) asset management and accounting for water supply utilities" and emphasized on the importance of asset accounting in water supply utility. On 28th January 2016, at the seminar with JICA Advisory Committee member, Mr. Naganuma made presentation on financial management of Tokyo Waterworks Bureau which included fixed asset and depreciation management. On 21st March 2016, the C/P made presentation on what the C/P understood from the presentations of the Expert and advisory committee members in a weekly meeting. At the start of this activities, the C/P and the executives of WRAWSA expressed much interest in this issue. On 2nd May 2016, the CE circulated an official order to all sections/divisions to prepare a fixed asset list of the whole WRAWSA facilities. Other activities such as study visit to YESC, presentation in weekly meetings by the C/P contributed to enhance the understanding of fixed asset accounting by not only the finance C/P but also by all WRAWSA sections.

2) Third country training and training in Japan

In November 2016, the third country training was held in MWA, Bangkok, which included the topic of fixed asset management. Ms. Moe Moe Khaing of the Finance Section's C/P participated in the training and she learned fixed asset management in an autonomous water utility.

At the end of January 2018, the training course in Japan was conducted. From the Finance Section's C/P, Ms. May Oo Lwin, Ms. Khin Khin Htwe and Ms. May Thet Kyaw participated in. The program related to fixed asset is as follows.

29th January 2018 (Monday), 13:00-13:45

Topic	Lecturer	Affiliation/ Position
Fixed asset management (13:00-13:10 Presentation by the C/P)	Mr. Tomofumi Ohmura	Assistant Director, Fixed Asset Section, Asset and Contract Management Division, Bureau of Waterworks, TMG

3) Seminar on fixed asset by Advisory Committee member

On 23rd February 2018, at 13:00-15:00, a workshop was held with attendance of the C/P and Mr. Takayuki Takahashi, an Advisory Committee member for Output 1 (Finance) from Tokyo Waterworks Bureau, at the meeting room No. 3 (No.1 afterwards) in WRAWSA.

The purpose of the workshop was to understand the fixed asset management and accounting from acquisition to disposal of assets by goods and constructing structures/buildings, in which the actual procedures practiced in Tokyo Waterworks Bureau were explained. Afterwards, the Expert explained the same topic in a workshop on 6th March in 2018 using the same material again.

Photo 2-15: Seminar on fixed asset by Advisory Committee member

(2) OJT on development of fixed asset ledger and management/accounting of fixed asset

1) Searching for former official letters relating to fixed asset management/accounting

At the beginning of the Project, the C/P and executives of WRAWSA were rather fast in understanding the importance of fixed asset. Thus, they looked back and searched for former documents related to fixed assets management in YCDC. They found some forms of asset registration and depreciation rate table in the orders which were issued decades ago by Union Government or Budget & Accounting Department of YCDC as shown below. However, this system had not been implemented in WRAWSA and other departments in YCDC.

- Depreciation Rate of Budget and Revenue Department (Budget Division), The Union Revolutionary Council Government, 8 May 1964
- Depreciation Rate of Budget Department, The Union of Socialist Myanmar, 15 August 1978
- Depreciation Rate of Budget Department, The Union of Socialist Myanmar, 8 July 1987
- Y.C.D.C (Budget & Accounting) Department, 21 May 1998

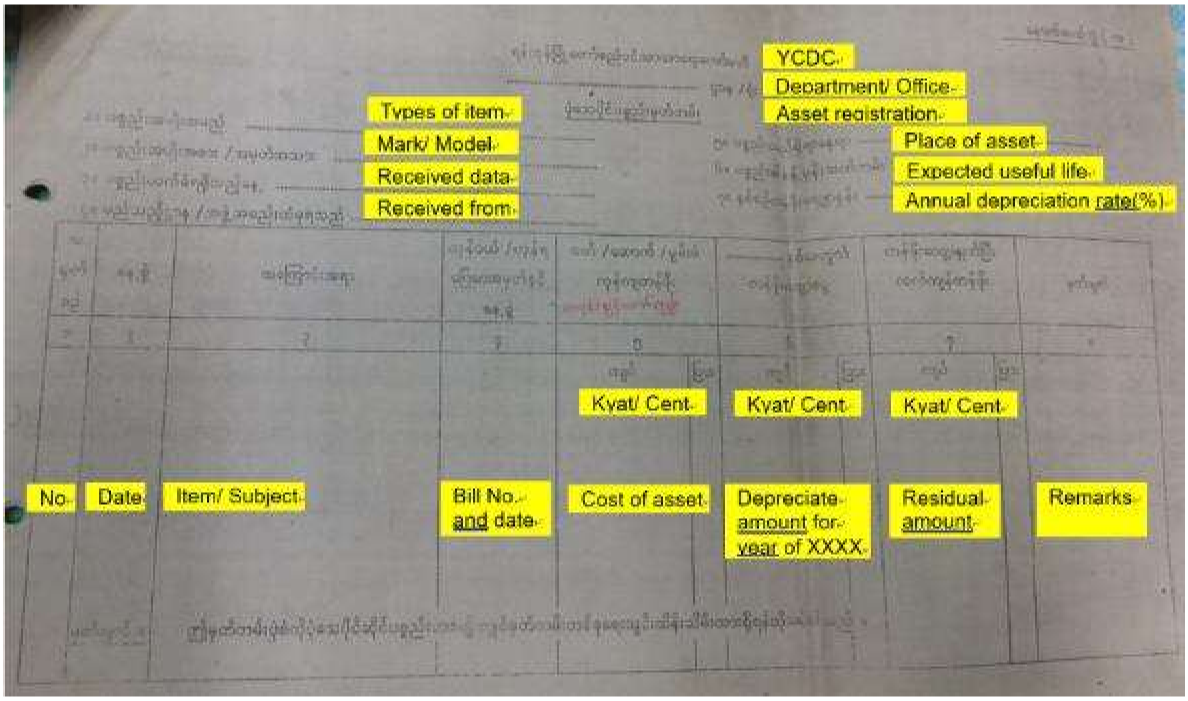


Photo 2-16: Form for fixed asset registration book

As mentioned above, forms of fixed asset ledger were found in former official letters and they included the list of useful-life and depreciation rate, although it did not include water supply facilities. It was found that there was a certain basis of fixed asset management although it has not been implemented in YCDC, and it was decided to use it. The next activities were set as follows.

- To establish a format for organizing fixed assets according to the type of water supply facility and the division/section that manages them.

- To decide appropriate depreciation rate for water supply facilities which were not stipulated in the former documents.
- To fill fixed asset data in the ledger by division/section and understand the entire assets of WRAWSA
- To fill monetary value of asset, documents of which were lost or not found

It was not an easy job for WRAWSA staff to develop asset ledger, especially to grasp monetary value of fixed asset. To grasp accurate monetary value of asset which was suitable for official B/S it was assumed that part of the works should be outsourced to a local accounting consultant firm.

2) Request for division/section to submit asset list:

An Order of submission of fixed asset list in Division/Section was issued by the CE on 2nd May 2016. However, it took much time and was not yet completed at the end of the Project. Most of the fixed assets were acquired very long time ago and documents were not found. Also, engineering section did not cooperate much because the engineering sections did not stress on this works and engineering sections are stronger than Finance Section. Then, the finance C/P conducted explanation meetings targeting engineers.

3) Study visits to YESC

On 15th June 2016, a study visit to YESC was carried out. YESC is one of the state enterprises of Myanmar and corporatized in April 2015. YESB (Yangon Electricity Supply Board) was changed to YESC (Yangon Electricity Supply Corporation), but the accounting system is the same as before. The visit was conducted to learn state enterprise system, such as fixed asset management and accounting, tariff system, general accounting system that might be very useful for the C/P to understand Myanmar system.

After the first visit, on 5th December 2016 and 28th February 2019, total three study visits were implemented. The C/P had tried to study several topics listed above. Although process/standards of accounting or detail documents could not be obtained, the C/P collected basic documents such as the table of useful-life, format of fixed asset in B/S and P/L & B/S statement. It is reconfirmed that it is essential to learn from the similar industry in the local place when introducing a new system.

4) Establishment of Fixed Asset Committee in WRAWSA

In order to proceed these pioneering works, WRAWSA established a committee named "Fixed Asset Committee" on 26th July 2017 and held the 1st meeting on 4th August. The committee consisted of Mr. Thein Min, DYCE3 as the chairperson, and representatives of engineering divisions/sections and Finance Section members. The names of the Committee members are listed below:

No	Name	Position	Responsible matters
1	U Thein Min	DYCE3	
2	Daw Aye Pa Pa Nyoe	EE	Mechanical Materials
3	U Zaw Oo	AE	Reservoirs
4	U Aung Htut Lin	AE	Pumping Stations
5	U Soe Kyine	EE	Electrics
6	U Tin Hla Htun	EE	Tube Wells
7	U Tint Zaw	AE	Distribution of Water
8	Daw Khin Aye Myint	EE	Wastewater Factory
9	Daw Myint Myint San	EE	Air Compressor
10	U Kyaw Tint	EE	Pipe Factory
11	Daw May Oo Lwin	EE	Finance
12	Daw Khin Khin Htwe	AE	Finance
13	Daw Moe Moe Khine	AE	Finance

Photo 2-17: The 1st Fixed Asset Committee meeting was held in WRAWSA

The committee discussed important items on fixed asset management and made recommendations or drafted papers to be submitted to the CE. In addition to moving forward one by one, such as the method of estimating the unknown part of the asset ledger and the formulation of the depreciation rate, activities such as the formulation of a manual for the overall procedure were carried out.

(a) Research and study of depreciation rate

Regarding the useful life and depreciation rate of facilities peculiar to water supply, which are not specified in the old orders, it was decided to refer to other businesses and water supply utilities in other countries. We collected information on the figures for water supply stipulated in Japan's Local Public Enterprise Law, and the useful life of MWA in Thailand, PPWSA in Cambodia, and YESC. In addition, in consultation with engineers from WRAWSA, it was decided to set a useful life suitable for Myanmar. The following examples of useful life were defined in SOP of WRAWSA.

Table 2-39: Form of useful-life/depreciation rate table (example)

အသုံးဝင်သက်တမ်းနှင့်တန်ဖိုးလျော့နှုန်းထား (Useful Life) /Depreciation Rate

Sr.no	1th Tier	2nd Tier	Year (useful life)		Depreciation Rate %		Remark
			Min	Max	Min	Max	
၁	မြေ	တော					
		Water Conservation forest					
၂	မြိုင်						
၃	အဆောက်အဦး	Steel		30		3.33	
		Brick		20		5	
		Meatal		5		20	
		wood		10		10	
		RC		50		2	
၄	မြေညီးမိုး	သစ်		10		10	
		ဝါး		3		33.33	
		အုတ်		50		2	
		သံဘော		10		10	
		အခြား		10		10	
		Concreate way		10		10	
၅	ရေစက်အိမ်နှင့်အခြားအဆောက်အဦးများ	Low Capacity Pumping House		10		10	
		Anti Hammer		10		10	
		Indoor Sub Station	30	60	3.33	1.7	
		Electro Chlorination Building	30	60	3.33	1.7	
		Pumping Station,	30	60	3.33	1.7	
		Compressor House	30	60	3.33	1.7	
		Chamber Building	30	60	3.33	1.7	
		Indoor ဓာတ်အားခွဲရုံ	30	60	3.33	1.7	
		Outdoor ဓာတ်အားခွဲရုံ	30	60	3.33	1.7	

Table 2-40: Form of useful-life (example-continued)

Sr.no	1th Tier	2nd Tier	Year (useful life)		Depreciation Rate %		Remark
			Min	Max	Min	Max	
၆	**Bridge**	Concreate		25		4	
		Wood		10		10	
၇	**ရေလှောင်ကန်(Reviserviors**	မြေစိုက်ကန်					
		RC ကန်	30	60	3.33	1.67	
		အနည်ထိုင်ကန်	30	60	3.33	1.67	
		ရေစုကန်	30	60	3.33	1.67	
		Reservoirs (Concrete above ground)		50		2.00	
		Reservoirs (Concrete in ground)		50		2.00	
		Head Regulator (RC)		50		2.00	
		Underground Tank	30	60	3.33	1.67	
		Overhead Tank	30	60	3.33	1.67	
		Reviserviors	30	60	3.33	1.67	
		Lake	30	60	3.33	1.67	
		other Intakes (RC)	30	60	3.33	1.67	
		Conduit	30	60	3.33	1.67	
		Intake weir (RC)	30	60	3.33	1.67	
		Intake tower (RC)	30	60	3.33	1.67	
		spill way (RC)	30	60	3.33	1.67	
		Sand setting basin (RC)	30	60	3.33	1.67	
		Storage Tank (Concreate)	30	60	3.33	1.67	
		Storage Tank (Meatal)	30	60	3.33	1.67	
၈	Channel	မြေသားမြောင်း					
		RC မြောင်း	25	35	4	3	
		Syphon (RC)		50		2	

There was a lengthy discussion by engineering members in fixed asset committee to define useful life and depreciation rate. One time the committee drafted the useful life table as shown below. They tried to categorize the same asset as three classes and set different useful life, by which Japan's products has shorter life for the same European products. It was surprising to see that engineers in WRAWSA thought this way. It seemed that their work experience on site had caused an impression like that.

Table 2-41: Form of useful life/depreciation rate table (First draft)

Useful Life (Draft)						
r .No	Categories	Class A	Class B	Class C	%	Remark
				Chin + Indea		
		European	Japan	Local Only		
	Electrical					
62	Distribution Power Transformer		20	10		YESC
63	Battery Chargers			3		17
64	Hand Tools	3	2	1		18
65	Safty Equipments	3	2	1		19
66	Control Panels	5	3	2		19
67	Lighting Accessories	5	2	1		8

On 26th June 2018, a discussion on useful life table was held. The Expert explained that the useful life table applies to fixed assets acquired based on certain specifications and should not differ depending on the country of manufacture or manufacturer, and existing old facilities should be evaluated for their residual value. When an engineer estimates useful life of existing fixed assets which had no document of its data, it may be convenient for the engineer to set useful life based on the range of maximum and minimum life.

(b) Category of fixed asset

One issue in the committee was how to categorize fixed assets. Firstly, Japan's categorization was thought to be suited for YCDC. Japan's categorization is as shown in the left table below. The first tier is like "Land", "Building", an "Structure" and the second tier is like "for purification" and "for distribution."

Table 2-42: Categories of fixed asset (Left: by asset itself, Right: by function)

Classification	
Tangible Fixed Assets	
	Land and trees
	Buildings
	Structures
	Machinery and equipment
	Others
	Construction in progress
	Leased assets

Account Title
Source of Supply Plant
Structures and Improvements
Collecting and Impounding Reservoirs
Lake, River and Other Intakes
Wells and Springs
Supply Mains
Other Water Source Plant
Pumping Plant
Structures and Improvements
Other Power Production Equipment
Electric Pumping Equipment
Diesel Pumping Equipment
Other Pumping Equipment
Water Treatment Plant
Structures and Improvements
Sand and Other Media Filtration Equipment
Membrane Filtration Equipment
Other Water Treatment Equipment

On the contrary, in the categorization of YESC, the first tier is like "for generation of power", "transmission" and "distribution" and the second tier is like "Land" and "Building," which is different from Japan's style. Such categories are shown in the right table above which is common in US. Then, the local YESC's system was selected as it might be suited for Myanmar. This issue was discussed on 27th August 2018 and they thought Japan's style is suitable for WRAWSA because they had a lot of branch offices and each office manages its fixed assets which might be convenient to categorize as per Japan's style.

5) Development of SOP for fixed asset management and accounting

(a) Workshop on drafting table of contents of the manual of fixed asset management and accounting in WRAWSA

On 6th March 2018, with the attendance of 9 C/Ps of Finance Section, a workshop was held to review information and knowledge of fixed asset management and accounting that the C/P obtained in the Project and tried to make the table of contents which might be used as manual on fixed asset management and accounting in WRAWSA.

Photo 2-18: Discussion on fixed asset management and accounting to make a manual for it.

The Expert explained the image of making a table of contents of manual using presentation materials of the advisory committee member on the fixed asset management and accounting of Tokyo Waterworks Bureau and the table of contents was discussed.

(b) Activities for development of SOPs

The C/P were impressed with the role of SOPs in water supply utility after the third country training in PPWSA. Then development of SOPs in WRAWSA started at Reservoir Division in the beginning of 2019. the CE ordered to make SOPs for all sections in WRAWSA. The C/P in Finance Section started to compile SOPs for management and accounting of fixed asset with advice and support they received in the Project.

They collected relevant information from Japan's practice in water utilities, asset accounting system on Myanmar Accounting Standard and practical information obtained by study visit to YESC, and prepared SOPs. One of the highlights of preparing SOPs was to prepare the useful life of fixed assets and its depreciation rate. It was a rather long discussion between engineer staff and accounting staff, but it was finally completed, and the tables were attached to SOPs that is listed above as "Form of useful-life (example)".

To prepare a sort of a manual was a big challenge for the C/P. For this purpose, it is important to have a driving force. When various materials were collected and prepared, WRAWSA started to make SOPs of the entire sections under the direction of the CE. It can be said that this driving force presented a good chance for the C/P to create SOPs related to fixed assets.

Reference: Transition of the C/P of finance team

At the start of the Project, three members of the C/P were appointed which included Ms. Myin Myin Than (Division Director), Ms. Khin Khin Htwe (Section Director) and Ms. Moe Moe Khaing (Section Manager). Furthermore, other 3 to 5 members usually attended the meetings. Ms. Myin Myin Than demonstrated strong leadership, understood the Expert's intentions, and supported the activities. Ms. Moe Moe Khaing and Ms. May Thet Kyaw, two members mainly worked for the Project, by making presentation materials and paper works.

After the leader, Ms. Myin Myin Than retired, Ms. May Oo Lwin succeeded her, who also retired in 2018 at the retirement age. Fortunately, Ms. Kin Kin Htwe who had experienced the Project from the start succeeded her position. Ms. Moe Moe Khaing who was the main player for the finance team was transferred to Drainage and Wastewater Authority. That was a big loss for WRAWSA but might be a big benefit for Drainage and Wastewater Authority. At the end of the Project, Ms. May Thet Kyaw was the vital member of the team who cooperated with her seniors and lead young new members.

C/P in July 2015 at the start of the Project

Name	
D. Myint Myint Than	EE level
D. Khin Khin Htwe	Section Head
D. Moe Moe Khaing	AE level
D. Tin Tin Moe	Acc 1
D. San San Myint	Acc 2
D. Thin Thin Yee	Acc 1
D. May Thet Kyaw	Acc 4
D. Ohnmar Soe	WA
D. Shwe Zin Aung	WA
D. Hnin Mya Khine	WA

C/P in April 2018

Name	
D. May Oo Lwin	EE level
D. Khin Khin Htwe	Section Head
D. Moe Moe Khaing	AE level
D. Tin Tin Moe	Acc 1
D. San San Myint	Acc 2
D. May Thet Kyaw	Acc 3
D. Hnin Mya Khine	WA
D. Abal Khin Myint	WA
D. Ohnmar Soe	WA

C/P who attended most meetings

Name	
D. Khin Khin Htwe	EE level

C/P in March 2020

Finance C/P members	
D. Khin Khin Htwe	EE level
D. Thin Thin Yee	Section Head

D. Moe Moe Khaing	Section Head
D. May Thet Kyaw	Acc 3
D. Hnin Mya Khine	WA

D. May Thet Kyaw	Acc 2
D. Hnin Mya Khine	
D. Ohnmar Soe	
D. Hla Hla Htwe	
D. Zarni Hlaing	Retired in Jan. 2020
U Khant Sithu	New member
U Zayyar Tun	ditto
D. Yin Min Thu	ditto
D. Thazin Wai Phyo Khine	ditto

Photo 2-19: Finance C/P in February 2016

Photo 2-20: Finance C/P in January 2020

1-7 Strengthen Public Relations

1-7-1 Analyze the effective public relations on water service of YCDC

To analyze the effective public relations (PR) content and activities for WRAWSA, a survey to understand the PR activities were implemented. The Public Relations & Information (PR&I) Department in YCDC published the YCDC Newspaper, magazine, and utilized the media such as FM City and TV to inform the public about the things that the public should know. At the timing of the Project start, there was no specific section in charge of PR in the WRAWSA but WRAWSA implemented some activities such as participating in exhibitions, distributing pamphlets and school activities. The distribution materials used in reservoirs and water treatment plant were prepared. However, there was no tool to share the information among district offices, T/S offices, and head office in WRAWSA. They depended on the personal network only to collect information.

In weekly meetings, several presentations were made by the Expert to explain the roles and the importance of PR, method, tools, complaint management, information sharing within the department and introduction of examples of PR in Japan and other countries. In addition to this, a seminar to explain the objectives of PR and detailed activities were conducted by JICA Advisory Committee.

As described in 1-3 Establishing Customer Service Division, discussions were carried out by the newly established PR Section for delineating effective PR activities, and the draft activity plan was prepared. In the action plan, the update and review of the PR activity plan, preparation of PR materials, publishing of WRAWSA News, school activities, improvement of YCDC website, PR activities to public in cooperation with PR&I Department in YCDC, utilization of mass media etc. were included. There was no full-time staff in PR Section, but all were part-time staff although PR Section was established. The PR activity plan is shown in the figure below.

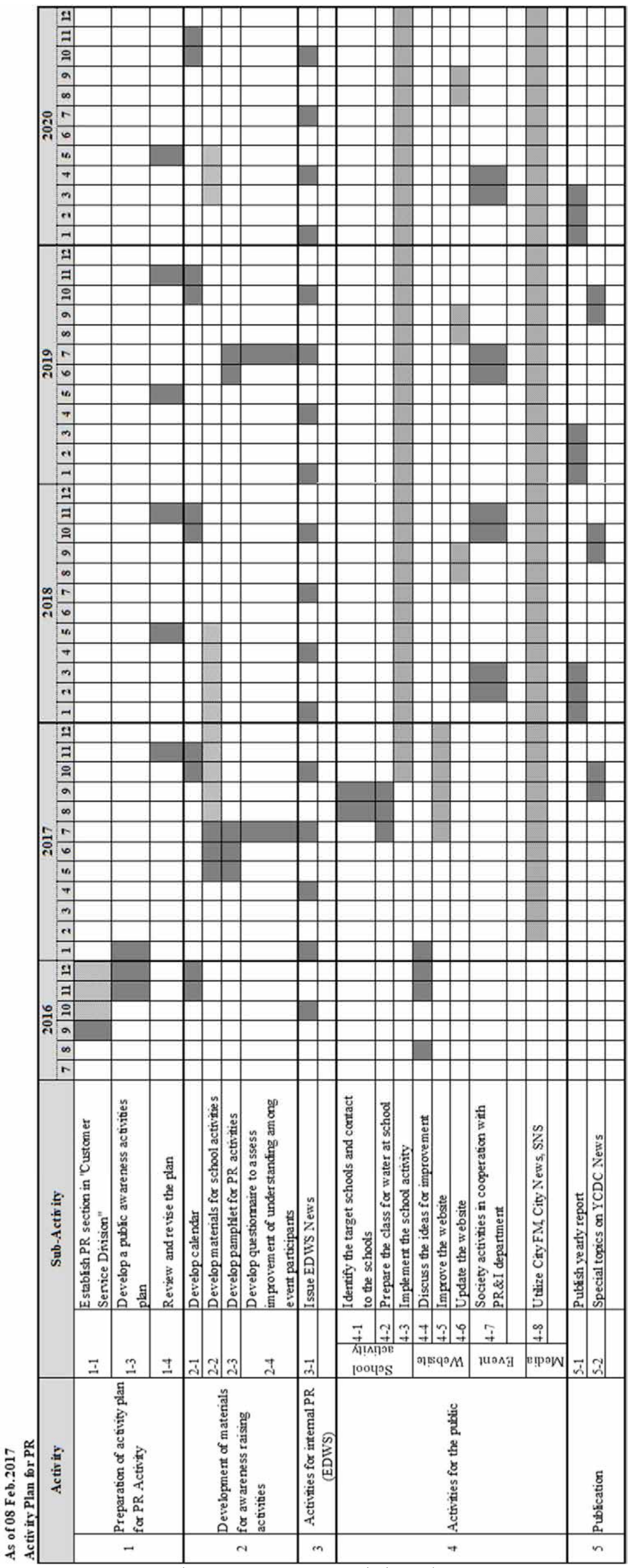


Figure 2-19: PR activity plan

1-7-2 Conduct awareness raising of YCDC staff

As stated above, the presentations to explain the roles and importance of PR were implemented in the weekly meetings. PR Section published WRAWSA News to share the information and enhance the awareness on PR to staff including district and T/S offices. WRAWSA News was published six times (October 2016, February, July 2017, June, December 2018, and January 2020) in the Project. The News included the introduction of top management, events to be shared, introduction of facilities and introduction of departments and sections of WRAWSA.

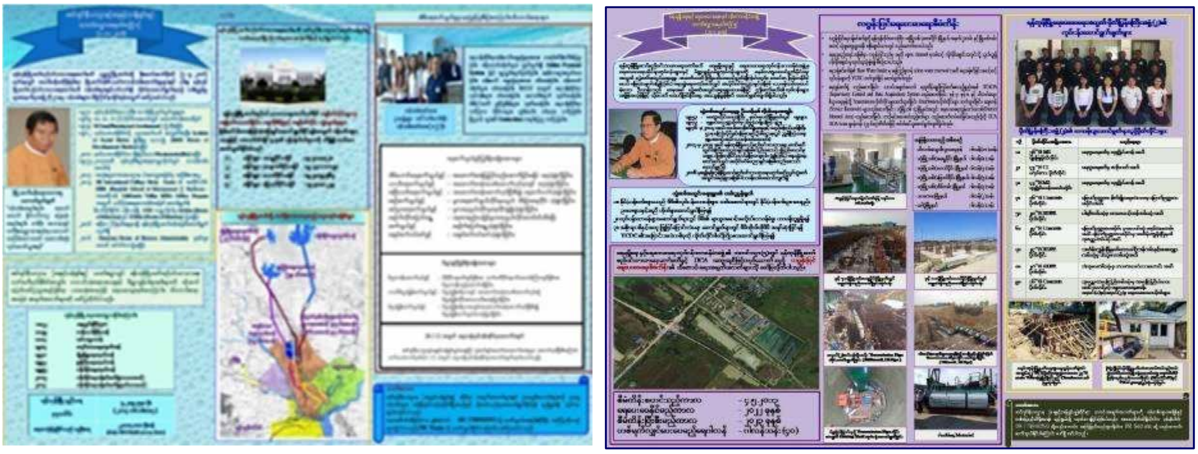


Photo 2-21: WRAWSA News

To share the information of the Project, white boards were set up on the 3rd and 4th floor corridor of WRAWSA. The schedule of weekly meetings, JCC, training schedule and results, reports and survey results were shared in this board.

Photo 2-22: White board in WRAWSA head office

The calendars have been published every year since 2016. The provision of the photos and preparation of explanation notes were requested to related sections and calendars were finalized in cooperation with many sections.

There was no official system to receive complaints about water supply from customers in WRAWSA. Instead, T/S offices received them. Due to this, WRAWSA head office did not know the number nor contents of complaints. To grasp the number and contents of complaints, data collection about complaints was started in April 2018. The category of complaints was fixed as shown below.

Table 2-43: Complaint category

Complaint category	Explanation (example)
Water supply	Poor water flow, poor water pressure, water shortage
Water quality	Turbidity, odor, color,
Construction	Noise, suspension of water supply,
Water charge	Expensive, miscalculation
Procedure	Slow process, connection is not accepted,
Meter reading	Misreading, no meter reading,
Response to customer	Bad attitude, poor response,
Others	

The complaint data from April till June 2018 was collected once by paper-based record from the district and T/S offices to PR Section. However, it took time to summarize and analyze the data in this method, so the datasheet in Excel format was distributed to district and T/S offices.

To explain how to input the complaint data into datasheet in Excel format, workshops were organized as shown in the table below. The objectives to collect complaint data, the use of datasheet and submission method were explained by the C/P to district and T/S officers and the data input was carried out.

Table 2-44: Workshops for complaint datasheet

Date	Target district, T/S	Participants
23 July, 10:00-	East district office and 8 T/S	14
23 July, 14:00-	West district office and 10 T/S	19
24 July, 10:00-	North district office and 10 T/S	16
24 July, 14:00-	South district office and 9 T/S	19

Most of the T/S submitted the complaint data from April 2018. As this was the first time for WRAWSA to collect all the complaint data, it was discussed and decided that the half-year report on complaints shall be prepared and shared within WRAWSA. For preparation, the complaint data from April 2018 to December 2018 was analyzed together with the C/P and the Expert. The C/P provided a practical guidance about how to prepare the graphs using Excel as well.

The data of complaints received in fiscal year 2018 (October 2018 to September 2019) were collected, analyzed, and summarized in the annual complaint report. The total number of complaints was 2,109, which indicated WRAWSA received 175 complaints per month on average. About 70 % of complaints were about "water supply", such as amount, supply hours, low pressures etc, followed by "sanitation" (such as septic tank is full, wastewater flows into the yard, breakage of sanitation pipes). On the other hand, the complaints about "construction", "water charge", "procedures", "meter reading" and "response to customer" were less. In the category of "Others," pipe breaks and leakage were reported. Some complaints related to "construction" were included in "others" due to misunderstanding of categories. The list of complaints which was difficult to categorize shall be prepared and shared with district and T/S offices so that the categories can be understood by all district and T/S offices. Almost all the complaints were solved by T/S offices.

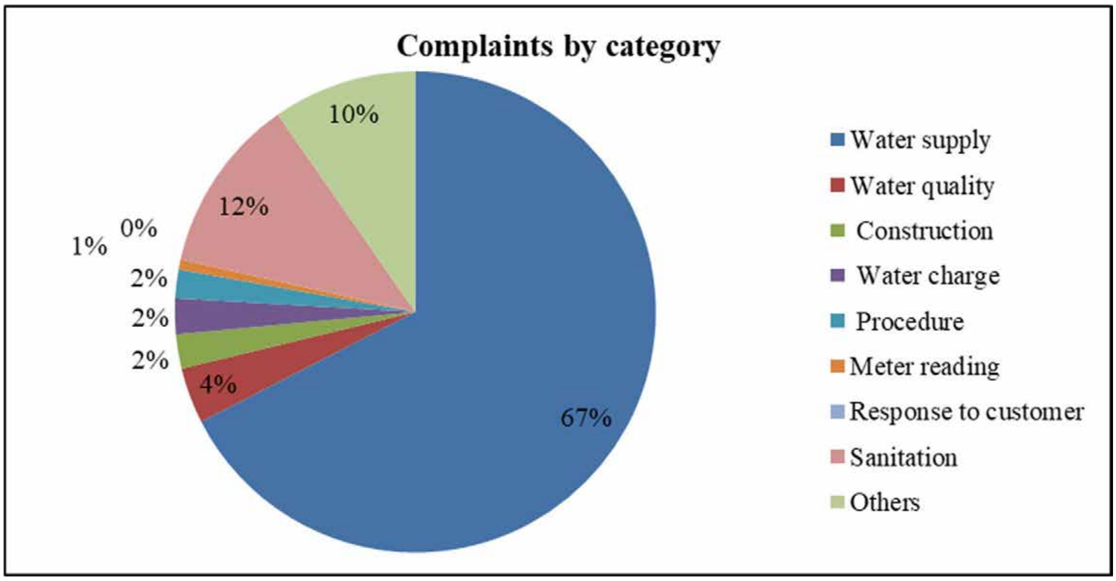


Figure 2-20: Complaint composition by category

The figure below shows the composition of complaints by month and category. There seems no trend by season nor category.

There were some comments on “procedures” in July 2019. Those were enquiries from the customers about house connection procedures in Shwepyithar T/S. The complaints on “construction” in July were due to replacement of broken pipes in Hlaingtharyar T/S and industrial zone. In October, the complaints on “water quality” increased and those were about water quality of wells. The number of complaints in October increased because the replacement of pipes was implemented.

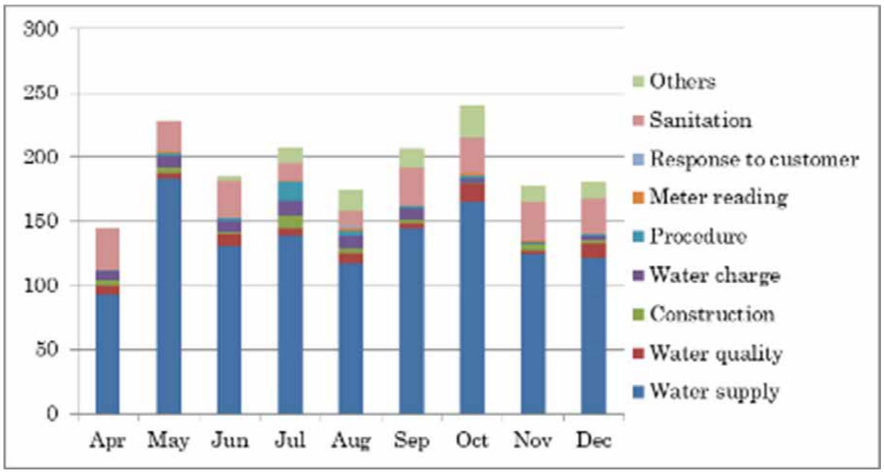


Figure 2-21: Number of complaints by category

The figure below shows the number of complaints by month and district. The complaints are relatively larger in number in North District considering the population is larger there than the other districts. In addition, the low pressure and the works of NRW reduction also increased the number of complaints in North District.

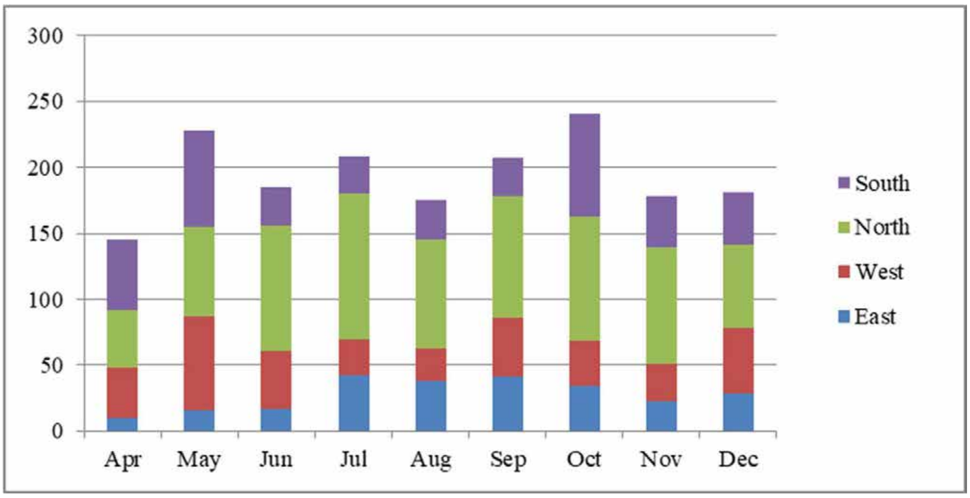


Figure 2-22: Number of complaints by district

The figures below show the composition of complaints by district. The common finding was that the complaints on "water supply" were the dominant complaints in all districts. In East District, the complaints "others" were more than 25 %, however, the complaints which should be categorized as "construction" were also included, so re-categorization was required. In South District, complaints on water quality such as smell of well water and contamination by pipe break were raised. The number of complaints on "water charge" were more than the other districts, such as the water charge being more expensive than expected, or the bill not being calculated based on the meter reading etc.

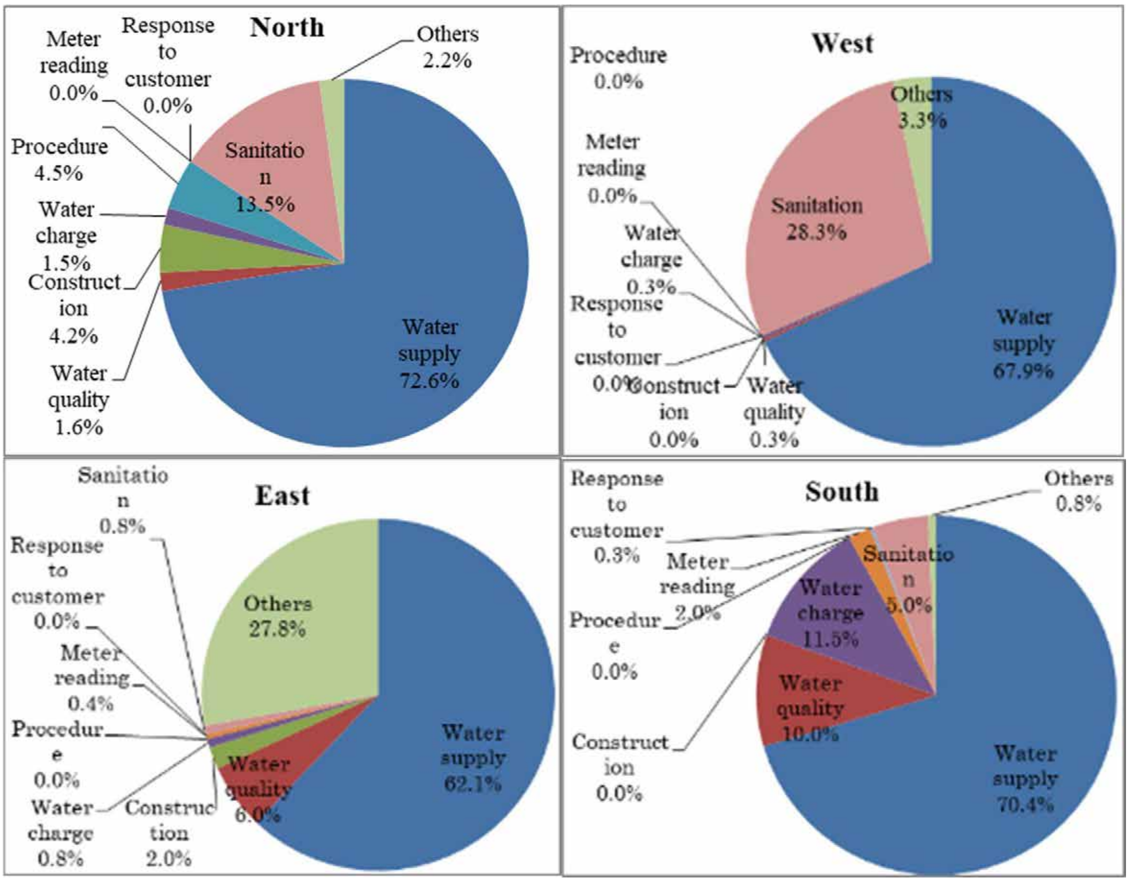


Figure 2-23: Composition of complaints by district

In the presentation of complaints data collection & analysis in a half monthly meeting, a comment that it would be better if the category of water supply is more detailed was made. Therefore, the category was divided into several sub-categories, and the excel sheet was also modified and distributed to all T/S offices. This modified sheet was started being used in October 2019.

The complaint data from October 2019 to September 2020 was collected by PR Section to prepare the annual complaint report. However, missing data was found in several T/S which generally receive several complaints. PR Section tried to collect the missing data but the work was suspended due to the political instability.

1-7-3 Conduct OJT on the public relations activities

All the activities were implemented in cooperation with the C/P and the OJT was conducted throughout all activities.

(1) Preparation of calendar

The calendars were published from 2017 to 2020 to introduce the works of WRAWSA and distributed to the public. The desk calendar was prepared until 2019. Then, the C/P wanted to try another style for 2020 calendar, so wall calendars were prepared (two types, one was four months in one page and the other was 12 months in one page). These calendars were distributed to other departments of YCDC, state governments and the public through T/S and district offices.

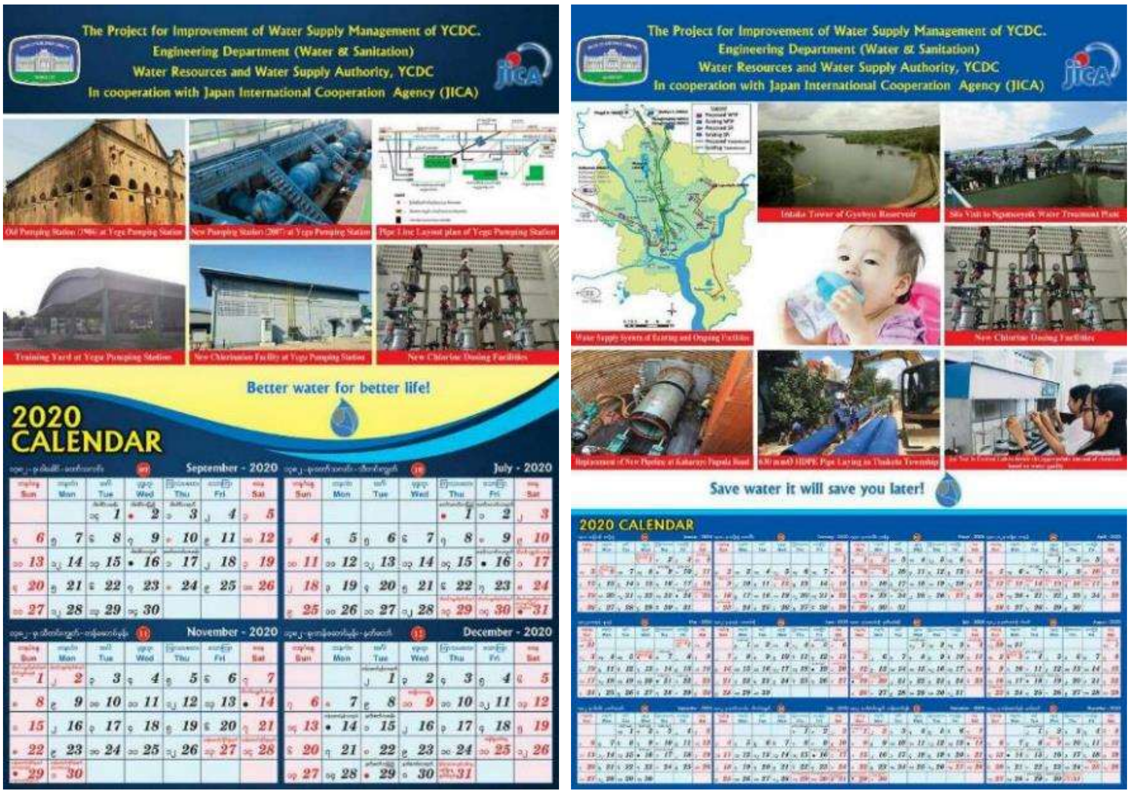


Figure 2-24: WRAWSA calendars

(2) School program

The school program started based on the activity plan in 2017. The target of the program is children of grade 4 and 5, and the purpose is to draw children's attention to the surrounding water and enhance their knowledge on water. The program consists of presentations using illustrations at school and site visits to water treatment plant. In Term 1 of the Project, the C/P accompanied to the school activities implemented by the JICA Expert from Fukuoka City and this experience was utilized to establish the program.

A first step was to prepare the presentations at school. Referring to the school materials which many Japanese local authorities published on the website, the C/P selected the theme that WRAWSA want to deliver to children based on discussions with the Expert. Then the C/P made the stories and decided the image of presentation. The presentation consists of: (1) water source on earth, (2) shape of water source and available sources for drinking water, (3) water circulation, (4) history of YCDC water supply system, (5) water sources in Yangon, (6) overall system of water supply, (7) process of purification, (8) main works of WRAWSA, (9) water use in daily life, (10) treatment of used water, (11) reasons of water importance, and (12) tips to save water. Then, illustrations were prepared by an illustrator who was selected by the C/P to make attractive, memorable, and understandable presentations for school children.

Figure 2-25: Presentation for school program (extracted)

Explanatory scenarios were developed together with the Expert. A simple demonstration model of filter basin of water treatment plant was also developed by the C/P and staff working at water treatment plant were eager to demonstrate an experiment about water purification process. Further, to make this event more attractive and memorable for children, distribution goods such as pens, rulers, hats, and water bottles were prepared after investigation of preference of such goods in Myanmar. The C/P was actively involved in the preparations including preparation of draft design, selecting of a design company, finalization of the design and making orders to the company.

Photo 2-23: PR materials

For implementing the school program, the C/P visited T/S Educational Office and explained the purpose of the program so that the implementation would be done smoothly.

Table 2-45: Implemented school program

No.	Date (Upper: Presentation, Lower: site visit)	T/S	Participants (Upper: Presentation, Lower: site visit)
1	2017/11/20 2017/11/21	Tarmwe	100 30
2	2018/1/10 2018/1/12	Thingangyun	152 30
3	2019/1/10 2019/1/11	Dagon	110 40
4	2019/1/30	Kamaryut	185 40
5	2020/1/23 2020/1/24	Mayangone	150 30
6	2020/1/28 2020/1/29	Insein	120 30

The presentation was rhythmically made by the C/P using many illustrations and songs along with the prepared slides. When introducing the facility, the program was carried out while attracting the attention of children by incorporating an experiment using a simple model of the filtration process of the water treatment plant.

During site visits to water treatment plant, at first the staff of the treatment plant explained the water sources, transmission & distribution area, process of treatment, and water quality analysis, and then the children visited each process from raw water to treated water processes with detail explanation.


School presentation


School presentation


School presentation


Site visit


Site visit


Article in City News (11 January 2018)

Photo 2-24: School program

The advice from members of Advisory Committee and notices by the C/P were considered for improvement, such as:

- Waiting time for experiments made children unfocused, so large experimental equipment was prepared to show the experiment at once for all the children. The C/P walked among the children to show the water before and after treatment to appeal the effectiveness of filtration.
- At one school, only female children participated in the site visit. After that, the C/P requested schools to consider the gender balance.

- The presentation was made before the site visit. Additionally, video was used to show the treatment process.
- The panels showing the water saving tips were posted at the stairs and corridors of the school before the school program to attract children's interest. Posters showing water saving tips was provided to school so that children can always see and act on the water saving tips.
- New topics were added (notice about chlorination injection).
- The officers of T/S where school was located joined the program.
- The C/P requested the media persons of City News to cover the school program for PR in the newspaper.

Photo 2-25: Panels at the school

(3) Awareness to the public

As the awareness activities to the public, PR Section participated actively in Myanwater (November 2017 and 2018), Myanmar Water (October 2017 and 2018), Literature for Children Festival (May and October 2018) etc.

Photo 2-26: Awareness activities to the public

Furthermore, chlorination of water supply for disinfection was started in December 2019, on which public awareness was implemented. The advantages and notices on chlorination injection were announced though SMS, City News and City FM. Poster was also prepared explaining the purpose, effects, chlorine smell of tap water, tips to eliminate the smell from tap water using illustrations and photos. This poster was hung in T/S offices, entrance of YCDC and floor of WRAWSA.

Photo 2-27: Poster in the entrance of YCDC building

In the Advisory Committee meeting in February 2020, a recommendation was made to enhance the awareness activities to adults. The implementation of T/S meeting, which was proposed by JICA Expert of Fukuoka City as a basic idea, was considered. However, it was suspended due to the pandemic of COVID-19.

1-8 Strengthen human resources development

1-8-1 Review the existing HRD system

Since the beginning of the Project, the existing HRD system and the areas requiring improvement were analyzed through PCM workshops, capacity assessment, and interviews with key counterpart members. The results were summarized in the Baseline Survey Report. Even during the Project implementation period, further surveys were conducted during the discussion for elaboration of HRD plan, and the results were reflected in the HRD plan. The key items reviewed are as follows:

- ✓ The number of WRAWSA staff by age and staff group
- ✓ Existing situation and issues of human resource management system; recruitment, transfers, turnover, personnel appraisal, promotions, salaries and allowance, and incentives.
- ✓ Institutes and organizations related to human resource development
- ✓ Existing training courses and its operation system
- ✓ The number and quality of internal trainers
- ✓ Motivation survey targeting all staff
- ✓ Turnover ratio and job analysis of WA in WRAWSA
- ✓ Comprehensive training needs

It was confirmed that the following factors were closely related to the necessity of strengthening the HRD system of WRAWSA.

- ✓ Employment age as permanent staff member was around 30 years old.
- ✓ Many clerks of WRAWSA were going to retire within 10 years.
- ✓ It was difficult to recruit qualified staff member since employment conditions are not attractive.
- ✓ There are only few institutes such as universities or research institutes related to water supply in the country.
- ✓ The water supply business scale of WRAWSA was projected to expand rapidly.

At the beginning of the Project, for establishment of a sustainable HRD system, WRAWSA had the following major issues to be solved:

- ✓ WRAWSA had not been responsible for HRD of its staff members (no policy, plan, section, activity, experience of HRD).
- ✓ It seemed that it is difficult to promote HRD activities in each workplace (OJT).
- ✓ Capacity of staff members was not fully activated.
- ✓ Training courses were not lined-up well and did not function well.
- ✓ The organization did not function efficiently enough.
- ✓ Turnover ratio of new staff was high.

Regarding high turnover ratio of new staff, especially WA (Working Authority; non-permanent staff as probation stage), HRD team conducted a survey in 2016 to confirm turnover situation and job of WA to prepare effective training course for them. The key results were as follows:

- ✓ Turnover rate of WA was higher than that of permanent staff members.
- ✓ WA with university degree tend to leave their jobs in shorter term (less than 2 years) since their working conditions were far poorer than that of private companies.
- ✓ WA graduates or under high school tended to stay longer since the working conditions were equivalent to those of private companies. They may quit in several years when they feel that their office has less possibility to promote them to a permanent staff member.
- ✓ In some T/S offices and site offices, WA accounted for more than 90 % of its staff members. Moreover, WA working for meter reading or pump operation carried out almost the same duties as permanent staff members and worked independently. WA's working conditions and frequent turnover significantly affected the efficiency of jobs.

1-8-2 Identify necessary improvement in structure and materials of the trainings

In the course of activities given under 1-8-1, review of existing situation of the HRD system, the issues and necessary improvements in existing training programs, training management, training materials and trainers were identified. The results were compiled and submitted as a Baseline Survey Report in January 2016. The followings describe the issues and measures for improvement based on the situation at the time of the baseline survey.

(1) System of training programs

The baseline survey showed that training courses provided by outside institutes such as UCSB (Union Civil Service Board), Administration Department of YCDC mostly addressed general topics with period of 2~3 months for limited number of staff. Those training courses mainly targeted officers, engineers and clerks; and on few occasions targeted technicians and non-permanent staff, and WRAWSA has been apt to put priorities on engineers for training. No regular training course was conducted by WRAWSA before the Project started, and only some donors and companies provided seminars and trainings related to water supply occasionally.

The future ideal image was set as “the waterworks has a continuous improvement structure of human resource capacity”. Considering rapid expansion of the service and large-scale projects of WRAWSA, it was urgently necessary to establish the sustainable training system which can provide various training courses related to water supply, and specific contents directly applicable to the duties. To realize it, training needs survey was required to be conducted in WRAWSA, based on which training program would be designed and implemented according to its priorities.

(2) Training management:

HRD Section was launched with 5 full-time members to be the responsible section for HRD related duties in WRAWSA in August 2016, when the first pilot training course was implemented. The present members of HRD Section are listed in the table below. Assigned duties of HRD Section are 1) assess HRD needs and propose HRD measures, 2) plan, implement, evaluate and record training affairs, 3) enhance OJT activities, and 4) maintain organization chart/job description updates.

Soon after the launching HRD Section, pilot training courses began based on the annual training management cycle, which were expected to strengthen and sustain regular training activities, as well as enable HRD Section to accumulate experience of training management.

Table 2-46: List of counterparts and staff in HRD Section

	Name	Position	Division
Full time staff	Ms. Swe Swe Win	Executive Engineer	HRD Sub-section, Admin Section, Admin& Finance Division
	Ms. Khin Zin Mar Myint	Section Head	
	Ms. Nyo Nyo Htun Kyaw	Assistant Supervisor	
	Ms. Wine Htet Htet Aung	Flat	
Part-time staff	Mr. Kyaw Kyaw Oo	Executive Engineer	East District Officer, Water Supply Division
	Ms. Su Nandar Lin	Assistant Engineer	Research Section, Water Supply Division
	Mr. Aung Moe Kyaw	Sub Assistant Engineer	Electrical Maintenance Section, Reservoir Division
	Ms. May Htoo Aung	W.A	Office Section, Reservoir Division

*as of the end of the Project

(3) Training materials

All training materials were necessary to be newly developed since WRAWSA had not conducted regular internal training before. For pilot training courses, after preparation by each trainer, training materials were reviewed and improved with modification and addition of necessary contents through repeated implementation of pilot trainings. Pilot training activities can also function to set up the system to verify and improve the quality of training materials. Moreover, the SOPs and manuals elaborated through other activities of the Project are being used as the verified training materials.

(4) Trainers

According to the baseline survey results, we found that only few staff had the experience of a trainer. In order to increase the number of internal trainers, the pilot training courses functioned effectively as well. Responding to trainees' position level and subject of each pilot training, officers from deputy section head level up to DYCE were appointed as trainers. To develop teaching skills of those trainers and candidate trainers, seminars and technical advice were needed. Furthermore, the measures for continuous improvement of trainers' capacity needed to be introduced, such as self-checking of a trainer, feedback from training participants at the end of each training.

1-8-3 Conduct trainings of trainers for planning and organizing the trainings

TOTs have been continuously conducted through implementation of pilot training courses. HRD Section was a target of TOTs for training program and training management, while internal trainers were targets of TOTs for training materials and teaching skills. By conducting pilot trainings, PDCA cycle of training was repeated to continue improving the training.

(1) TOTs for HRD Section

The system of training programs: In order to establish comprehensive training programs with a long-term point of view, it was essential to start scrutinizing training needs as well as raising awareness on HRD of related officers and top management. Therefore, prior to designing comprehensive training programs, implementation of pilot training courses was selected as eye-catching activities. For training subjects other than pilot training, training needs were studied during formulation of HRD Plan (Activity 1-8-4), the results of which were incorporated in the comprehensive training programs.

Training Management: Regarding training management, as shown in the table below, the works were listed in line with the PDCA cycle of training management, for which the schedule was set up with the staff in-charge in order to get those works established as routine works. At the time of the first training, the C/P could carry out few works independently, but gradually became capable of managing routine works autonomously, and now the C/P can take responsibility for most of the training management works.

Table 2-47: Training management work performance comparison before and after the Project

No.	Preparation tasks for every training course	1st course	Now
1	Making syllabus	D	B
2	Finalizing list of participants	C	A
3	Submitting proposals to CE (Programs, Trainers)	B	A
4	Preparing invitation of lecturers / trainers	B	A
5	Sending invitations to all sections	B	A
6	Making requests for trainers (Kick off meeting)	C	A
7	Collecting training handouts from trainers	C	A
8	Printing training handouts	B	A
9	Arranging training venues	B	A
10	Arranging training equipment (desks, chairs, WB, map, PC, projector)	C	A
11	Arranging transportation for site visit (Dep. of Transportation)	B	A
12	Making feedback sheet (answered by participants, trainers)	D	A
13	Preparing achievement evaluation sheet of participants	D	A
14	Making certificates	D	A
15	Orientation	C	A
16	Implementation of training	C	B

No.	Preparation tasks for every training course	1st course	Now
17	Meeting for review	D	B
18	Wrap up meeting	C	A
19	Making course evaluation report	D	A
20	Recording the results in staff profile sheet	B	A

Legend: A. Fully independent; B. Partly advised; C. Mostly advised, D. Mainly by Expert
Source: Extracted from presentation slides of the C/P presented at Advisory Committee seminar in Jan. 2020.

Training plan: In FY2016, as the launching stage of pilot training course, training course for new staff was selected and implemented. The contents of the new staff training are as follows.

- ✓ Current work situation, organizational structure, and missions of WRAWSA
- ✓ Current workflows
- ✓ The roles of WRAWSA for realization of its mission
- ✓ Current issues and future ideal images/targets
- ✓ Main points which trainees should pay attention to during site visits.

From FY2017, we decided to sequentially identify and implement training courses with high needs. It was confirmed that around 11 training courses could be conducted in a year and set as an annual plan for securing budget and firm implementation. As shown in Table 2-48, we developed training courses in all three categories: level-specific training, job-specific training, and self-development support. By the end of the Project, a total of 40 training courses were provided to 839 staff members cumulatively. Regular implementation of training courses was successfully established. In 2020, training activities were temporarily suspended due to the pandemic of COVID-19, but preparations were made to implement online training, and the training was conducted online from November 2020 onwards.

Table 2-48: All implemented pilot training courses

No.	Group	Training course	Target	Times/the number of participants
1	Training by level	For new staff (Engineer, clerk, worker)	New staff (less than 3 years of service)	For Engineer 6 times, 140 trainees For clerk 6 times, 119 trainees For worker 7 times, 210 trainees
2		For pre-officers	Deputy T/S engineers, Sub-Assistant Engineer level	4 times, 67 trainees
3		For T/S engineers	T/S engineers	2 times, 40 trainees
4	Training by duty	O&M of tube-well pump	Pump operators of T/S	3 times, 60 trainees
		GIS and pipe mapping	Engineers in Pipe Section (1-4)	1 time, 12 trainees
		NRW management	SAEs, supervisors	2 time, 33 trainees
5	Support for self-learning	Basic PC skill	Office staff of each Section	10 times,118 trainees
		Water engineering	Young engineers	1 time, 40 trainees
Total				43 times, 839 trainees

In FY2018, we conducted a training needs survey from a long-term perspective, organized training courses considered necessary in the future, and integrated them into the HRD plan. Table 2-49 outlines the future training program included in the HRD plan.

Table 2-49: Necessary training program included in HRD plan (outline)

No.	Training Course	Target (trainee)
A. Training courses by Level		
1.	1. (a) Pre-officer level training (Administration 1)	SAEs, Supervisors, Dy Supervisors, Ass. Supervisors
2.	1. (b) Staff level training (Administration 2)	Staff
3.	1. (c) New staff training	All new staff (within 3 years)
B. Training courses by duties		
4.	2. Accounting	Cashier, staff in charge of accounting in sections, divisions and T/Ss
5.	3. (a) Pipe Connection and repair (Distribution & Service pipe)	NRW staff in townships
6.	3. (b) Pipe Connection and repair (Transmission pipe)	Workers in Pipe Section
7.	3. (c) NRW countermeasure	NRW Management Section, Pipe Section (Engineer)
8.	4. (a) O&M of pump and Tube-well	Pump operators in T/S
9.	4. (b) Distribution pumps in P/S	Pump operators in reservoirs and P/S
10.	5. Meter Reading and billing collection	Meter readers and bill collection staff in T/S
11.	6. Water supply planning & design	Staff in charge in Pipe Sections, Reservoir Div. Design, Planning Section
12.	7. Design Standards/ Criteria of pipe installation & Cost Estimation	Engineers in T/S & Pipe Section, Planning Section
13.	8. Service Connection (Domestic Water Supply)	License Plumber (LWSE) House Conn. Section, T/S Workers
14.	9. Basic knowledge on Water Engineering	Engineers
C. Support courses for self-learning		
15.	10. PC Skills: Basic skills	All staff
16.	11. PC Skills: MS Excel Advanced	All staff
17.	12. PC Skills: AutoCAD (2D)	Staff in charge of Pipe Sections, T/S (SAE & JE), Reservoir Div.
18.	13. English	All Staff (2 Groups: Graduated level, High School level)

Training evaluation: As participant evaluation, for each training course, evaluation items are set, such as written examination, oral presentation, field report, positive attitude, attendance, compliance with rules, etc. Each participant is quantitatively evaluated, and those who get high marks are awarded at a closing ceremony. The scores of each training participant are recorded in the training participation history of the individual personnel track records. Since 2017, those with excellent training results have been evaluated highly in personnel selection for promotion and transfer within WRAWSA, and participation in overseas trainings, etc. This shows that the training results are effectively utilized, and therefore, staff are motivated to participate in trainings actively.

Regarding the evaluation of training course itself, all training participants and trainers are requested to fill a feedback questionnaire at the end of each training course. After each training, HRD Section holds a wrap-up workshop for trainers and top management, reports the overview of training results and evaluation, and proposes improvement measures for the next course. In particular, the evaluation votes from the training participants are shared with the trainers including the degree of overall satisfaction and many comments that can contribute to future improvements such as the training method and time allocation. Table 2-50 shows the outline of the results of each training course.

Lecture by officer

Presentation by all participants

WTP site observation

Basic PC skill training

Awarding an excellent participant

Group photo of training participants

Photo 2-28: Training

Table 2-50: Overview of implementation and evaluation of pilot training courses

1. Training by staff level

1) New Staff Training

Training target	Engineers							Clerks						Workers							
No.	1	3	7	10	11	17	20	2	6	9	13	15	19	4	5	8	12	14	16	18	Total
Month/Year	Jun 2016	Dec 2016	Jun 2017	Dec 2017	Jan 2018	July 2019	Jul 2020	Sep 2016	Mar 2017	Oct 2017	Aug 2018	Jan 2019	Jan 2019	Feb 2017	Feb 2017	Aug 2017	July 2018	Dec 2018	June 2019	Feb 2020	
No. of participants	20	20	20	25	37	13	5	20	20	20	20	20	19	30	30	30	30	30	30	30	469
Training period (days)	7.5	8.5	8.5	8.5	4.0	5.0	3.0	9.5	7.5	5.5	5.5	6.0	5.8	2.5	2.5	2.5	3.0	3.0	3.0	3.0	-
Feed-back from participants																					
Overall assessment (/10 points)	7.61	8.11	8.95	8.50	7.51	9.15	9.00	8.16	7.61	8.68	7.32	8.75	7.74	6.13	7.97	9.16	8.35	9.73	8.00	8.18	8.17
Q1; meeting expectation (/5 points	4.4	4.75	4.70	4.54	4.54	4.77	4.80	4.45	4.55	4.80	4.90	4.60	4.21	4.72	4.77	4.80	4.67	4.62	4.80	4.23	4.65
Q3. applicable for work (/5 points)	4.65	4.90	4.85	4.74	4.70	4.92	4.80	4.95	4.80	4.85	4.95	5.00	4.84	4.97	4.97	4.88	4.70	4.93	4.77	4.53	4.86
Q5; Conveyance method (/5 points	4.6	4.80	4.70	4.46	4.62	4.85	4.80	4.8	4.75	4.85	4.95	5.00	4.79	4.90	4.90	4.95	4.70	4.93	4.73	4.70	4.79

2) Officers、Pre-Officer

Training target	Dy TS Officer & SAE					TS Officer		
No.	1	2	3	4	Total	1	2	Total
Month/Year	Sep 2018	Dec 2018	Jun 2019	Nov 2020		Nov 2018	Jan 2019	
No. of participants	20	20	18	9	67	20	20	40
Training period (days)	8.8	7.3	7.5	7.5	-	5.0	6.0	-
Feed-back from participants								
Overall assessment (/10 points)	8.55	8.55	8.96	9.33	8.77	9.40	9.33	9.37
Q1; meeting expectation (/5 points	4.70	4.75	4.72	4.33	4.67	4.85	4.47	4.66
Q3. applicable for work (/5 points)	4.45	4.70	4.61	4.56	4.58	4.75	4.53	4.64
Q5; Conveyance method (/5 points	4.70	4.75	4.67	4.44	4.67	4.80	4.58	4.69
Q6; participatory metnod (/5 points	4.70	4.65	4.56	4.56	4.63	4.75	4.32	4.53

2. Training by duty

Training course	O&M of Pump				NRW management		
Training target	Pump Operators				SAE level		
No.	1	2	3	Total	1	2	Total
Month/Year	Mar 2018	May 2018	March 2019		Jan 2020	Dec 2020	
No. of participants	20	20	20	60	20	13	33
Training period (days)	2.8	2.8	2.8	-	6.3	10.0	-
Feed-back from participants							
Overall assessment (/10 point	8.93	9.75	8.90	9.19	7.79	8.08	7.91
Q1; meeting expectation (/5 po	4.95	4.85	4.93	4.91	4.30	4.29	4.29
Q3. applicable for work (/5 poi	5.00	4.90	4.90	4.93	4.70	4.07	4.45
Q5; Conveyance method (/5 p	4.89	4.95	5.00	4.95	4.40	4.29	4.35
Q6; participatory metnod (/5 p	5.00	4.95	5.00	4.98	4.40	4.29	4.35

3. Training to support self-learning

Basic PC skills

No.	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Total
Month/Year	May 2017	Jun 2017	Aug 2017	Nov 2017	Feb 2018	May 2018	Jun 2018	Feb 2019	May 2019	Oct 2019	
Training target	Bch+HO staffs	Tsh staffs	Tsh staffs	Bch+HO staffs	Tsh staffs	Bch+HO staffs	Tsh staffs	Bch+HO staffs	Tsh staffs	Tsh staffs	
No. of participants	8 (10)	12	12	12	11(12)	12	12	12	12	12	118
Training period (days)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	-
Feed-back from participants											
Overall assessment (/10 points)	9.25	9.17	8.38	9.13	8.40	8.92	7.91	9.42	8.75	9.50	8.88
Q1; meeting expectation (/5 points	4.22	4.27	4.17	4.20	5.00	4.06	4.58	4.27	4.06	4.11	4.30
Q3. applicable for work (/5 points)	4.38	4.58	3.96	4.06	4.55	3.96	4.79	4.17	3.96	3.75	4.21
Q4; Improved my skills	4.38	4.38	4.27	4.06	4.43	4.17	4.48	4.17	4.38	4.27	4.30
Q5; Conveyance method (/5 points	4.22	4.38	3.98	3.96	4.72	4.06	4.38	4.38	4.38	3.85	4.23

Note: This table excludes some courses which did not conduct course evaluation.

(2) TOTs for trainers

One of the objectives of pilot training was to empower staff and officers to become internal trainers. Trainers have mainly been assigned from section head level or above. In addition, they are expected to appoint their subordinates as training assistants to bring the younger generation up to trainer level in future in order to increase the number of internal trainers. At the workshops held before and after the training, the Expert held mini seminars in order to improve their teaching ability with specific topics such as the role of a trainer, how to organize a lesson structure, facilitation skills, and evaluation methods. We successfully strengthened the system for continuous training in the future by promoting to bring up the next-generation trainers although some senior officers who had rich experience in teaching retired or some were transferred to Sanitation Authority even during the Project implementation period. Moreover, the teaching skills, training contents, and slide materials were gradually improving. Table 2-51 shows list of internal trainers who gained experience in teaching in pilot training courses.

Table 2-51: List of internal trainers (actual)

Fields	**Subjects covered**	**Trainers in charge (of a part of subjects listed in the left column)**
Overview	Mission & vision of WRAWSA, Overall concept of YCDC WRAWSA water utility business cycle Future Plan of WRAWSA, Sanitation	Mr. Myint Zaw Than (CE) Mr. Zaw Win Aung (EE) 2 trainers
Administration, Finance, management	Leadership & Management, Administration, Finance, HRM&HRD, Way of Working, Regulations, Safety Working, 5S & Kaizen	Mr. Myint Zaw Than (CE) Mr.Win Zaw Oo (EE) Ms. Khin Zin Mar Myint (AE) Mr.Win Zaw Oo (EE) Ms. Ni Mar Zin (AE) 5 trainers
Services, customer related	House Connection, Customer Service, Billing & Collection, Public Relation, Complaint Management House Connection, Township Office Work	Ms. Thin Thin Soe (ACE) Ms. Thwae Naing Oo (ACE) Mr.Tin Win Aung (EE) Ms. Aye Aye Mar (EE) Ms. Mar Mar Aye (AE) Ms. Ni Mar Zin (AE), Ms. Cho Lae Soe (AE) 7 trainers
Technical, engineering related	Water supply and distribution (El & Mech facilities management) Reservoir and production, water treatment Water Quality	Ms. Aye Pa Pa Nyo (ACE), Mr. Tin Hla Tun (EE), Mr.Kyaw Kyaw San (AE) Mr.Thein Myint Zaw (SAE) Mr. Phone Naing (AE), Mr. Min Thu (AE), Mr. Aung Htoo Naing (AE), Mr. Pyi Soe(EE), Mr. Zaw Oo (AE), Mr. Nyi Nyi Aung (AE) Mr. Lin Htin Kyaw (SAE), Mr. Tun Win (Dy Supervisor) Mr. Aung Htut Lin (AE), Ms.Naw Elin Dar (SAE), Mr. Zin Min Latt (SAE), Ms.Tin Zar Lwin (Dy Supervisor) Ms. Ei Khine Mon (AE), Ms.Thandar Myat (SAE), Ms.Nwe Nwe Zin (SAE), Ms.May Zin Oo (SAE) Mr. Zayyar Tun (AE) Ms. Mi Mi Khine (AE) Ms. Thandar Htway (AE) Mr. Aung Min Oo (SAE)

Fields	Subjects covered	Trainers in charge (of a part of subjects listed in the left column)
		Mr. Myo Thant Tun (SAE) Mr. Yan Naing Tun (SAE) Ms. Khaing Khaing Soe (SAE) Ms. Win Sandar Oo (Asst: Supv) Mr. Kaung Zaw Htet (Flat) 29 trainers
Computer	Win 8, MS Word, MS PowerPoint, MS Excel	Ms. Phu Pwint Wai (SAE) Ms. Thiri Win (Flat) Ms. Htet Htet Wai (Flat) Ms. Lae Lae Win (WA) Ms. May Moe Thu (Flat) Ms. Nway Nway Htoo (Flat) Ms. Thandar Soe (Programmer) Ms. Thin Nwe Aye (Flat) 8 trainers

Note: The list excludes the trainers who have retired or transferred to other authority.

1-8-4 Develop 5-year and 10-year human resources development plans

HRD team implemented various activities and made discussions with the top management. Through these, the importance and necessity of HRD has been widely agreed in WRAWSA. Discussions for formulation of HRD plan were initiated in 2017. In formulating the HRD Plan, all related officers and the C/P had confirmed to include discussions not only on training activities, OJT, and self-development, but also on applicable system of motivation management and personnel appraisal that would contribute to the future HRD system of WRAWSA. As for the part of the training programs that would be the main part of HRD plan, it was necessary to integrate and coordinate with training needs and training plans of other fields/ teams/ sections. Since the related activities of other teams were scheduled for the second half of the Term 2 of the Project, the formulation of the training program of the HRD Plan was accordingly planned for the latter half of the formulation process.

As the CE of WRAWSA was changed two times in April 2017 and April 2019, HRD Section explained again the necessity of strengthening HRD at WRAWSA and the activities of HRD until then. With their understanding and agreement about the significance and necessity of the HRD Plan, the CE decided to join discussions about the proposals of each chapter. Therefore, it has received a commitment of top management to the implementation of measures of the HRD Plan although the implementation schedule was affected by some delay from the roadmap originally drawn.

In the discussion towards the formulation, in addition to the five full-time staff of HRD Section, four part-time counterpart members (many of whom are in a higher position than the full-time staff, and one of the officers retired in Jan 2021) also participated, resulting in lively discussions. At the third country training (in MWA and PPWSA) conducted in the latter half of FY2016, the major counterparts from HRD members participated, which led to discussions among the C/P during the formulation of HRD plan. This may be because a lot of information and related cases could be studied through the trainings by fostering awareness of problems and clarifying question items before those trainings. Also, through training in Japan in January 2018 and discussions with Advisory Committee members in February 2019, the C/P had occasions to review the contents of HRD plan which they had been considering and learned the relevant knowledge of Tokyo to implement the plan. These training and discussions were a great help for the C/P to understand how to implement those HRD measures in practice.

The final draft of HRD plan was presented at the 8th JCC in October 2019. The structure of the plan is as follows.

Table 2-52: Structure of HRD plan

Structure (Chapters)
Ch 1. Vision of HRD Ch 2 Current situation of HR Ch 3. Integrated training program based on training needs Ch 4. Promotion of OJT Ch 5. Self-learning Ch 6. Motivation management system Ch 7. Personnel appraisal system Ch 8. Prioritized actions and implementation schedule Ch 9. Expected impact on the productivity

Reference: Annex 3.D

HRD team implemented various activities and made discussions with the top management. Through these, the importance and necessity of HRD has been widely agreed in WRAWSA. The final draft has been completed and is in the process of being confirmed by senior officers of WRAWSA. For final approval of HRD plan, it is necessary to coordinate with the intentions of the management of YCDC, especially regarding measures to retain younger staff.

1-8-5 Launch priority activities as a part of implementing the 5-year human resources development plans

Some activities which were assessed to be prioritized to be implemented prior to formulation of HRD plan from a perspective of the entire WRAWSA management have been launched: 1) Making organization chart of WRAWSA, 2) Making duties and responsibilities of each section, 3) Setting up of HRD Section, 4) TOT for strengthening HRD implementation system through implementation of pilot training courses, and 5) 5S-Kaizen seminars and workshops. In addition, in the discussion of HRD plan, 6) measures to retain younger staff were confirmed on high priority; therefore, some related activities have begun.

(1) Updating organization chart of WRAWSA

HRD Section updated the organization chart of WRAWSA every month. By the amendment of YCDC Law in June 2018, EDWS was split into two authorities: water supply and sanitation. As newly established Water Resources and Water Supply Authority has proposed new organization structure to upper level and has been functioning with unofficial organizational structure, the organization chart has not been updated. The latest organization chart was updated in January 2019, and the translation into English is shown in Figure 2-26.

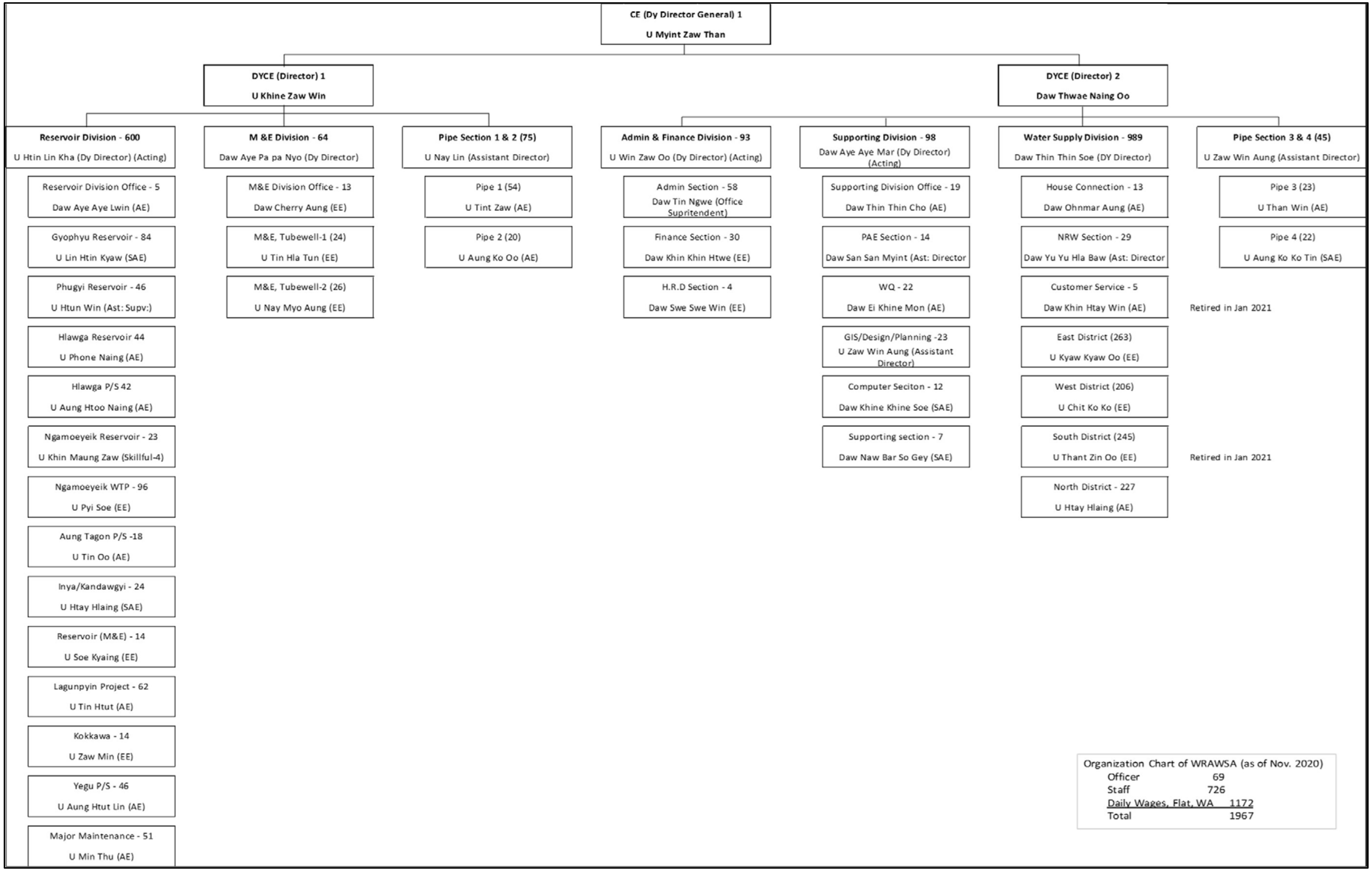


Figure 2-26: Organization chart of WRAWSA

(2) Updating “duties and responsibilities” of each section
“Duties and Responsibilities” of each office was completed for all seven Divisions and 44 Sections. Currently WRAWSA is reconsidering the organizational restructuring, so this document will also be updated after the organizational change.

(3) Setting up of Human Resource Development Section
Since WRAWSA did not have a section in charge of human resource development, a plan to divide the Administration Section into Administration Section and Human Resource Development Section (including personnel affairs) was proposed. As a section responsible for HRD related activities, HRD Sub-section was set in HRD Section. Figure 2-27 shows the original structure of Administration Section, while Figure 2-28 indicates the proposed structure of HRD Section and Administration Section after the split. The number in figures shows the assumed number of staff to be allocated.

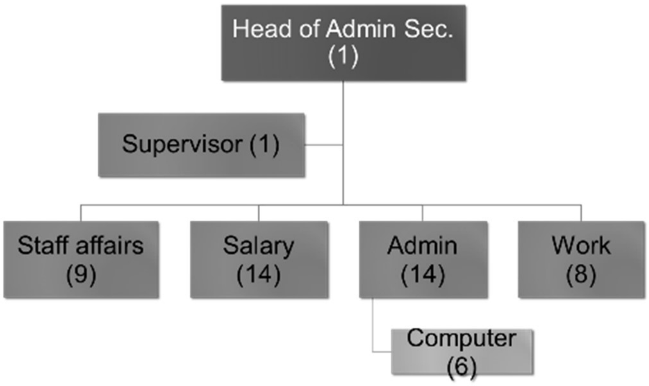


Figure 2-27: Organization structure of original Admin Section

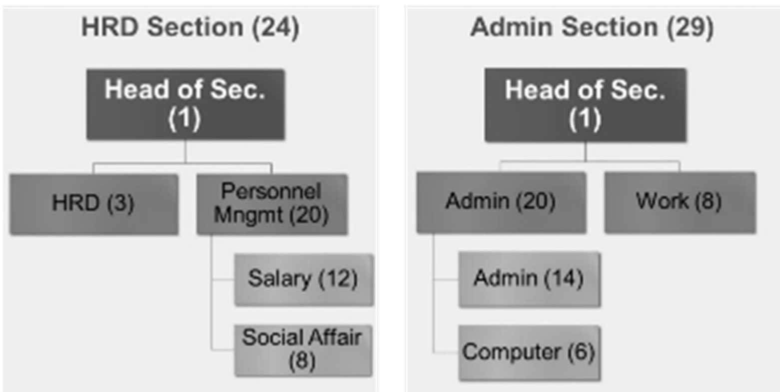


Figure 2-28: HRD Section and Administration Section after the split into two sections (proposal)

Table 2-53: Duties and responsibilities of HRD Section (Proposal)

Unit	Sub-Unit	Duties
HRD (3)	HRD (3)	a. Assess HRD needs and propose HRD measures. b. Plan, implement, evaluate and record training affairs. c. Enhance OJT activities. d. Maintain organization chart/job description updated.
Personnel Management (20)	Salary (12)	a. Prepare paying salary and make request to Budget Dep. b. Check working records of staff and reflect them to calculation of salary.
	Personnel management	a. Announce personnel transfer/promotion b. Arrange recruitment and retirement

Unit	Sub-Unit	Duties
	and Social Affair (8)	c. Execute punishment for staff d. Work for staff benefit, social welfare including accommodation.

In August 2016, with approval of the CE for HRD Section establishment, one of the seven counterparts was assigned as the head of HRD Sub Section, and four new full-time staff members (two newly hired) were placed. As a result, the training was carried out with responsibility, and the autonomy of training management dramatically increased.

At the end of the Project, the sub-section head was retained, and the other four full-time members were all transferred or left, but three full-time members were replaced. It can be said that the sub-section has been stably established as a section in charge of the HRD work in WRAWSA. The expectations of top management of WRAWSA for HRD Section are high, and opinions from officers and staff and information on HRD are easy to be collected by HRD Section. The necessary budget for training is also allocated based on the annual training plan.

As mentioned in 1-8-3, by conducting the pilot training course as regular work, HRD Section has become capable of managing training courses independently; from the preparation of a schedule to the making of draft evaluation report. In addition, they have accumulated the knowledge and deepened the understanding about HRD by discussing HRD on a daily basis with trainers, WRAWSA top management, and the Expert through the implementation of training courses and formulation of the HRD Plan.

(4) TOT to strengthen HRD implementation system through implementation of pilot training courses

In FY2016, the implementation of pilot training courses was started in the areas that were assessed as high priority. The overview of the implementation is as described in Activity 1-8-3. The top managements and officers made requests to HRD Section for training in other areas. Among them, after consulting with relevant officers, some prioritized courses were incorporated into the annual training plan and implemented, which included basic O&M pump operation course targeting pump operators, water supply overview course targeting junior engineers in T/S, and basic skill training for PC. The HRD Plan includes an implementation schedule of prioritized training courses. In the implementation of the courses by assessing from past activities of pilot training courses, HRD Section is believed to conduct them efficiently and effectively.

In addition, in order to raise the knowledge of basic water engineering technology amongst young technical staff, with the cooperation of Yangon Technological University (YTU), a series of training courses titled "basic knowledge of water engineering" including theory and practice of water supply technology were conducted.

(5) 5S, Kaizen seminars and workshop

These activities started in 2016 to improve work at the workplace by conducting a combination of a seminar inviting an external lecturer and a workshop for presenting improvement cases, so that each section or office could apply the contents of the seminar to their office for improvement. It became a mechanism to promote behavioral change, not just to raise awareness. Mutual learning of good practices through meetings presenting case studies of each section or office enhanced further efforts and improvement actions in other sections and offices. These activities were not limited to the counterpart's sections of the Project, but participants of all sections and offices in WRAWSA, which greatly contributed to activating the entire organization and empowering staff at workplaces.

Table 2-54: 5S/Kaizen activities

Activities	Main contents	Participants
1st Seminar On 30/09/2016	Lecture "5S and 7 Wastes" explained the effectiveness of continuous improvement and working place safety which can be applied in each working place.	All head of sections, T/S offices
Follow-up workshop of the 1st seminar On 27&28/10/2016	Presentations by each section on their applications of the contents of the 1st seminar. 7 sections were awarded as good practice.	All head of sections, T/S offices. 63 offices made presentations
2nd Seminar On 28/03/2017	Lecture on necessity and procedures of continuous improvement at workplace	All head of sections, T/S offices
Follow-up workshop of the 2nd seminar On 25/05/2017	Presentations by each section on their applications of the contents of the 2nd seminar. 5 sections were awarded as good practice.	All head of sections, T/S offices. 62 offices made presentations
Making check list of 5S monitoring On 12/06/2017	Discussion to make check list to be used in each workplace for monitoring of continuous 5S activities. Planning Section plays a key role to compile and direct all sections to apply it.	14 staff were assigned to work, who were selected from good practice offices of 5S activities.
Workshop to present cases of PC utilization On 30/08/2017	Presentation by each section on their improvement by PC utilization. Although there was a big gap in the progress of the improvement, good practices and ways to improve were shared.	52 offices made presentations. All presentations include some improvement actions
3rd Seminar On 11/09/2017	Following 5S practice patrol by external lecturer in Tarmwe T/S, lecture reviewed the application of 5S in WRAWSA. Lecture on "Cause and Effect Analysis, -fish-bone analysis", and group work to do the analysis.	All head of sections, T/S offices
4th Seminar and 5S patrol 19/01/2018	Based on the results of fish-bone analysis in each office, discuss what to take action to improve by group work. Each division compile the opinions of following sections.	All head of sections, T/S offices ACEs and District Officers presented their results of discussions.

(6) Measures to retain younger staff

In the course of discussion to formulate the HRD plan, the measures to prevent younger staff from leaving their jobs was confirmed as one of the most important issues for the sustainable development of the organization. This point was also emphasized in the terminal evaluation conducted in January 2020, in which it was suggested that the immediate measures should be implemented with priority.

There are two major approaches that can be taken to prevent the turnover of capable young staff: improving personnel treatment including salaries and promotion systems and improving support for young staff in their workplaces. There is no doubt that the former approach is highly necessary and would have immediate effect, but the personnel regulations of national civil servants and the personnel policies of the Yangon Regional Government had a strong influence on the approach. To realize this approach, it is necessary to explain the necessity of the reform continuously to the higher level. The measure that can be taken in WRAWSA is to implement priority activities to promote OJT which strengthen support for young staff in the workplace.

First, senior OJT instructors were appointed in May 2019 as listed in Table 2-55. They are mainly the C/P for HRD, or supportive members of training courses and HRD activities, and are expected to play a central role in promoting OJT in entire WRAWSA. By February 2020, those senior OJT instructors were invited to a series of TOT workshops so that they could discuss OJT issues in WRAWSA, visualize their own OJT experience, and exchange opinions on how to persuade younger managers to promote OJT. Based on the discussions here, HRD Section compiled the OJT Handbook. In the future, senior instructors will deliver OJT promotion workshop for younger managers using this handbook, by which OJT in each workplace is expected to be enhanced.

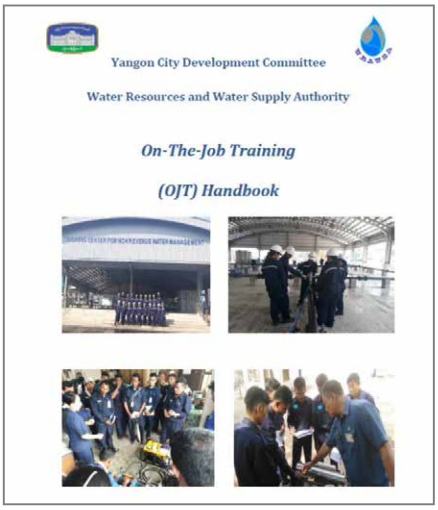
Table 2-55: List of senior OJT instructors

No.	Name	Position	Office
1.	U Kyaw Kyaw Oo	EE	East District
2.	U Nay Lin	EE	Transmission Pipe Maintenance
3.	Daw Yu Yu Hla Baw	EE	Design Section, NRW
4.	Daw Su Nandar Lin	AE	Design Section
5.	Daw Mar Mar Aye	AE	Deputy District Officer (East)
6.	Daw Ni Mar Zin	AE	Tarmwe Township
7.	U Zayyar Htun	AE	M & E
8.	U Zaw Win Aung	AE	GIS Section
9.	Daw Ohmar Aung	AE	House Connection Section
10.	Daw Khin Zin Mar Myint	AE	HRD Section

Lectures in workshop

Group discussion

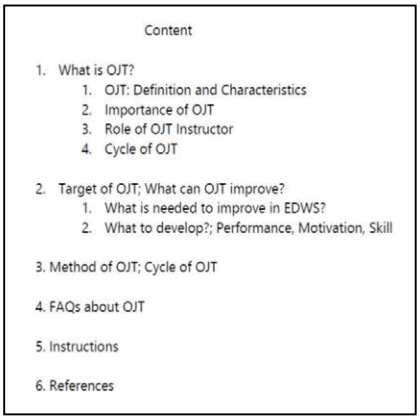
Photo 2-29: Senior OJT instructor workshop


Yangon City Development Committee

Water Resources and Water Supply Authority

On-The-Job Training

(OJT) Handbook


Content

1. What is OJT?
    1. OJT: Definition and Characteristics
    2. Importance of OJT
    3. Role of OJT Instructor
    4. Cycle of OJT
2. Target of OJT; What can OJT improve?
    1. What is needed to improve in EDWS?
    2. What to develop?; Performance, Motivation, Skill

3. Method of OJT; Cycle of OJT

4. FAQs about OJT

5. Instructions

6. References

Photo 2-30: OJT handbook, cover page (left), and table of contents (right)

1-9 Developing and Supporting Implementation of the Institutional Management Plans

1-9-1 Developing 5-year and 10-year Institutional Management Plans

(1) Necessity of development of mid-term management plan

In the 3rd JCC, the Expert proposed preparation of overall plans, and WRAWSA agreed to develop a mid-term management plan and an annual plan. The visions and missions, and the M/P as a long-term plan were already developed; hence, it was necessary to develop a mid-term management plan and an annual plan to translate a roadmap of the M/P into practice.

(2) Contents of a mid-term management plan
It was decided to include the following elements in the contents of a mid-term management plan:

Table of Contents for Mid-term management Plan

1. Mission and vision, long-term plan of WRAWSA
2. Current status of water service
3. Improvement plan
   (1) Mid-term policy and the priority areas of WRAWSA
   (2) Challenges of implementation of mid-term management plan
   (3) Targets of mid-term management plan
4. Major activities in the mid-term (FY2018/19-2020/21)
5. Financial projection in the mid-term

In Chapter 1, the mission, vision and M/P, which was already developed, and the ideal future images shared with the C/P in the Project are described. In Chapter 2, current water service situation was grasped based on PIs data as much as possible. In Chapter 3, the mid-term management plan indicates the direction of improvement activities and plan. In Chapter 4, the major activities in each activity area are described. In Chapter 5, financial projection for the mid-term was carried out.

(3) Planning cycle of a mid-term plan
The planning cycle of a national development plan is for 5 years; thus, the planning cycle of a mid-term plan also adopted this target period. The target period of the latest National Development Plan was between FY2016/17 -FY2020/21. Hence, it was proposed by the Expert that the target period of the 1st mid-term plan shall be for 3 years between FY2018/19 -FY2020/21, and that the 2nd mid-term plan be for 5 years in accordance with the planning cycle of national development plan.

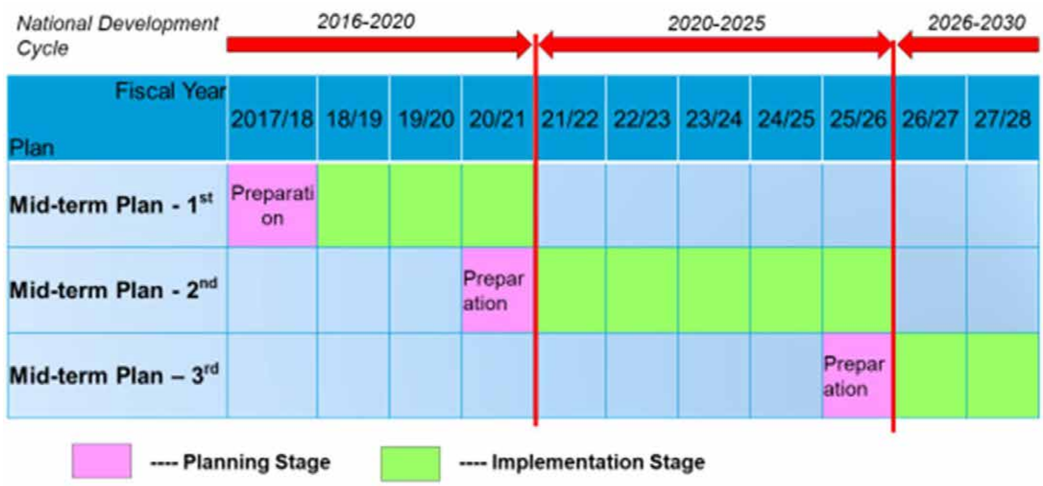


Figure 2-29: Development cycle of mid-term management plan

(4) Development process of mid-term plan
The development process of mid-term plan is shown in Figure 2-30. Planning Section requests the relevant sections to make a proposal of the mid-term plan for three years. Each relevant section prepares an activity list with priority numbers and its costs and submits to Planning Section. Planning Section estimates the budget amount for three years together with Finance Section. Planning Section makes a

screening for activities by considering budget limitations and priority. After coordination with the top management of WRAWSA, the activities and the items, to which the budget would be provided, are selected for implementation, and finalized. The plan shall be approved by S/C, and the Mid-term Management Plan (MTP) would be officially issued. The development process of MTP is shown in the table below.

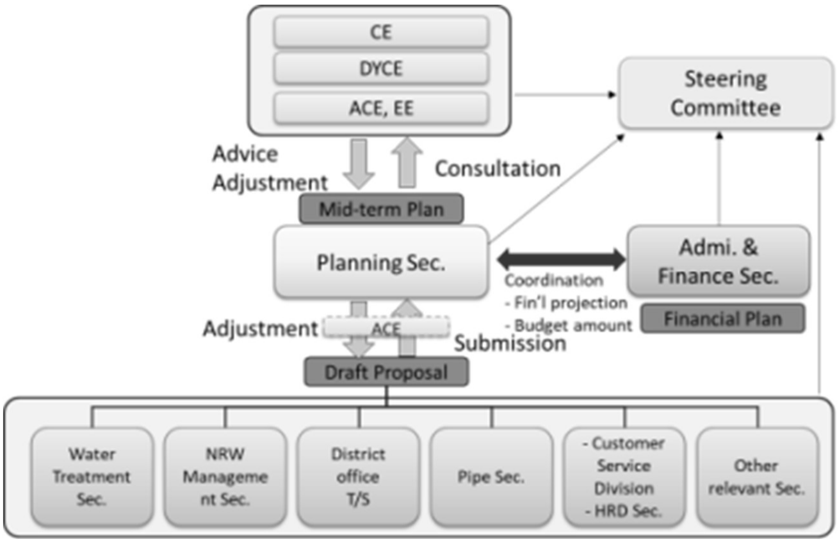


Figure 2-30: Development process of mid-term plans

(5) Development schedule
The cycle of fiscal year of Myanmar was changed in FY 2017. The previous cycle of fiscal year was from April to March, but the new cycle was from October to September. In accordance with this change, the Union Government determined that the period between April and September in 2018 was a transition period as temporal fiscal year. Therefore, the development schedule of Mid-term Management Plan was adjusted to this shift. The first year of Mid-term Management Plan started from October 2018 and the target period of Mid-term Management Plan was for October 2018 /19– September 2020/21. The deadline of preparation of the plan was fixed at the end of September 2018 and the preparation activity was done together with the C/P.

(6) Preparation of the draft proposal of Mid-term Management Plan by each section and T/S
In the process of development of Mid-term Management Plan, Planning Section requested the relevant sections and T/S to prepare and submit the draft proposal of Mid-term Management Plan. Planning Section distributed the format in advance and requested it to be filled by entering the necessary information such as activity, priority order, budget, staffing, and so on. The Expert carried out the training for the C/P in Planning Section in June and September 2018. The C/P checked the proposal and arranged the proposed activities in the list and categorized them into the following areas.

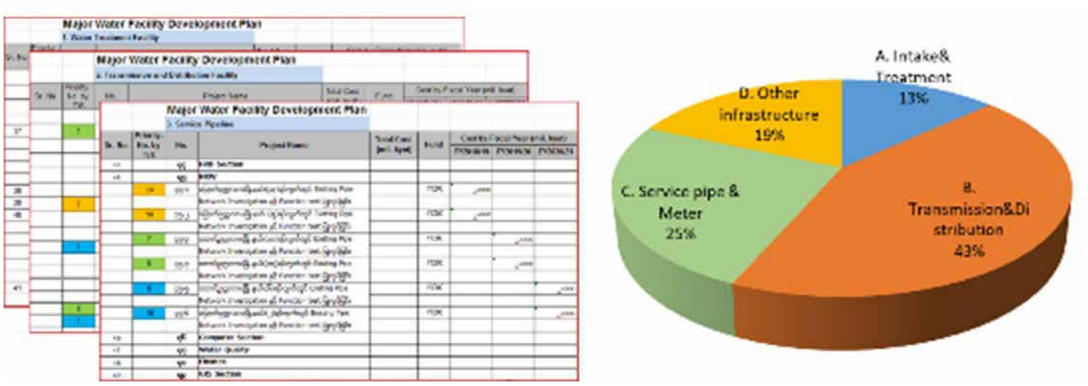
Table 2-56: Categorization of activities

Category by Mid-term policy

1	NRW Reduction
2	Rehabilitation/ Replacement of Distribution and Service Pipe
3	Development of Regulation, Standards, Guideline, Manual
4	Enhancement of Customer Service
5	Consideration on Increase of Water Tariff and Revision of Tariff Structure
6	Reduction of FOC/ Illegal connection
7	Water Resource Conservation
8	Enhancement of Chlorination for Drinkable Water
9	Enhancement of Human Resource Development
10	Improvement of Water Treatment Technology
11	Rearrangement of Organization Structure
12	Development of Water Supply Facilities (WTP, Pipeline, Service connection)

Category by activity type

A	Intake and Treatment Facilities
B	Transmission and Distribution Facilities
C	Service Pipe and Water Meter Facilities
D	Others



Proposed activities by each section   Categorization of proposed activities

Figure 2-31: Activity plan of Mid-term Management Plan

(7) Setting budget amount

Budget amount for mid-term was set up together with the C/P of Planning Section and Finance Section based on financial information from Financial Section. In setting, the estimation was made both for 1) operating expenditure and 2) capital expenditure according to current accounting system of WRAWSA.

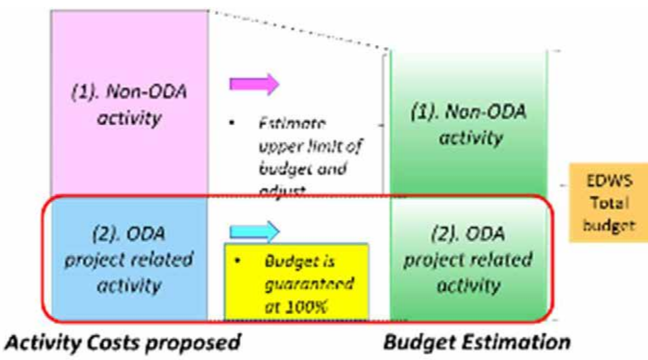


Figure 2-32: Concept of budget estimation

Operating expenditure for three years was estimated by considering the past executed budget amount, its increase ratio and new costs to be incurred. Regarding capital expenditure, the past executed budget was categorized into two: 1) Expenditure for ODA projects, 2) Expenditure for Non-ODA projects. Expenditure for ODA projects was assumed to be fully accounted for the budget up to 100%. It was relatively possible to know the accurate expenditure according to Yen-loan project plan to some extent. Capital expenditure related to YCDC activity was estimated by considering the past executed budget amount, its increase ratio and new costs to be incurred. The new costs were mainly construction costs for YCDC portion of the Yen-loan project and operating costs such as staffing costs, chemical costs, and electricity costs of a partial starting of Lagunbyin WTP operation.

(8) Training on water demand projection

Water demand in the area responsible for WRAWSA needs to be projected and the balance between demand and supply capacity of existing facilities and new water facility development needs to be checked in the process of development of Mid-term Management Plan. The training was carried out for the C/P in Planning Section. The outline of the training is shown below.

Table 2-57: Outline of training on water demand projection

Date	Trainees	Number of trainees	Outline
2nd – 4th Apr. 2018	Planning Sec. C/P	16 persons	**Purpose** 1) Understand the estimation flowchart for water demand projection, 2) Confirm water demand by re-estimation based on the existing information and data, 3) Check the supply-demand balance by comparing the demand with the supply amount calculated by water facility development plan, 4) the results would be reflected on strategic development of Mid-term Plan **Activity** After formulation of “M/P of Development of Water Supply System (JICA 2012)”, population projections of Greater Yangon area were updated. Based on the latest information of population projection, population served was re-estimated by T/S-base. Concretely, the revision had been made using the following reports: 1) National Census for Household (Union Government: 2014), 2) Data Collection Survey on urban planning of Greater Yangon (JICA 2017). Population served and coverage ratio were re-estimated based on the above sources and difference was confirmed with the M/P.
14th - 15th Jun. 2018	Planning Sec. C/P	9 persons	**Activity** Continuous training from April. 1) Estimation of population served and difference between M/P and Data Collection Survey were confirmed based on population projection of (1) National Census Survey by the Union Government (2014), (2) Data Collection Survey on Urban Development Planning in the Greater Yangon. Then, overall water demand was estimated with estimation flow based on water consumption per capita as a basic unit. The result was compared with the one in M/P.
30th – 31st Jul. 2018	Planning Sec. C/P	10 persons	**Activity** Water resource volume which WRAWSA can supply was updated from the volume in M/P. The estimated volume for mid-term was compared with the volume calculated in the training of April and June. The practical training of development of chart was carried out by indicating two different data in one chart based on the estimated water resource volume and water demand amount.

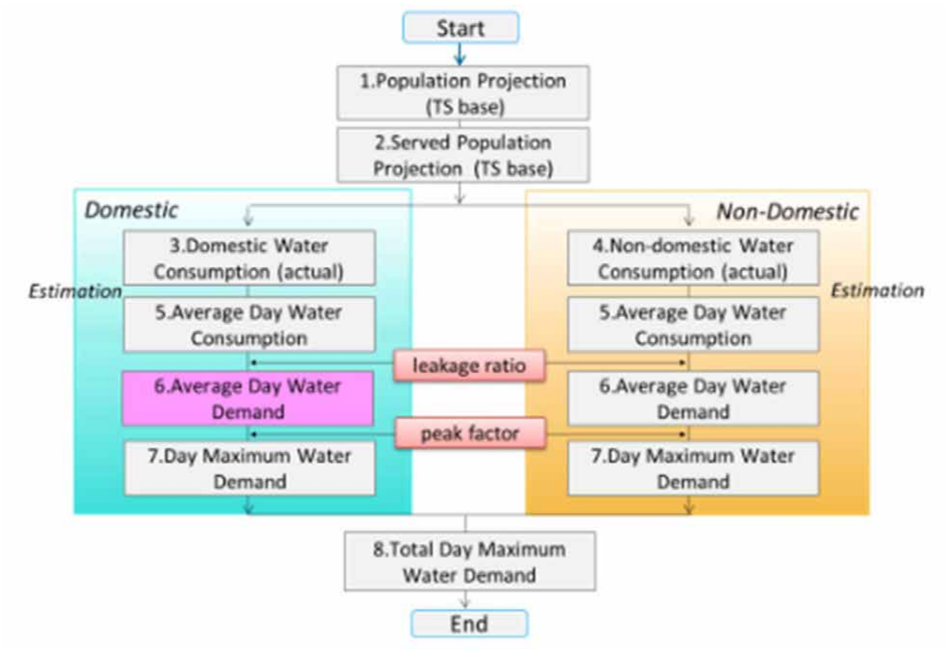
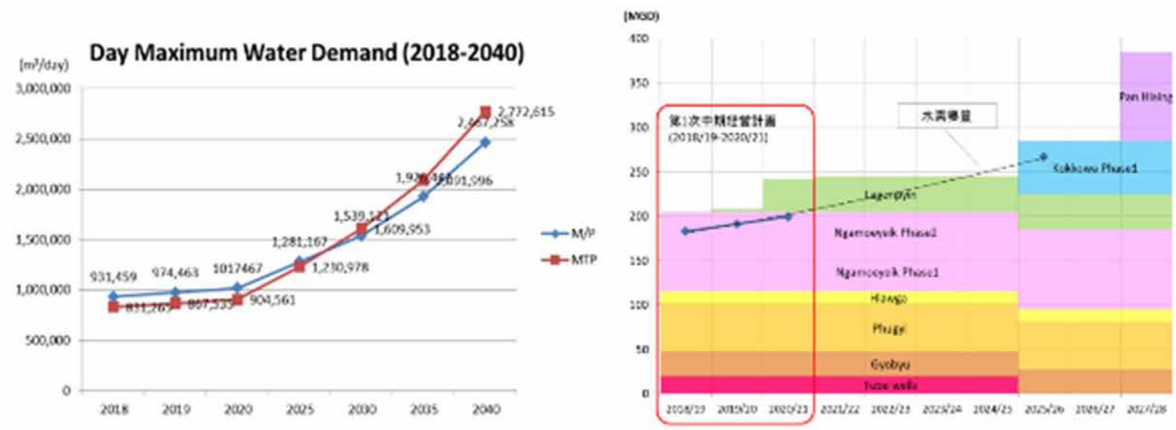


Figure 2-33: Calculation of water demand projection



Day maximum water demand (M/P, MTP)

Water resource volume and water demand volume

Figure 2-34: Water demand and supply plan

Photo 2-31: Training on water demand projection 1

Photo 2-32: Training on water demand projection 2

(9) Screening and selection of activities in Mid-term Management Plan

The screening and the selection of activities were carried out in accordance with the following policies. 1) Consistency with achievement of M/P targets, 2) Consistency with Mid-term Policy, 3) ODA related activity, and 4) Urgency and Importance. The C/P in Planning Section firstly made the screening and the selection of activities by following the policies. Afterwards, the Expert and the C/P in Planning Section had a meeting with the top management of WRAWSA based on the draft activity proposal. The selection started in the activities of FY2018/19, as the first year. Consideration was given not to exceed the budget ceiling of each fiscal year.

Total amount of capital expenditure proposed by the relevant sections accounted for 1.5 times more than the budget ceiling, so all activities of the first year proposed by the sections were not necessarily selected. Some activities were either shifted to the second year or later or not included as the target activity in the mid-term. The selection flow of activities is shown as below.

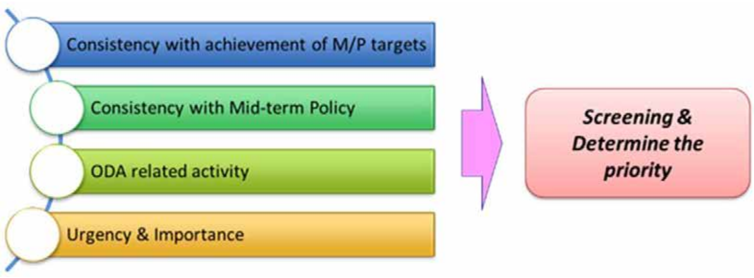


Figure 2-35: Selection policy of activities

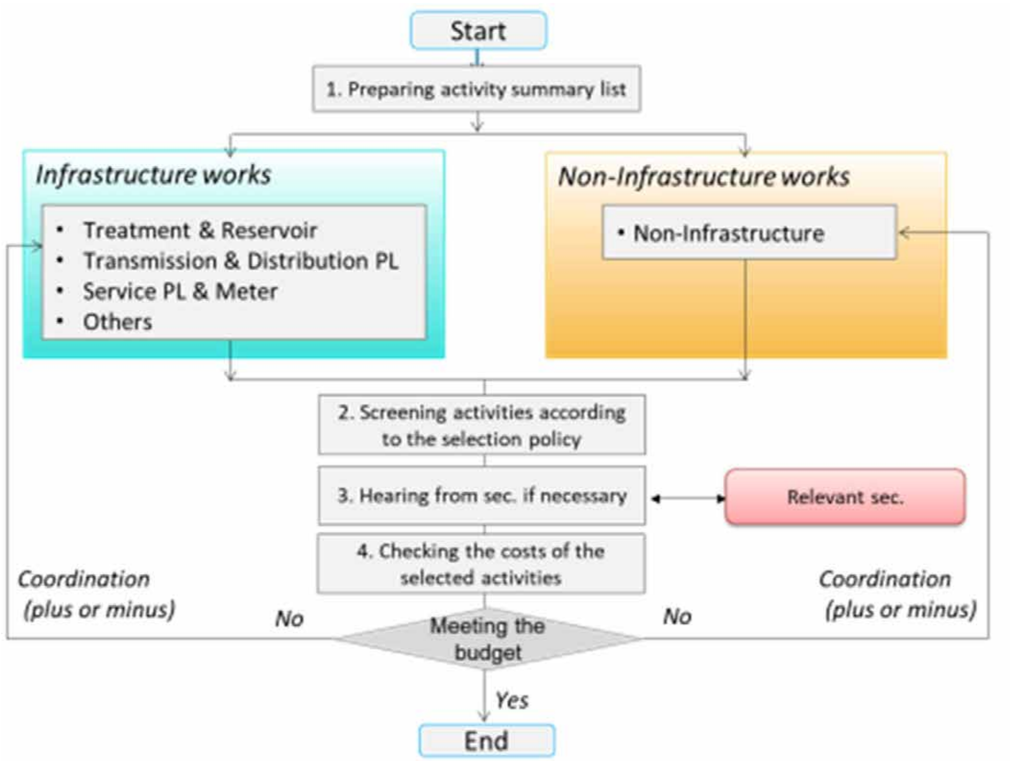


Figure 2-36: Selection flow of activity for Mid-term Management Plan

(10) Approval of Mid-term Management Plan and dissemination to staff members

The Mid-term Management Plan was eventually approved by the CE on 5th October 2018 through a series of presentations and discussions at the 1st to 6th meetings of S/C. The 6th JCC with the theme of "Finalization of Mid-term Management Plan of WRAWSA" was held on 10th October 2018. In the JCC, the C/P in Planning Section made a presentation on the outline and the participants had a discussion. This JCC contributed to disseminating the outline of Mid-term Management Plan to the staff members in the main offices of WRAWSA. Afterwards, the main book with approximately 150 copies both in English and in Burmese, and the booklet with 300 copies in Burmese were printed out.

In addition, the seminar on Mid-term Management Plan targeting T/S and district offices was held on 28th January 2019. In the seminar, the C/P in Planning Section and the Expert explained the contents again to deepen the understanding of T/S and district officers on the plan, who had less opportunities to participate in the planning process. In the presentation, the C/P and the Expert put importance especially on the activities and the PIs which was related to their regular works in the offices. Also, the Expert emphasized that WRAWSA could not only deepen the understanding of the staff but also can be accountable by appealing to the citizen that they are operating the utility based on the plan. It could contribute to increase of their accountability to the citizen. Furthermore, the Expert encouraged the participants to distribute the main book and the booklet and shared the contents with the staff who could not attend the seminar.

Photo 2-33: Main book and booklet of Mid-term Management Plan

Photo 2-34: Seminar on Mid-term Management Plan

1-9-2 Launch priority activities as a part of implementing the 5-year institutional management plan

The mid-term period was commenced in October 2018, and WRAWSA started the priority activities gradually. As of March 2021, the first year (FY2018/19) and the second year (FY2019/20) of MTP were finished. Currently, the activities of the third year of MTP are underway. The following project activities were carried out based on the activity of the first year of MTP.

(1) Calculation of MKPIs for the 1st year (FY2018/19)

The first step for monitoring was to enhance calculation of the actual indicator values of MKPIs to confirm the performance of WRAWSA in the 1st year of FY2018/19. The work on data collection, confirmation, and modification of PIs data of MKPIs were carried out from October 2019 to April 2020. Also, the PIs data for MKPIs for FY2018/19 was compared with that for FY2016/17 together with the C/P. The comparison table of MKPIs between FY2016/17 and 2018/19 is shown in the table below.

Table 2-58: Comparison table of MKPIs (FY2016/17, FY2018/19) in Mid-term Management Plan

Sq./N	Symbol	Indicators	Unit	FY2016/17 (actual)	FY2018/19 (actual)
1. Water Supply Service					
1	S1	Service population	'000 inhabitants	1,392	1,928
2	S2	Total connections	Nb.	327,285	342,364
3	S28	Service coverage rate	%	30.1	42.4
2. Production & Transmission					
4	PT4-4	Daily average total production	m^3/day	761,255	795,909
3. Distribution & NRW					
5	D17	NRW	%	—	63.0
6	D23	The number of repaired pipe breaks per pipe length	Repaired Nb./km/year	0.28	0.32

Sq./N	Symbol	Indicators	Unit	FY2016/17 (actual)	FY2018/19 (actual)
4. Water Quality					
7	Q7-1-1	Compliance ratio of monthly water test in water facilities (turbidity)	%	69.0	72.0
8	Q7-5-2	Compliance ratio of monthly water test at tap water in T/S (Residual chlorine)	%	—	—
5. Sales & Collection					
9	C15-3	Operating metering ratio (by total connection)	%	—	74.0
10	C20-2	Collection ratio in amount	%	72.7	100.7
6. Finance					
11	F5	Operating ratio (Operating cost coverage)	%	63.7	68.1
12	F9	Average revenue per m^3 sold	Kyat/m^3 water sold	98	153
13	F12	Unit operational cost for water sold	Kyat/m^3 water sold	173	225
7. Administration & Human Resource					
14	H8	Training period*number of trainee/Total staff	Person*day	2.9	1.4
15	H11	Total staff number/1000 connections	Person/1000 conn.	7.4	6.3

Source: PIs Datasheet of WRAWSA

(2) Monitoring Results of MKPIs

MTP set up the monitoring targets of each fiscal year for three years. After April 2021, the Expert and the C/P of Planning Section compared the actual and the target values for the 1st year (FY2018/19). The training on monitoring the performance was carried out by the C/P. In October 2020, re-confirmation of the collected data and modifications were completed, and the Expert provided guidance on final estimation of MKPIs to the C/P and made a comparison together with the C/P.

In MTP, sixteen (16) indicators were selected as the monitoring indicators and the targets were set up. Out of 16 indicators, there are no target values for coverage ratio and NRW ratio due to a lack of reliable data at that time. 12 out of 16 monitoring indicators, were the same indicators as MKPIs. 4 non-MKPIs were additionally adopted as the monitoring indicators.

With regard to the results of the monitoring indicators, the actual value of overall number of the staff members and total connection numbers were below the target values. The actual performance of unit operational costs was mostly same as the target value, while good performances exceeding the target values were seen in the indicators of collection ratio, average tariff revenue, operating cost coverage ratio and pipe length (new/replacement).

The indicators of pipe length for new installation and repair/replacement largely achieved the target value. It was remarkable that the collection ratio had been improved. This improvement could be considered as the effect that the CE acknowledged the importance and request the T/S for thorough revenue collection proactively. The reason why the collection ratio was more than 100% is that the collections included the collection of outstanding amounts of the previous year.

The second year in MTP was also completed, and the C/P arranged the collected data and started carrying out data checking. However, the activities with the C/P are suspended due to the political instability in Myanmar.

Table 2-59: Comparison of targets and actuals in Mid-term Management Plan

Symbol	Indicators	Unit	FY2016/17 (Actual)	FY2018/19 (Actual)	FY2018/19 MTP Targets
S2	Total connections	Nb.	327,285	342,364	345,232
S28	Service coverage rate	%	30.1	42.4	No setting
D17	NRW ratio	%		63.0	No setting
Q7-1-1	Compliance ratio of monthly water test in water facilities -treated water- (turbidity)	%	69.0	89.2	74.0
C20-2	Collection ratio in amount	%	72.7	101.6	75.4
F5	Operating ratio (Operating cost coverage)	%	63.7	68.1	53.8
F9	Average revenue per m^3 sold	Kyat/m^3 water sold	98	132	103
F12	Unit operational cost for water sold	Kyat/m^3 water sold	173	194	192
H8	Training period*number of trainee/Total staff	Person*day	2.9	1.4	1.39
H11	Total staffs number/1000 connections	person/ 000 conn.	7.4	6.9	6.0
MTP Monitoring Indicators of Non-MKPIs					
PT1	Resource Capacity	MGD		205	205
		m^3/day		932,000	932,000
C19-1	Water Volume Sold	Mil m^3/year		112	116
D2-7	New Pipeline Extension	km		237	158
	Pipe Rehabilitation/Replacement	km		94	83
H2	Total Staff Number	km		2,172	2,244

Source: WRAWSA PIs Datasheet

1-10 Conduct support activities in response to the COVID-19 emergency

Due to the COVID-19 pandemic, the Project was continued remotely from Japan after April 2020. The following activities were carried out as domestic operations.

No.	Output	Additional Activity
1	1	Preparation of Materials of Management of Water Utility in YCDC (Annex CD8)
2	1	Preparation of PPP materials (Annex CD9)
3	1	Preparation of Future Vision of Customer Service Section (Draft) (Annex 3.E)
4	1	Preparation of Materials for Public Relations Activities (Annex CD7)
5	Overall	Preparation of Technical Handouts by the Advisory Committee (Annex CD10)
6	Overall	Preparation of Records of Project Activities (Annex CD11)
7	1	Preparation of Guidebook for Water Tariff Setting in YCDC (Annex 2.B)
8	1	Assistance to improvement and implementation of Water Supply Regulation (Draft)
9	1	Assistance to implementation of Future Vision of Customer Service Section (Draft)
10	1	Continued public awareness activities including the COVID-19 during the extended period
11	2	Preparation of Training Materials for NRW Management (On-Line Training) (Annex CD2)
12	3	Continued guidance of operation of new chlorination facilities
13	3	Continued guidance of operation of Lagunbyin WTP
14	3	Preparation of a paper for an academic society (water quality management)
15	Overall	Continued remote meetings and preparation of monthly reports
16	Overall	Continued guidance to deepening of each activity
17	1	Assistance to JICA office's implemented public awareness activities

2.2.2. Output 2: Capacity of YCDC in NRW management is improved

2-1 Establish NRW Management Unit

2-1-1 Establish NRW Management Unit

The NRW Management Section was established according to the agreement of the 2nd JCC in August 2016, and 16 staff members were assigned including 11 full time staff members in Jan 2017.

2-1-2 Define the division of duties of NRW Management Unit (Section)

The organization chart and duties of NRW Management Section, which were agreed at the 1st JCC meeting in Term 1, are shown in Figure 2-37 and Table 2-60. However, presently NRW Management Section implements the works on pipeline planning, design and construction which are out of their duty. It is necessary to establish a work system according to their duties to make a plan and to implement their work steadily.

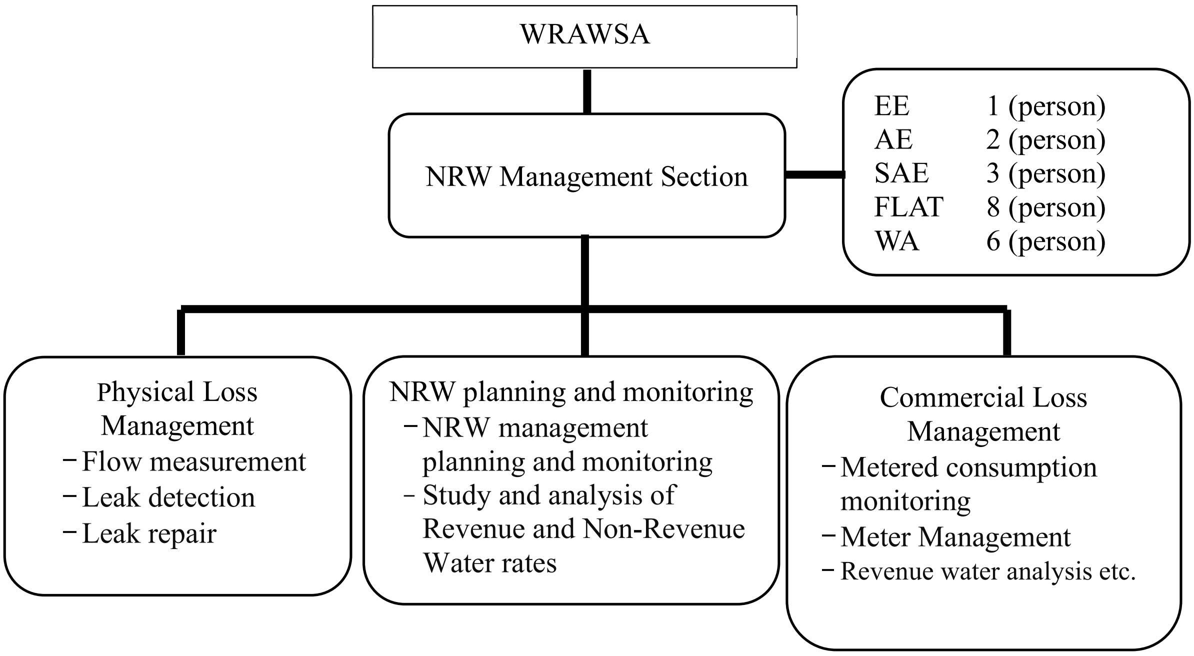


Figure 2-37: Organization chart of NRW Management Section

Table 2-60: Define the division of duties of NRW Management Section

Section	Team	Duties
NRW Planning and Monitoring		● Study and analysis of Revenue & NRW rates －To study and analyze "Effective billed consumption", "Effective unbilled consumption", and "Ineffective water" etc. ● Planning of specific survey and study for NRW management ● Formulation of NRW management plan and monitoring the progress of the plan －To formulate 5 year/10 years NRW management plan and monitor the progress of plan, and if required revise the plan.
Commercial Loss		● Checking and studying on the causes of inaccurate monthly meter reading data and guidance for collection of customer movement. －To check the accuracy of the data of meter reading of T/S with T/S staff, prescribe and perform corrective actions. ● Study of water charge collection rate of each T/S －To check the water charge collection rate and the reason of nonpayment through the monthly meter reading data. Study and give guidance on how

Section	Team	Duties
		to collect the water charge, etc. ● Analysis of water meter conditions and reporting. Guide T/S staff members based on the analysis. ● Quarterly Analysis of revenue water on the basis of monthly meter reading －To analyze Revenue & NRW from the data of monthly meter readings and leakage volume, report the outcome quarterly, and provide the results to NRW Planning and Monitoring Section.
Physical Loss Management (Leakage)	Flow measurement	● Water flow measurement of main distribution system －To measure water flow (by Ultrasonic flow meter) at fixed points periodically by main water distribution system in the city. －To analyze the water balance between the water supply and demand, and to provide information to "NRW Planning and Monitoring Section". ● Establishment of "Model district for water flow measurement" －To measure water flow and leakage and the change of water flow volume resulting from leakage repair etc. －To collect and analyze the information above to estimate NRW rate in other areas.
	Leak detection	● Leakage patrol and detection －To formulate an annual leakage detection plan. －To perform a training for detecting leakage visually in the daytime and by using detector in the nighttime in the training yard and the field.
	Leak repair	● Instruction of leakage repair and inspection on site －To instruct T/S to repair the leakage detected and inspect the repairing work according to guidelines prepared. ● Leakage repairing －To repair leakage as needed, and to report the water leak volume to "NRW Planning and Monitoring Section". ● Provide materials and equipment for leakage repair －To keep the tools and equipment for leakage repair and provide them as needed.

2-2 Collect and compile information of NRW

2-2-1 Collect information on NRW and implement a baseline survey

(1) T/S survey

Out of 33 T/S offices, 31 offices, which are directly managed by YCDC, were surveyed to grasp water supply situation in Yangon city. Before conducting this survey, questionnaire as shown in Table 2-61 was prepared for the C/P who joined and understood the survey. Survey items are shown below.

- Coverage of water supply
- Duration of daily water supply
- Distribution system
- Pipe laying situation
- Management system of leakage repair, etc.
- Meter reading system
- Water user situation by water tariff, etc.

T/S survey was carried out for a total of three times. The survey team composed of the Expert and the C/P could not grasp actual issues in the first survey due to T/S office’s cautiousness on the survey. However, the more we visited T/S office, the more it became clear that there were many issues such as technical issues (lack of equipment and skills), and improper meter reading. The survey team proposed improvement measures such that equipment for leak repair should be prepared in all T/S offices and meter reading shall be done every two months. The baseline (water supply situation and technical issues), which were found in the survey, and countermeasures in the Project are shown in Table 2-62.

Table 2-61: Questionnaire for T/S survey

Township office survey of WRAWSA

Author	Akanuma

Township	K y a u t a d a	Interviewee	Pan Yee Phyu Ray Kyae	M	F
Population	29, 796	Investigation Date	21/9/2015 AM／PM 14：00～15：30		
lumber of household	6, 109	※Population and number of households are based on 2014 Myanmar census.			
Number of water supply units※a	7, 506	he amount of fee collect	Total amount of Revenue water	t of non re	Total
er of units colle	6, 738	18, 181, 564Kyat/月	115, 826. 0m^3／月	760m^3／M	16, 586m^3/M

Service coverage	Average water usage	Collection rate
%	41.3m^3/Unit·M	89.80%

	akdown of Water sup		Fee Category	e of collected by usage&amount			Amount of water	ater usage ra
	collected	ncollecte		ount collect	enue rate	m^3／M	m^3／M	%
domestic	2, 073		88K/m^3× m^3+ 100K	3, 277, 614	18. 0	34, 890. 0		29.9
domestic	3, 935		flat rate 1, 800K/M	7, 083, 000	39. 0			
domestic	0		flat rate 3, 000K/M					
commercial	646		110K/m^3× m^3+ 100K	3, 083, 400	17. 0	27, 444. 0		23.5
foreigner	0		440K/m^3× m^3+1000K					
hotel	18		880K/m^3× m^3+1000K	3, 714, 000	20. 4	42, 184. 0		36.2
school	7		88K/m^3× m^3+ 100K					
hospital	1		88K/m^3× m^3+ 100K	914, 020	5. 0	10, 315. 0		8.8
Government	55		88K/m^3× m^3+ 100K					
Government	3		110K/m^3× m^3+ 100K	109, 530	0. 6	993. 0		0.9
Government	0		Flat rate 1, 800K/M					
staff	0		88K/m^3× m^3+ 100K					
army	0		88K/m^3× m^3+ 100K					
army	0		flat rate／Residents					
pagoda	0		88K/m^3× m^3+ 100K					
pagoda	0	33	Meter installed Max 40mm,				760. 0	0.7
V I P	0	0						
public tan	0	0						
absence	0	717	Meter installed 630 units.					
Total	6, 738	750	2, 230 units are under inve	18, 181, 564	100. 0	115, 826. 0	760. 0	100.0

※a；The number of houses supplied with water includes those with long-term absenteeism for which an outl

※ ；The average water usage is calculated as follows: The amount of water revenue / (number of units co

※ ；The collection rate is caliculated as follows: (number of units collected / number of water supply

Collecting Method	Using both method: meter reading at the end of the month and collection by the 7th end of the month for the current month and the previous month'			
	number of meter rea	6		
Distribution system	HLAWGA Distribution System		ater Pressu	0.009Mpa
	Shwedagon reserver Distributi			0.009Mpa
dwater sumpling fa	7 points	12″× point	unt of wate	
		10″× point		
		8″× 3 point		5,000G/D
		6″× 4 point		3,500G/D
		4″× point		
		3″× point		
		2″× point		
	Pump	AM 7:00～ AM 12:00， PM 3:00～PM 7:00		
	perating tin	AM 00:00～ AM 00:00， PM 00:00～PM 00:00		
	Total	9. 0 H	er source r	25.59%
			計	29,637m^3/M
Water supply time	24 H			
	AM 00:00～ AM 00:00， PM 00:00～PM 00:0		0. 0 H	
	AM 00:00～ AM 00:00， PM 00:00～PM 00:0			
	Although it's a 24-hour water supply area, water is not available			

temce of repair rec	Y · N	r of repair	2 ／M
Recording method	YCDC format	mission to Bureau Headquar	
	Original	Y · N	
How to repair a w	Constructo YCDC	per of emplo	専・兼 1 名
supply installation	Material Customers buy		
for repairing moun	There is no rule that YCDC is responsible for repairing w		
Number of meter replacement	2 ／M		

Other special notes

- ☞ Groundwater quality tests are conducted twice a year, and the quality is good.
- ☞ There is a lot of CIP buried in the district and the depth of the pipe burial is about 3 feet.
- ☞ There are no housing locations in the district.
- ☞ In the district, the number of water supply units exceeds the number of residential households due to the large number of tenants such a

Table 2-62: Issues found by T/S survey and countermeasures

Survey item	Baseline	Countermeasures	(Reference)
Water supply situation	• Low water pressure • Intermittent water supply • Broken/dirty meter	• Appropriate pipe diameter calculation based on hydraulic analysis • Damaged/dirty meter survey	• 2-3-2 • 2-4-1(2)
Technical issues	• Frequent leakage occurrence due to inappropriate pipe jointing. • Inappropriate leakage repair • Spaghetti pipes	• OJT through pilot project • Training in NRW training center	• 2-3-9(6)-(14) • 2-5-6
	• Meter located where meter reader cannot read	• OJT through pilot project	• 2-4-7(1)
	• Lack of drawing skill (Low accuracy pipeline map)	• Survey and preparation of topographic map • As-built drawing	• 2-2-2(4) • 2-3-9(11)-(12)
	• Leakage information was not recorded	• Create leakage repair record format. (Record managed by NRW Management Section)	• 2-3-1(3)
	• Inappropriate meter reading	• Proposed every two months meter-reading	-
Lack of tools for repair work	• T/S did not have tools for repair work	• The Expert listed necessary tools, and WRAWSA provided tools for every T/S	-

(2) Water supply situation survey in Yangon city

a) Water supply situation was analyzed based on customer information of July 2015 and the T/S survey results. (Population data is based on Myanmar census in 2014). Then, calculations of water supply coverage ratio, collection rate and average consumption etc. were done at the time of T/S survey as shown in Table 2-63.

b) Survey of applications by customers for water supply connections, permissions, construction work, completion inspections, and procedure of application of customers for water supply was carried out. The workflow relating to service connections, results of this survey, is shown in Figure 2-38.

c) Investigations of workflow of planning, basic plan, drawing, inspection of construction cost, inspection of construction design, implementation of construction and completion inspection, and referred regulation etc. were carried out. The workflow relating to construction of distribution pipes, results of this survey, are shown in Figure 2-39.

Table 2-63: Service population by T/S

No	Town ship	Population	House hold number (A)	Water Supply number (B)	Spread [B/A]%	Collection number ©	Collected fee (Kyat)	Collection rate [C/B]%	Flat D	Use water supply (m³)	Average (m³/M) Overall	Each house	omestic water rate (%) Revenue rate	Supply rate	UN-collected facilities Pagoda	G-facilities	VIP	Tank	Absence	Total	未収水量 (m³/M)	Repair n/year	Pressure (Mpa)	Supply Time	Grand Water
1	Dagon North	203,883	42,658	12,353	29.0%	10,820	18,316,298	87.6%	0	190,890.0	17.6	16.1	87.5%	86.9%	6	4	0	0	1,523	1,533	1,676	300	0.030	24H	0%
2	Dagon East	165,518	33,943	4,198	12.4%	4,038	4,165,690	96.2%	0	42,412.0	10.5	18.4	96.2%	96.7%	0	0	0	0	160	160		60	0.020	12H	33.7%
3	Dagon South	371,579	76,899	16,132	21.0%	6,303	6,524,814	39.1%	0	64,480.0	10.23	8.7	79.6%	81.0%	5	21	0	0	9803	9,829		300	0.015	8~12H	32.6%
4	Thingangyun	209,301	43,549	16,051	36.9%	13,689	25,730,992	85.3%	0	256,383.0	18.7	18.1	76.0%	81.0%	103	6	0	0	2253	2,362		2,500	0.015	24H	3.7%
5	Dawbon	74,994	14,405	2,935	20.4%	2,074	2,560,832	70.7%	102	23,438.0	11.9	9.7	69.0%	76.7%	0	0	0	0	861	861		72	0.003	24H	%
6	Mingaladon	332,520	66,231	7,343	11.1%	6,963	51,902,514	94.8%	97	403,253.0	58.8	22.7	25.8%	35.9%	46	0	0	0	334	380		120	0.120	24H	0%
7	Northokkalapa	332,869	64,876	36,542	56.3%	33,866	60,265,818	92.7%	5,084	518,519.0	18.0	15.0	62.4%	76.6%	219	0	0	316	2141	2,676		300	0.210	24H	%
8	Southokkalapa	160,956	32,745	16,393	50.1%	13,477	24,974,060	82.2%	1,183	235,840.0	19.2	17.3	72.8%	82.2%	100	16	0	159	2641	2,916		600	0.020	24H	18%
9	Tamwe	165,348	35,268	31,226	88.5%	27,770	73,590,192	88.9%	5,518	537,784.0	24.2	21.0	56.3%	81.9%	108	1	0	0	3347	3,456		240	0.018	24H	0%
10	Mingala Taungnyunt	132,209	25,916	19,394	74.8%	16,439	63,258,754	84.8%	4250	424,317.0	34.8	25.3	39.3%	62.9%	140	1	0	0	2814	2,955		240	0.018	24H	2%
11	Pazuntaung	48,245	10,195	9,472	92.9%	8,253	19,294,972	87.1%	3,137	123,395.0	24.1	16.9	38.2%	62.9%	51	1	0	0	1167	1,219	1,296	24	0.012	24H	0%
12	Thakayta	220,447	45,394	7,665	16.9%	6,175	12,049,054	80.6%	1,670	98,980.0	22.0	17.5	51.8%	67.3%	55	1	0	47	1387	1,490		60	0.021	24H	1%
13	Shwepyitha	343,270	73,900	1,361	1.8%	1,357	9,644,086	99.7%	0	88,051.0	64.9	24.2	20.0%	16.8%	4	0	0	0	0	4		50	0.060	24H	0%
14	Insein	305,670	61,692	10,911	17.7%	8,980	35,045,499	82.3%	40	329,430.0	36.8	34.1	62.7%	73.4%	84	16	0	1	1,830	1,931		240	0.030	24H	18.5%
15	Mayangone	198,038	38,737	10,107	26.1%	9,212	66,867,346	91.1%	577	408,270.0	47.3	32.9	35.2%	63.3%	73	0	28	0	794	895		480	0.015	24H	%
16	Hline	160,018	32,751	7,735	23.6%	6,497	20,115,096	84.0%	1,051	190,576.0	35.0	24.6	55.5%	63.8%	45	0	0	0	1,193	1,238		120	0.013	24H	6.5%
17	Hlinethaya	686,827	148,695	2,642	1.8%	1,724	13,614,260	65.3%	0	117,406.0	68.1	27.6	19.0%	24.0%	51	4	0	10	853	918		180	0.003	24H	
18	Botahtaung	40,849	8,352	8,237	98.6%	5,887	18,628,810	71.5%	2,164	109,882.0	29.5	17.4	26.5%	46.7%	34	1	0	0	2,315	2,350		36	0.013	24H	2.1%
19	Kamayut	84,368	16,262	2,940	18.1%	2,293	7,209,714	78.0%	1,538	41,116.0	54.5	28.1	15.4%	30.0%	7	33	0	29	578	647		36	–	4H	%
20	Kyimyindine	111,566	23,041	1,630	7.1%	1,515	2,600,630	92.9%	743	12,178.0	15.8	14.1	34.7%	76.8%	6	4	0	0	105	115	183	60	0.060	6H	%
21	Kyauktada	29,796	6,109	7,506	122.9%	6,738	18,181,564	89.8%	3,935	115,826.0	41.3	18.8	18.0%	29.9%	33	0	0	0	717	750	760	24	0.009	24H	25.6%
22	Bahan	96,703	17,414	11,728	67.3%	9,635	51,598,558	82.2%	1,548	373,284.0	46.2	26.3	33.2%	50.0%	361	28	33	3	1,668	2,093		420	0.045	3~12H	0.03%
23	Yankin	70,992	14,617	10,503	71.9%	9,669	79,314,226	92.1%	3,304	352,013.0	55.3	30.5	18.7%	44.1%	56	3	5	0	770	834	16,065	300	0.300	24H	%
24	Dagon	25,563	4,610	2,571	55.8%	1,927	11,886,638	75.0%	842	47,887.0	44.1	29.9	19.9%	47.3%	34	3	0	0	538	575	6,798	24	–	24H	71.1%
25	Sangchaung	99,772	20,753	3,519	17.0%	2,887	6,802,000	82.0%	1,765	37,030.0	33.0	29.4	34.1%	61.1%	48	0	0	20	406	474	4,501	145	0.007	2~7H	%
26	Ahlon	55,412	10,993	2,639	24.0%	2,300	6,107,376	87.2%	1,111	38,564.0	32.4	21.3	34.2%	58.4%	7	0	0	0	332	339		24	0.010	8H	2%
27	Lanmadaw	47,123	8,639	7,137	82.6%	6,124	14,536,510	85.8%	2,979	74,777.0	23.8	17.2	28.6%	59.2%	28	3	0	0	751	782	103	120	0.007	1H	3%
28	Latha	24,926	4,470	6,184	138.3%	4,983	11,006,416	80.6%	2,417	53,407.0	20.8	15.0	25.1%	54.4%	23	5	0	0	1,541	1,569	144	30	0.003	24H	71.4%
29	Pabendan	33,264	6,564	8,001	121.9%	7,940	17,129,702	99.2%	3,735	88,401.0	21.0	18.2	26.7%	53.6%	60	1	0	0	873	934	3,006	60	0.006	24H	57.5%
30	Dala	173,376	37,905	3,916	10.3%	3,709	5,239,236	94.7%	0	54,308.0	14.6	14.0	89.3%	88.5%	24	1	0	25	182	232	1,271	360	0.015	6H	100%
31	Seikkan	2,815	412	0	0.0%	0	0	0.0%	0	0.0	0	0.0	0	0	0	0	0	0	0	0		0			%
32	Seikkyi/khana	33,978	7,727	0	0.0%	0	0	0.0%	0	0.0	0	0.0	0	0	0	0	0	0	0	0		0			0%
33	Dagon Seikkan	167,346	37,887	0	0.0%	0	0	0.0%	0	0.0	0	0.0	0	0	0	0	0	0	0	0		0			%
	計	5,209,541	1,073,609	288,971	26.9%	243,244	758,161,657	84.2%	48,790	5,452,097	28.0	19.9	42.9%	64.1%	1,811	153	66	610	43,877	46,517	35,803	7,525	(Mpa)		

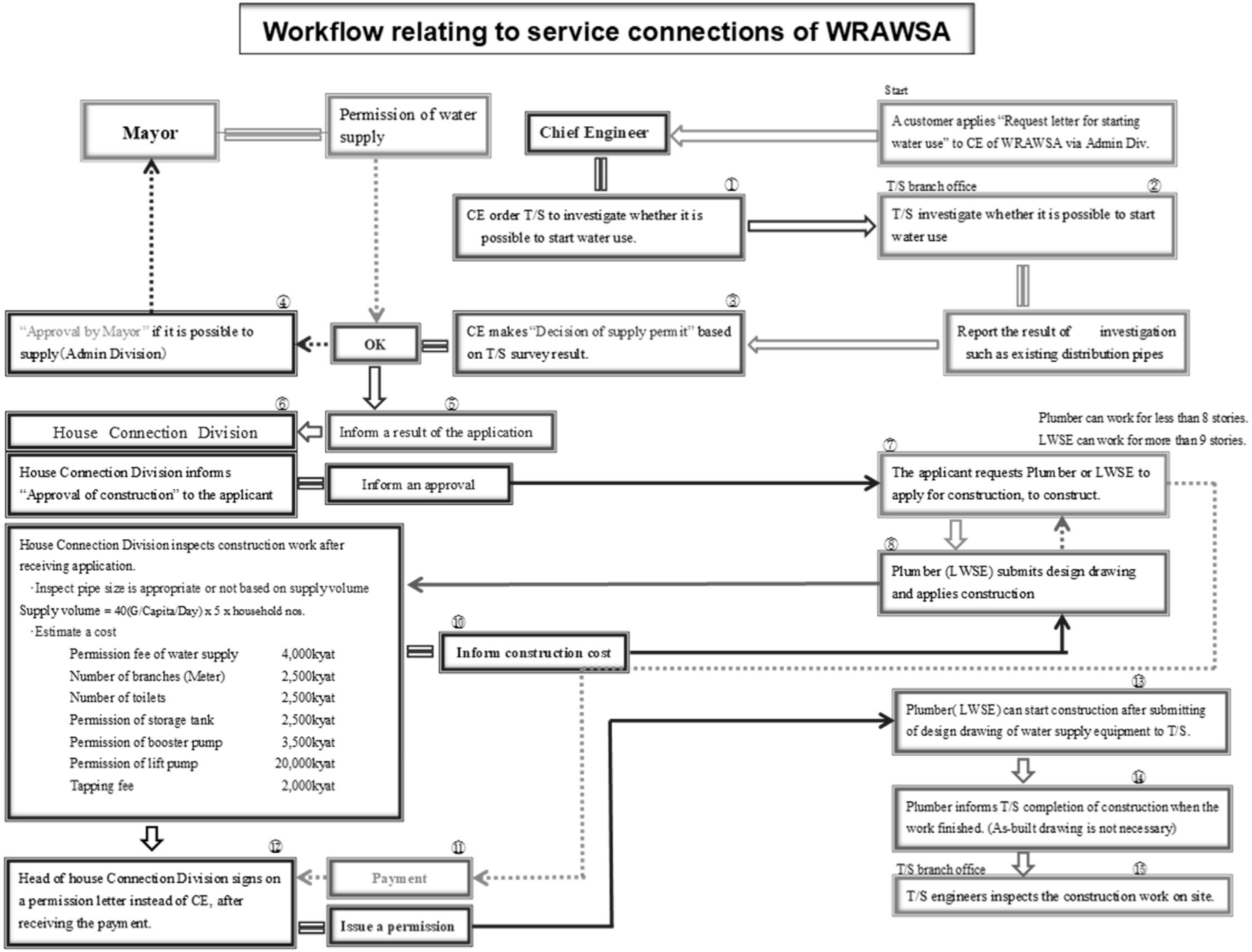


Figure 2-38: Workflow relating to service connections of WRAWSA

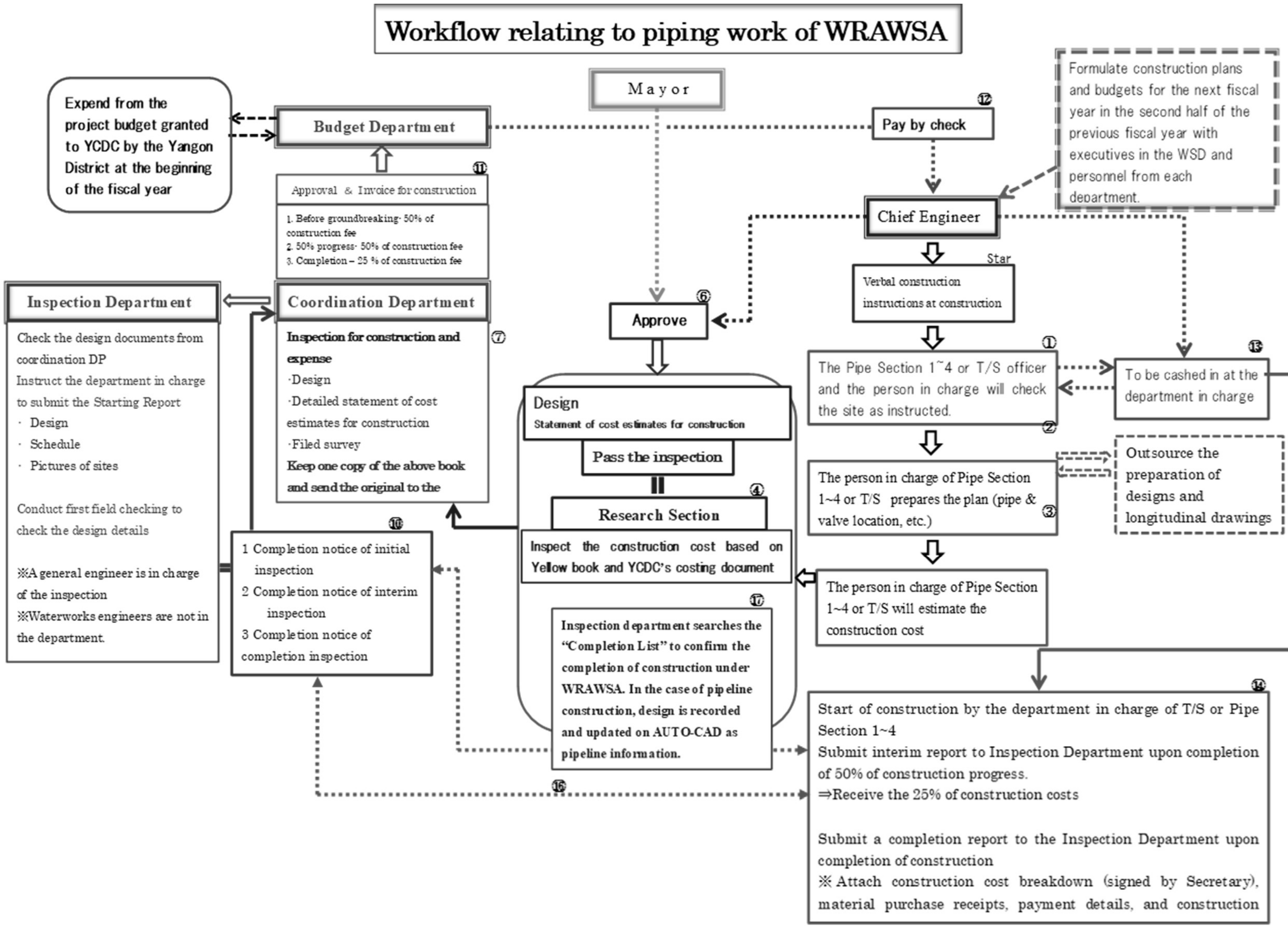


Figure 2-39: Workflow relating to piping work of WRAWSA

(3) Issues on water supply

a) Limited water supply due to unplanned pipe laying

The downtown area is located far from the reservoirs but is considered a 24-hour water supply area in principle. Service reservoirs are not enough to distribute water and there are many unplanned tapings on distribution pipes on upstream. Thus, required water volume does not reach the downtown area. Inevitably, currently WRAWSA can only supply water for limited hours to the downtown area. To solve the water shortage, WRAWSA pumps water from tube-wells and connects to existing distribution pipes directly.

b) Long-term absence of people in many buildings

In Yangon city, many houses belonging to some wealthy people have been uninhabited for a long time. There are about 43,800 such houses. Water supply disconnection for those houses should be considered in near future.

c) Uncertain water supply management for pagodas and religious facilities

WRAWSA supplies water to approximately 1,800 pagodas and other religious facilities. Almost all these facilities have water meters provided and installed by YCDC. However, almost all pagodas and religious facilities, except those built recently, have not paid water charges. Meter reading for one of the most famous religious facilities which has φ150mm water meter has not been carried out. Reading value of water consumption of these religious facilities is counted as “Domestic”. Domestic is the category of ordinary citizen’s consumption. The Expert guided Computer Section to move this consumption from “Domestic” to “Unbilled Authorized Consumption” from April 2016.

d) Unfair water supply service for VIPs

There are 66 residents who are called “VIP” in Yangon city. VIP people have over φ50mm individual service pipe and have not paid water charge. This issue also needs to be solved.

e) Broken water meter caused by raw water supply

Currently, WRAWSA is distributing raw water without treatment to more than 50% of their water supply amount from three reservoirs including Hlawga reservoir. The raw water, which is distributed to customers directly, contains impurities such as shells, small fish, and waterweed. Many water meters lose accuracy of flow measurement function due to impurities even before their expected life. To understand this situation, customer’s meter survey was carried out in 2018. A result of this survey is as follows.

- Meter removed: 2.7%
- Meter malfunctioned: 8.8%
- Cannot read due to dirt: 13.2%

In total, 24.7% meters cannot be read.

f) Lack of regulation for securing meter function

Most of the installed meters in Yangon city were initially purchased by the customers; however, recently, YCDC purchased specific meters for the customers (for new connection or replacement) through T/S office to unify the functions of meter. However, there is no periodic check on their measurement accuracy so far. Meter reading accuracy and fair tariff collection are major issues on water meter. Proper meter reading and tariff collection including meter ownership should be examined.

g) Unknow quantities of installed meter by diameter

House Connection Section is in charge of inspection and permission of water supply equipment. Computer Section is in charge of issuing and managing customer ID when customers start water supply services. However, diameter-wise quantities of meters installed are not managed and grasped in WRAWSA. In the near future, WRAWSA needs to grasp the installed meter quantities by diameter whey they consider changing water tariff into commodity charge. WRAWSA should also compare the consumption between estimated adequate flow volume by service pipe diameters and estimated revenue water volume from current meter readings.

(4) NRW Project by Donors

The outlines of NRW projects by donors are shown in Table 2-64, and target locations of these projects are shown in Figure 2-40. Six projects were completed, and “NRW reduction project in Mayangone township” is on-going.

Regulations or guidelines related to NRW management are not established in WRAWSA. Therefore, different types and specifications of pipe materials and water meters are used in different construction projects. Regulations or guidelines established in the Project will be applied to donor projects in the future.

There was no NRW Management Section in WRAWSA before. The DYCE or the ACE used to be assigned as responsible persons for NRW projects. Therefore, deliverables such as technical reports and seminar documents of each project were not managed in one section and cannot be used effectively. At present, NRW Management Section is in charge of collecting and managing information about past NRW projects.

Table 2-64: Outline of NRW projects by donors

No.	Project	Area (T/S)	Year	Player	Project cost	Construction	YCDC	Connections	Length of replaced pipe	NRW reduction
①	Pilot project consulting	Tarmwe & Thingangyun	—	EGIS, WMI	EUR 0.663 million	(Survey)	—	-	-	-
②	The Project for Urgent Improvement of Water Supply System in Yangon	Yankin	2016	JICA	JPY104 million	JICA (TODA)	U Moy Thein	1944	8	70→8.2
③	NRW reduction DMA pilot project in Yangon	Insein	2019	Manila Water-Mitsubishi	USD0.7 million	n.a	Daw Thawe Naing Oo	315	5.5	52→17.3
		South Okkalapa						496	5.6	56→12.3
④	Water supply and sanitation improvement advisor	Yankin	2014	JICA	USD0.16 million	YCDC	U Myint Oo	271	5.6	75→15
⑤	NRW reduction project in Mayangone township	Mayangone	2015	Japan Grassroots Grant Aid, Japan consortium (Tokyo Water, Toyo Engineering)	USD0.61 million	YCDC	U Myo Thein	292	5	76.6→32
⑥	Project for Improvement of Water Supply Management f YCDC	Yankin	2020	JICA	—	YCDC	NRW Management Section	310	2.1	86.1→5.5
⑦	The Project for Reduction of Non-Revenue Water in Mayangone Township in Yangon city	Mayangone	On going	JICS, Japan consortium (Tokyo Water, Toyo Engineering)	—	YCDC	U Myo Thein	9686	10.1	Half of initial NRW rate
⑧	NRW reduction pilot project	Tarmwe	—	AFD, France (EGIS)	—	—	U Myo Thein			

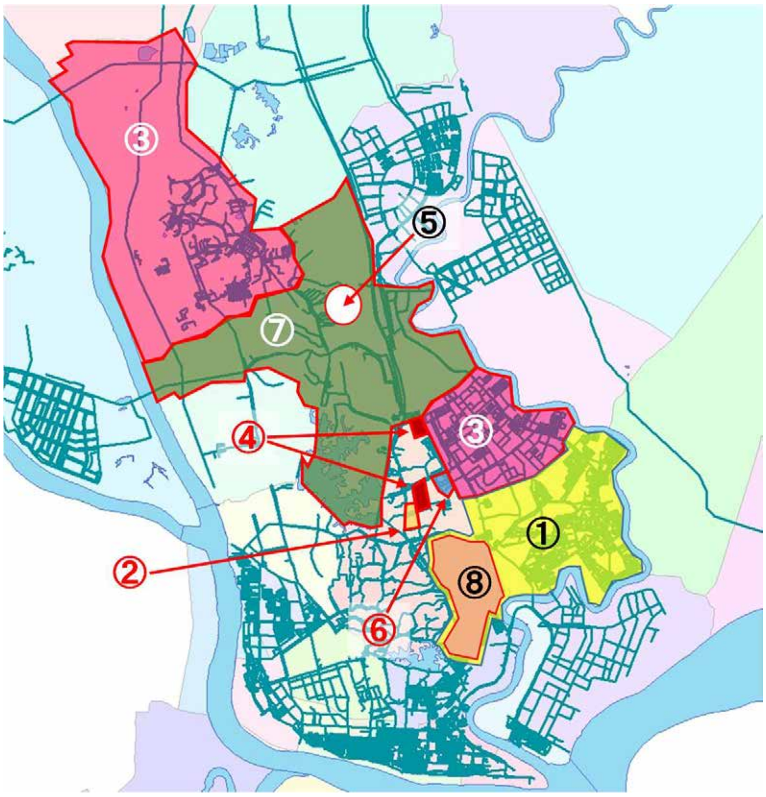


Figure 2-40: Location of NRW projects by donor

2-2-2 Collection of pipeline map and establishment of GIS database

(1) Collecting pipeline information

The C/P and the Expert surveyed current situation of map management not only in WRAWSA office but also in the entire YCDC, such as Road & Bridge Department and City Planning & Land Administration Department. Table 2-65 shows result of the survey.

Table 2-65: Current situation of map management in YCDC (as of 2015)

No.				1	2	3	4	5	6	7	8
Map name				Branch Map1	Branch Map2	Drawings & Research Section (AutoCAD Map)	Map (Mr. Matsuoka summarized)	GIS Team Map	Egis GIS Map	Road & Bridge Map	Land Admin Map
Map management section				Each Township (T/S) Branch Offices(BO)		YCDC Head Office(HO) Water & Sanitation Dept.				YCDC Road & Bridge Dept.	YCDC City Planning & Land administration Dept.
Software used				Adobe Photoshop	Correcting the AutoCAD map by handwriting	AutoCAD	Correcting the AutoCAD map by handwriting	ArcGIS	ArcGIS	unutilized	QGIS & ArcGIS
Coverage area				Ex, Mayangone T/S	Ex, Tamwe T/S	Whole Yangon City	Whole Yangon City	Whole Yangon City	Thingangyun, Tamwe, Thaketa T/S	-	27 T/Ss
Overall accuracy				less-accurate	less-accurate	annual updating based on Pipe Design Maps	less-accurate	less-accurate	relatively high-accurate	-	less-accurate based on air photos
Drawing Scale				no scale	no scale	no scale	unified scale	unified scale with GIS		-	no scale
Data components	Pipe-network & facilities & customer data	Location of pipe network	Transmission Pipe	✓	✓	✓	✓	✓	✓	-	-
			Distribution Pipe	✓	✓	✓	✓	✓	✓	-	-
			House connection	-	-	-	-	-	✓	-	-
			Pipe for fire fighting	✓	✓	✓	✓	✓	✓	-	-
		Attribute of pipes	Diameter	✓	✓	✓	✓	✓	✓	-	-
			Material	-	-	-	✓	-	✓	-	-
			Installation year	-	-	-	✓ (only one part)	-	-	-	-
		Location of network facilities	Valves	✓	✓	✓	-	-	-	-	-
			Air valves	-	-	-	-	-	-	-	-
			Fire hydrants	✓	✓	✓	-	-	-	-	-
		Location of facilities	Reservoirs	✓	✓	✓	-	✓	-	-	-
			Tube wells	✓	✓	✓	-	-	✓	-	-
			Booster pumps	✓	✓	✓	-	-	✓	-	-
		Location of customer	Customer meters	-	-	-	-	-	✓	-	-
			Housings	-	-	-	-	-	✓	-	-
		Attribute of meters	Meter condition	-	-	-	-	-	✓	-	-
			Usage condition (regal / illegal)	-	-	-	-	-	✓	-	-
	Maintenance record & monitoring data	Location of leakages		-	-	-	-	-	-	-	-
		Location of leakage repair works		-	-	-	-	-	-	-	-
		Method of leakage repair works		-	-	-	-	-	-	-	-
		Water Pressure		-	-	-	-	-	-	-	-
		Water flow		-	-	-	-	-	-	-	-
	Other	Street & river		✓ (Google map hardcopy)	✓ (Yangon map hardcopy)	✓ (n/a)	✓ (Google map hardcopy)	✓ (GIS softcopy)	✓ (GIS softcopy)	-	-
		Parcel (Partition between housings and public area)		-	-	-	-	-	✓ (Land administration dept. data)	-	✓
		Shape of housing		-	-	-	-	-	-	-	-
		Air Photo		✓	-	-	-	-	-	-	✓
		Coordinate system		-	-	-	-	WGS84	WGS84	-	WGS84

Note;

- No.3 map is annually updated.
- No.8 map is as parcel map. A part of the map is established as building shape map.

Drawing Section (current Design Section) of WRAWSA annually updates AutoCAD data (No.3 map) with township officers. However, WRAWSA has not been making as-built drawings and the AutoCAD data is updated according to brief design drawings as shown in Figure 2-41. Therefore, the accuracy of the updated maps is not yet good.

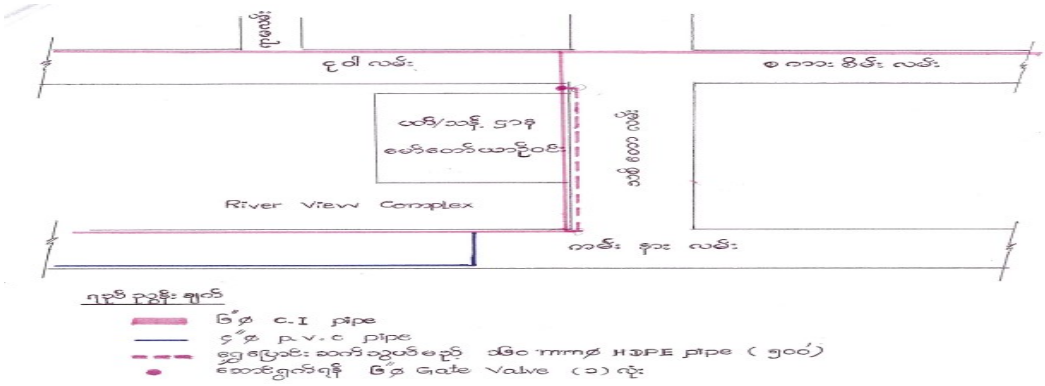


Figure 2-41: WRAWSA 's design drawing (sample) for updating AutoCAD pipeline map

In June and July 2016, GIS Section manually entered the information of the No. 4 map into the No. 5 and all township officers checked it to improve the accuracy. Maps of No.1 to No.4 was integrated into the No.5 map. But the No.5 map remains in low accuracy in terms of locations of pipes, valves, and caps. In particular, information of joints of pipes is less accurate (pipes are not connected on the map.)

In October and December 2016, GIS Section added the information of YCDC self-funded construction project in Shwepyithar T/S to No.5 map. However, the map was created based on design drawings and the memories of the township officer who is in charge of this project. Therefore, the No.5 map remains low in accuracy.

For the time being, WRAWSA has no choice but to refer these maps in daily works. The C/P in NRW Management Section and GIS Section and the Expert decided to formulate a procedure that all maps should be centralized in the No. 5 map (ArcGIS database, hereinafter referred to as " WRAWSA-GIS") and updating work should be executed according to as-built drawings based on SOP prepared by the Expert’s improvement guidance.

(2) Collection of leakage point information

NRW Management Section collects and manages leakage repair records of each T/S. As described in Figure 2-41, they have made leak repair location maps for two T/S. NRW Management Section inputs leak information on their GIS and GIS Section integrates it into the WRAWSA-GIS. They need to make leak maps for all T/S.

(3) Future GIS development

NRW Management Section prepares as-built drawings after the completion of construction works. As shown in 2-3-2(13), as-built drawings in the North Okkalapa area are currently being prepared and one in the Yankin area is finished by hand-drawn draft version.

NRW Management Section has planned that as-built drawings of construction works carried out by WRAWSA will be continuously made by AutoCAD. Currently, GIS Section integrates the hand-drawings into the WRAWSA -GIS.

The Expert confirmed that the GIS Section staff started to input the position data and information (such as pipe diameter and material) of pipes to WRAWSA-GIS based on the as-built drawings of the project in the North Okkalapa and Yankin areas, but the input work was not completed nor confirmed, and accuracy check was not implemented by the Expert due to political instability.

(4) Collecting of pipeline information in the pilot site in Yankin

Procedure of the collection is as follows.

1) Collecting pipeline maps

In regard to existing pipe information in the pilot site, the C/P and the Expert collected AutoCAD data

(No.3 map in Table 2-65) of Drawing Section (the current Design Section) and unified scale map (No.4 map in Table 2-65) together with the data collected from the engineers of Yankin township office through interview.

2) Site reconnaissance

Based on the prepared maps, the NRW C/P and the Expert (the survey team) visited the pilot site and visually checked for location, diameter, and material of pipes.

3) Field survey

The survey team executed field survey work (refer to 2-3-2(1) for detail), grasped shape of roads (boundary between public and private), and integrated results of field survey into a base-map (scale 1:500) in the pilot area. The base-map is shown as Figure 2-42.

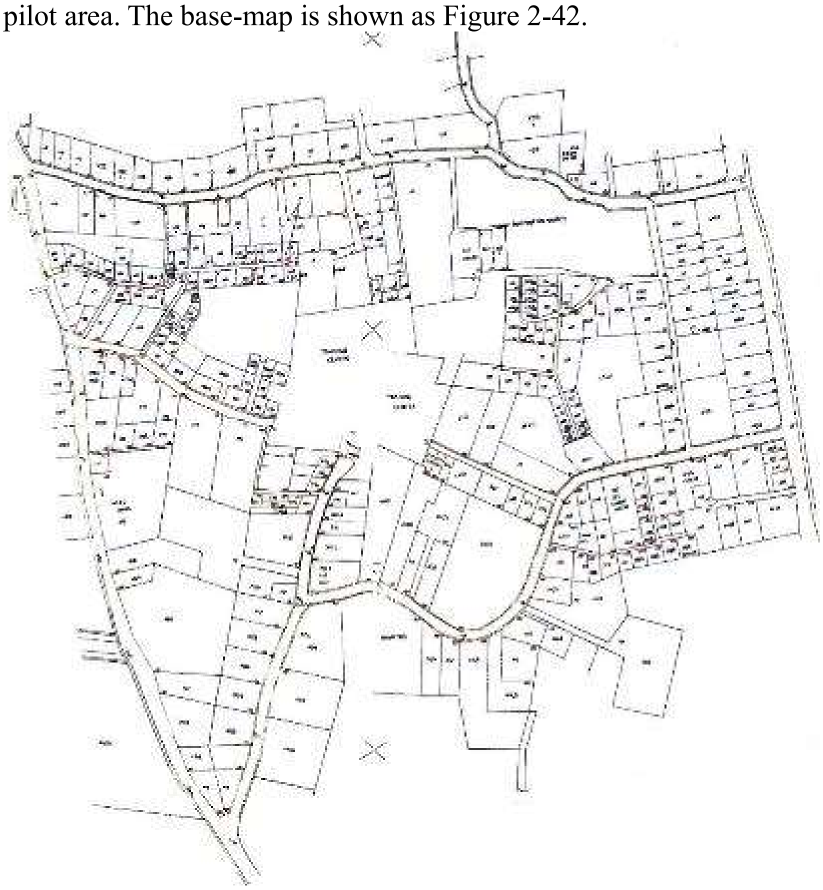


Figure 2-42: Base-map according to field survey (road and parcel)

4) Test digging

For buried pipes which are not revealed on the street, the survey team executed test digging works and checked the situation of joints, diameter, and materials of pipes at 7 points in the pilot area. The location and results of the test digging are shown as Figure 2-43.

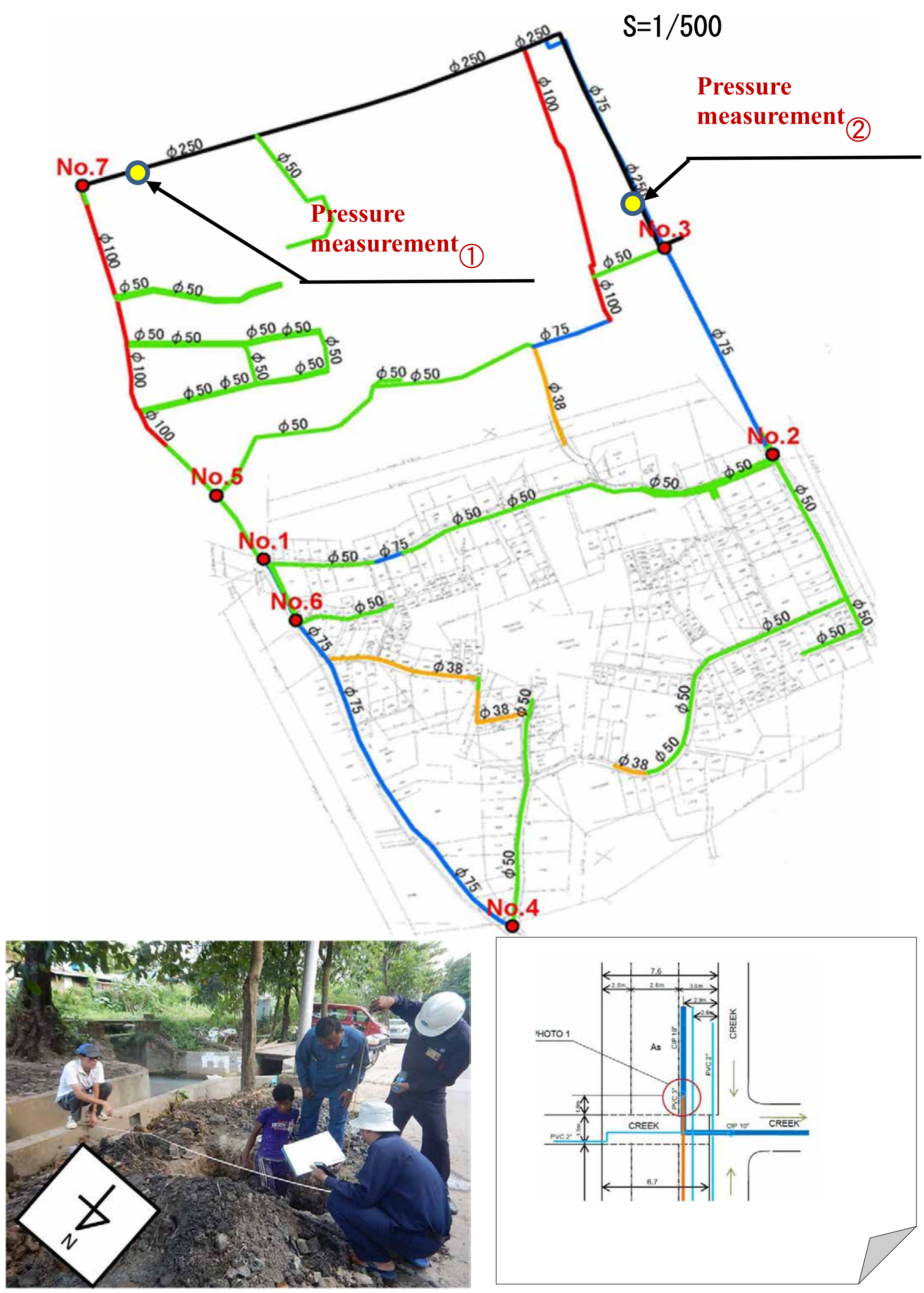


Figure 2-43: Location of test digging and existing pipeline and results of test digging

(5) Establishment of GIS database

According to the collected information, the survey team made GIS database (for details refer to 2-3-2-(7) as GIS training). DMA design work (for details to 2-3-2(2)) could be carried out efficiently by using the GIS data on a PC. The workflow of the making of GIS database is as follows.

1) Making of road and parcel maps

According to the results of the field survey, the road and parcel maps were prepared and the image of the map was input into GIS.

2) Inputting road and parcel information

The survey team traced the image on GIS and input road and parcel information as base-map.

3) Inputting of pipeline information

According to the result of the site reconnaissance and test digging, the survey team input pipeline information (location and diameter) into the GIS base map.

2-2-3 Establishment of customer database

(1) Customer data management utilizing GIS in the pilot site

WRAWSA manages customers by database of each township based on resident register-list and customer database of Computer Section.

In Term 1 of the Project, the survey team surveyed each customer house to estimate water demand for DMA design work, grasped the current situation of customer meters in the pilot site and established customer database for each parcel on GIS.

In the customer survey, the condition of customer meters and category of households with or without service connection were investigated. The established customer database on GIS is shown in Figure 2-44.

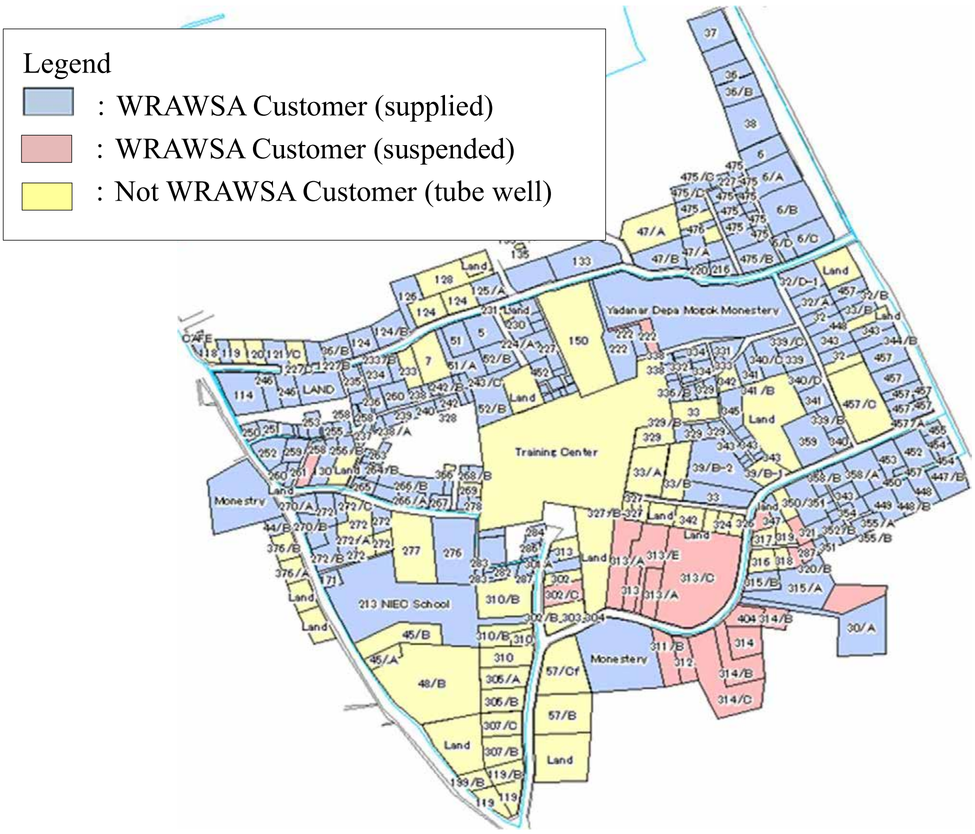


Figure 2-44: Customer information (category of contract)

(2) Improvement plan of management of customer data on GIS

In Shwepyithar T/S where WRAWSA constructed distribution pipelines with its own budget, GIS Section established pipeline data utilizing GIS by the method described above. Customer data is managed by parcel maps on GIS including customer ID and House No. Hereafter, GIS Section plans to extend it in the whole of Yangon city.

The customer database in the pilot project area was made by GIS. In the whole of Yangon city, customer management database system is currently being developed based on Output 1 of the Project, and digitization of customer management information (not provided by GIS) is underway (for details refer to 1-3-3).

2-2-4 Formulating SOPs to manage pipeline and customer data

The NRW C/P, GIS Section staff and the Expert made manuals for establishment work of pipeline and customer database. SOPs (Standard Operating Procedures) are needed in order to control quality of management of the database. Therefore, they have formulated the SOPs. The SOP for input work of as-built drawings into WRAWSA-GIS is shown as Table 2-66. The SOP for making of a hydraulic analysis model is shown as Table 2-67.

Table 2-66: SOP in GIS Section (Input of as-built drawings)

<table>
<tr><th colspan="5">Standard Operating Procedure</th></tr>
<tr><td>SOP No.</td><td>GIS-OP1-W01</td><td colspan="3">GIS Section, Engineering Department (Water and Sanitation)</td></tr>
<tr><td colspan="2">[Name of the procedure]
Input of distribution pipes of as-built drawings into GIS</td><td colspan="3">[Work category]
Making as-built drawings</td></tr>
<tr><td colspan="2">[Outline of the procedure]
OP1: Asbuilt Drawings into GIS
OP2: Design Drawings making and converting into GIS
OP3: Leak repair record into GIS</td><td colspan="3">[Software]
- ArcGIS 10.2

[Folder]
-</td></tr>
<tr><td colspan="2">Work step</td><td colspan="3">Key point to work</td></tr>
<tr><td>1</td><td>For the input operation method, refer to Manual "GIS+EPAnet Operation Manual".</td><td colspan="3"></td></tr>
<tr><td>2</td><td>Enter the position and shape of pipe / valve into GIS based on as-built drawings.
(Make sure to enter the plan view from directly above.)</td><td colspan="3" rowspan="2">Be sure to refer to the as-built drawings that has been approved by pipe section, T/S office or NRW management section.</td></tr>
<tr><td>3</td><td>If the position and shape of the existing pipe and road are different, correct it in GIS.</td></tr>
<tr><td>4</td><td>If you remove the valve, be sure to check with pipe section or T/S office.</td><td colspan="3"></td></tr>
<tr><td>5</td><td>Connect the new pipe and the existing pipe with one node.</td><td colspan="3"></td></tr>
<tr><td>6</td><td>Enter the attribute information for pipes and valves.</td><td colspan="3">Refer to page 134 of "GIS+EPAnet Operation Manual" for the recommended attribute information list.</td></tr>
<tr><td></td><td></td><td colspan="3"></td></tr>
<tr><td></td><td></td><td colspan="3"></td></tr>
<tr><td colspan="2">Formulation</td><td colspan="3">Amendment</td></tr>
<tr><td>Date</td><td>15th, Dec., 2020</td><td>Date</td><td>Approved by</td><td>Modification</td></tr>
<tr><td>Prepared by</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Approved by</td><td></td><td></td><td></td><td></td></tr>
</table>

Table 2-67: SOP in GIS Section (Making of a hydraulic analysis model)

Standard Operating Procedure				
SOP No.	***(#1/1)	GIS Section, Engineering Department (Water and Sanitation)		
[Name of the procedure] Converting the data from ArcGIS into EPA-net.		[Work category] Making a hydralic analysys model for pipe design		
[Outline of the procedure]		[Software] - ArcGIS 10.2 - shp2epa.exe - Node-Matching Ver1.0.exe - EPA-net 2.0 - Microsoft Excel [Folder]		
Work step		Key point to work		
1	Making SHP-file and DBF-file of pipe data from the ArcGIS.	ID of pipe shoud be unique.		
2	Converting the data from SHP-file into EPA-net.	Utilizing shp2epa.exe.		
3	Converting the data from line-data into network-data of the EPA-net.	Utilizing Node-Matching Ver1.0.exe. Launch the software in situation that "SmallBasicLibrary.dll" is in the same holder.		
4	Setting diameter and length according to the DBF-file.			
5	Setting customer demand on each node.	If according to the 2025 or 2040 of the M/P, population growth and increase of water consumption(m3/cpd) are required as analysys consition.		
6	(Selecting suitable diameter)	Pressure should be secured within the YCDC water pressure standard.		
Formulation		Amendment		
Date	15th, Dec., 2016	Date	Approved by	Modification
Prepared by				
Approved by				

2-3 Develop a model on the management of physical loss (leakage, overflow) and human resource development

2-3-1 Review current situation and develop phased countermeasures

(1) Cause of leakage

1) Planning and Design

Planning work in WRAWSA is implemented by Pipe Section and T/S engineers based on the CE's orders. Current drawing of WRAWSA is shown in Figure 2-45. This is drawn with free scale and it is difficult to identify the accurate position of pipes and accessories of pipelines.

Regarding pipe materials, there are no standards. WRAWSA cannot secure enough budget for the piping works and the technical capacity of WRAWSA is low. Therefore, low quality pipes having poor durability, and low pressure and load resistant capacity are being used for piping work. Many cases of use of thin and poor strength PVC and HDPE pipes have been observed in Yangon city.

WRAWSA started to use PN 10.0bar for HDPE and PVC pipes instead of PN6.3bar since the middle of 2019.

Overflow from the reservoir at pumping stations is common. It is considered necessary to implement countermeasures to stop overflow after reviewing overflow pipe equipment.

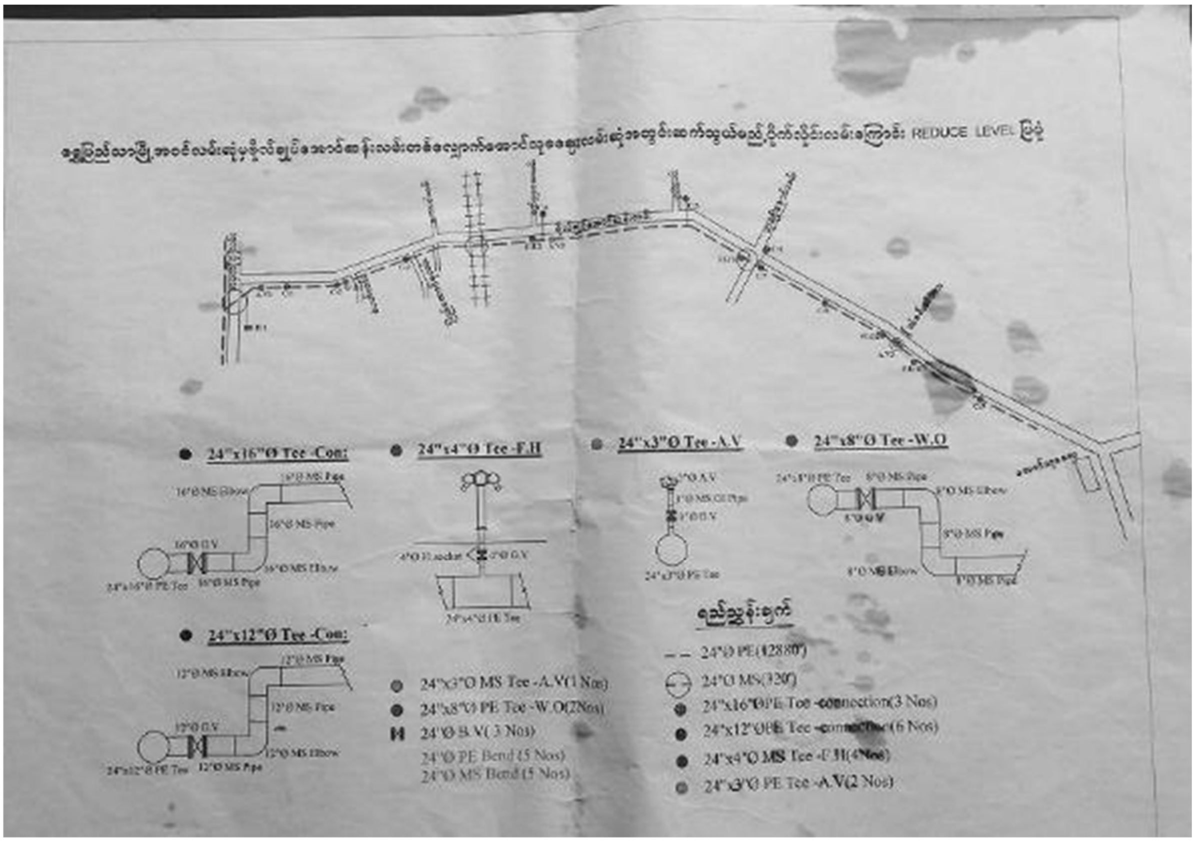


Figure 2-45: Sample of pipeline design drawing with no scale

2) Construction

Pipes for water supply are categorized into transmission-distribution pipes which are planned and constructed by water supply utility, and house connections for customers to use water. In Yangon city, there are no regulations and standards concerning planning, construction and any other aspects of these two pipes. There are also no records after construction. Therefore, necessary "construction standards", relevant SOPs etc. need to be developed. In addition, each division/section of WRAWSA should clarify the responsibility related to formulation of standards and manuals. Efforts to enable planned business operation among sections/offices are also important.

a. Construction of main water supply facilities

Currently, WRAWSA implements the master plan formulated by the JICA cooperation for which the target year is 2040 with assistance from donors such as financial assistance or technical assistance with projects. It will take time for WRAWSA to develop enough basic technical capacity. YCDC should actively pursue the development of technical capacity related to basic planning, designing, and supervision by changing the construction system under the direct control of YCDC. On the other hand, WRAWSA should contract local contractors with good skills for construction work in the future. Also, capacity development of engineers of utility and contractor will be necessary.

Regarding standard for selecting materials for water supply facilities such as pipes, “Material Selection Standard” should be formulated. In addition, it is also necessary to formulate "Standard for Construction of Water Distribution Pipe etc." which defines proper construction method and required skills for construction and should be gradually disseminated for adoption in the work.

b. Construction of house service connection

To supply water, distribution pipes laid by utility and house service connections (HS/C) installed by customers are needed. Generally, a person who designs and installs the HS/C needs official permission from the water supply utility. In Yangon city, there are plumbers and LWSE (Licensed Water Supply Engineer; former staff members of YCDC). However, level of their actual technical skills is unknown.

Selection of proper material to be used for branching from the distribution sub-mains to the water meters in the residential premises and making proper connections is important as leakage occurs with highest frequency at the branch points. It is necessary to construct carefully at these points. Since it is currently conducted without any rules, it is necessary to discuss with WRAWSA, and formulate SOP for drilling work of service branch from distribution sub-main.

In the future, WRAWSA should consider adopting technical certification examination. It is also essential to encourage technicians recognized as having certain technical capabilities regardless of public or private sectors as "construction engineers" and raise their social status. In addition, it is necessary to secure technical personnel backed up by technical strength and to build high quality water supply system together with the public and private sectors.

There is an actual situation where many customers have water storage tanks in their premises. This situation is caused by intermittent supply and low pressure of water supply. Float valves to stop water supply automatically in these storage tanks when the tanks are filled, are often missing. Since overflow from storage tanks is the issue at the downstream from water meters, it is recorded by meters and accounted as “revenue water”. Low service coverage rate is one of the factors of limited water supply. It is necessary to take effective measures against these types of water losses from the viewpoint of effective use of limited water resources. “Guideline of Design and Installation of Water Supply Equipment (Annex 5.B)” was prepared in the Project to solve this issue based on meetings with all T/S officers.

3) Inspection

Inspection of WRAWSA is conducted through the following steps. First, Coordination Department, which is an external department of WRAWSA, inspects the appropriateness of construction and the validity of estimation of the construction based on the drawing. After that, the Inspection Department carries out preliminary confirmation of the construction design outline (basis of advance payment), intermediate inspection and completion inspection of construction on site. However, currently there is no engineer who has knowledge of waterworks in Inspection Department.

In the completion inspection, confirmation works such as length check of the laid pipeline on site are being conducted, but pressure test is not being implemented. Therefore, WRAWSA has not been able to find leakage caused by poor jointing work or fittings. Confirmation of leakage is not being carried out before filling water under the condition that proper pipe jointing technique has not been established. This is one of the main factors affecting NRW reduction. “Inspection Guideline of Installation of Water Supply Equipment (Annex 5.B)” was drafted and was explained to the CE and T/S officers. However, Yangon Regional Government decided to inspect pipeline construction by consulting company assigned in 2019.

4) As-built drawing of construction has not been created

There is no recognition of the necessity of "as-built drawing" which is a record book of construction contents such as pipeline improvement work and is necessary for management. Until now, WRAWSA has not created “as-built drawing”.

Information of existing pipelines has been input into GIS and AutoCAD data by Research Section and GIS Section based on “drawings of construction plan”.

In the current workflow, the "design change" process which is a procedure for creating "change design drawing" and re-estimating is not defined as a standard rule. In addition, there are some cases where "drawing of construction plan" is created. If there are significant changes such as pipe laying position due to local circumstances, it will not be reflected as a record. The information recorded is thus not of completed construction but of the initial plan. Thus, accurate information as pipeline maps has not been secured. Therefore, it is difficult to use the maps effectively for basic data in leakage survey, pipe maintenance work when leakages occur, new pipeline development plans and any other purposes.

(2) Situation of leakage countermeasures in T/S

A survey of 31 T/S offices was conducted to understand the situation of "Countermeasures against leakage" (how to repair, system for leak repair, tools, etc.). Seikkyi Kanaungto T/S was not a water supply area, and Dagon Seikkan was not the WRAWSA's service area at that time so that these two T/Ss were excluded from this survey. Before establishing NRW Management Section, there was no section in charge of leakage detection and repair. So, information and experience of leakage countermeasures had not been concentrated in WRAWSA.

Leakage Detection

Leakages in the distribution pipes are found by the citizens and the staff members of WRAWSA. Public interest in leakage is low. Many visible leakage points are left for several days without being repaired. It is extremely difficult to find water leakage locations due to the absence of as-built drawings and informative pipeline maps.

Leakage repair and reporting

T/S is in-charge of repairing distribution pipes smaller than 6 inches. From the survey of T/S, the present situation and issues related to leak repair and its record became clear as shown in the table below.

Table 2-68: Situation and issues of leakage management in T/S

Item	Situation and Issue
Leak Repair	1. A standard repair method has not been established, the repair methods are different at each T/S office, and the materials are not unified. 2. There are many cases where only temporary repair is done, such as wrapping rubber around the leak point. 3. Proper materials for leakage repair cannot be prepared due to budget problem. 4. About 1 or 2 persons in charge of repairing leak are assigned in each T/S office, but most of them have other works as well. 5. Insufficient maintenance of tools and equipment necessary for leak repair. Each T/S has only a pipe wrench, chisel, and hammer etc. There are many unknown parts about the burden of material cost necessary for leakage repair. (In some T/S, repair works of large-diameter distribution pipes are implemented.)
Leakage records	1. There is no common format of leakage records. 2. There are many T/S that sometimes do not take records, and some T/S have never recorded such reports. 3. The records have been reported separately to the responsible ACE as there was no NRW Management Section. 4. No utilization of leakage records.

As mentioned above, leakage repair in the T/S is handled by staff members in charge of the T/S office. Pipe Sections 1-4 separately manage and maintain reservoirs, WTPs, pumping stations and transmission pipes. The total numbers of staff members who are in-charge of maintenance work are approximately 100 people.

Pipe Section 1: It has 55 staff members who are in charge of managing transmission pipes from Gyobyu, Phugyi, Hlawga reservoirs and Nyaunghnapin WTP to Yegu pumping station and water distribution lines in the northern area.

Pipe Section 2: In charge of managing transmission and distribution pipes between Yegu pumping station and Kokkine reservoir located on the southern hill of Inya Lake.

Pipe Section 3: In charge of managing Kokkine reservoir and distribution lines between Kokkine reservoir and Shwedagon reservoir.

Pipe Section 4: In charge of managing distribution mains and sub-mains in the downtown area.

Photo 2-35: Leakage repair work in a creek

(3) Leakage repair records

According to the result of the leakage recording work survey in Term 1 of the Project, WRAWSA made leakage records but the number of records were not enough. Because of this situation, an issue became evident that WRAWSA cannot grasp the causes of leakage and repair methods.

1) Current situation of leakage records

Pipe Sections 1-4 are in charge of repair work for over 6” and T/Ss are in charge of less than 6” distribution pipes. WRAWSA is supposed to record leakage information and repair method when leakage repair is carried out. As a result of T/S survey on leakage records, it was revealed that some T/S used a format which was proposed by JICA Expert dispatched from Fukuoka city, but some other T/S still used their own record format. 16 T/S recorded leakage information in 2016 and 19 T/S recorded in 2017. Recording status has gradually improved by continuous advice by the Expert. Additionally, the CE requested all T/S to record the leakage and repair information.

2) Revise leakage repair record

Based on the situation that status of leakage records has gradually improved after 2014, NRW Management Section started to collect those leakage records from T/S and analyzed the leak factors. Some more record items were needed which were not in the former leakage format; therefore, the format was partially revised. To reduce the work on site, the format was revised from A3 size 4 pages into 2 pages. In addition, the format was improved to record general description. The former format is shown in Figure 2-46 and revised format is shown in Figure 2-47. Leakage repair records were submitted to the ACE in charge via district offices so far but were not utilized well. The Expert proposed a new workflow that includes NRW Management Section as shown in Figure 2-48.

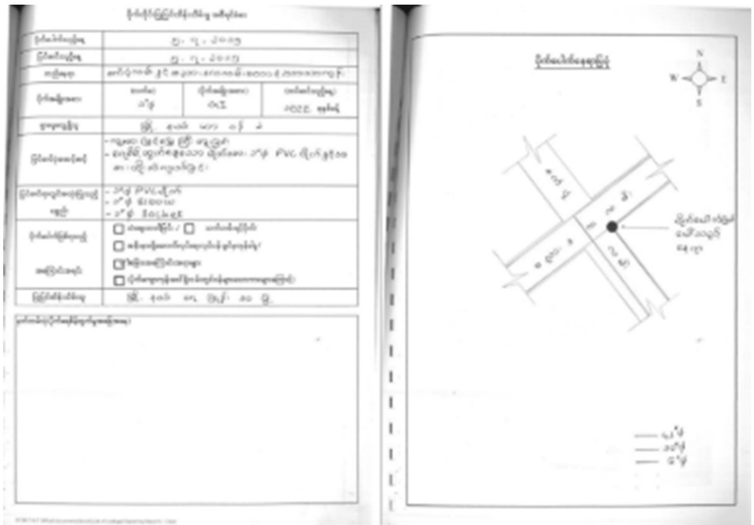


Figure 2-46: Former leakage repair record format

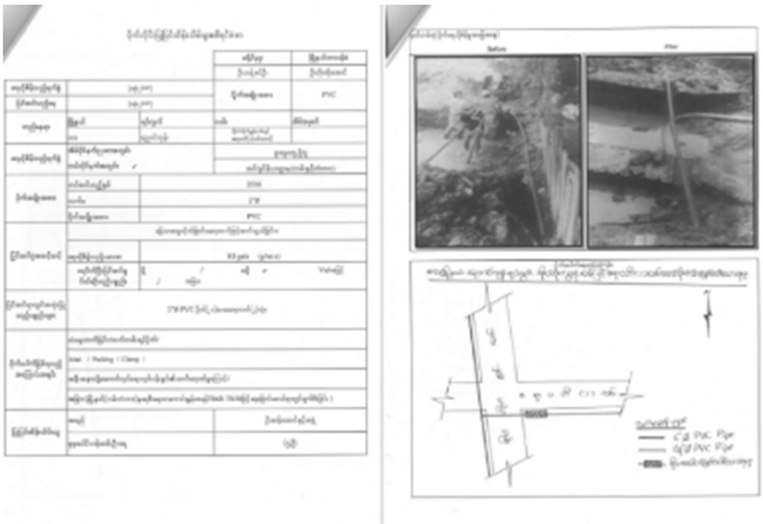


Figure 2-47: Revised leakage repair record format

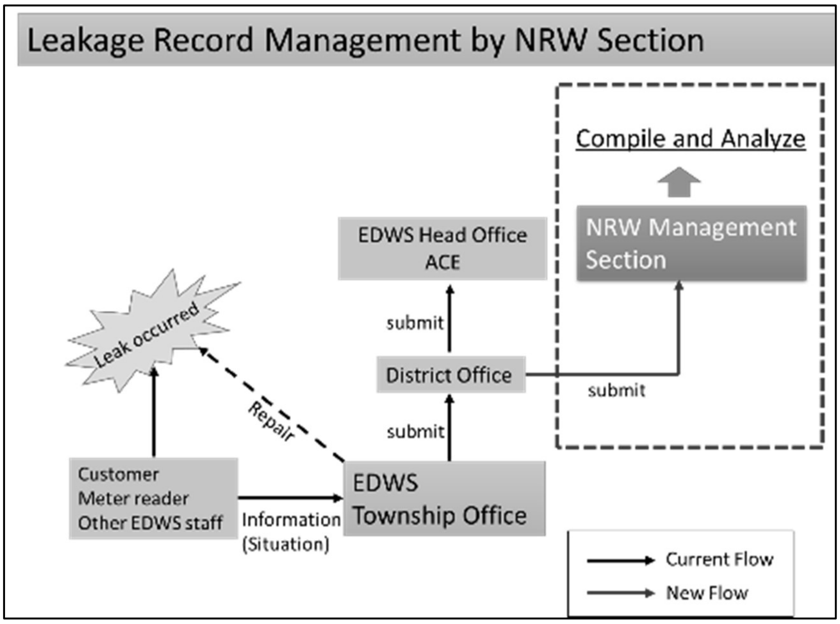


Figure 2-48: Workflow on leakage repair work

3) Compile the data of leakage repair records

Leakage repair records of past two years 2015 and 2016 were collected from all T/S. As mentioned above, some T/S do not use the common format and some other T/S do not make any records. Because of this situation, only about 60% of the T/S submitted the records. Collected leakage records were input into Excel. Table 2-69 shows compiled data in Excel.

Table 2-69: Excel format of leakage repair records

No.	Leakage Information															Repair Work Record							
	Date (Day/Month/Year)			Address					Leak Point					Leakage Factor	How to find	Repair Work							
									Pipe information				Accessory (If leak from accessory)			Date (Day/Month/Year)			How to suspend water	Used material	Photo Record	Leakage volume (L/min)	Number of staff for repair work
	D	M	Y	Township	Ward	Street	No.	Road or Accommodation	Category	Material	Diameter	Pipe laying year				D	M	Y					
322	16	12	2015	MingalraT.N.	Phoe Myay	Theinphyu&Bo min Yaung		Road	Service connection	GI	1″	2000	Other	Corrosion	YCDC staff	16	12	2015	Other	Earth Work Excavation,1″ØPVC Plug	Yes	4.0 L/min	
323	9	12	2015	MingalraT.N.	Satsan	Satsan		Road	Service connection	GI	4″	1996	Other	Corrosion	YCDC staff	9	12	2015	Other	Cement,Gunny twine	Yes	5.0 L/min	
324	9	12	2015	MingalraT.N.	Mingalr aT.N.	Bo Min Yaung		Accommodation	Service connection	GI	2″	1990	Other	Others	YCDC staff	9	12	2015	Other	2″ØPVC Plug	Yes	4.0 L/min	
325	26	10	2015	MingalraT.N.	Mingalr aT.N.	Conner of Bo Min		Road	Service connection	PVC	1″	1996	Other	Others	YCDC staff	26	10	2015	Other	1″ØPVC Plug	Yes	4.0 L/min	
326	7	10	2015	MingalraT.N.	Mingalr aT.N.	Conner of Bo Min		Road	Service connection	PVC	1″	2000	Other	Others	YCDC staff	7	10	2015	Other	1″ØPVC short pipe,1″Øelbow,1″Ø socket	Yes	4.0 L/min	
327	3	9	2015	MingalraT.N.		Upper Pansodan		Road	Distribtuion	PVC	12″	2001	Other	Others	YCDC staff	3	9	2015	Other	Cement,Gonshaw Rope	Yes	6.0 L/min	
328	26	8	2015	MingalraT.N.	Phoe Myay	101	17	Accommodation	Service connection	GI	1″	2000	Other	Aged pipe	YCDC staff	26	8	2015	Other	Earth Work Excavation,1″ØPVC Plug	Yes	4.0 L/min	
329	17	8	2015	MingalraT.N.	East Kandaw	92	95	Accommodation	Service connection	GI	1″	1995	Other	Corrosion	YCDC staff	17	8	2015	Other	Earth Work Excavation,1″ØPVC Plug	Yes	4.0 L/min	
330	12	8	2015	MingalraT.N.	Loat Lat Yae	98	16	Accommodation	Service connection	GI	1″	2000	Other	Corrosion	YCDC staff	12	8	2015	Other	Earth Work Excavation ,1″Ø PVC Pipe	Yes	4.0 L/min	
331	29	7	2015	MingalraT.N.	Tharyar Gon	Conner of Banyar Dala		Road	Service connection	PVC	1″	2002	Other	Others	YCDC staff	29	7	2015	Other	1″ØPVC short pipe,1″Øelbow,1″Ø socket	Yes	4.0 L/min	
332	21	7	2015	MingalraT.N.		Conner of Satsan(9)&Uppe		Road	Distribtuion	CI	6″	1980	Other	Joint	YCDC staff	21	7	2015	Other	Cement,Gonshaw Rope	Yes	5.0 L/min	
333	5	7	2015	MingalraT.N.	Tharyar Gon	Conner of Satyon &Banyar		Road	Service connection	GI	1″	1999	Other	Others	YCDC staff	5	7	2015	Other	1″ØPVC short pipe,1″Øelbow,1″Ø socket	Yes	4.0 L/min	
334	1	7	2015	MingalraT.N.	Pathein Nyunt	Thamainbayan		Road	Distribtuion	CI	18″	1962	Other	Joint	YCDC staff	1	7	2015	Other	Cement,Gonshaw Rope	Yes	6.0 L/min	
335	11	6	2015	MingalraT.N.	Theinp hyu	Conner of Theinphyu&Bo			Service connection	GI	1.5″	1995	Other	Others	YCDC staff	11	6	2015	Other	Earth Work Excavation,1.5″ØPVC Plug	Yes	4.0 L/min	
336	7	4	2015	MingalraT.N.	Taung Nyunt	Myanmar Gonyae			Service connection	GI	1″	1996	Other	Corrosion	YCDC staff	7	4	2015	Other	1″ØPVC Plug	Yes	4.0 L/min	
337	5	2	2015	MingalraT.N.	Taung Nyunt	Conner of Bominyaung&11		Road	Service connection	PVC	1″	2013	Other	Others	YCDC staff	5	2	2015	Other	1″ØPVC Pipe,1″Øsocket	Yes	4.0 L/min	
338	16	1	2015	MingalraT.N.	Taung Nyunt	106		Road	Service connection	PVC	1″	1999	Other	Corrosion	YCDC staff	16	1	2015	Other	1″ØPVC pipe,1″Øelbow,1″Øsocket	Yes	4.0 L/min	
339	2	1	2015	MingalraT.N.	Satsan	Upper Pazundaung	240	Road	Distribtuion	CI	12″	1962	Other	Joint	YCDC staff	2	1	2015	Other	Cement,Gonshaw Rope	Yes	6.0 L/min	
340	1	1	2015	MingalraT.N.	Taung Nyunt	112	7	Accommodation	Service connection	GI	1″	2001	Other	Corrosion	YCDC staff	1	1	2015	Other	1″ØPVC pipe,1″Øelbow,1″Øsocket	Yes	4.0 L/min	

4) Data analysis

The C/P and the Expert made graphs of leakage status by materials or diameter based on collected data and studied the situation of leakage occurrence in Yangon city. However, the collected data was not enough to analyze because many T/S did not make leakage records in 2015 and 2016. Leakage records should be continuously collected from T/S and the accuracy of analysis be improved.

According to Figure 2-49 and Figure 2-50, leakage on 1" service pipes is the most frequent from the viewpoint of diameter, and leakage on PVC pipes is considered most frequent from the viewpoint of material. This is caused because the thickness of pipes is not enough to resist outside loads and jointing technique is inferior.

Through the result of the survey in Term 1, it was found that materials for repair were purchased by T/S office by every leakage repair work. To repair leakage immediately, WRAWSA should keep stock of repair material in terms of diameter and material where leakages occur frequently.

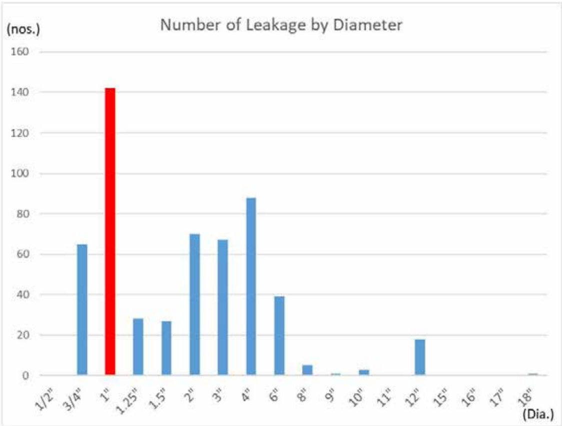


Figure 2-49: Number of leakage by diameter

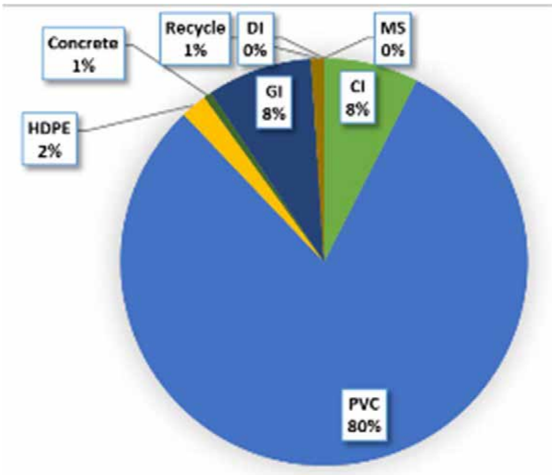


Figure 2-50: Leakage rate by pipe material

5) Leakage point management on pipeline map

Frequency and location of leakage can be grasped by collected leakage records. In order to visually grasp the areas where leakages occur frequently, the Expert proposed to mark the leakage locations on the pipeline map in addition to Excel data. In former record format, there are many cases where only address is recorded. Marking leakage points of 2015 and 2016 on the pipeline map with a T/S engineer was started. Until now, marking leakage points in the pipeline map has been completed for two T/S as shown in the figures below.

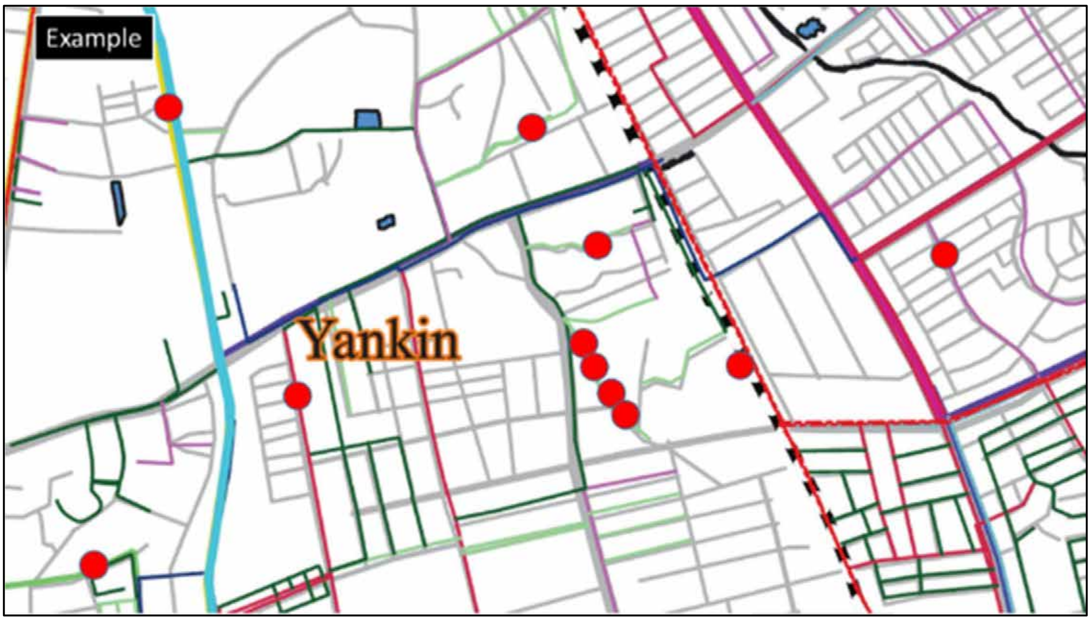
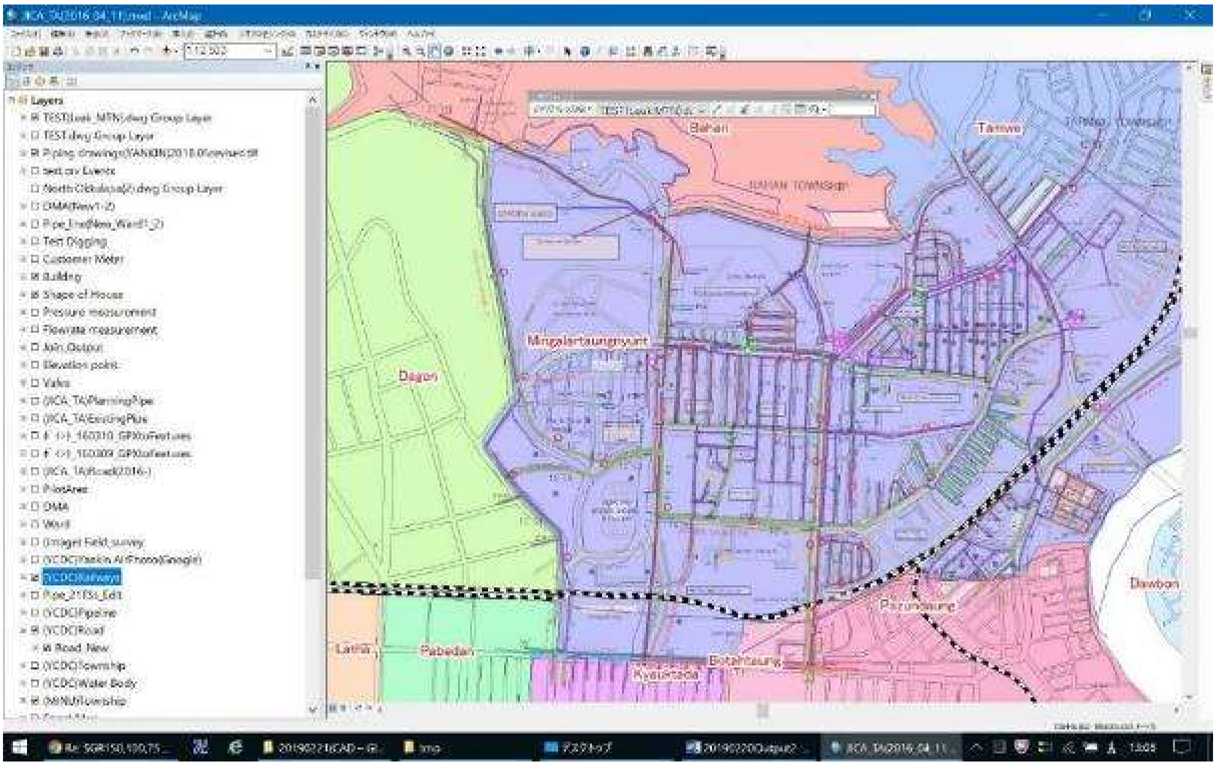


Figure 2-51: Image of leakage marking on pipeline map



(MINGALARTAUNGNYUNT)
Figure 2-52: Leakage point overlay on WRAWSA -GIS

Leakage point map and plotting work on GIS will be continued for other T/S by NRW Management Section. Presently, information of leakage map is input into GIS in collaboration with GIS Section as shown in Figure 2-52. The C/P and the Expert have formulated the SOP for input work of leakage map into WRAWSA-GIS.

6) Utilization of leakage repair records

From the results of collecting leakage records, leak factor and frequency in Yangon city was revealed, and this result was utilized as basic information of future leak prevention. Leakage detection work is quite difficult in Yangon city due to low water pressure. This data can also be used for effective leakage detection work. Besides, until now YCDC has not made a completion drawing, so YCDC does not have accurate pipe information. This leakage repair record can be utilized not only for revealing leakage causes but also for information such as details of aged pipes for formulating pipe renewal plan.

(4) Situation of planned leak survey

WRAWSA is conducting leakage detection work on Gyobyu transmission pipeline periodically. Gyobyu transmission pipeline can be divided into three parts. From the upstream side, the first section is managed by Gyobyu Reservoir, the second section is managed by Phugyi Reservoir and the third section is managed by Pipe section (1). Leakage detection work on each section is being carried out by each responsible section. Pipe Section (1) is implementing leakage detection work by three teams every day, and they have been recording the information of leakage and repair methods into new leakage record format from 2017. Repair staff take a picture of the leakage by their smartphones. It is assumed that the awareness of WRAWSA staff has improved compared to before. WRAWSA only used to repair the leakages, however, from then onwards, WRAWSA started to record leakage information continuously to identify the causes of leakage and to identify areas where leakages occur frequently. It is expected that efficient leakage detection work will be made based on recording work. Since water pressure monitoring on Gyobyu transmission main was not conducted, the effect of water pressure on leakage is unknown.

Many small sized distribution pipes, which directly branched from Gyobyu transmission main, were found by the survey. Photo 2-36 shows such a situation. There are many leakage points due to unsystematic piping and branching. As almost all of these pipes lay on the ground, and T/S engineers are not aware of it, so WRAWSA could not identify all the branches. These pipes may also include illegal connections.

Photo 2-36: Water leakage from small size distribution pipe

(5) Distribution branch and service connections from Gyobyu transmission main

Water supply from Gyobyu transmission main to areas outside of Yangon city was found, so direct branches of distribution and service pipes from transmission pipes were surveyed. As a result of this survey, 28 branches in Gyobyu management area, 21 branches in Phugyi management area and 54 branches in Pipe Section 1 area were found. Apart from this, some service connections which were not managed were found. Many bad branches from air valve or pipe joint, which was an unexpected use, were found in this field survey as shown in Photo 2-37. Such branches cause leakage, and cause problems when repairing. Each of those service pipes is for supplying water to special places such as pagoda, and the distance is long. Because of this, many leakage points were found due to less management of service connections. This survey should be implemented continuously.

Photo 2-37: Direct branching from transmission main

2-3-2 Conduct trainings of trainers

(1) Training for preparing a geographical map (scale 1:500) with plane table survey

There are no scaled maps and drawings in WRAWSA. Currently drawing of WRAWSA is without scale, so it is impossible to prepare the details of the pipeline improvement plan.

Most of WRAWSA engineers have experience of surveying, however, they never utilize it in their usual work. After they received this training, they utilized this experience to North Okkalapa NRW project and Yankin pilot project by using total station. Training for surveying and creating map with scale 1:500 was carried out as shown in the table below.

Table 2-70: Training for preparing a geographical map with plane table survey

Date	Contents of training
2nd Feb,2016	・How to use equipment of Plane Table Survey ・How to draw survey map ・Pin striking of survey point in Yankin pilot area
1st Feb,2016 – 10th Mar,2016	・Training: Surveying on site ・Training: Merge surveying map (1:500), tracing work
11th Mar,2016	・Training: Import the results of the survey into GIS

(2) Training of pipeline design (DMA design)

WRAWSA has been estimating pipe diameter based on the knowledge of their experience without considering proper diameter and has laid pipes accordingly. WRAWSA recognized the importance of calculating the proper pipe diameter as a current issue, and strongly requested the Expert for lecture and practical training for engineers of the sections involved in design and construction. From this background, following training was carried out to teach how to calculate the proper diameter as shown in Table 2-71.

The participants worked on practical pipeline design such as calculating proper diameter of distribution pipes by operating Excel and EPANET (hydraulic analysis software). Especially, the NRW C/P achieved results such as actual DMA design in the pilot area.

Table 2-71: Contents and schedule of pipeline design training

<table>
<tr><th>No.</th><th>Date</th><th>Training Content</th><th>Participants</th></tr>
<tr><td>1</td><td>17 Mar.,2016</td><td rowspan="2">・Plan and design related to distribution pipe
・Necessity of proper pipe diameter
・Basic hydraulic calculation (concept of head loss, exercise in example)
・How to calculate and define future demand
－Future population forecast
－Future water consumption (per capita)
－Hourly factor</td><td rowspan="4">NRW C/P</td></tr>
<tr><td>2</td><td>18 Mar.,2016</td></tr>
<tr><td>3</td><td>21 Mar.
～31 Mar.,2016</td><td>Hydraulic analysis and pipeline design practice on the pilot area (Total 6 Times)
(Design practice for DMA construction in 2-3-8(1))</td></tr>
<tr><td>4</td><td>1 Apr.,2016</td><td>Material of water pipe (Introduction)</td></tr>
<tr><td>5</td><td>14 Dec.,2016</td><td>Basic pipeline design</td><td rowspan="2">NRW C/P, GIS Section, Design Section, District Office, Pipe Sections</td></tr>
<tr><td>6</td><td>16 Dec.,2016</td><td>Hydraulic analysis and pipeline design practice on North Okkalapa and Mayangone township</td></tr>
</table>

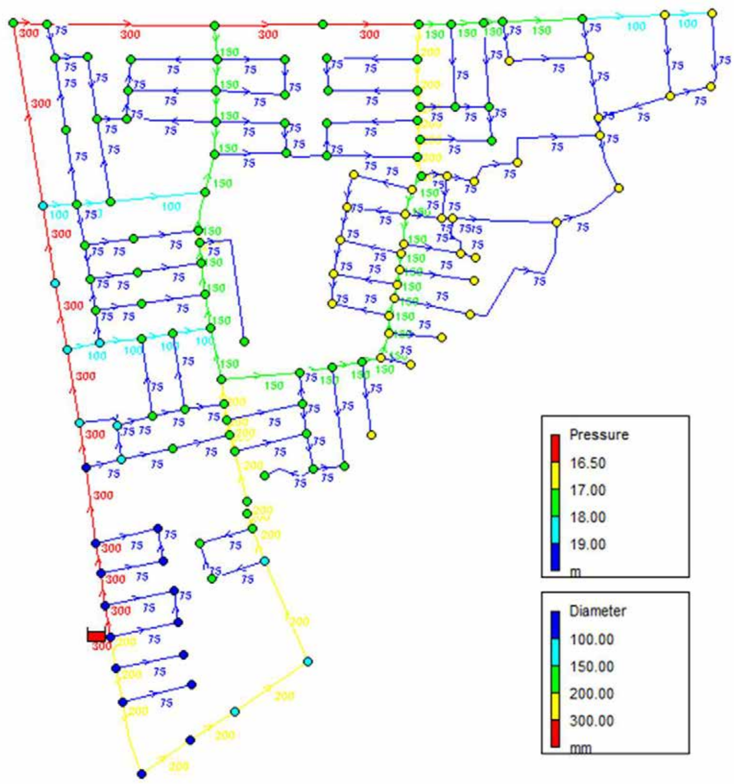


Figure 2-53: Hydraulic model on North Okkalapa (Southern area) (EPANET)

(3) Training for water pressure measurement and analysis

In Yangon city, there are many areas where the water pressure is low, and the supply is not for 24 hours. When measuring the water pressure in distribution pipes etc., it is possible to temporarily measure the instantaneous water pressure by using pressure gauge installed in other projects. However, WRAWSA does not have equipment for measuring water pressure variation for longer time such as for one day (24 hours), one week or more. Therefore, training on continuous water pressure measurement in the pilot area was conducted. For this training, a water pressure gauge with a data logger was installed which could measure the pressure continuously, and the pressure was measured continuously within a certain period. Water pressure at the inflow point of DMA in the pilot area was necessary for pipeline design. The continuous water pressure was measured for one week in two points as a training. The NRW C/P and Yankin T/S engineers participated in this training.

1) Training for installation of water pressure logger and drilling under pressure

When measuring the water pressure of the existing pipe, drilling work was done on a 250mm diameter cast iron pipe using saddle snap tap and a drilling machine under pressure, and a 20mm service pipe was connected. Then, logger was connected to the 20mm service pipe and pressure measurement was conducted for one week.

2) Determination of water pressure measurement points

Pressure measurement points of pilot area are shown in Figure 2-43. Point 1 is located near the inlet point in the north-west, Point 2 is near the inlet of the east side. Water pressure was measured at those two points.

3) Result of pressure measurement

Result of pressure measurement is shown in Figure 2-54. At Point 1, the maximum pressure was 0.05-0.06Mpa and minimum pressure was 0.04Mpa. At Point 2, the maximum pressure was 0.04Mpa and minimum pressure was 0.02Mpa. As a result of pressure measurement, the cause of sudden drop in water pressure every day at Point 2 became clear. The valve was opened and closed on the upstream of the pilot area every day to secure water distribution to the downtown area. It was found that the simple countermeasures by opening and closing the valve were being carried out without investigating the influence caused by that work, such as fluctuations of water pressure in neighboring areas.

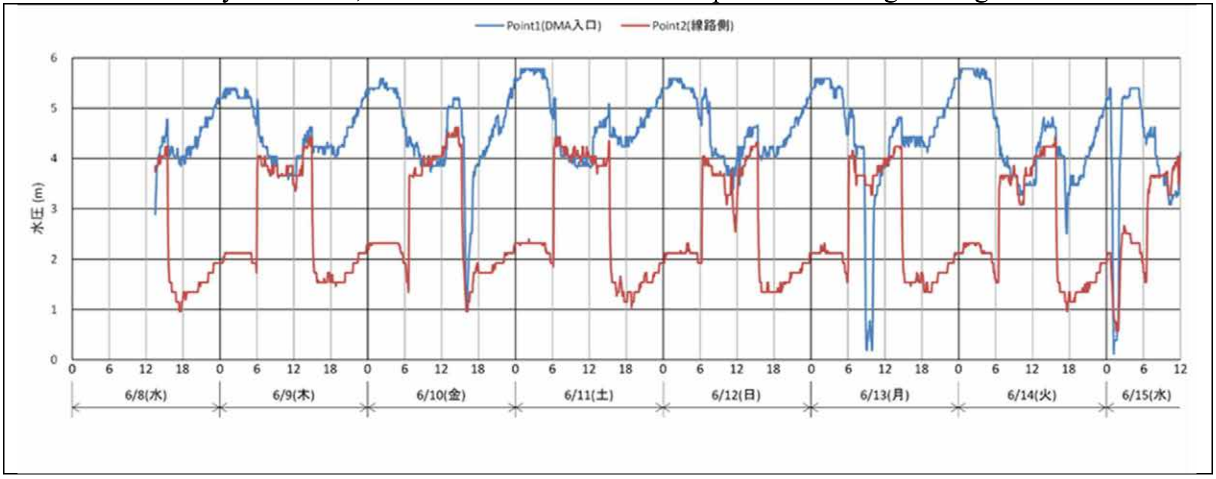


Figure 2-54: Result of water pressure measurement at future inlet of pilot area

(4) Water meter function test and training on service pipe installation

Water meter function test for existing meters was carried out in Yankin pilot area by using portable electric test meter (TR-III). To check the function of target meters, difference between test meter and existing meter was measured as below.

- Date：11/7/2016 – 25/11/2016 (3 weeks)
- Households：340
- Test duration：30 sec./each

The following guidance were conducted in removing and installing the meter:

- How to remove/re-install water meter
- Proper piping for easy maintenance
- Meter installation with meter union for easy removing
- Appropriate meter position for easy meter-reading

(5) Seminar on subjects related to leak detection

A seminar of leak detection was carried out before leak detection training on site. The types of detectors, the work content which would be conducted by the NRW Management Section and the role of NRW Management Section in WRAWSA and some other items were shown in this seminar on November 29th, 2016 utilizing the documents of Advisory Committee. In addition, the status of WRAWSA and the improvement proposal were also shown.

(6) Practical training of nighttime leak detection on site

At midnight on 5th Dec. 2016, nighttime leak detection training was conducted in North Okkalapa T/S. The selection of training implementation area was made subject to the following conditions.

1. Securing a certain water pressure
2. Existing pipes are aged, and many leaks are expected
3. Less traffic during nighttime

North Okkalapa T/S is located in the north of Yangon city and is relatively upstream in terms of water receiving. Compared to the Downtown area, North Okkalapa T/S has higher water pressure (0.06-0.07Mpa) and lesser traffic.

Organizing three teams with the NRW C/P and T/S staff members, leak detection training was carried out by using leak detector. Dia.8 inches PVC pipe was selected as a target and the length was 900m. Three suspicious leak points were found by the participants.

Trainings in Japan and third countries on leak detection for WRAWSA engineers had been conducted several times; however, there was no one who had experience of nighttime leakage detection work in Yangon city at that time. Every participant of this training joined very eagerly and knew how difficult leak detection was under low pressure.

(7) Training for utilization of GIS

The Expert carried out the training (seminars and workshops) about advantage, plan and procedure of utilization of GIS as per schedule shown in Table 2-72. The C/P took lectures positively. The result was that they were able to utilize GIS data for design of DMA in the pilot site.

Table 2-72: Schedule and subjects of GIS training

No.	Date	Subjects	Students
1	8 Oct., 2015	Plan of utilization of GIS	NRW C/P
2	9 Mar., 2016	Tracing work with result of field survey	
3	11 Mar., 2016	Importing of survey result into GIS	
4	14 Mar., 2016	Tracing work (practical work)	
5	15 Mar., 2016	Inputting work for pipe, road, customer (practical work)	
6	16 Mar., 2016		
7	2 Jun., 2016	Inputting work for result of pressure measurement (practical work)	
8	14 Dec., 2016	Advantage of utilization of GIS	NRW C/P, GIS Section, Design Section, District Office, Pipe Sections
9	15 Dec., 2016	Operating instructions of ArcGIS	GIS Section, Design Section, District Office Staffs, Pipe sections

*Manuals for No.2-7 were formulated.

(8) Training for measurement of flowrate

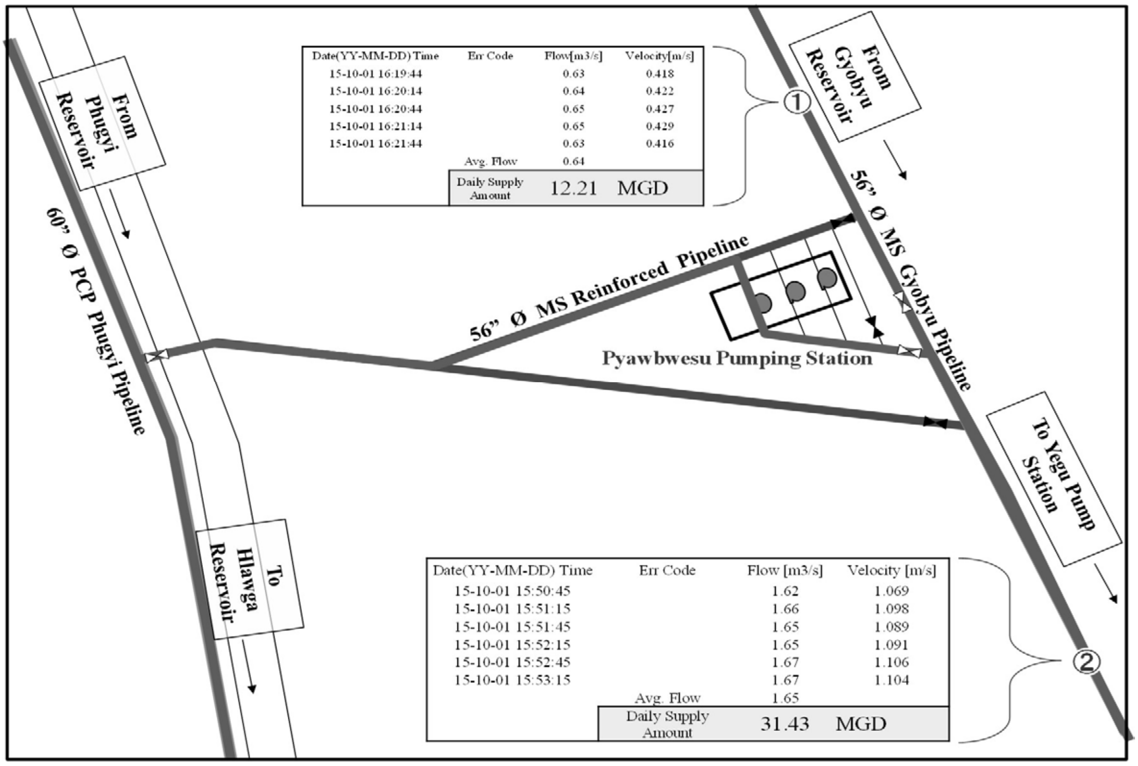
The grasp of flowrate for calculating of NRW ratio and monitoring of PI is required. Flowrates are monitored by permanent flowmeters regularly. In addition, measurement using portable flowmeters is needed. Therefore, the C/P and the Expert carried out training in the field utilizing potable ultra-sonic flowmeter which had been provided by past donor project.

The location of measurement is shown in Table 2-73. Not every point had permanent flowmeters and it is difficult to estimate flowrate by pump operation record on transmission pipe.

Table 2-73: Location of flow measurement

No.	Date	Location	Detail
1	1 Oct.,2015	On transmission pipe from Gyobyu at the Pywbwesu Pumping Station	① in Figure 2-55
2	1 Oct.,2015	On transmission pipe to Yegu P/S at the Pywbwesu Pumping Station	② in Figure 2-55
3	9 Oct.,2015	On transmission pipe from Gyobyu by gravity	③ in Figure 2-56

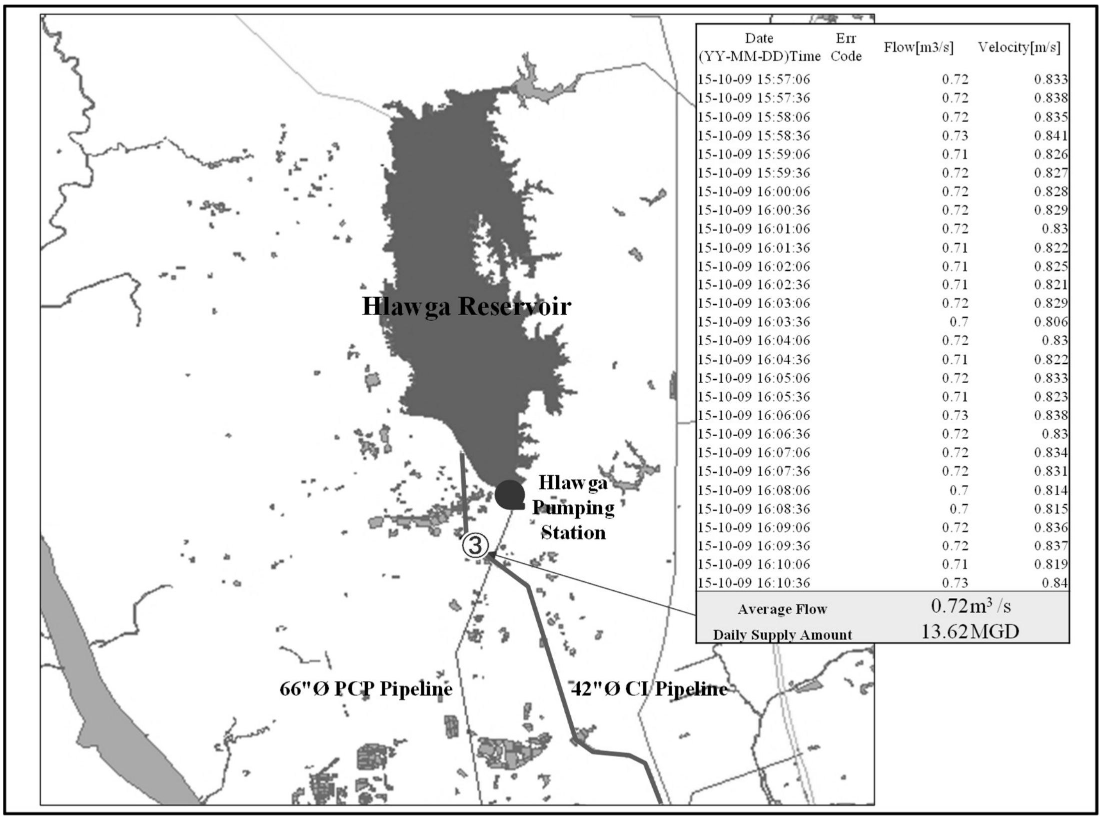
The results of measurement at No.1 and No.2 are shown as Figure 2-55. The result of measurement at No.3 is shown in Figure 2-56. The flowrates at No.1 and No.2 were similar to WRAWSA 's estimation. But the flowrates at No.3 was almost twice as much as WRAWSA 's estimation. (WRAWSA 's estimation was 8 MGD but the actual flowrate was 13.6 MGD.)



Date(YY-MM-DD) Time	Err Code	Flow[m3/s]	Velocity[m/s]
15-10-01 16:19:44		0.63	0.418
15-10-01 16:20:14		0.64	0.422
15-10-01 16:20:44		0.65	0.427
15-10-01 16:21:14		0.65	0.429
15-10-01 16:21:44		0.63	0.416
	Avg. Flow	0.64	
	Daily Supply Amount	12.21	MGD

Date(YY-MM-DD) Time	Err Code	Flow [m3/s]	Velocity [m/s]
15-10-01 15:50:45		1.62	1.069
15-10-01 15:51:15		1.66	1.098
15-10-01 15:51:45		1.65	1.089
15-10-01 15:52:15		1.65	1.091
15-10-01 15:52:45		1.67	1.106
15-10-01 15:53:15		1.67	1.104
	Avg. Flow	1.65	
	Daily Supply Amount	31.43	MGD

Figure 2-55: Result at the Pywbwesu PS (Location No.1and No.2)



Date (YY-MM-DD)Time	Err Code	Flow[m3/s]	Velocity[m/s]
15-10-09 15:57:06		0.72	0.833
15-10-09 15:57:36		0.72	0.838
15-10-09 15:58:06		0.72	0.835
15-10-09 15:58:36		0.73	0.841
15-10-09 15:59:06		0.71	0.826
15-10-09 15:59:36		0.72	0.827
15-10-09 16:00:06		0.72	0.828
15-10-09 16:00:36		0.72	0.829
15-10-09 16:01:06		0.72	0.83
15-10-09 16:01:36		0.71	0.822
15-10-09 16:02:06		0.71	0.825
15-10-09 16:02:36		0.71	0.821
15-10-09 16:03:06		0.72	0.829
15-10-09 16:03:36		0.7	0.806
15-10-09 16:04:06		0.72	0.83
15-10-09 16:04:36		0.71	0.822
15-10-09 16:05:06		0.72	0.833
15-10-09 16:05:36		0.71	0.823
15-10-09 16:06:06		0.73	0.838
15-10-09 16:06:36		0.72	0.83
15-10-09 16:07:06		0.72	0.834
15-10-09 16:07:36		0.72	0.831
15-10-09 16:08:06		0.7	0.814
15-10-09 16:08:36		0.7	0.815
15-10-09 16:09:06		0.72	0.836
15-10-09 16:09:36		0.72	0.837
15-10-09 16:10:06		0.71	0.819
15-10-09 16:10:36		0.73	0.84
Average Flow		$0.72 m^3/s$	
Daily Supply Amount		13.62MGD	

Figure 2-56: Result on the transmission pipe from Gyobyu by gravity (Location No.3)

(9) Water pressure test with local pipe material

Currently, plastic pipes (HDPE, PVC, RRVP), which can be purchased in Myanmar or imported from the neighboring countries, conform to the ISO standard. However, some of those materials do not conform to the ISO standard. Therefore, the Expert conducted water pressure test training to check performance of water pressure resistance of the pipes which WRAWSA usually use. In addition, the Expert taught a drilling method with drilling machine and how to use a test pump.

1. Plastic saddle was installed onto HDPE pipe and PVC pipe (φ3", φ4", φ6") which are generally used in WRAWSA (Photo 2-38). Then, this pipe was drilled by drilling machine which was granted to WRAWSA by the Japanese grass root project in Mayangone T/S.
2. Pressure test by a test pump with 0.5MPa was carried out and principle of air discharging in pipe was explained.

As a result of this test, leakage at the joint between PVC nipple and PVC valve was confirmed. WRAWSA engineers recognized if quality of pipe material is not enough, it causes leakage. In the work of WRAWSA, drilling by electric drilling machine had been made after installing saddle clamp. The Expert explained the importance of proper drilling machine through the advice and practice. Finally, NRW Management Section started to use the drilling machine in the North Okkalapa NRW reduction project.

Photo 2-38: Water pressure test

(10) Measurement of leakage volume

Training for measurement of leakage volume was carried out as shown in Table 2-74. Since, only few DMAs were established in Yangon city, it is difficult to grasp the conditions of actual volume of leakage. The Expert proposed leakage volume measurement work which would provide data for grasping actual situation on physical loss. WRAWSA does not measure leakage volume at leakage repair. An input column for estimated leakage volume was added to the revised format.

Table 2-74: Training contents and schedule

Date	Contents	Participants
Feb.8 2018	➢ How to collect leak water ➢ Measuring leak volume and recording measurement duration ➢ Convert leak volume into one day volume	Expert C/P

This training was carried out using a leakage found in Mayangone T/S. The result of measurement is shown in Table 2-75. Converting the measured leakage volume into yearly volume amounted to 44,254.2m^3, that is, if water charge is 88kyat/m^3, the revenue loss will be 3.9 million kyat per year. Another leakage as large as this measured leakage was found during the survey of Gyobyu pipeline. The extent of the effect of leakage on NRW could be speculated.

Repair work was done with a clamp by Pipe Section (1). However, repair work on small size pipe less than 6 inch was T/S responsibility. In principle, a direct branching from transmission main should not be made. However, many direct branches can be found all over Yangon city, because of unsystematic pipe network development. In the future, an improvement plan of operation/maintenance work should be prepared together with a water distribution plan.

Table 2-75: Result of leak volume measurement

Pipe Material /Diameter	Leak factor	Duration	Measured Volume(L)	Leakage (L/min)	Leakage (m^3/month)	Leakage (m^3/year)
PVC 4”	Broken by other Construction (Base of fence)	18.26sec.	25.98	85.37	3687.85	44254.2

(11) Seminar on design drawing

At present, WRAWSA does not use topographic maps with scale prepared based on survey and design drawings, which is drawn by WRAWSA, has only little information such as diameter and approximate location. Also, the scale of drawings used is not unified in WRAWSA and descriptions of design drawings are not unified either, because there is no clear rule of drawings. Therefore, seminar of design drawing was held on 21st March 2018. The Expert explained roles of map and the necessary items of drawing when making design drawing as follows.

1. Necessary information and preparation before drawing a planning drawing
2. Necessary indicators on design drawing
   - Compare drawing by WRAWSA and drawing prepared by the Expert in North Okkalapa project (Figure 2-57 and Figure 2-58)
3. Off-set map, Detail diagram
4. Roles of design drawing and as-built drawing

After this seminar, a lively discussion was made on how to describe scale, how to draw by CAD, reason why offset drawing is needed and other topics. It was assumed that the C/P improved their willingness to make planning drawings through this seminar. In the future, descriptions on design drawings, such as layouts, will be improved step by step based on this discussion.

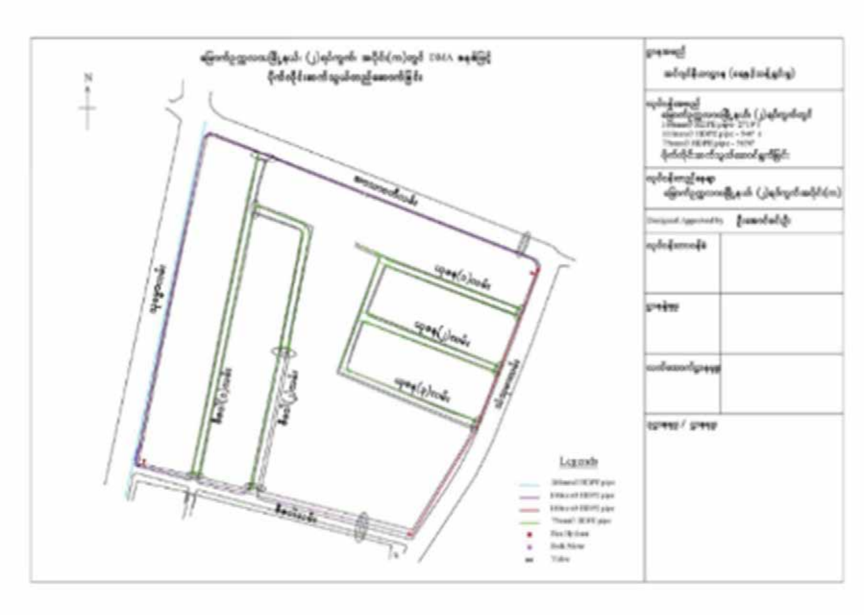


Figure 2-57: Design drawing by WRAWSA

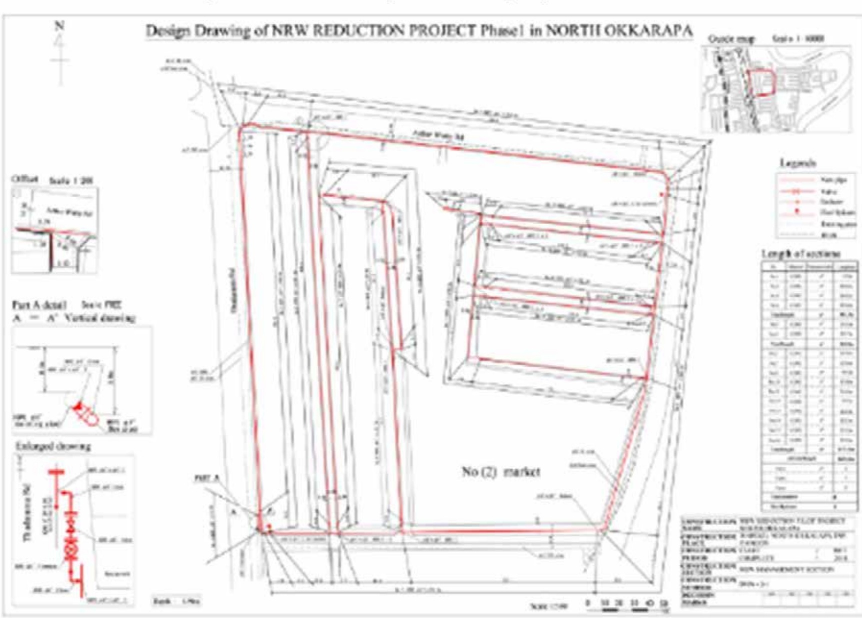


Figure 2-58: Design drawing by the Expert

(12) Training for utilization of GIS and hydraulic analysis software

The Expert term conducted training on utilization and operation of GIS, calculation method of future demand and operation of EPANET (hydraulic analysis software) as per the schedule shown in Table 2-76. The C/P took the trainings positively. As a result, they were able to utilize the GIS and EPANET for DMA design in North Okkalapa T/S.

Table 2-76: Schedule and subjects of training for GIS and hydraulic analysis software

No.	Date	Subjects	Students
1	31th Aug., 2017	Utilization and operation of GIS (as shown in Photo 2-39:)	NRW C/P
2	8th Sep., 2017	Calculation method of future demand (as shown in Photo 2-40:)	
3	9th - 10th Nov., 2017	Hydraulic analysis and DMA design practice in North Okkalapa and Thingangyun T/S (as shown in Figure 2-59 and Figure 2-60)	


Photo 2-39: GIS training


Photo 2-40: Calculation of future demand

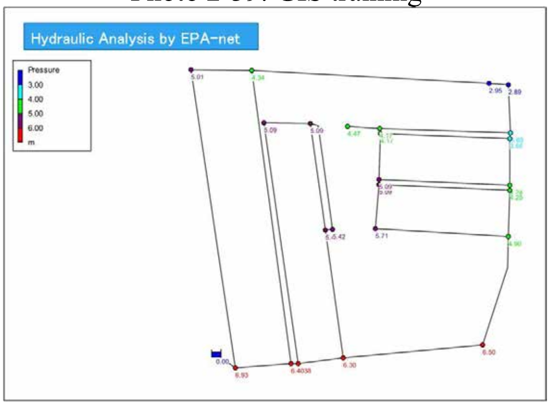


Figure 2-59: DMA model for North Okkalapa T/S

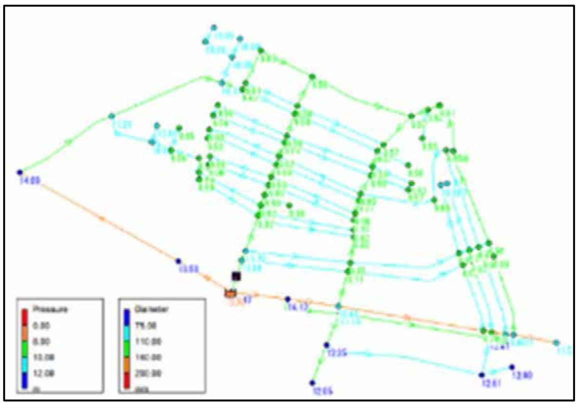


Figure 2-60: DMA model for Thingangyun T/S

(13) TOT through NRW reduction project in North Okkalapa T/S

Training of pipeline and DMA design was carried out as a part of training of trainers (TOT) in NRW reduction project in North Okkalapa T/S as shown in Table 2-77.

Table 2-77: Schedule and subject of TOT for physical loss management

Date	Subjects	Participants
1.Sep 2017	1st Hydraulic analysis practice (case study on North Okkalapa NRW reduction project)	C/P
8.Sep. 2017	2nd Hydraulic analysis practice (case study on North Okkalapa NRW reduction project)	
6-8. Sep. 2017	Training for measurement by ultra-sonic flowmeter on site in North Okkalapa T/S	
9-10. Sep. 2017	Pipeline and DMA design practice	

Photo 2-41: Flowmeter chamber (inlet)

Photo 2-42: Meter box (WRAWSA original)

Photo 2-43: Tapping with drilling machine

Photo 2-44: Valve box (WRAWSA original)

The workflow from DMA design to the start of construction is shown in Table 2-78. According to GIS training material, hydraulic model was prepared based on survey results. According to pipeline design training material, the models were analyzed in consideration of the number of population/households and water demand in 2040. The DMA design was the outcome from these works. The GIS training manual above is given in Annex CD3"GIS & EPA-net Operation Manual ".

Table 2-78: Workflow from DMA design to start of construction work

Step	Work
1.	Topographical survey and grasping of location and population of inhabitants
2.	Grasping of location of DMA inlet and circumstance of existing pipe (location, diameter and connection)
3.	Decision of DMA area and inlet point
4.	Calculation of diameter and structure of pipeline for future demand
5.	Planning for construction work
6.	Measurement of initial NRW rate
7.	Start of construction work

1) Topographical survey and grasping of location and population of inhabitants

Figure 2-61 shows information of existing pipeline held by WRAWSA in Ward2 of North Okkalapa T/S as the target site. Before DMA design work, the C/P carried out topographical survey by total-station in which angle measurement function and distance function are integrated and survey is carried out in the site. Their topographical survey is shown in Photo 2-45 and their collected information of the inhabitants is shown in Table 2-79.

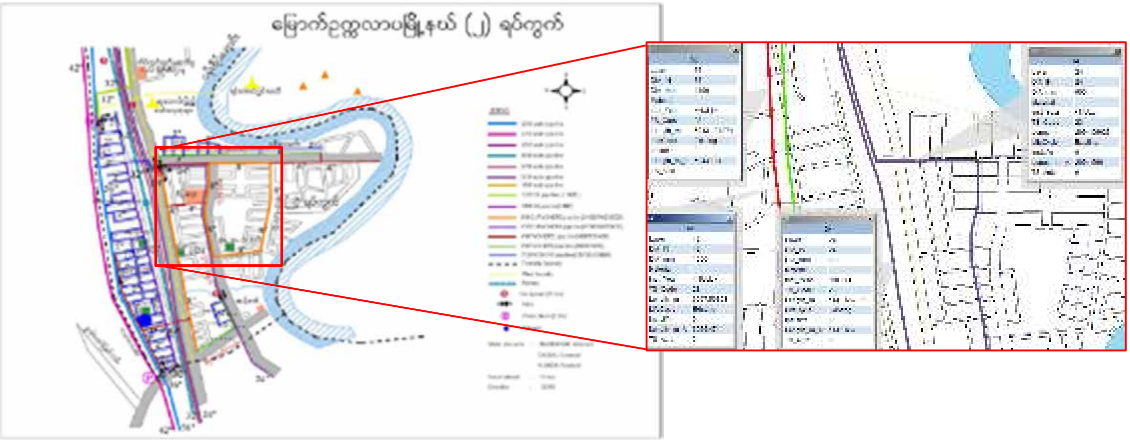


Figure 2-61: Information of existing pipeline held by WRAWSA 's Design section and GIS Section

Photo 2-45: Topographical survey by total-station

Table 2-79: Collected information of the inhabitants (population per household)

2) Grasping of location of DMA inlet and conditions of existing pipe

Result of the field survey is shown in Figure 2-62. The survey found the following problems.

- Test digging works for checking the existing pipe were not executed sufficiently and the C/P and the Expert were forced to carry out visual investigation mainly from the ground. Because road closure was not permitted, we were not able to execute breaking work of the pavement.
- The survey revealed that the prior and existing information was different from the current situation. We found so-called support pipes newly installed for backup of the existing inlet point as shown in a red dashed circle of Figure 2-62.

- Figure 2-63 shows the detailed situation of existing pipe in a red dashed box of Figure 2-62. Because the above support pipes were newly installed, there were several inlet points in this area.
- As described later, the C/P carried out test diggings for flow measurement work and found unknown distribution pipes and branches for house connections. It was difficult to clarify the current situation of existing pipes only from visual investigations.

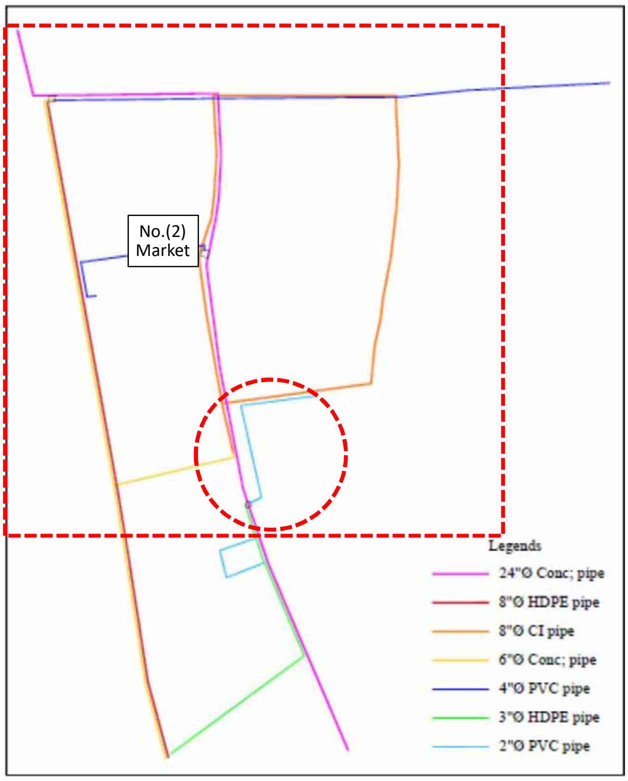


Figure 2-62: Existing pipeline clarified by the survey

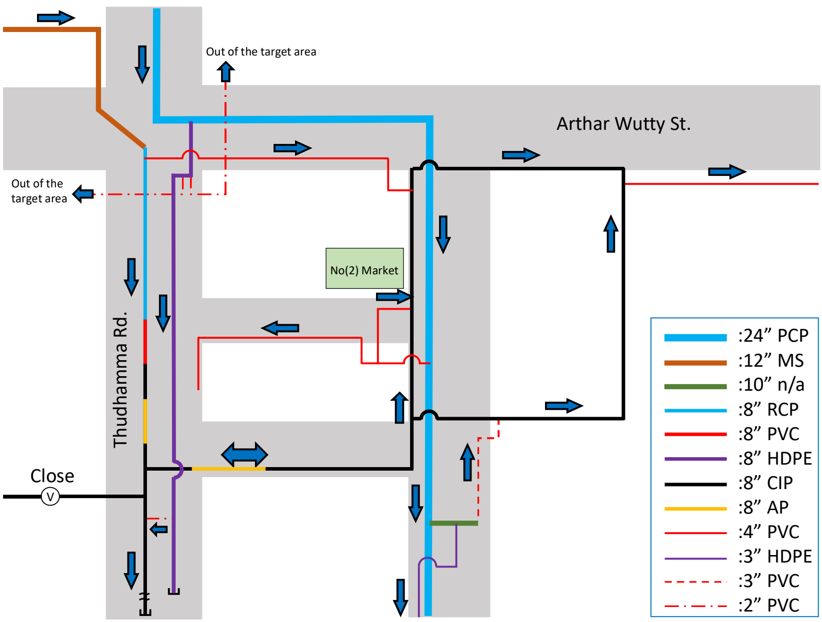


Figure 2-63: Detailed situation of existing pipe

3) Decision of DMA area and inlet points

According to budget and construction period of WRAWSA, DMAs were to be established in 3 (three) phases as shown in Figure 2-64. The C/P and the Expert made detailed design of DMA for Phase 1 and decided a plan to restructure distribution pipeline, in which only an inlet point would be set for a DMA so that WRAWSA can properly manage NRW.

Figure 2-64: Inlet points of DMAs (Plan)

4) Calculation of diameter and pipeline form for future demand

For DMA in Phase1, the C/P and the Expert reflected the result of the topographic survey into GIS and made a hydraulic model in consideration of the locations of inhabitants. The model was used for analysis for suitable diameters based on water demand in 2040. The Expert instructed an arrangement of pipelines for the future DMA. The C/P carried out the design work for DMA of Phase 2 by themselves following the same procedure for the DMA of Phase 1 and calculated the suitable diameter and pipeline arrangement.

5) Construction planning

According to the DMA design work for Phase 1 and Phase 2, the C/P estimated the required quantity of materials and equipment as shown in Table 2-80.

Table 2-80: Material and equipment for Phase1 and Phase2

No	Name	Materials & Equipment
1.	HDPE pipe	75mmφ,110mmφ,160mmφ
2.	Pipe Accessories	Tee, Elbow45, Elbow 90, Straight Coupler, Gate Valve, Male Thread, Cover and Frame, Flange Spigot, Fire hydrant, Bolts & Nuts, Reducer, Butterfly Valve and Bulk Meter
3.	House Connection	1''φPE Clamp Saddle,1''φNipple,1''φBall Valve,3/4''φ Ball Valve,1''φ V-Elbow,1''*3/4''φ Reducer,3/4''φ F-Socket,20mm*3/4φ Male Thread Adaptor, 20mm*3/4''φ Male Thread Elbow,1''φ GI Pipe, 20mmφ(PN12.5 SDR13.6)Pipe , Seal Tape, Meter Box, 20mm Water Meter

List of HDPE for Phase-1

160Ømm HDPE = 2710'
110Ømm HDPE = 940'
75Ømm HDPE = 5650'

List of HDPE for Phase-2

160Ømm HDPE = 3300'
110Ømm HDPE = 2400'
75Ømm HDPE = 12700'

6) Flow measurement to estimate an initial NRW rate

As mentioned above, there were several inlets into Phase 1 area. No existing flowmeter was installed so we set an ultra-sonic flowmeter and measured water flow at inlets. Test digging was carried out for grasping situation around measurement points to make plans of measurement in advance. As a result, the issues mentioned below were found.

(Issues)

- Since we could not get permission to stop traffic, it was impossible to measure any existing pipes underground.
- It was impossible to measure flow by phase because it was unable to grasp water supply lines.
- It was better to measure some points simultaneously; however, one of two WRAWSA owned ultra-sonic flowmeters was broken.
- Actual situation that we knew by test digging was different from the pipeline map of WRAWSA. So, it took time to make a measurement plan.

(Decide measurement place)

Because of the issues above, we selected measurement places where there was not so much traffic. Duration of measurement was 24-hour to grasp hourly variation of flowrate. To measure all system input volume, finally we selected 7 places for setting ultra-sonic flowmeters as shown in Figure 2-65.

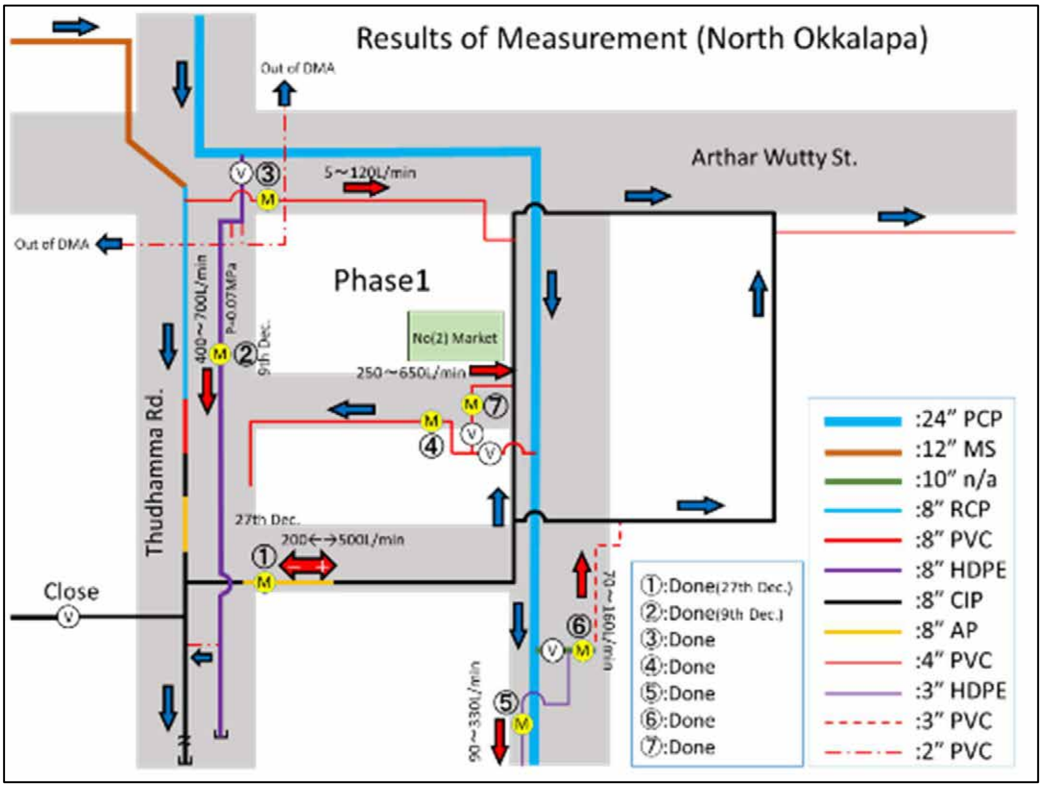


Figure 2-65: Measurement points

(Result of the flow measurement)

The results at each measurement point are shown in Figure 2-66. Measurement at point No4 was implemented again due to an error (the 2nd data is not included in the graph below). Water supply sources of this area are Gyobyu reservoir and Nyaunghnapin WTP. At point No1, the water flow direction was changed to backflow sometimes, but we could not find the reason why it happened due to lack of information. Moreover, the water flow was stable between AM00:00 and AM 5:00, therefore, it was assumed that either that amount of water supplied was stored in storage tank or there was large amount of leakage.

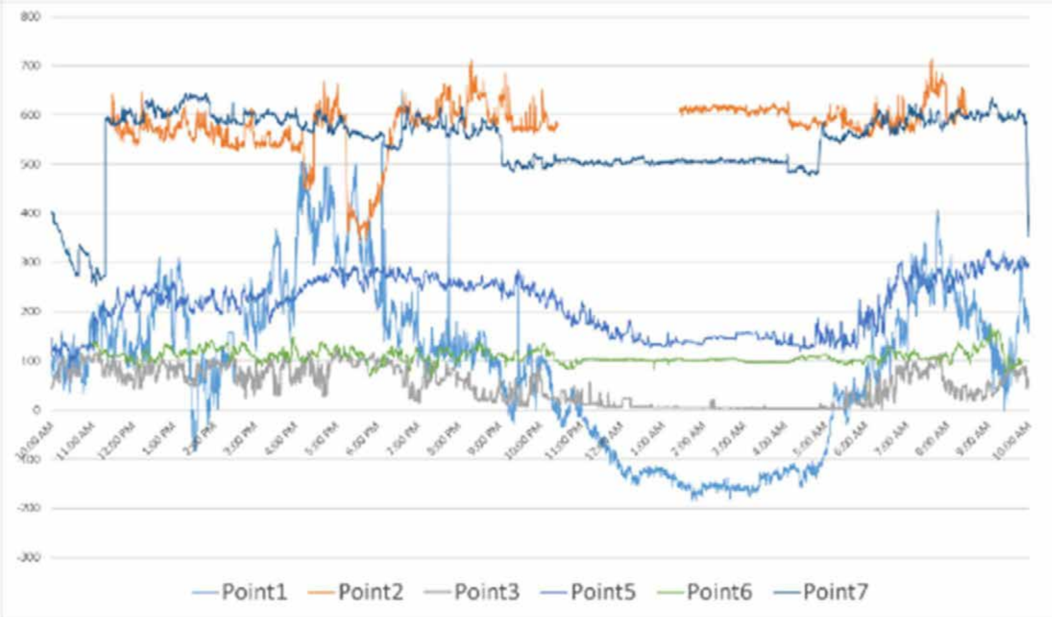


Figure 2-66: Result of flow measurement North Okkalapa

7) NRW rate before project

The estimated system input volume per month is shown in Table 2-81, and meter-reading units in Jan 2018 are shown in Table 2-82.

Table 2-81: System input volume (North-Okkalapa)

(m^3/month)

Measurement Point	Supply volume
Point1	7,452.8
Point2	24,993.2
Point3	4,747.8
Point4	23,487.6
Point5	9,175.8
Point6	2,131.0
Point7	48,156.3
Total	120144.5

Table 2-82: Meter-reading units in Jan 2018(North Okkalapa)

(m^3/month)

Tariff category	Consumption
Domestic	44,716
Commercial	8,150
Department	155
Commercial-FE	6
Flat Rate	5,640

Based on the value above, we estimated an initial NRW rate at 51.2%.

8) Construction

After design work finished, the C/P started construction work for Phase 1 and Phase 2 projects. WRAWSA decided to implement the project by using materials that WRAWSA generally uses due to limited budget and prescribed schedule as mentioned in "⑤Planning/design". Also, the construction method employed was conventional. The situation of the projects is shown in Photo 2-46 to Photo 2-50.

Photo 2-46: Pipe laying work

Photo 2-47: Flow meter chamber (Inlet)

Photo 2-48: WRAWSA meter box

Photo 2-49: Branching work with drilling machine

Photo 2-50: WRAWSA valve box

9) Making of as-built drawings

A drawing seminar for the C/P was carried out. The C/P created as-built drawings and compiled customer data according to that seminar after North Okkalapa project finished. The information on as-built drawings will be reflected on WRAWSA-GIS. Two staff members from GIS Section were assigned for input work. They are trying to input based on the as-built drawings of North Okkalapa project as shown in Figure 2-67.

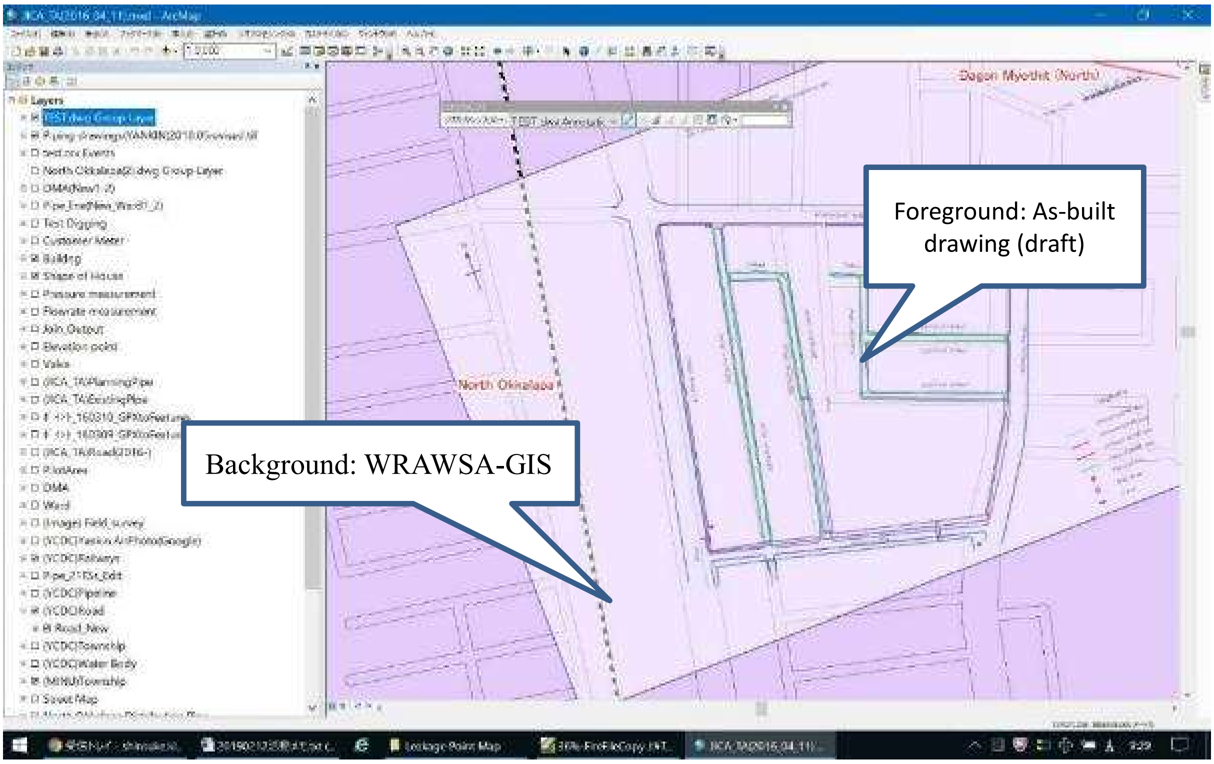


Figure 2-67: Matching between as-built drawing and WRAWSA -GIS

In future, as-built drawings will be continuously made for WRAWSA's own construction work by AutoCAD. The flowchart of making of as-built drawings in WRAWSA is shown in Figure 2-68. This flow has been accepted by the DYCE, NRW Management Section and GIS Section. As mentioned above, the two GIS support staff will be trainers of map integration works in future.

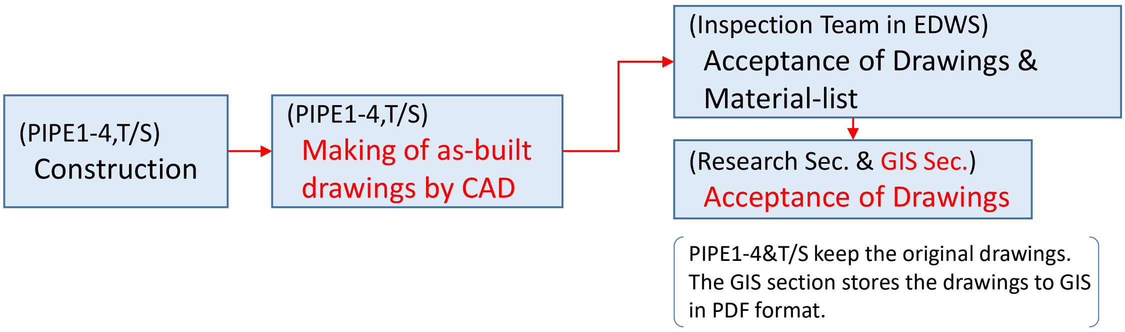


Figure 2-68: Workflow for creating as-built drawings and map integration in WRAWSA (in future)

(14) Seminar of night step test and minimum night flow

Date: 31st May, 4th June 2018

Training of night step test and minimum night flow for the staff of NRW Management Section and Research Section were carried out to grasp leakage situation.

Training contents are as follows.

1. What can be grasped by minimum night flow measurement
2. How to carry out minimum night flow measurement
3. What can be grasped by night step test
4. How to carry out night step test

(15) On-site training of minimum night flow and step test

[Preliminary work] 2018/6/5 PM:2:00～5:00

The Expert selected the place where the grant aid project was carried out in Yankin T/S as a training field because there were only a few DMAs in Yangon currently. Digging work at inlet point and function check of ultra-sonic flow meter were carried out as a preliminary work for night step test.

[Training for measurement] 2018/6/6 AM1:00～5:00
Even though the training time was mid-night, South District officer, the NRW Management Section C/P and Yankin T/S office staff - total 22 persons participated in this training. Practical training for grasping leakage and leak suspected pipeline was carried out. Result of this work is shown in Figure 2-69. Although it was a small amount, leakage was found.


Photo 2-51: Working condition


Photo 2-52: Measurement by ultra-sonic flowmeter

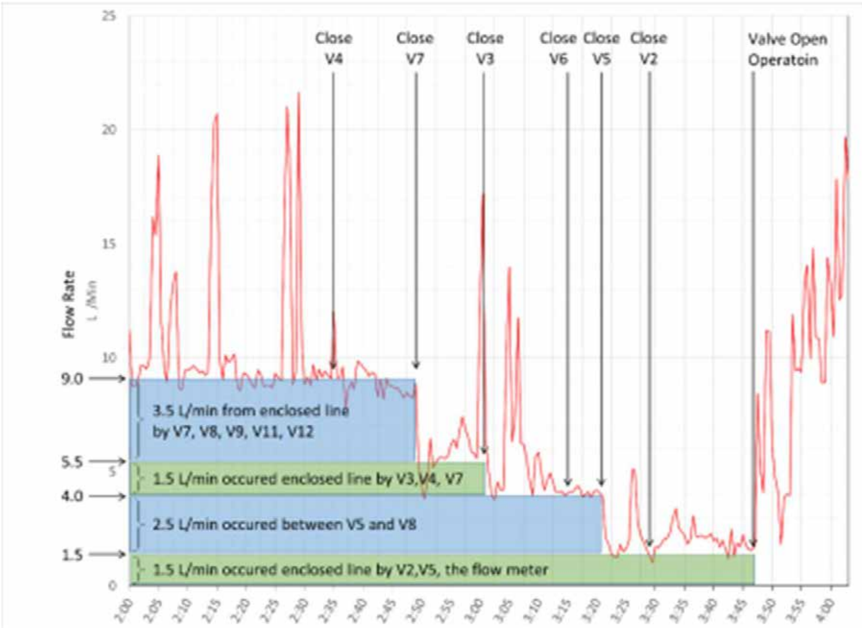


Figure 2-69: Result of night step test

Several trainings for trainers were carried out, which include not only the trainings mentioned above but also the ones carried out in the pilot project. Activities of pilot project are mentioned in 2-3-6. Also, the related trainings were conducted in NRW training yard, which describes later.

2-3-3 Prepare training plan and training materials by the trainers

(1) Training plan

ToT for trainers were implemented mainly through the pilot project and the activities in the training yard. In Yankin Project Phase 3 (refer to 2-3-11) which was implemented after the completion of the pilot project, training for new staff in NRW Management Section was carried out based on the pilot project training plan (Table 2-84). In addition, the trainers and the Expert collaborated to develop a training plan of the training yard (refer to 2-5-2.).

(2) GIS training materials
Manuals, textbooks, and slides made in pilot project Phase 1 are used as GIS training materials. However, survey results with total station were newly available as mentioned in “2-3-2(13) TOT through NRW reduction project in North Okkalapa T/S”; therefore, GIS Operation Manual (Image-Matching) was revised and a training for importing total station data into GIS was carried out. The GIS training manual is given in Annex CD3 "GIS & EPA-net Operation Manual ".

GIS operation manuals	• Benefits of GIS and Operation of ArcGIS (GIS view & print starter manual) • GIS Operation Manual (Image-Matching) rev3 (GIS editing starter manual) • GIS+EPANET Operation Manual (Data conversion, Hydraulic analysis) rev1 (GIS editing manual)
GIS related reference	• GIS Tutorial 1 Basic Workbook (Esri Press) • GIS Tutorial 2 Spatial Analysis Workbook (Esri Press)

(3) Training materials for NRW management
OJT will be conducted by using the SOPs that were formulated in the pilot project. And practical and classroom training on NRW management will be conducted at the training center (training yard and training building) built in January 2020. In the training center, 10 practical courses with 12 lectures have been provided, and training materials for their implementation also have been prepared. The training materials were prepared including the above SOPs in the materials so that the trainees can use them in practice in their offices after the training. Table 2-83 and Table 2-84 show the training materials for the training centers, and Table 2-85 shows the list of SOPs.

Table 2-83: Training materials for lecture

No.	Training Course
1	Water supply plan
2	Hydraulic analysis
3	Distribution pipe laying
4	Water pressure test
5	Completion drawing
6	Flow rate measurement
7	Minimum night flow, Night step test
8	Leakage detection
9	Leakage repair
10	Water supply equipment
11	Issues caused by water meter
12	Non-Revenue Water management

Table 2-84: Training materials for practical skill in training yard

No.	Training Course (Practical, established)
1	Service pipe branch
2	Function check of water meter
No	(Under preparation by the C/P)
1	Pipe cutting and jointing (by material type)
2	Re-jointing with repair joint material
3	Jointing with flange type material
4	Water pressure test
5	Branching method (Tapping under pressure)
6	Flow measurement (Electro-magnetic flowmeter, Ultra-

No.	Training Course (Practical, established)
	sonic flowmeter)
7	Night step test
8	Leakage detection method

2-3-4 Formulate manuals on physical loss

Following SOPs were prepared by the C/P through the pilot project activities:

Table 2-85: SOPs related to NRW management prepared in pilot project

No.	Title of SOP
SOP-01	Plane Table Survey
SOP-02	Pavement Cutting Line Marking
SOP-03	How to check digging depth and so on
SOP-04	Construction Signboard
SOP-05	Pipe laying
SOP-06	Pressure Test
SOP-07	Drilling for service connection
SOP-08	Back Fill
SOP-09	Material management
SOP-10	Equipment management
SOP-11	Pipe Line Drawing
SOP-12	Pressure Measurement
SOP-13	Flow Measurement
SOP-14	Leakage Volume Measurement
SOP-15	Leak Detection
SOP-16	Leak Correlator
SOP-17	Minimum Night Flow Measurement
SOP-18	Night Step Test
SOP-19	Customer Survey
SOP-20	DMA Monitoring
SOP-21	Meter Function Check
SOP-22	Survey of Damage Meters
SOP-23	Leakage Record
SOP-24	Daily Report
SOP-25	Tasks of NRW Management Section
SOP-26	Valve Box installation

2-3-5 Conduct Off-JT by the trainers

Training by trainers in the training yard was carried out as a demonstration in Jan. 2020 (refer to 2-5-6).

After the pilot project was completed, it was planned that trainers who were developed by the Project shall carry out training and seminars in Training Center for NRW Management including training yard.

Although restarting training in training yard was delayed due to the COVID-19 pandemic, an online training for deputy T/S officers was conducted from 18th to 30th December 2020 by trainers mainly composed of NRW Management Section.

2-3-6 Select a pilot area for NRW management

(1) Survey and select a pilot area

A survey to select a pilot area to implement OJT for NRW management was carried out from July to October 2015 in South Okkalapa, Bahan, Yankin and North Okkalapa townships. As a result of discussion with the C/P, an agreement was made between WRAWSA and the Expert that OJT for NRW management will be implemented at Ward No. 13 of Yankin T/S. In Yankin, 2 pilot projects by Fukuoka-city advisor and JICA Project for Urgent Improvement of Water Supply System were implemented. The pilot project for the Project was the fourth NRW improvement project in Yankin.

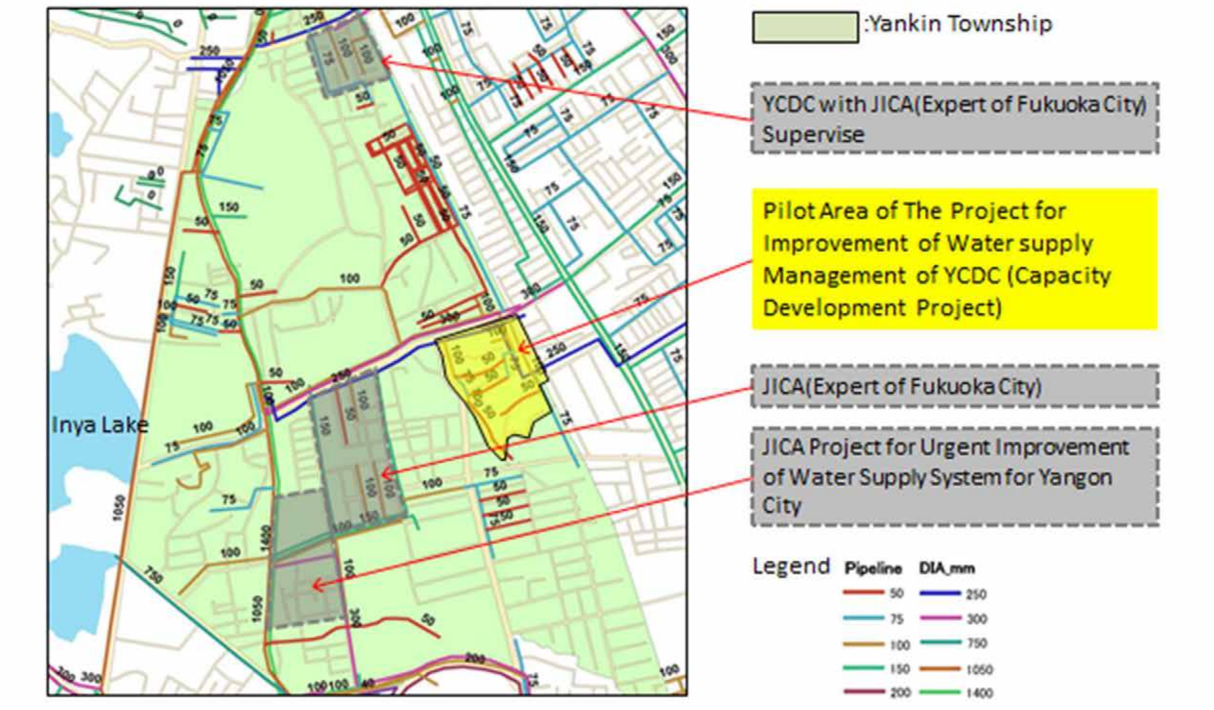


Figure 2-70: The pilot area of the Project, and situation of NRW projects by donor

The pilot area was selected considering the following criteria as much as possible.

Criteria for pilot area selection
a. It has old and aged pipe
b. It has damaged pipe
c. It has many leaks
d. It has spaghetti pipes
e. It does not have many inlet and outlet pipes (3～4) from and to the pilot area
f. It includes metallic pipe
g. Traffic is not congested, not busy, (which eases leak detection)
h. It has 24 hours water supply
i. It has good water pressure
j. It does not have tube well supply
k. It has several types of housing (individual and apartments)
l. It has damaged meter
m. It has flat rate customer (customers without meter)
n. The area in which water is not supplied from Hlawga reservoir, the supplied water from which has lots of debris, which break customer water meters even after replacement with good quality meters.
o. The number of customers is around 300~500

2-3-7 Prepare action plan and procure equipment for the countermeasures to be taken for reducing physical loss in the pilot areas

(1) Approach and process of the pilot project (pipe renewal)

The Expert considered to try to use existing pipes in this pilot project, but the following issues became evident from the preliminary site survey. Therefore, the Expert decided to replace all the existing pipes with new pipes and construct a DMA.

(Issues)

- Diameter of existing pipes are inappropriate.
- Inlet water pressure in the pilot area is quite low. Some inlets are made to increase water pressure, but water cannot reach the houses at the terminal.
  ⇒ It is difficult to apply existing pipe for constructing DMA
- YCDC does not have accurate pipeline maps, and as-built drawings are not created. The location of existing pipes is not clear.
- Depth of existing pipes are quite shallow and pipe material is not appropriate. Also, joints of existing pipes are not good. Therefore, it is necessary to replace all pipelines.

A lot of issues related not only to NRW but also design or inspection were present. Therefore, the Expert decided to conduct the pilot project in a process shown below. OJT of appropriate planning and design, construction, inspection, and recording were carried out.

1) Planning, hydraulic analysis and design relating to pipe laying work (Determination of proper diameter and material)
2) NRW reduction project
   - Setting up DMA, and improving and monitoring physical loss
   - Improving and monitoring commercial loss
3) Water pressure test (inspection)
4) Creating as-built drawing (record)

(2) Pipe materials for the pilot project

List of necessary materials was finalized in collaboration with the C/P. Suitable materials are necessary to implement proper NRW improvement. However, as a result of survey of materials which can be procured in Yangon city, it became clear that Butt-Fusion type HDPE which WRAWSA usually uses, is poor in adaptability and workability when pipe is installed avoiding obstacles of drains and ditches, and leaks frequently occur at jointed portions of these fittings. Therefore, materials which could be procured in Yangon were not appropriate for NRW pilot project. In addition, as a result of discussion about materials for NRW pilot project with the C/P, the C/P requested the Expert for learning about jointing technique with various pipe types and fittings. According to this request, TOT in the Phase 1 pilot project was implemented by using various materials such as ductile iron pipe, electro-fusion type HDPE and rubber ring type PVC. All of these materials were procured in Japan. The use of these materials was started in Myanmar, and they will be used more commonly in the future. The procured materials for pilot project are shown in the table below.

(Procurement in Japan)

1. Pipe and joint	DIP RRVP HDPE-Butt-Fusion Valve box Mechanical type metal joint Double layer PE pipe (For service connection)
2. Leak detector/ Repair material	Leak noise correlator Leak detector for resin pipe Metal locator Simple joint etc.
3. Equipment for construction	Concrete cutter Rammer Hammer drill etc.
4. Equipment for DMA construction	Electromagnetic flowmeter Ultra-sonic flowmeter Data logger
5. Water meter	Impeller type water meter

(Procurement in Myanmar)

1. Pipe	PVC pipe (25mm - 40mm)
2. Meter box	Meter box

(3) Implementation plan

Schedule from planning/design of pilot project is shown in Figure 2-71. A pilot area was selected in Oct. 2015. Surveying, customer survey and planning/design work were completed in 2016. However, OJT in pilot area was delayed and started in Jan. 2019 because procurement of equipment in Japan was delayed. Detailed construction schedule of pilot project is shown in Table 2-86. Construction work was suspended between end of Aug. and Sep. 2019 due to frequent heavy rain.

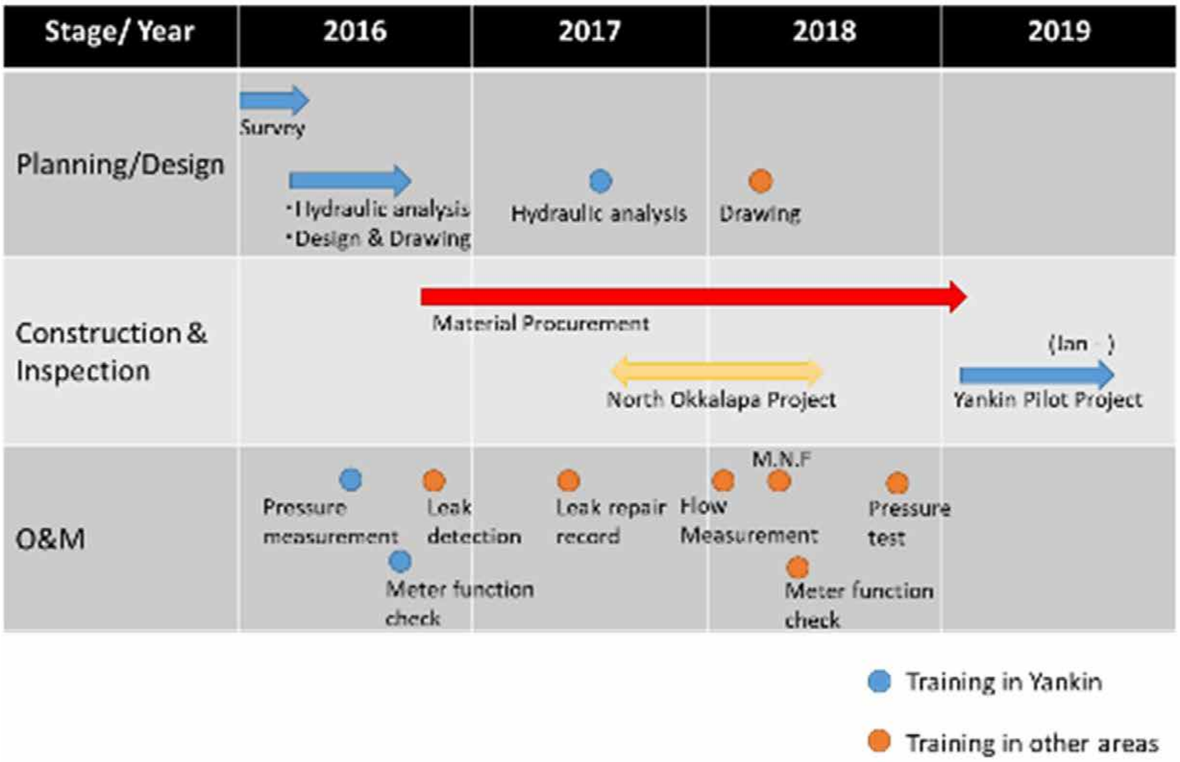
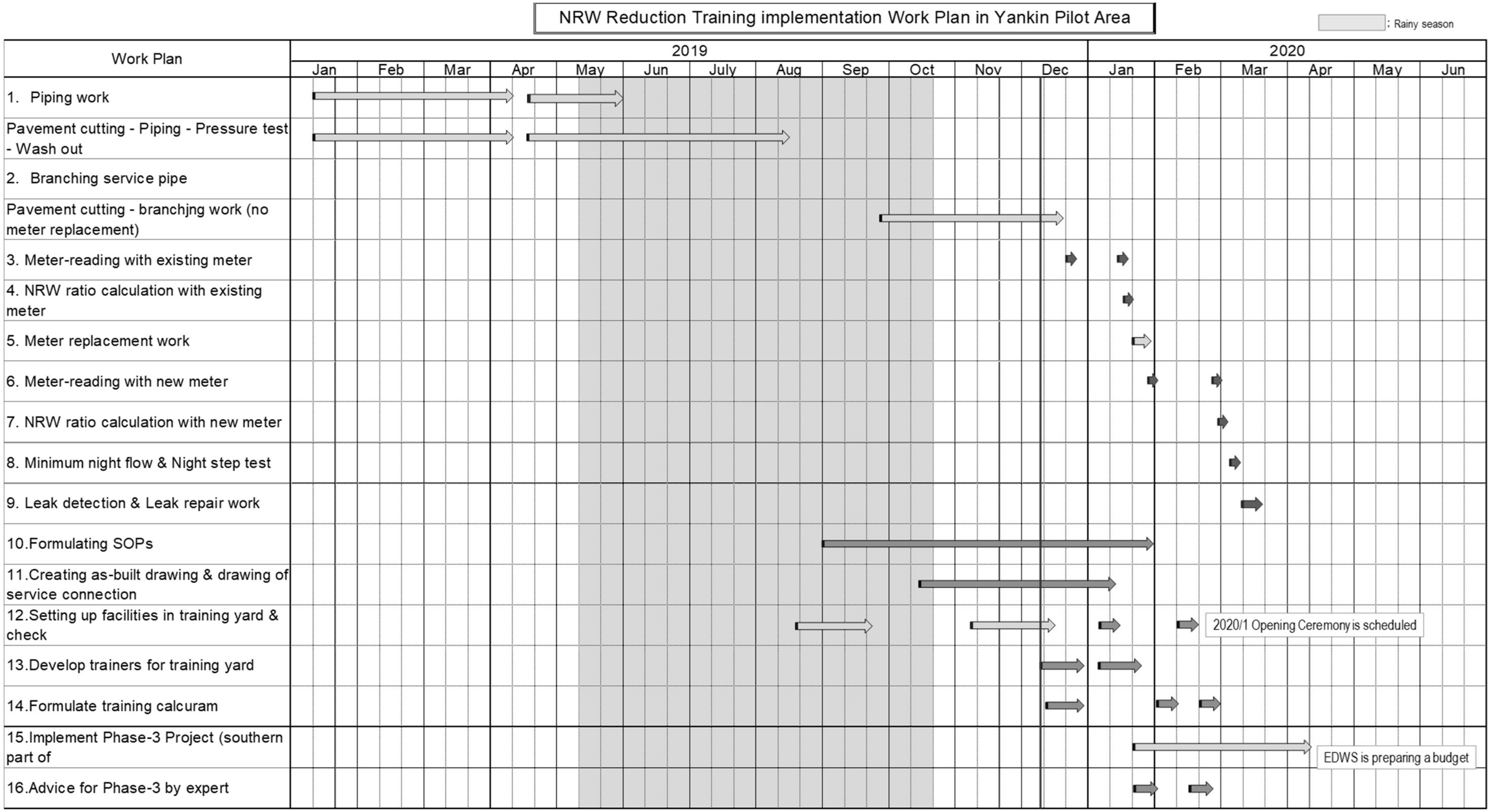


Figure 2-71: Entire schedule of pilot project

Table 2-86: Construction schedule of pilot project



(4) Training plan

Training plan on NRW management was decided in Feb. 2017 as shown in Table 2-87. According to this training plan, OJT in pilot area was carried out.

Table 2-87: Training plan on NRW management

Activities	Objectives/ expected outcomes	Main Contents	Activities
1) Understanding of materials for water supply. (Distribution, House connection)	To understand characteristics of materials	• Studying characteristic of materials • Studying standards for materials (Pipe, Valve, Joint)	Seminar/Training course/ OJT
2) Studying planning and design	To study proper planning and design	• Studying how to make distribution plan • Training for drawing • Training for completion drawing	Seminar/Training course/ OJT
3) Understanding necessity of inspection	To understand necessity of inspection and how to implement	• Studying basic knowledge of joint (DIP, HDPE, PVC, etc.) • Training for jointing and leakage repairing • Training for pressure test	Seminar/Training course/ OJT
4) Construction techniques	To improve pipe installation technique (DIP, HDPE, PVC, etc.) To improve leakage repairing technique	• Studying basic knowledge of joint (DIP, HDPE, PVC, etc.) • Training for jointing and leakage repairing • Training for pressure test	Seminar/Training course/ OJT
5) Studying water supply equipment	To understand proper meter installation and materials for water supply equipment	• Studying proper meter installation • Studying materials for water supply equipment • Training proper branching from distribution pipe	Seminar/Training course/ OJT
6) Leakage detection training	To improve leakage detection technique	• Studying type of leakage detector • Training for using leakage detector • Training for leak volume measurement	Seminar/Training course/ OJT
7) Survey for making scale map	To understand necessity of scale map and how to make	• Studying necessity of scale map • Training for making and using scale map	Seminar/OJT
8) Measuring water inflow	To understand how to measure flow meter	• Studying type of flow meter • Training how to measure actual water flow (Minimum night flow measurement)	Seminar/OJT
9) OJT training in pilot area	To estimate NRW ratio To improve NRW	• Training knowledge and techniques of NRW	OJT

Activities	Objectives/ expected outcomes	Main Contents	Activities
	countermeasures To prepare NRW Reduction model	countermeasures of Physical loss and Commercial loss • Developing CPs for trainer	
10) Understanding of waterworks concept	To understand duties of their own job	• Studying concept of waterworks	Seminar/OJT
11) Understanding of NRW	To understand definition of NRW	• Studying concept of NRW • Studying countermeasures against NRW	Seminar/OJT
12) Training for meter reading	Able to find meter error To understand proper meter reading	• Training for meter reading • Training for checking water consumption unit of customer	Seminar/OJT
13) Establish SOPs and manual	To establish SOPs and manual To understand how to use and revise the SOPs and manual	• Establishing SOPs and manuals • Revising the SOPs and manuals through Pilot Project	Seminar/OJT
14) Training for billing and collection	To understand proper billing and collection of water charge	• Discussion • Studying proper billing and collection	Workshop
15) Understanding of illegal connections	To understand types of illegal connections To understand how to deal with illegal connections	• Studying and training how to find illegal connections • Discuss how to reduce illegal connections	Seminar/OJT
16) Water supply equipment	To understand proper water supply equipment	• Training for making service pipe branch • Understanding of proper water meter installation	Seminar/OJT

2-3-8 Set up DMAs at the pilot area

(1) DMA Design

1) Design

The C/P designed DMA through the training of hydraulic analysis as shown in Table 2-88.

Table 2-88: Schedule of DMA designing

Date	Contents	In charge
21 Mar. 2016	Hydraulic analysis by road (according to target year 2040 in M/P)	C/P, Expert
22 Mar. 2016	Modeling by ArcGIS imported from EPANET (Hydraulic analysis software)	
28 Mar. 2016	Hydraulic analysis of existing pipeline (before DMA set up)	
29 Mar. 2016	Considering pipeline and its diameter	
30 Mar. 2016	Considering pipe diameter at inlet and terminal point of DMA to secure water pressure	
31 Mar. 2016	Final design of pipe diameter and pipeline of DMA	

In the DMA plan, a hydraulic model was made based on pipeline data of pilot area created through GIS training. The design was conducted by using the design manual which was created considering the result of water pressure measurement on site and the water demand in 2040 (based on the M/P).

2) Result of design

As a result, the final design of pipe network arrangement with diameter are as shown in Figure 2-72.

(Setting conditions of water demand)

- Households (Based on field survey)
- Population per household (Based on census, 2014 of Yankin T/S)
- Population growth rate (Adopting the population growth rate until 2040 in Yankin T/S from M/P)
- Water consumption volume of domestic customers (200 l/c/d), water consumption volume of non-domestic customers (the values in Yankin T/S in 2040 in M/P)
- Water consumption volume of school and religious buildings (Based on the M/P)
- Physical loss assumed 0% due to pipe replacement

(Basis of pipeline arrangement and diameter calculation)

- As per the results of the design, dia.150mm pipes in outer pilot area, dia.100mm in the internal main road and dia.75mm and dia.50mm in the alley considering branches to each house were planned. There were also routes which cannot be avoided, and dia.38mm was considered in such routes due to limited road width.
- Pipe diameter was determined by keeping maximum head loss within 4m in a DMA, assuming future water pressure control. (In order to make it easy to formulate water pressure control targets for future distribution mains by establishing upper limit of head loss for newly established DMA)
- According to 2-3-2(3) above, measured water pressures at the inlet point of the pilot area were approximately from 0.04 to 0.06 MPa (water head from 4 to 6 m). The goal was to keep the head loss within 4m in the DMA to maintain water pressure even if the consumption volume reached the estimated future volume in the year 2040.

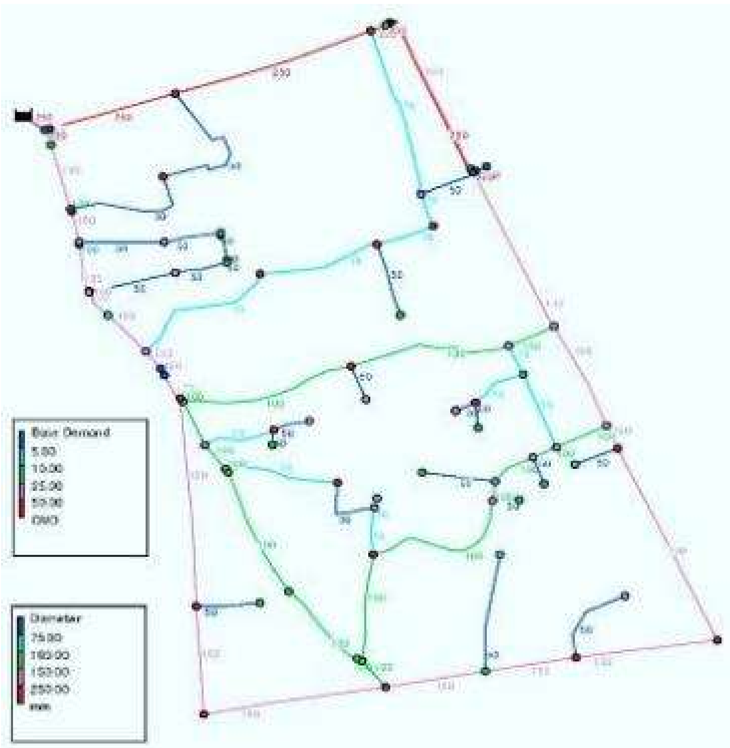


Figure 2-72: DMA final design (Pipeline arrangement with diameter)

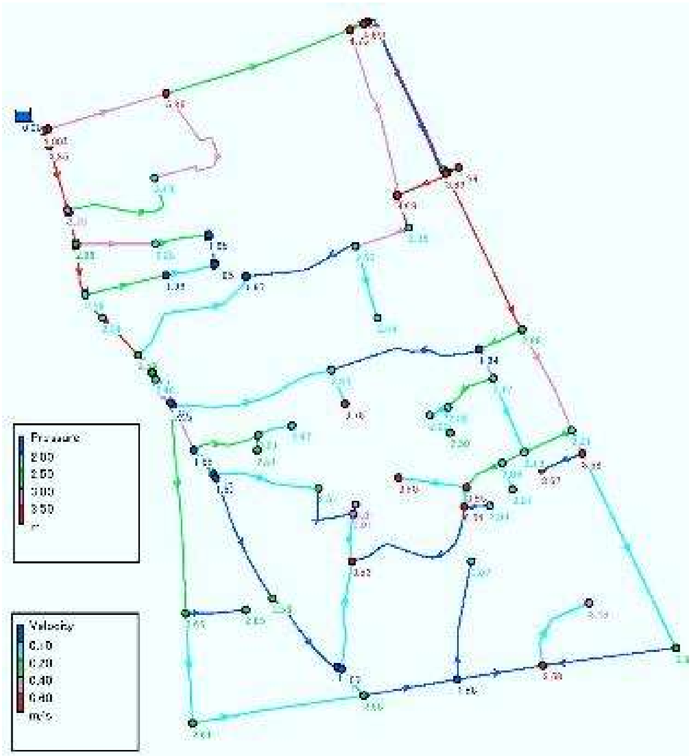


Figure 2-73: Water pressure distribution in DMA design (in case inlet pressure is 4m)

The result of hydraulic analysis of final design of pilot area is shown in Figure 2-72. The maximum head loss in the DMA is about 2.6 m. If the pipe diameter is reduced smaller than it is in this plan, the maximum head loss in the DMA exceeds 4m. Therefore, this design was decided as the final DMA plan.

We planned that TOT was to be carried out in Phase 1 area; then, OJT by trainers was to be performed in Phase 2 area during the same fiscal year. However, Phase 1 project was delayed due to rainy season; therefore, it became difficult to finish Phase 2 project in the same fiscal year. Phase 2 project had to be finished in the same fiscal year (before Sep 2019) because of budget constraints of WRAWSA; therefore, we changed the plan to conduct OJT by trainers in Phase3 area. The areas of phases of the pilot project are shown in Figure 2-74.

Phase 1: Area for conducting training for the C/P as a trainer
Phase 2: Project area conducted by WRAWSA
Phase 3: Area for OJT by trainers

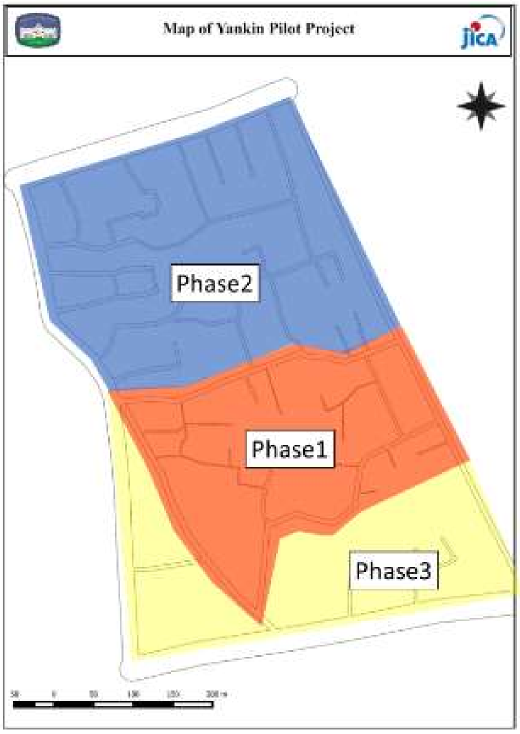


Figure 2-74: Pilot area by phase

Construction of DMAs set up was carried out based on the design. Construction details are mentioned in 2-3-9.

2-3-9 Conduct the countermeasures against physical loss in the pilot area

(1) Outline of Yankin pilot project (phase1)

Project period	Jan 2019 to Jan 2020
Total pipe length	2.13km
No. of target connections	218
No. of households in pilot area	311

(2) Public announcement

Public announcement of the pilot project was held at a monastery in the target area on Jan 17th, 2019. Although it was held in morning, about 50 customers participated. The DYCE3, two ACEs, South District officer and the C/P from WRAWSA participated, and the project purpose was explained by the DYCE3 and South District officer. Detailed construction schedule, methods and how to respond to complaints were explained by the C/P. A member of the local government who was elected from Yankin T/S attended this announcement, and she requested customers of this area to cooperate with our project.

(3) Pipe jointing training

Pipe materials, such as DIP, RRVP and PE (electro-fusion) for pilot project was procured from Japan to study effect of leak reduction by proper pipe jointing methods. Jointing training for RRVP on ground was carried out on Jan 21st before starting on-site work. The C/P trained not only jointing method, but they also learned pipe cutting work, making taper and how to remove pipes.

Photo 2-53: Jointing training of RRVP

(4) System input volume measurement in pilot area

WRAWSA had an ultra-sonic flowmeter before the start of the Project. A new ultra-sonic flowmeter was procured by the Project additionally, so we could use two flowmeters for this pilot project. It made it possible for us to measure system input volume at two inlets simultaneously.

We collected information of pipeline from Yankin T/S and GIS Section, then test digging was carried out. As a result, 4 existing inlet points were found. If we reduced the inlet points from four to one, we could not secure enough water pressure to distribute. Finally, we decided to measure at those four inlet points with original pipe conditions based on hydraulic analysis. Measurement points are shown in Figure 2-75. Measurement schedule and result are shown in Table 2-89.

Table 2-89: Result of measurement (Pilot area)

Location	Material/Diameter	Duration	Water flow
Inlet Point 1	PVC φ50	2019/2/8 17:35 ～ 2/9 17:35	53.9 m^3/day
Inlet Point 2	HDPE φ90	2019/2/8 17:35 ～ 2/9 17:35	472.5 m^3/day
Inlet Point 3	PVC φ40	2019/2/22 11:00 ～ 2/23 11:00	150.0 m^3/day
Inlet Point 4	PVC φ75	2019/2/12 18:00 ～ 2/13 18:00	87.8 m3/day
		Total	764.2 m^3/day

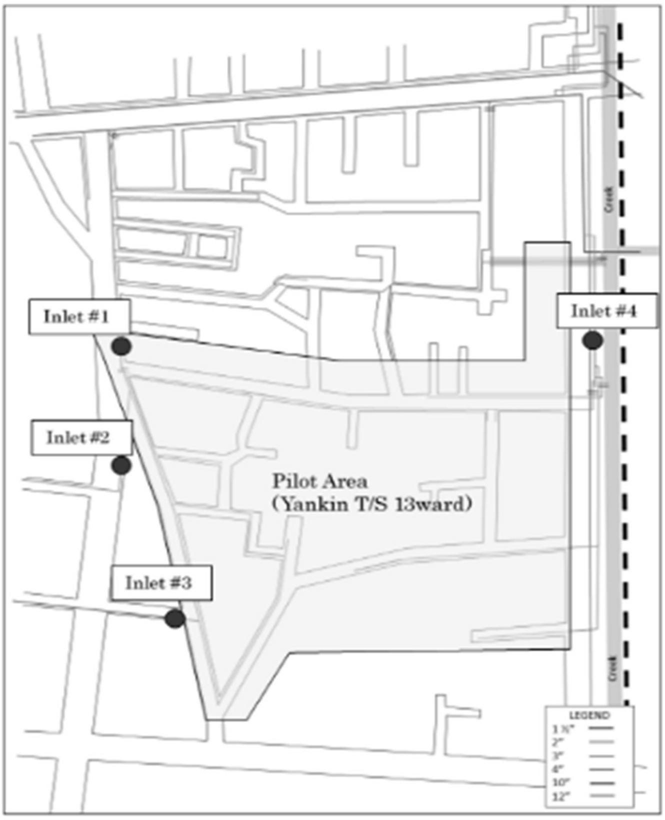


Figure 2-75: Measurement points

(5) Calculate NRW rate of pilot area
Water consumption data were collected based on meter-reading data from T/S and customer survey. The consumption units were calculated using three months data, Aug, Sep, and Oct 2018. Then we calculated NRW ratio with inlet volume which was measured in Feb. 2018. The result is shown below. The initial NRW rate of pilot area was estimated as 86%.

Table 2-90: System input volume and water consumption of pilot project (before project)

System input Volume (Daily) (m^3/day)	
Inlet Point 1 (PVC φ50mm)	53.9
Inlet Point 2 (HDPE φ75mm)	472.50
Inlet Point 3 (PVC φ50mm)	150.00
Inlet Point 4 (PVC φ75mm)	87.80
Total	**764.20**

Daily Consumption
106.32 (m^3/day)
Monthly Consumption
3,189.46(m^3/month)
Monthly Consumption per household
16.61 (m^3/day/household)

NRW rate (%) = (764.2-106.32) / 764.2x100= 86%

(6) OJT on site
In principle, WRAWSA engineers only supervise construction work. However, the C/P conducted practical training including training on piping work by themselves in this time. Training items are shown below.

Table 2-91: Training items of pilot project

Creating pipeline map	Survey on site
	Plane table survey and creating geographical map
	Customer survey
	Test digging
Customer survey	Water consumption survey
Planning & Design	Standard of planning & design
	DMA (District Metering Area)
	Characteristic of material
	Pipe Joints
	Pipe accessories (Valve etc.)
Grasping NRW	Planning of water flow measurement
	Conduct flow measurement
	Calculation of NRW rate
	Minimum night flow measurement
	Analysis of water supply (Water balance)
Material & equipment procurement	Inspection of pipe material
	Understanding of tools and machines
Pipe laying (Distribution)	Proper pipe jointing (DIP, RRVP, HDPE-EF)
	Proper backfilling
	Construction record
House connections	Type and characteristic of water meter
	Appropriate location of water meter
	Protecting water meter
	Proper branching work of house connections (Proper drilling work)
	Proper service pipe laying
Countermeasures against physical loss	Leak detection
	Minimum night flow measurement
	Night step test
	Leak volume measurement
	Proper leak repair
Countermeasures against commercial loss	Meter function test
Inspection of construction	Water pressure test
	Creating as-built drawing
Safety management	Wearing safety clothes (clothes & shoes)
	Setting safety device
PR	Construction board
	Public announcement
Operation & Maintenance	Monitoring of NRW
	Up-dating pipeline map

(7) Set up DMA

Procured pipe materials and equipment arrived at Yangon in mid January 2019. Then, piping work aiming at making a DMA as a pilot project was started at the end of Jan 2019. Many distribution pipes installed by WRAWSA were located inside of the road shoulder or drain. These pipes sometimes caused obstruction when the drain rehabilitation work was carried out. Because of this kind of situation, we determined the pipe laying locations where it was easy and proper for operation and maintenance by discussing about the importance of pipe locations with the C/P. And we also explained about the installation of valves including their functions, importance, proper location, and ability to operate any time even during emergencies.

Distribution pipes were planned to be installed mainly on Moe Kaung Road, Damayone Road, Shwe Yinmar Roads, Myanandar Road. Since we predicted that ground water level is quite high on Shwe Yinmar and Myanandar road, we selected Rubber Ring type PVC, so the piping work did not have to stop even in rainy days or high ground water conditions.

Currently, WRAWSA is using HDPE butt-fusion type generally; however, we used EF type HDPE for part of pilot project to secure pipe jointing quality. Additionally, Moe Kaung Road, one of the main roads, has so much traffic so that we had to install DIP to bear the load of the traffic. Pipe installation length by road and pipe material is shown below.

Table 2-92: Pipe installation length by road and pipe material

Road	Mon	DIP Φ150	DIP Φ100	DIP Φ75	RRVP Φ150	RRVP Φ100	RRVP Φ75	RRVP Φ50	HDPE Φ75	TOTAL	
Mou Kaung	Jan										
	Feb										
	Mar				13.8m					13.8m	
	Apr					15.2m				15.2m	
	May	110.8m			3.3m					114.1m	
	Jun	151.3m								151.3m	
	Jul	10.2m			1.6m					11.8m	306.2m
Damar Yone	Jan										
	Feb					10.0m				10.0m	
	Mar					304.4m	103.1m			407.5m	
	Apr					37.2m				37.2m	
	May										
	Jun										
	Jul										454.7m
Mya Nandar	Jan						55.0m			55.0m	
	Feb					296.9m	4.1m			301.0m	
	Mar					99.4m				99.4m	
	Apr					1.5m				1.5m	
	May					11.5m				11.5m	
	Jun										
	Jul										468.4m
AungChan Tar	Jan										
	Feb										
	Mar				26.4m					26.4m	
	Apr				32.7m					132.7m	
	May				114.3m					114.3m	
	Jun										
	Jul										273.4m
Shwe Yin mar	Jan										
	Feb										
	Mar										
	Apr					13.8m				13.8m	
	May					117.4m				117.4m	
	Jun					81.1m				81.1m	
	Jul					169.5m				169.5m	381.8m
Phase 2 Lane	May		5.4m	5.4m						10.8m	
	Jun			10.9m			5.5m			10.9m	21.7m
Private Lane	Feb							25.7m		25.7m	
	Mar						4.7m	27.5m		32.2m	
	Apr							38.4m		38.4m	
	May						10.7m	12.3m	94.4m	117.4m	
	Jun						6.4m			6.4m	
	Jul						0.8m	1.2m	4.0m	6.0m	226.1m
	Month	D I P Φ150	D I P Φ100	D I P Φ75	RVP Φ150	RRVP Φ100	RRVP Φ75	RRVP Φ50	HDPE Φ75	TOTAL	Working Days
	Jan						55.0m			55.0m	3 days
	Feb					306.9m	4.1m	25.7m		336.7m	20days
	Mar		5.4m	5.4m	40.2m	403.8m	107.8m	27.5m		590.1m	27days
	Apr			10.9m	132.7m	67.7m		38.4m		249.7m	13days
	May	110.8m			117.6m	128.9m	10.7m	12.3m	94.4m	474.7m	28days
	Jun	151.3m				81.1m	11.9m			244.3m	28days
	Jul	10.2m			1.6m	169.5m	0.8m	1.2m	4.0m	187.3m	8days
TOTAL		272.3m	5.4m	16.3m	292.1m	1,157.9m	190.3m	105.1m	98.4m	2,137.8m	127days

The daily progress of piping work is shown below.

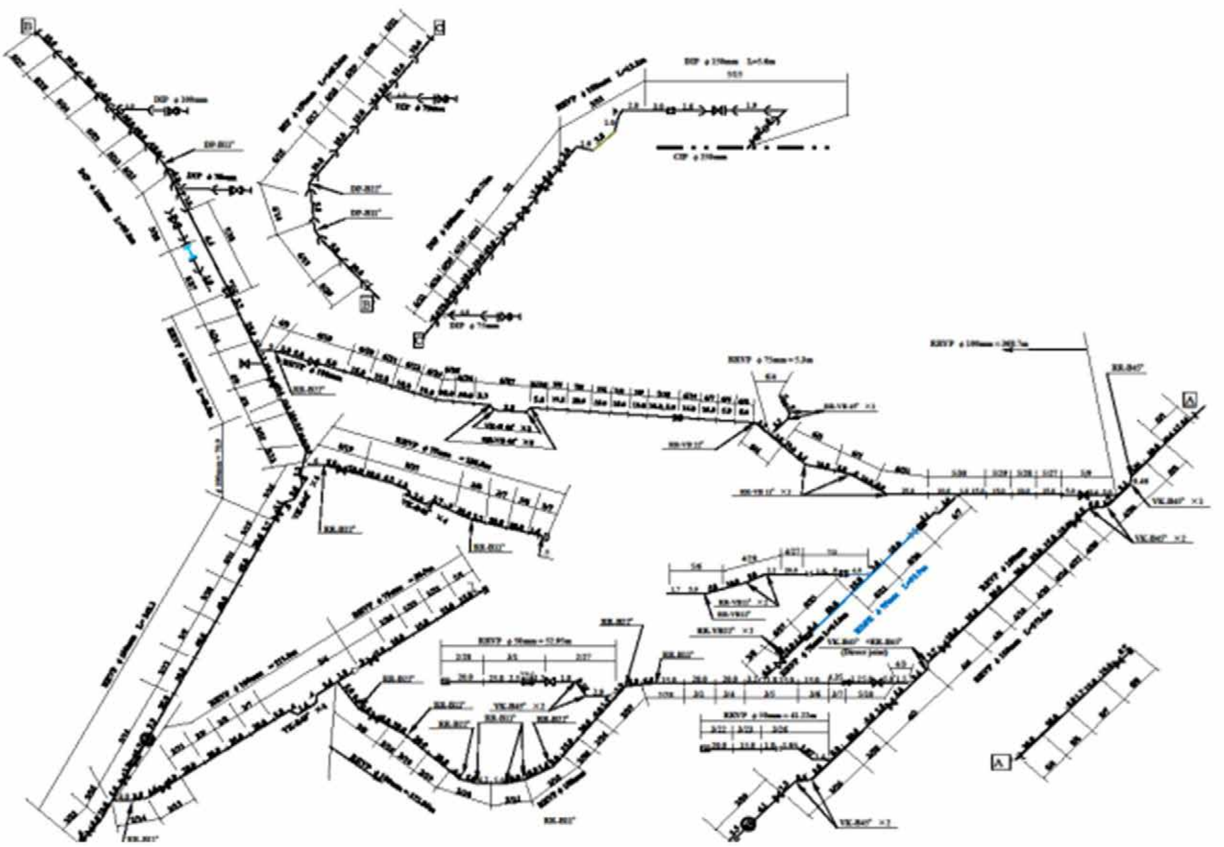


Figure 2-76: Daily progress of piping work

(8) Consider how to lay pipes avoiding structures under roads

Culverts under roads are installed as countermeasures against rainwater in rainy season everywhere in Yangon city. Also, we found two culverts for rainwater collection where DIP was planned to be installed in the pilot area. Test digging was carried out to check the situation of those culverts such as width and depth in advance. Based on the result of test digging, the Expert instructed how to draw a detailed drawing for that place; then the C/P conducted piping work.

(9) Improve service connections

Saddle snap tap was applied for service pipes branching from distribution pipes. Leakage at a service pipe branching point is one of the main reasons of NRW even in countries with advanced water supply service. The Expert aimed that WRAWSA would continue to use saddle snap tap as a standard material for construction work of service pipes after the Project.

TS type tee joint was used for branching from integrated (main) service pipes, and installation location of service pipes upstream from meters was decided to be underground to prevent PVC pipes from damage by UV or other factors which may cause water leaks.

Almost all roads in Yangon city have ditches on each side of the road for draining rainwater and domestic wastewater. To pass this ditch, WRAWSA chose their piping method called “pusher” like manual jacking method, to reduce the breaking of pavement. This method is not safe and cannot secure jointing quality, and there is a possibility of causing road subsidence. The Expert instructed piping work on house connections shown below as a standard.

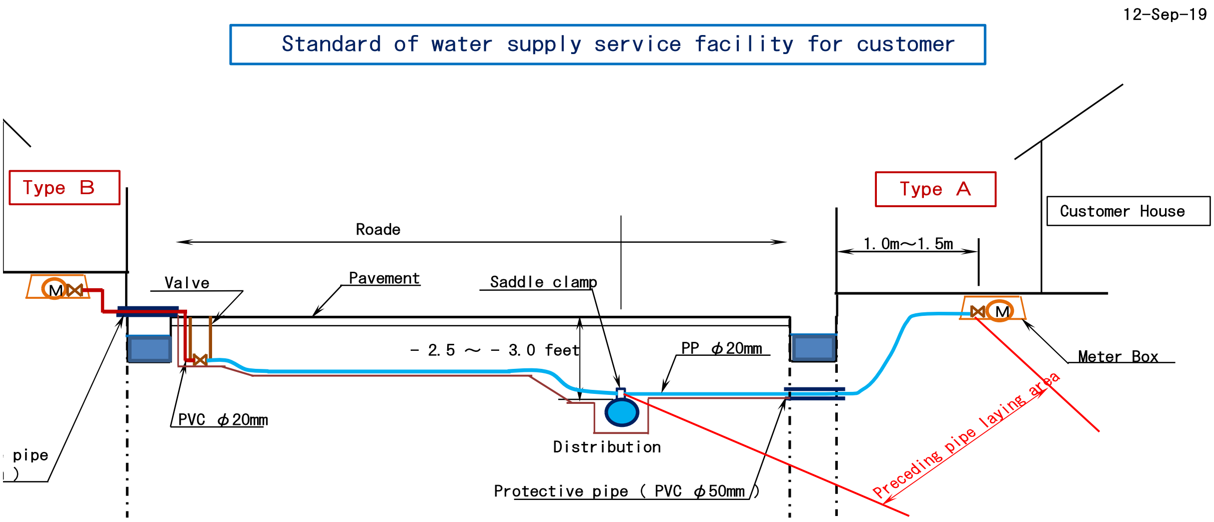


Figure 2-77: Standard design of service pipe connection for pilot project

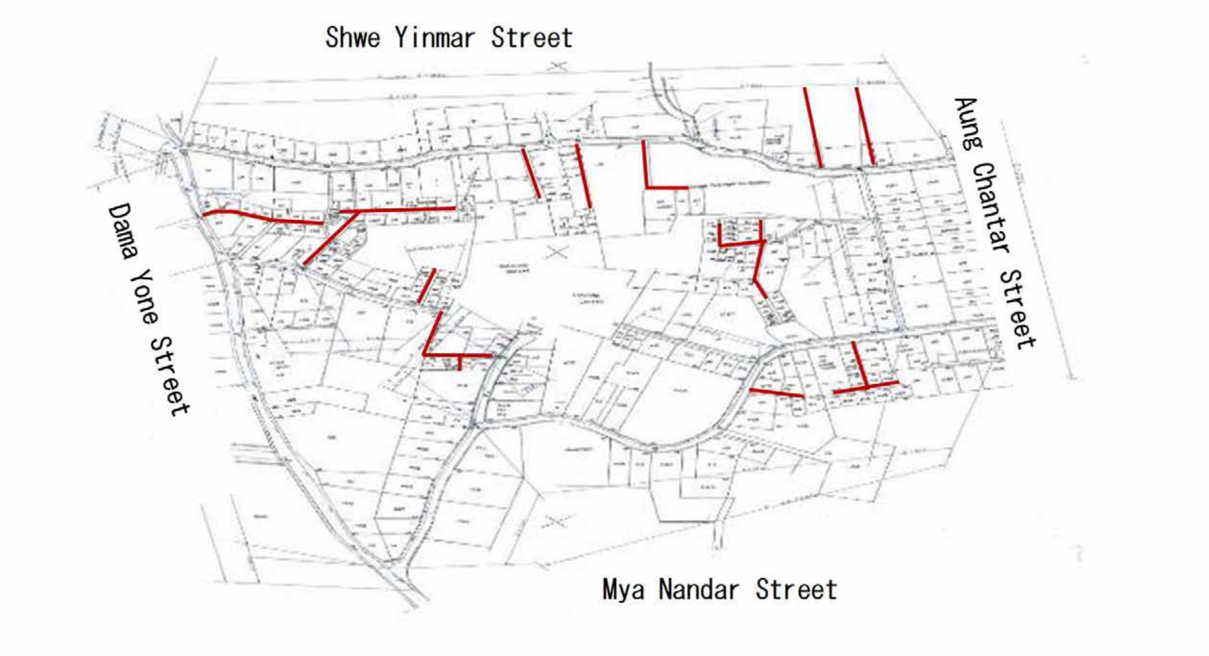
(10) Laying integrated service pipe

The Expert found a lot of cases where low-quality PVC pipe were used for house connections and many small diameter service pipes were installed inside ditches and drains on the side of the private passage in a disorderly state (spaghetti piping) in the pilot area in this time. This situation is rampant in Yangon city due to the inadequate condition of water distribution pipes. To solve this problem, many existing service pipes were integrated into one service pipe of lager diameter (φ25mm～φ40m), as an integrated service pipe. To determine the diameter of service pipe, the Expert instructed the C/P on how to calculate hydraulic gradient based on number of connections, maximum water use (200l/day), and current water pressure. The outline of integrated pipe laying work is shown in Table 2-93.

Table 2-93: Progress of integrated pipe laying work

Integrated Pipe No,	Diameter of pipe & Pipe length				Total Length	Number of Branches(φ20mm)
	φ50mm	φ40mm	φ30mm	φ25mm		
Shwe YinmarI		69.5m			69.5m	11
Shwe YinmarII		41.2m			41.2m	9
Shwe YinmarIII				139.3m	139.3m	3
Shwe YinmarIV						4
Shwe YinmarV				39.4m	39.4m	5
Damayone I	42.6m				42.6m	9
Damayone II	83.8m	7.3m			91.1m	22
Damayone III		1.0m	50.1m	4.0m	55.1m	6
MyanandarI		60.0m				11
MyanandarII				0.0m		4
Total	126.4m	179.0m	50.1m	182.7m	538.2m	84

The locations of integrated pipes are shown below.



: Integrated pipe

Figure 2-78: Location of integrated pipes

A sample drawing of integrated pipe is shown below.

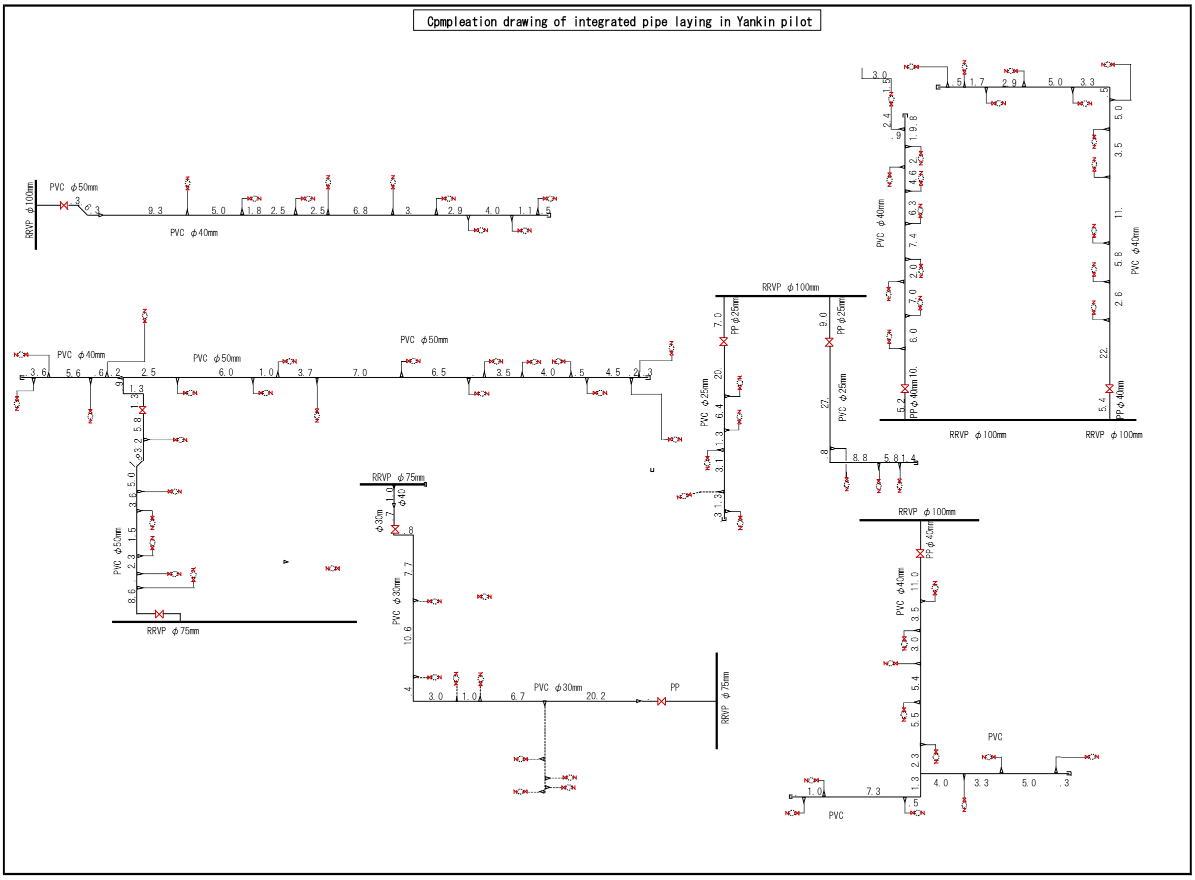
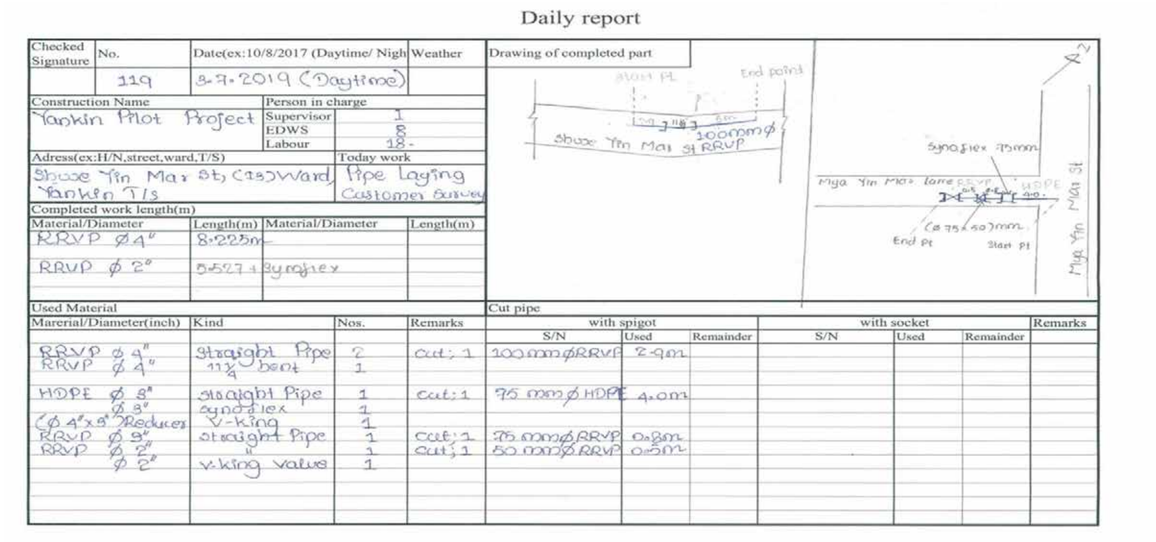


Figure 2-79: Integrated service pipeline in the pilot project

(11) Daily construction report

The Expert made a format of daily construction report and instructed how to use that format and draw a pipeline before starting pilot project. Piping work progress, detailed location, and used material were recorded in this daily report. This daily report will be utilized for making as built drawings. As a result of preparing the report every day, the C/P was able to draw even complicated pipelines such as underpass lines. A sample of daily report made by the C/P is shown in Figure 2-80.



Daily report

Checked Signature	No.	Date(ex:10/8/2017 (Daytime/ Nigh	Weather
	119	3-7-2019 (Daytime)	

Construction Name	Person in charge	
Yankin Pilot Project	Supervisor	1
	EDWS	8
	Labour	18

Adress(ex:H/N,street,ward,T/S)	Today work
Shwe Yin Mar St, (13) Ward, Yankin T/S	Pipe Laying, Customer Survey

Completed work length(m)

Material/Diameter	Length(m)	Material/Diameter	Length(m)
RRVP ø4"	8.225m		
RRVP ø 2"	5.527 + Synoflex		

Drawing of completed part

Used Material

Marerial/Diameter(inch)	Kind	Nos.	Remarks
RRVP ø 4"	straight Pipe	2	cut; 1
RRVP ø 4"	11¼ bent	1	
HDPE ø 3"	straight Pipe	1	cut; 1
ø 3"	synoflex	1	
(ø 4"x3")Reducer	V-King	1	
RRVP ø 3"	straight Pipe	1	cut; 1
RRVP ø 2"	"	1	cut; 1
ø 2"	v-king value	1	

Cut pipe

with spigot S/N	with spigot Used	with spigot Remainder	with socket S/N	with socket Used	with socket Remainder	Remarks
100 mmø RRVP	2.9m					
75 mm ø HDPE	4.0m					
75 mmø RRVP	0.8m					
50 mmø RRVP	0.5m					

Figure 2-80: Daily construction report

(12) As-built drawings

The Expert explained to the C/P about the necessary information to draw as-built drawings. Off-set measurement of tee or bend, valves, and fire hydrant was carried out based on daily report shown above. After off-set measurement, the C/P wrote the pipe information into geographical map which the C/P made by plane table survey. And for complicated places such as at underpass or branched location, detailed drawings were made, and dimensions and location of joints were marked. For tee and valve, off-set drawing was created to be able to grasp by road shape. As-built drawings of Yankin pilot project is now under creation by the C/P according to the sample shown below.

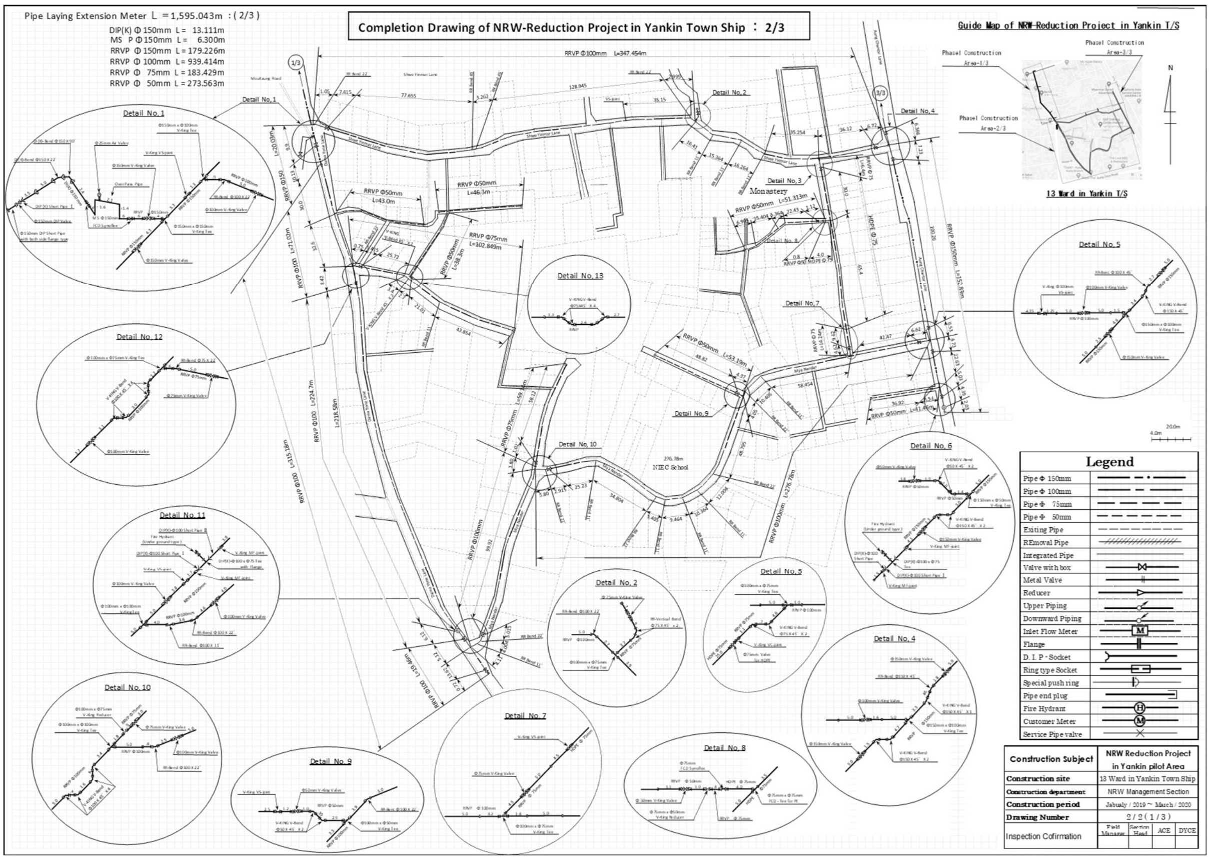


Figure 2-81: Sample of as-built drawing of Yankin pilot project (prepared by the Expert)

(13) Water pressure test (Method and how to use test pump and planning)
After the valves were installed, water pressure test was carried out on each section between two valves, and leakage was confirmed. Test pressure was decided by situation of each section and set between 0.5MPa～0.75MPa. Test schedule and result are shown in Table 2-94.

Currently, water pressure test is not carried out in piping works by each T/S. According to our survey, there is a lot of inappropriate pipe jointing and it causes water leaks. Water pressure test after the completion of piping work is an urgent activity to test leakage, so the Expert requested officers and deputy officers of T/S to attend the pressure test training. Training items are shown below. The C/P conducted water pressure test in Phase 2 project by themselves.

- Necessity of water pressure test
- How to fill water (Discharging inside air)
- How to use test pump (Manual type, electrically driven type)

Table 2-94: Outline of water pressure test and the result

Date	Road	Time	Material, Diameter, Length	Test pressure	Result
14th Feb	Mya Nandar Lane (1)	14:02 - 14:32	RRVP 3" 57.0m	0.75MPa	OK No Leaks
21th Mar	Mya Nandar Lane (2)	10:00 - 10:30	RRVP 4" 120.0m	0.75MPa	OK No Leaks
22nd Mar	Mya Nandar Lan Thwe	15:50 – 16:20	RRVP 2" 67.0m	0.75MPa	OK No Leaks
23rd Mar	Mya Nandar Lane (3)	13:00～	RRVP 4" 241.0m	0.75MPa	pressure did not increase
2nd Oct	Mya Nandar Lane	16:15 - 16:45	RRVP 4"	0.50MPa	OK

Date	Road	Time	Material, Diameter, Length	Test pressure	Result
	(3) (2nd test)		241.0m		No Leaks
4th Oct	Shwe Yin Mar	12:15 - 12:45	RRVP 4" 357.5m	0.75MPa	OK No Leaks
7th Oct	Aung Chan Thar (North)	15:07 - 15:37	RRVP 6" 126.4m	0.50MPa	OK No Leaks
8th Oct	Aung Chan Thar (South)	15:45 - 16:15	RRVP 6" 151.6m	0.75MPa	OK No Leaks
9th Oct	Aung Chan Thar Lane	12:17 - 12:47	RRVP 2" 35.0m	0.50MPa	OK No Leaks
9th Oct	Damaryone Lane	14:02 - 14:32	RRVP 3" 114.0m	0.50MPa	OK No Leaks

A pressure test was conducted for more than 2 hours on Mya Nandar Lane (3) on 23rd March 2019, but the pressure did not increase. Therefore, leak detection work was conducted, and three leakage points were found and repaired. After carrying out the repairs, a pressure test was conducted once again, and it was confirmed that there were no leaks on 2nd Oct. 2019

(14) Leak repair

Presently, in order to repair leakage, some engineers use only rubber tubes or PVC with processed sockets by heating. These repair methods make pipes thin, and leaks reoccur at that repair point. The Expert instructed how to repair leakage on PVC pipes using special fitting (V-king) procured in Japan.

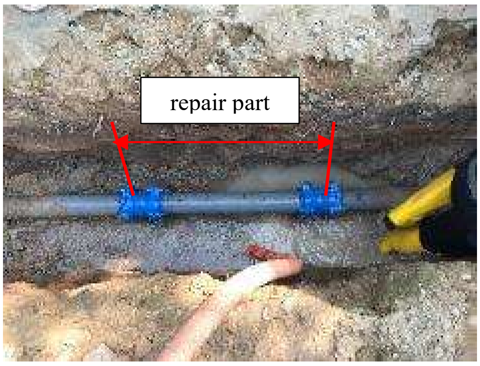
Reason of leakage: Rubber ring turned up due to improper jointing work

Repair method: Cut the pipe then joint by using V-king VS joint (collar)

Finding a leak

Situation of a leak

Turned up rubber ring



Situation of leak repair

Photo 2-54: Leak situation and repair work

(15) Decide the C/P for pilot project and transition

At the stage of planning the pilot project, firstly staff of NRW Management Section were selected as full-time counterparts for the pilot project. However, those staff of NRW Management Section were assigned for another project as well, so they could not work for the pilot project as full-time counterparts. Thereafter, 4 members from NRW Management Section and 8 young members from T/S in South District Office (in total 12 members) were assigned as full-time counterpart staff, and the pilot project was started.

Difficulty in retaining counterparts

Pre-training (planning, design, and basic knowledge) of Yankin pilot project was started on Nov. 2018, and OJT on site was started on Jan. 2019. At the starting time, as mentioned above, 8 members from South District and 4 members from NRW Management Section were assigned, but after that the C/P was decreasing because of resignations or transfer to other sections. Reasons why they left are mainly private; however, there are real reasons in background such as unstable position, salary, and difficulty of promotion. For continual technology transfer, this high rate of turnover is a crucial issue. This issue should be solved as soon as possible.

The C/P of pilot project reduced to two by Oct. 2019 and we therefore requested the CE to fill up the C/P. Finally, the staff members of NRW Management Section (including Yegu pumping station etc.) were assigned to the pilot project as part-time staff.

(16) NRW ratio after pilot project

NRW ratio calculations were carried out twice to grasp the effects of physical loss reduction and commercial loss reduction. Firstly, we performed meter-reading with existing meters after pipe replacement work to know the effect of physical loss reduction. Secondly, we measured with new meters after all meters had been replaced to grasp the effect of commercial loss reduction. The results are shown below.

Table 2-95: NRW ratio (Before & After the pilot project)

Item	Before project	After project (1st: With existing meter)	After project (2nd: With new meter)
System input volume (m^3/month)	22,926	13,141	11,719
Revenue water (m^3/month)	3,190	6,424	11,079
Non-revenue water(m^3/month)	19,736	6,717	640
NRW ratio (%)	86.1	51.1	5.5

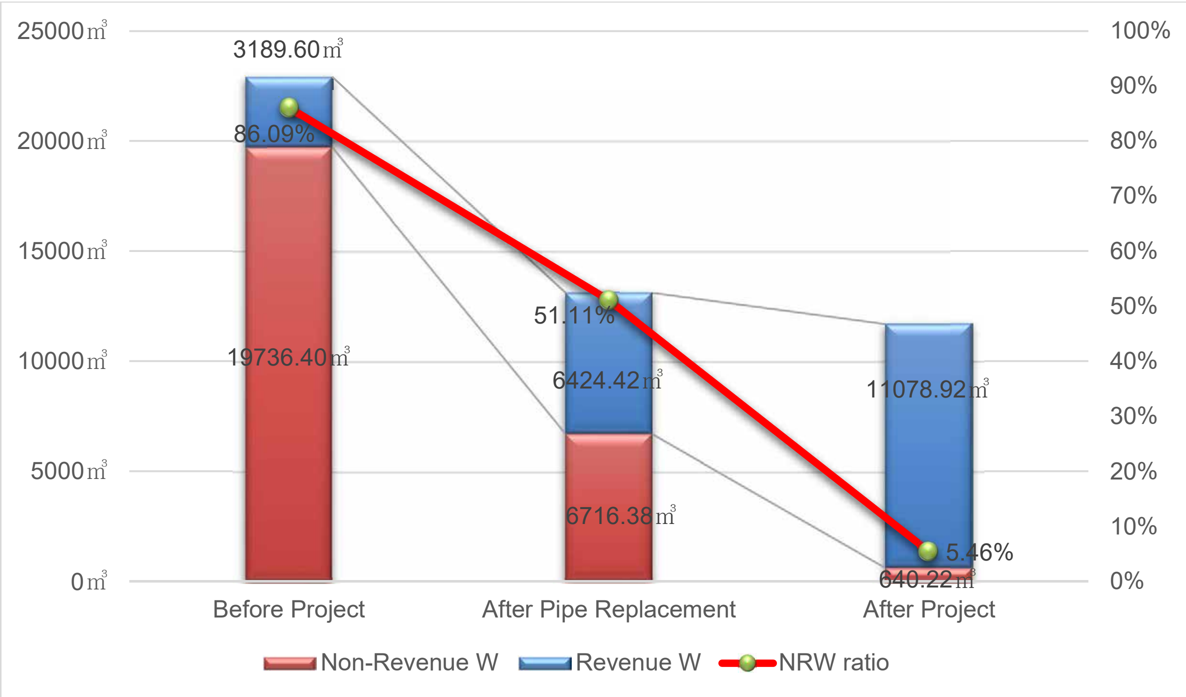


Figure 2-82: NRW ratio (Before & After the pilot project)

Training for minimum night flow measurement and night step test should be continuously carried out by WRAWSA to find leakage. Moreover, the trainings of leak detection work by using leak detector or leak correlator, and leak repair work should be continuously carried out for the staff of WRAWSA.

(17) Improvement of water supply

We measured the water supply condition on water tap in selected houses. The C/P selected ten target houses evenly in pilot area. Pressure changes in morning and afternoon was recorded by pressure measurement work on existing 10" CIP before the pilot project. The water supply volume of every house was measured twice (AM and PM) in a day before and after the pilot project.

At all houses except two houses water supply volume were extremely improved after the pilot project. This was because all pipelines were replaced to proper diameter so that water head loss was decreased. Afterwards, we checked meters of the two houses where improvement had not occurred, and we found impurities in the strainer upstream of their water meters. The result is shown below.

Table 2-96: Improvement of water supply situation

(L/min)

Monitoring point				Flow rate of each customer house			
				AM		PM	
Measurement Point		Address	Metering Tap	OCT / 2019 (Old Pipe)	FEB / 2020 (New pipe)	OCT / 2019 (Old Pipe)	FEB / 2020 (New pipe)
1.	MAP No,100	Damayone lane. 238/A	D −φ13	8.7	23.8	9.8	23.1
2.	MAP No,−	Mya Nandar St.	P −φ13	0.0	21.0	0.0	21.2L
3.	MAP No,183	Mya Nandar lane.2283/A	D −φ13	0.0	16.1	20.4	16.1n
4.	MAP No,253	Mya Yin Mar lane. 341/B	D −φ13	5.0	16.0	4.7	13.7
5.	MAP No,261	Aung Chan Thar St. 447/B	D −φ13	0.0	21.7	3.7	25.0n
6.	MAP No, 39	Aung Chan Thar St. 343	D −φ13	7.6	19.0	6.9	20.4
7.	MAP No, 27	Aung Chan Thar St. 38	D −φ13	4.4	10.0	6.3	11.1
8.	MAP No,318	Shwe yin mar St. 475	D −φ13	3.6	8.0	3.5	8.8
9.	MAP No,110	Shwe yin mar St. 247	D −φ13	20.7	13.0	17.3	11.4
10.	MAP No, 73	Shwe yin mar St. 227	D −φ13	4.2	12.2	6.1	7.5

2-3-10 Evaluate cost-benefit of countermeasures against physical loss in the pilot area and formulate the optimal model of activities

(1) Cost benefit analysis of physical loss measures of Yankin pilot project

The main purpose of Yankin pilot project is to learn appropriate construction technology. To achieve this purpose, Japanese materials were selected for the pilot project. For physical loss measures, materials shown in the table below were procured such as pipes, jointing tools, drilling machine etc. Reduced physical loss volume is shown in 2-3-9(16), which was calculated at the time of 1st measurement with existing meters. In this cost calculation, the costs paid by YCDC such as cost of civil work or labour were not included since this cost data was not received from the C/P.

Items	Material/Equipment cost (JPY)	Material/Equipment cost (USD) 1USD=110JPY
Material cost (Pipe, Joint, Saddle clamp etc.)	14,456,614	131,424
Equipment (Drilling machine, etc.)	3,342,110	30,383
Total cost	17,798,724	**161,807**

The reduction water volume of physical loss is 13,020 m^3/month as shown in Table 2-95. Estimated cost benefit of physical loss reduction is as following.

Physical loss reduction volume	Cost	Cost/Benefit
13,020(m^3/month)	161,807 (USD)	**80.46(m^3/month/1000USD)**

(2) Cost benefit analysis of commercial loss measures of Yankin pilot project

To reduce commercial loss, water meters at locations where commercial loss mainly happens should be replaced with proper new meters and meter installation place should be where meter readers can read the meters easily and precisely. The cost of commercial measures of pilot project is shown below.

Items	Material/Equipment cost (JPY)	Material/Equipment cost (USD) 1USD=110JPY
Material cost (Meter, Union)	900,340	8,285
Total Cost	900,340	8,285

A new meter and two meter-unions which are installed on both sides of water meter are counted as commercial loss cost. As in the case of physical loss, the cost of civil work or labour was not included.

Commercial loss reduction volume	Cost	Cost/Benefit
6,076(m^3/month)	8,285 (USD)	**733.37(m^3/month/1000USD)**

218 exiting customer meters of all YCDC customers in the pilot area were replaced with new meters in the pilot project. Reduced commercial loss volume is shown in 2-3-9(16), which was calculated at the time of (2nd measurement: with new meter). The volume shown in the table above indicates the difference of measured volume between existing meter and new meter for one month. Although Japanese import material was used for the pilot project, price of a meter which can be procured locally or YCDC standard model is not much different from the Japanese meter. Therefore, this cost shown above can be taken as a reference value.

(3) Cost benefit analysis in case of local materials

This pilot project was carried out by using only Japanese materials and equipment not only for distribution pipe laying but also service pipe branching work. It is much different from actual project costs of a project which is using local materials, so the estimated cost is not suited for actual economic level of Yangon. It is difficult to know the cost of civil work or labour, so we estimated a cost in case of using local material with following criteria.

- Based on comparison of Japanese materials and local materials, 30% of construction cost shown above is estimated as total cost of a construction by using local material. Therefore, we used this ratio and estimated cost benefit analysis with local material.
- For the cost of equipment which is difficult to procure locally such as drilling machine, we applied Japanese equipment cost. The one-sixth of the acquired cost was applied as the depreciation cost with reference to useful life of general construction equipment.
- For the cost of commercial loss reduction measures, as mentioned above, the difference of cost (water meter) is not much between Japanese materials and local materials so that Japanese material cost was applied.

A result of cost benefit analysis is shown below.

(Cost for physical loss measures)

Items	Japanese Material/Equipment cost (USD)	Local Material/Equipment cost (USD)
Material cost (Pipe, Joint, Saddle clamp etc.)	131,424	39,427
Equipment (Drilling machine, etc.)	30,383	5,059
Total Cost	**161,807**	**44,486**

Physical loss reduction volume is 13,020 m^3/month as shown in 2-3-9(15). Cost benefit of physical loss is shown in table below.

Physical loss reduction volume	Cost	Cost/Benefit
13,020 m^3/month	44,486(USD)	**276.68(m^3/month/1000USD)**

Commercial loss reduction volume is 6,076 m^3/month as shown in (1) above. Cost benefit of commercial loss is shown in table below.

Commercial loss reduction volume	Cost	Cost/Benefit
6,076(m^3/Month)	8,285(USD)	**733.37(m^3/month/1000USD)**

(4) Cost recovery in case of using local materials (Physical loss/ Commercial loss)
The required months for cost recovery are estimated based on current water tariff (88 kyat/m^3) of Yangon city as shown in the table below.

The current water tariff of YCDC is set quite low, which is about a half to one-eighth that of Southeast Asian countries. Therefore, if water tariff rate of Mandalay city is adopted as a reference, the cost recovery period is estimated. The results are shown in the table below. Cost recovery periods are estimated as 18 months for total loss reduction and 8.8 months for commercial loss reduction.

Table 2-97: Estimation of cost recovery period based on pilot project

Items	Total	Physical loss	Commercial loss
①Cost (USD)	52,771	44,486	8,285
②Reduction volume (m^3/month)	19,096	13,020	6,076
③Cost recovery per month (kyat/month) = reduction volume (m^3/month) x (88kyat)	1,680,448	1,145,760	534,688
④Cost recovery per month(USD) （100USD = 130,000kyat）	1,293	882	411
⑤Cost recovery period (month) (①/④)	40.8	50.4	20.1
Reference: Cost recovery period estimated with water tariff of Mandalay city	18.0	22.2	8.8

Note: The cost does not include civil work and labours cost but only material and equipment cost.

(5) Formulate the NRW management model through DMA set up activity in pilot project

All activities in pilot project from selecting pilot area to creating as-built drawings were carried out together with the C/P so that WRAWSA could implement NRW reduction project by themselves. The NRW management model (including commercial loss) was formulated based on this pilot project as shown below. After the Project, it is necessary for the C/P to set up DMAs with reference to the model below.

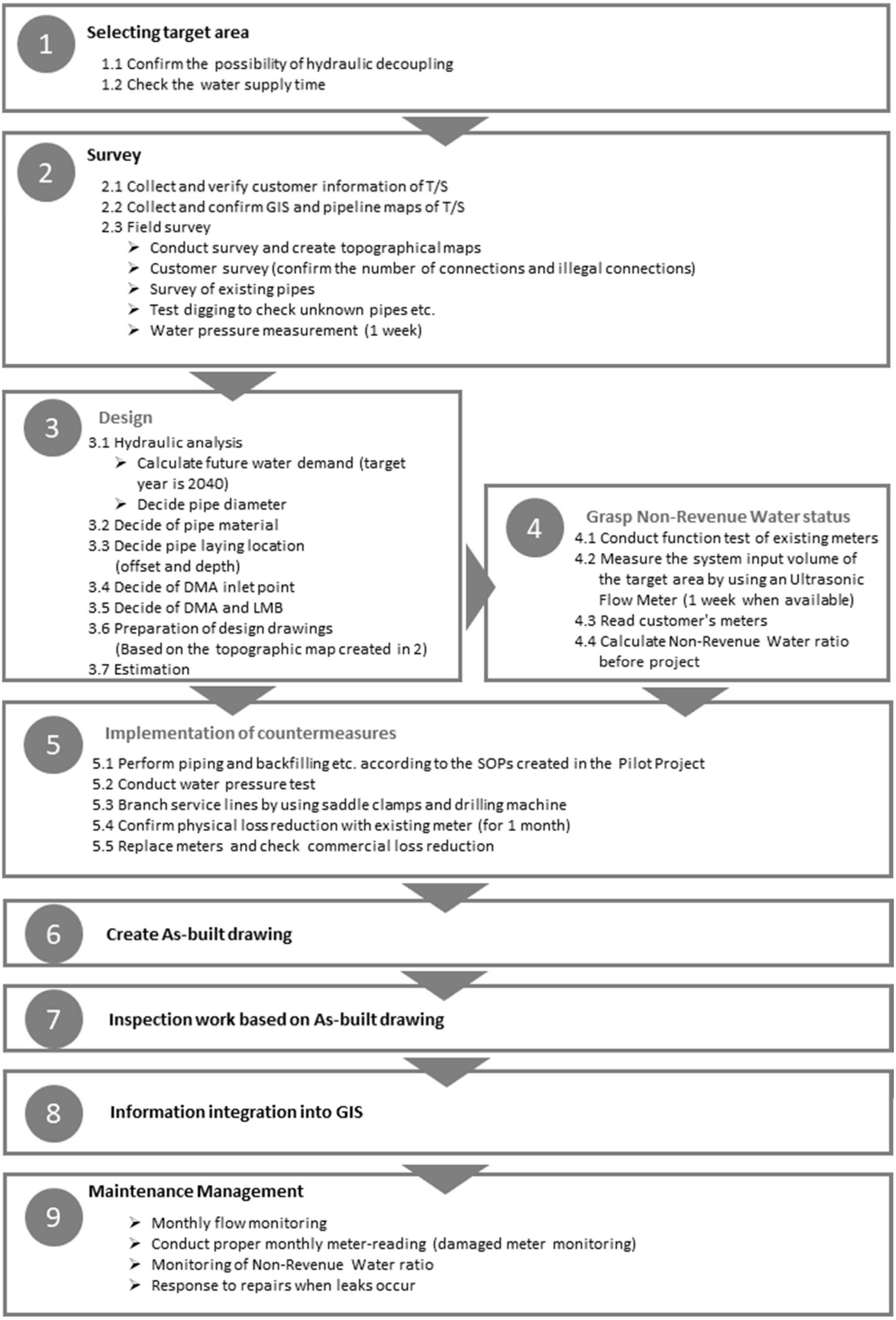


Figure 2-83: NRW management model by DMA construction

2-3-11 Implement OJT by the trainers in the pilot area

OJT for new staff members of NRW Management Section was carried out by the C/P of the pilot project as a trainer in pilot project (Phase 3 pilot project). As shown in Figure 2-74, the Phase 3 area is located in the southern part of the Phase 1 area and there was no distribution pipe installed.

The initial plan was to use Japanese materials in the Phase 1 area to teach the C/P appropriate techniques by using proper materials, and to use local materials in the Phase 2 area to adopt them to local conditions utilizing what was learned in Phase 1. However, because of delay of procurement of equipment from Japan and YCDC's budget issues, the work in the Phase 2 area was implemented before the work in Phase 1. Therefore, we selected the Phase 3 area for training field, and OJT was conducted by the C/P trainers.

【Outline of construction】

Training period (construction period)	2nd April to 29th July 2020
Outline	New pipeline laying work Length φ160mm – 844m (2770 feet) φ110mm – 31m (101 feet) φ63mm - 286m (939 feet) Diameter：φ160mm - φ63 Connections：206 Pipe materials Distribution pipe: HDPE(Butt-Fusion) Service pipe: PE
Training items	Pipe laying work: Pavement cutting (marking) Pipe laying position, proper backfill (around pipe) Pipe jointing(HDPE-Butt fusion) Valve box installation Flow measurement Pressure test Safety while working (clothes, helmet, safety equipment) Water supply equipment: Proper branching work by using drilling machine Water meter installation, Mete box installation

【Participants of the OJT (trainer, trainee)】

OJT Trainer		
Name	Section	Position
U Aung Min Oo	NRW Management Section	SAE
U Kaung Zaw Thet	NRW Management Section	Flat
U Phyo Han Kyaw	NRW Management Section	Flat
U Sithu Win	NRW Management Section	Flat
Daw Zin Nwe Oo	NRW Management Section	SAE
OJT Trainee		
Name	Section	Position
Daw Phyu Phyu Myint Myat	NRW Management Section	Flat
Daw Zin Mar Htwe	NRW Management Section	Flat
Daw Yu Ya Myat Noe Aung	NRW Management Section	WA
Daw May Zin Kyaw	NRW Management Section	WA
U Si Thu Naung	NRW Management Section	WA

2-3-12 Verify the manuals on physical loss

Verification could not be conducted due to the pandemic of COVID-19 and the political instability.

2-4 Develop a model on the management of commercial loss (meter fault, miss reading of meter, illegal connection) and human resources development

2-4-1 Review current situation and develop phased countermeasures

At present, 24 hours water supply is achieved only in some areas of Yangon city. Furthermore, even in the 24 hours water supply area, some area can only receive water for limited hours in the downstream area due to water shortage caused by upstream area where water is directly sucked from the mains using motor pumps. Because of this situation, currently water supply pressure, which is essential for water supply, is not enough in almost all areas in Yangon city. There must be leakages owing to bad joints or aging pipes; however, we can find leakages only by visual detection because it is difficult to utilize leakage detector due to low water pressure which leads to difficulty in observing the leakage sound. In the Project, all T/S were surveyed three times to grasp the situation and analyze the factors of commercial loss.

(1) Investigate and analyze the number of installed water meters by business category

Since the Expert pointed out that WRAWSA does not have a record of the number of installed meters by diameter or business category, a survey for grasping the number of installed meters was carried out in all T/S. The result of the survey by diameter (φ13mm～φ250mm) is shown below.

Table 2-98: Number of existing meters by business category

DEC / 2016 — Number of installations by the diameter of the water meter

YCDC facilities				
φ20～φ40	φ 50	φ 75	φ100	φ150
30	0	0	0	0
30				

Hospital				
φ20～φ40	φ 50	φ 75	φ100	φ150
20	3	3	2	1
29				

Hotel					
φ20～φ40	φ 50	φ 75	φ100	φ150	φ200
231	21	7	7	7	1
274					

Condominium				
φ20～φ40	φ 50	φ 75	φ100	φ150
1	4	0	0	0
5				

Housing				
φ20～φ40	φ 50	φ 75	φ100	φ150
144	21	6	20	6
197				

Administrative facilities					
φ20～φ40	φ 50	φ 75	φ100	φ150	φ200
180	11	5	5	3	0
204					

School				
φ20～φ40	φ 50	φ 75	φ100	φ150
38	2	0	0	0
40				

Commercial				
φ20～φ40	φ 50	φ 75	φ100	φ150
22,575	540	38	34	6
23,193				

Domestic					
φ20～φ40	φ 50	φ 75	φ100	φ150	φ200
228,167	122	25	37	17	2
228,370					

Factory & Industrial Zone				
φ20～φ40	φ 50	φ 75	φ100	φ150
538	23	12	2	0
575				

Pagoda				
φ20～φ40	φ 50	φ 75	φ100	φ150
1,662	59	3	8	3
1,735				

Military-related facilities				
φ20～φ40	φ 50	φ 75	φ100	φ150
6	3	4	3	3
19				

TOTAL					
φ20～φ40	φ 50	φ 75	φ100	φ150	φ200
253,592	809	103	118	46	3
254,671					

Estimated average water consumption by diameter and proper diameter of water meter were confirmed based on the result of this survey. This data is also utilized as basic data for formulating the water distribution plan. The Expert also found that meter reading for domestic use was made once every 2 or 3 months except for commercial use.

(2) Survey on malfunction/broken water meter

At present, WRAWSA sells water meters to customers which WRAWSA selected and purchased in bulk. However, before WRAWSA specified meters, customers purchased and installed cheap water meters without considering the meter function. Water meter is needed to be calibrated periodically; however, there is no rule of meter calibration not only in WRAWSA service area but also in Myanmar. It is assumed that many broken meters or malfunctioning meters exist in all T/S. Moreover, the result of a meter function test in the pilot project area in Yankin T/S which was implemented in Term 1 shows a high malfunction rate on existing water meters. Thus, all T/S were surveyed for malfunctioning water meters which were broken, too dirty to read or having positioning problems. The result of this survey is shown below.

Table 2-99: Result of meter function survey

Damage Meter Check List

30-Jan-18

No	TOWN SHIP	Connection number	Nomal	Unreadable: Broken	Unreadable: Moss	Unreadable: position	Subtotal: nomal	Subtotal: Unreadable	No-Meter	TOTAL	Flat Late	Supply TOTAL
1	Dagon N	13,657	7,318	5,635	0	0	7,318	5,635	7	12,960	0	12,960
		12,960	56.5%	43.5%	0%	0%	56.5%	43.5%	0.1%	100%		
2	Dagon E	4,198	0	0	0	0	0	0		0	0	0
		0	#DIV/0!	######	######	######	#DIV/0!	#DIV/0!	#DIV/0!	100%		
3	Dagon S	16,192	3,012	2,622	0	0	3,012	2,622	1,498	7,132	0	7,132
		7,132	42.2%	36.8%	0%	0%	42.2%	36.8%	21.0%	100%		
4	Thingan	17,068	11,450	0	5,854	0	11,450	5,854	0	17,304	0	17,304
		17,304	66.2%	0.0%	34%	0%	66.2%	33.8%	0.00%	100%		
5	Dawbon	2,821	390	1,433	0	0	390	1,433	10	1,833	97	1,930
		1,930	21.3%	78.2%	0%	0%	21.3%	78.2%	0.5%	100%		
6	Mingala	9,674	10,438	28	6	0	10,438	34	0	10,472	136	10,608
		10,608	99.7%	0.3%	0%	0%	99.7%	0.3%	0.0%	100%		
7	N-okkal	35,118	14,375	0	18,122	0	14,375	18,122	2,192	34,689	3,276	37,965
		37,965	41.4%	0.0%	52%	0%	41.4%	52.2%	6.32%	100%		
8	S-okkal	17,620	9,600	0	6,766	280	9,600	7,046	1,321	17,967	25	17,992
		17,992	53.4%	0.0%	38%	2%	53.4%	39.2%	7.35%	100%		
9	Tarmwe	27,292	18,848	909	2,380	1,970	18,848	5,259	673	24,780	5,904	30,684
		30,684	76.1%	3.7%	10%	8%	76.1%	21.2%	2.7%	100%		
10	Ming Ta	16,086	9,938	2,504	0	0	9,938	2,504	328	12,770	5,012	17,782
		17,782	77.8%	19.6%	0%	0%	77.8%	19.6%	2.57%	100%		
11	Pazunta	6,677	4,933	284	0	0	4,933	284	118	5,335	3,380	8,715
		8,715	92.5%	5.3%	0%	0%	92.5%	5.3%	2.2%	100%		
12	Thakayt	6,397	1,601	1,728	0	0	1,601	1,728	1,007	4,336	1,560	5,896
		5,896	36.9%	39.9%	0%	0%	36.9%	39.9%	23.2%	100%		
13	Shwepyi	8,620	9,677	33	0	0	9,677	33	0	9,710	1	9,711
		9,711	99.7%	0.3%	0%	0%	99.7%	0.3%	0.0%	100%		
14	Insein	11,596	12,172	0	85	0	12,172	85	0	12,257	0	12,257
		12,257	99.3%	0.0%	1%	0%	99.3%	0.7%	0.00%	100%		
15	Mayang	10,718	9,854	0	112	0	9,854	112	0	9,966	277	10,243
		10,243	98.9%	0.0%	1%	0%	98.9%	1.1%	0.0%	100%		
16	Hlaing	7,057	5,607	0	134	15	5,607	149	0	5,756	1,042	6,798
		6,798	97.4%	0.0%	2%	0%	97.4%	2.6%	0.0%	100%		

No	TOWN SHIP	Connection number	Nomal	Unreadable: Broken	Unreadable: Moss	Unreadable: position	Subtotal: nomal	Subtotal: Unreadable	No-Meter	TOTAL	Flat Late	Supply TOTAL
17	Hlaingtha	3,055	2,228	7	0	0	2,228	7	0	2,235	0	2,235
		2,235	99.7%	0.3%	0%	0%	17.2%	0.3%	0.0%	100%		
18	Botahta	5,087	3,494	399	0	0	3,494	399	73	3,966	2,158	6,124
		6,124	88.1%	10.1%	0%	0%	#DIV/0!	10.1%	#DIV/0!	100%		
19	Kamayu	1,323	1,387	13	0	0	1,387	13		1,400	1,532	2,932
		2,932	99.1%	0.9%	0%	0%	19.4%	0.9%	0.0%	100%		
20	Kyeemyin	934	411	531	0	0	411	531	0	942	702	1,644
		1,644	43.6%	56.4%	0%	0%	2.4%	56.4%	0.0%	100%		
21	Kyaukta	3,608	2,549	503	144	378	2,549	1,025	25	3,599	4,000	7,599
		7,599	70.8%	14.0%	8%	21%	139.1%	28.5%	1.4%	100%		
22	Bahan	10,366	7,226	2,679	266	271	7,226	3,216	4	10,446	1,583	12,029
		12,029	69.2%	25.6%	3%	3%	69.0%	30.8%	0.0%	100%		
23	Yankin	9,016	6,177	1,687	0	0	6,177	1,687	72	7,936	1,749	9,685
		9,685	77.8%	21.3%	0%	0%	17.8%	21.3%	0.2%	100%		
24	Dagon	2,821	678	931	0	0	678	931		1,609	835	2,444
		2,444	42.1%	57.9%	0%	0%	3.8%	57.9%	0.0%	100%		
25	Sangch	1,658	1,070	35	493	20	1,070	548	74	1,692	1,697	3,389
		3,389	63.2%	2.1%	2%	0%	4.3%	32.4%	0.3%	100%		
26	Ahlon	1,608	1,106	263	28	11	1,106	302		1,408	1,048	2,456
		2,456	78.6%	18.7%	0%	0%	8.7%	21.4%	0.0%	100%		
27	Lanma	4,131	3,866	222	0	0	3,866	222		4,088	2,941	7,029
		7,029	94.6%	5.4%	0%	0%	72.5%	5.4%	0.0%	100%		
28	Latha	3,111	2,970	32	31	97	2,970	160	0	3,130	2,368	5,498
		5,498	94.9%	1.0%	1%	2%	68.5%	5.1%	0.0%	100%		
29	pabend	5,221	4,786	483	0	0	4,786	483		5,269	3,704	8,973
		8,973	90.8%	9.2%	0%	0%	49.3%	9.2%	0.0%	100%		
30	Dala	4,490	1,851	2,016	0	0	1,851	2,016	231	4,098	0	4,098
		4,098	45.2%	49.2%	0%	0%	15.1%	49.2%	1.9%	100%		
31	Seikkan	17	15	2	0	0	15	2	0	17	0	17
		17	88%	11.8%	0%	0%	0.2%	11.8%	0.0%	100%		
	TOTAL	267,237	169,027	24,979	34,421	3,042	169,027	62,442	7,633	239,102	45,027	284,129
		284,129	59.5%	8.8%	12.1%	1.1%	59.5%	22.0%	2.7%	84.2%	15.8%	100.0%

Results of analysisi based on information collecting

- Total connection number ⇨ 284,129 (100%) ------------A
- Meter installation number ⇨ 231,469 (81.5%) ----------B
- No meter number ⇨ 7,633 (2.7%) ------
- Number of usage at flat rate ⇨ 45,027 (15.8%) ----------(

Number of unknown amount of water used

- Total number of no-meter ⇨ 52,660 (18.5%) ----------
- Number of unreadable ⇨ 62,442 (22.0%) ---------

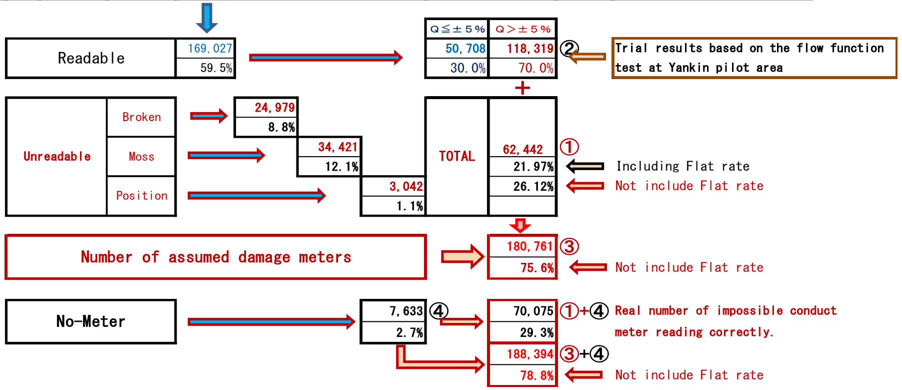
II

TOTAL 115,102 (40.5%) -------D

Number of assumed bad meters

- Q>±5% ⇨ 118,319 (41.6%) -----------②

Total number of assumed damage meters ⇛ 233,421 (82.2%)----D+②



Summary of function rate of meter is as follows.

- ❑ Normal (able to read) ➪ 59.5%
- ❑ Broken or unable to read ➪ 22.0% (A)
- ❑ No meter (previously existed) ➪ 2.7% (B)
- ❑ Flat rate (No meter) ➪ 15.8% (C)

As a result, it is revealed that the ratio of improper meter reading due to malfunction meter is up to 40.5% (A＋B＋C). Readable meter rate is 59.5% judged by T/S meter readers. Approximately 70% of readable water meter were found to be malfunctioning in our meter function test in the pilot project in Yankin T/S. Based on that result, it is assumed that 41.65% of 59.5% readable meters are malfunctioning. Totally 82.15% (40.5%+41.65%) water meters are malfunctioning. Therefore, efficient and urgent commercial loss countermeasures against water meter problem are needed.

Since raw water supply without treatment is assumed to be one of the main causes of meter malfunction, meter test survey in raw water supply areas should be planned and implemented.

(3) Survey the water use of public facilities such as parks
There are many parks and gardens in Yangon city, such as Kandawgyi park. Since huge amount of water for uses such as sprinkling water is needed, actual situation of water use of parks and gardens was surveyed.

The survey was conducted in consultation with Park & Playground & Garden Department of YCDC which manages public parks and gardens. The survey results indicated that almost all large public parks use YCDC water without water meter. They explained to us that there is no water supply equipment in the playgrounds because there is no planting.

Large parks consume approximately 20,000 Gallon per day (90m^3/day). Small and middle size parks use tube-well water and water from water trucks which transport water from Yegu Pump Station and Kyauk Taing Pump Station in Thaketa T/S. Approximately 108 m^3 per day is transported from Yegu Pump Station. Water transport is an important activity from the viewpoint of preserving parks; however, supplied water for parks is free of charge. WRAWSA should consider water supply activities for those public facilities in the future.

Photo 2-55: Water truck (At Yegu pumping station)

(4) Water supply to no water supply area
It was also found in this survey that WRAWSA periodically supply water to part of no water supply area by water trucks or ships.

- ❑ Hlaingtharyar T/S Nyaung daung area ➪ Transport by water truck
- ❑ Kyeemyindaing (Eastern from Yangon river) ➪ Transport by water transport ship

Yearly average=13,140 m^3
(Fee of water transport by ship=7 Kyat/m^3)

Photo 2-56: Water supply equipment for transport ship

Photo 2-57: Water transport by ship

(5) Water supply to ship

We surveyed water supply activity for ships which arrive at the Yangon Port. WRAWSA used to supply water to ships by water supply equipment in Seikkan T/S, but now Sea Agency Department supplies tube well water to ships.

(6) Survey on direct branches from raw water transmission pipeline

Definition of water supply area in Yangon is not clearly described in the present YCDC Law. In general, the whole area of Yangon city is supply service area. YCDC has four water reservoirs outside of Yangon city as water resources. There are two raw water transmission lines to supply water into Yangon city, one is 56" from Gyobyu reservoir and the other is 60" from Phugyi reservoir. It was found that direct service pipe branches from raw water transmission pipes outside of the service area between those two reservoirs and the city limit, which is outside of Yangon city. The survey was made to identify direct service branches from raw water transmission pipe, presence or absence of water meter, and billing & collection activities. The management status of customer data or water tariff at Finance Section and Computer Section was checked.

(Result)

❏ Number of branches from Gyobyu(56") pipeline

Gyobyu Office management area:28 points (Outside of Yangon city)
Phugyi Office management area:21 points (Outside of Yangon city)
Pipe Section1 management area:54 points (Outside of Yangon city)
11Points (North Okkalapa T/S Area)
4 points (Mayangone T/S Area)

❏ Number of branches from Phugyi(60") pipeline

Phugyi Office management area: 21 points (Outside of Yangon city)

As mentioned above, 124 points of direct service pipe branches, which supplied water to places outside of Yangon city, were found. Almost all connections were used by villages, army, and religious facilities. Although, most of those service connections have water meters and their consumptions were measured. However, many meters seemed to be malfunctioning.


Photo 2-58: Damaged meter near the Gyobyu transmission pipe

The tariff collection was carried out in same way as inside Yangon city. Some customers of those service connections were managed by the T/S which is outside Yangon city.

(7) Non-detectable flow on large size meters due to flow deficiency
In Term 1, meter function error due to flow deficiency was found on large size water meters installed in downstream side of distribution area. Non detected flow on large size water meters may contribute to a huge commercial loss. The number of installed large size water meters in Yangon city are available through the meter survey. Based on that result, a plan to improve layout of piping method or adopt vertical installation of water meters should be considered. The Expert explained the purpose and necessity of NRW countermeasures related to this issue to NRW Management Section. The Expert continued surveying, collecting related information, and guiding WRAWSA in utilizing the information.

(8) Issues on commercial loss revealed through T/S survey
Two times (in 2015 and 2016) T/S survey related to NRW were carried out, and the issues on commercial loss were identified.

1) Water meter

Up until a few years ago, customers who wanted to receive water service had to purchase and install water meters by themselves. At that time, many customers selected cheap water meters. Moreover, YCDC leased water meters to customers many years ago.

Water meters confirm the water consumption of customers and the collected water charge based on the meter reading is a major revenue of water supply business. Therefore, from the viewpoint of fairness to customers, durability and accuracy of water meters have to be defined in the technical standards or specifications of WRAWSA. However, there are no standards or specifications in WRAWSA related to water meters. Thus, the performance standards and specifications of water meters should be decided by WRAWSA.

It is desirable to lend water meters to all customers by YCDC to assure functioning of water meters and adequateness of meter readings. However, water quality of supplied water should be improved simultaneously to avoid meter problems after installation.

2) Meter reading work

Tariff collection of flat rate (1,800 kyat or 3,000 kyat) customers is managed by Administration Department of YCDC along with a collection of land fee.

In principle, meter readings are supposed to be done on monthly (mid-late) basis except for flat rate customers. Meter reading of large commercial facilities and the facilities that have large size water meters is conducted every month. However, meter readings of "Domestic" customers is done once in three to five months because of the shortage of manpower of meter readers. On the other hand, billing of water charge is done every month. Meter reading should be carried out properly and fairly every month. However, some of meter readings are not conducted correctly so that some meter readings were made by estimated value of readings. Fair billing system including efficient meter reading plan needs to be established.

In the survey in 2015, the total number of meter readers in 30 T/S offices to which YCDC supplied piped water was 294. The number of monthly meter reading work per meter reader was calculated below.

Less than 500 houses / meter reader = 10 T/S
500 to 1,000 houses / meter reader = 11 T/S
More than 1,000 houses / meter reader = 9 T/S

T/S in which a meter reader read more than 1,000 water meters was located in downtown areas such as Bahan, Pazundan, and Tarmwe which have many housing complexes. The minimum number of meter reading work was 216 houses / meter reader / month in Hlaingtharyar T/S and the maximum was 1,782 houses / meter reader / month in North Okkalapa T/S.
The density of buildings and population affects the number of meter readings. It is necessary to reconsider whether WRAWSA will continue meter readings under the direct management with many meter readers in T/S offices from the viewpoint of business efficiency.
Furthermore, during the second T/S survey in 2016, it was found that some well-known hotels located in downtown area installed water meters in places which were either impossible-to-read or difficult to access such as in storage tanks, drains, narrow places, or underground machine rooms surrounded by electric wiring. Through the survey, it appeared that water meter issues were not only public health problems but also authenticity of meter readings. Thus, it is necessary to formulate "Guidelines of Water Meter Installation" or SOP and apply it as soon as possible.

3) Collection of water charge

Regarding water charge collection work, Computer Section prepares bill and receipt based on the meter reading data by meter reader of each T/S. In most T/S, it is common to charge and collect the last month's water charge at the time of meter reading.
In T/S office, document control of customer ledger and record of meter reading are done by manually by handwriting and manual calculation. Therefore, errors in revenue data due to errors caused during manual recording and calculation is a concern.
Thus, it is necessary to improve the accuracy and efficiency of payment collection and improve customer service including storage and browsing of working records etc. by introducing computerization.
In Myanmar, major method of bill collection is done by visiting customers because the receiving agent service of utility charges has not developed.

(9) Illegal connection and suspension

The second T/S survey was carried out in Sep. 2015 to investigate the situation of approximately 43,800 houses of long-term-absence and situation of malfunctioning meters, which was revealed in first T/S survey. The result of the survey is shown below.

1. Illegal connections	As a result of the survey of illegal connections (illegal connections and unbilled users), unauthorized water uses from distribution pipe and service pipe in residential area without obtaining construction permission was confirmed. The largest number of cases were related to the government affiliated organizations, which were aiming to acquire votes at the time of elections. They constructed service pipe from WRAWSA pipeline without permission.
2. Suspension	Currently, T/S office instructs the use of water supply by regular procedures and then manages the customer ledger. It was also found that T/S office created "temporary suspension list" to manage vacant houses.
3. Malfunction meter rate	Malfunction rate and damage rate of water meters were obtained by the T/S survey. It was found that 40 to 60% of water meters were broken or malfunctioning in every T/S.

(10) Research on commercial loss through international study program in Tokyo University
One of the C/P, Ms. Khaing Khaing Soe studied at the University of Tokyo in 2018-19 and researched on "Assessment of revenue loss due to damaged meters in different housing types of Yangon city". In this research, 50 houses were selected as the target and replaced their water meters. She compared water consumption of these customers between existing meter and replaced meter. Moreover, she read meters and grasped actual water consumption by different housing types in three T/S: Mayangone, Yankin and North Okkalapa, in which meter replacement were completed by projects including ODA projects. The findings of this research are as follows.

- Water consumption data by housing types in Yangon city was acquired from the survey of water consumption by research area. The average water consumption per customer by survey area was as follows.
  - ✓ Mayangone → 52.4(m^3/month)
  - ✓ Yankin → 36.5(m^3/month)
  - ✓ North Okkalapa → 31.8(m^3/month)
- The water consumption before the meter replacement, which was charged at a flat rate, was 2,037 (m^3/month) in total, and billing was 120 USD in total.
- Water consumption after meter replacement improved to a total of 5,359 m^3/month and 315 USD in total.
- The cost of meter replacement work was 2,670USD which is possible to be recovered in 8.5 months.
- The revenue improved by meter replacement was 2.6 times for large house and 1.8 times for ordinary house.
- Clogging of meters by impurities was also observed in this research area.

Reference: Khaing Khaing Soe, Shinobu Kazama and Satoshi Takizawa: Assessment of Revenue Loss due to Damaged Water Meters in Different Housing Types of Yangon city, Tokyo University master's thesis, 2020.

2-4-2 Conduct trainings of trainers
(1) Basic knowledge of waterworks
During three days from 2nd to 4th November 2016, the seminar of “What is waterworks?” was conducted for WRAWSA engineers including the DYCEs and the ACEs, and T/S staff members, for a total of 120 participants. The Expert explained about basic and comprehensive information from water source to tap, meter reading, billing, and collection. After the presentation, discussions were held with the participants. The T/S office and district office staff members were particularly interested and could actively exchange opinions. The agenda of this seminar was as shown below.

Agenda of “What is waterworks?” Seminar
1) What is waterworks? − What is waterworks? − Water Quality − Facilities for water supply − Planning and Design 2) Necessity of water meter − Water supply regulations − Proper water meter laying − Meter Reading − Water Tariff 3) NRW management − Overall management of NRW

(2) Training for checking situation of meter installation, possibility of meter reading and meter function.
As part of the OJT for countermeasures against commercial loss in the pilot area, survey of meter connection, meter function and difficulty of meter reading was conducted.

- Target houses = 321 (nos.)
- Supplied by YCDC= 208 (nos.) (Service Coverage = 65%)

As a result of this survey, it was found that some water meters were installed at inaccessible locations or drains, which was not adequate in terms of hygienic and health aspect. Following are summary of the issues found.

- Difficult to remove water meter = Approx. 30%
- Unreadable because of meter broken or defacement = Approx. 7%
- Meter flow rate detector difference over ±5% = Approx. 41%
- Meter flow rate detector difference within ±5% = Approx. 16%*

(*Within the nominal instrument standard difference / Japan)

Approximately, 50% of the surveyed meters had errors. Therefore, it appeared that the effect of commercial loss caused by the water meter trouble is larger than assumed. In addition, there were many cases of meter installation without considering maintenance of water meter.

- OJT on commercial loss was conducted for the staff of NRW Management Section as follows.
  - How to survey number of connections by business category and how to compile.
  - How to check average and maximum water flow by business category and service pipe diameter.
  - How to estimate malfunction water meter based on the result of the survey
  - How to apply the average water flow data from the survey to plan of water supply amount.
  - How to survey broken/malfunctioning meter and how to compile.
  - How to estimate broken/malfunctioning meter based on the survey result including the test result which was carried out in pilot area.
  - How to estimate rate of service coverage based on the result of supply connection survey by business categories.
  - Understanding types of existing service connection in Yangon city.
  - Broken meter survey in all T/S
  - Meter function test in pilot area
  - Capacity development in pilot project and training yard

(3) Meter function test in North Okkalapa T/S

- Duration：2018/05/14～5/24

Customer meter function test was carried out in the Yankin pilot project area in November 2016. From August to December 2017, damaged meter survey was carried out by all T/S, and it was found that malfunction rate of present customers was so high in Yangon city. Considering the result of these meters' condition, a further meter function test was carried in North-Okkalapa T/S Nya-ward located in the Nyaughnapin water supply area to get more accurate broken rate of customer meters. The previous target area in Yankin T/S is located in Hlawga reservoir water supply area.
As a result, there were many cases of malfunction meters as in the previous survey conducted in 2016. It was difficult to remove some of the existing meters due to improper installation place, so the target area was expanded to get enough numbers of meters. Some customers in this area complained about meter readings by broken meters. Improvement of meter function is urgent issue in Yangon city.

Photo 2-59: Meter function check by the C/P

Photo 2-60: Removed broken meters

2-4-3 Prepare training plan and training materials by the trainers
The activities are included in 2-3-3.

2-4-4 Conduct Off-JT by the trainers
The necessary RGSMs are shown in Table 2-100.

Table 2-100: Necessary RGSMs

Section in charge	Necessary RGSM
House-Connection	➢ Installation of house connections ➢ Meter installation ➢ Construction of water supply equipment

The RGSMs related to NRW Management Section and the relationship with the other sections are shown in Figure 2-84.

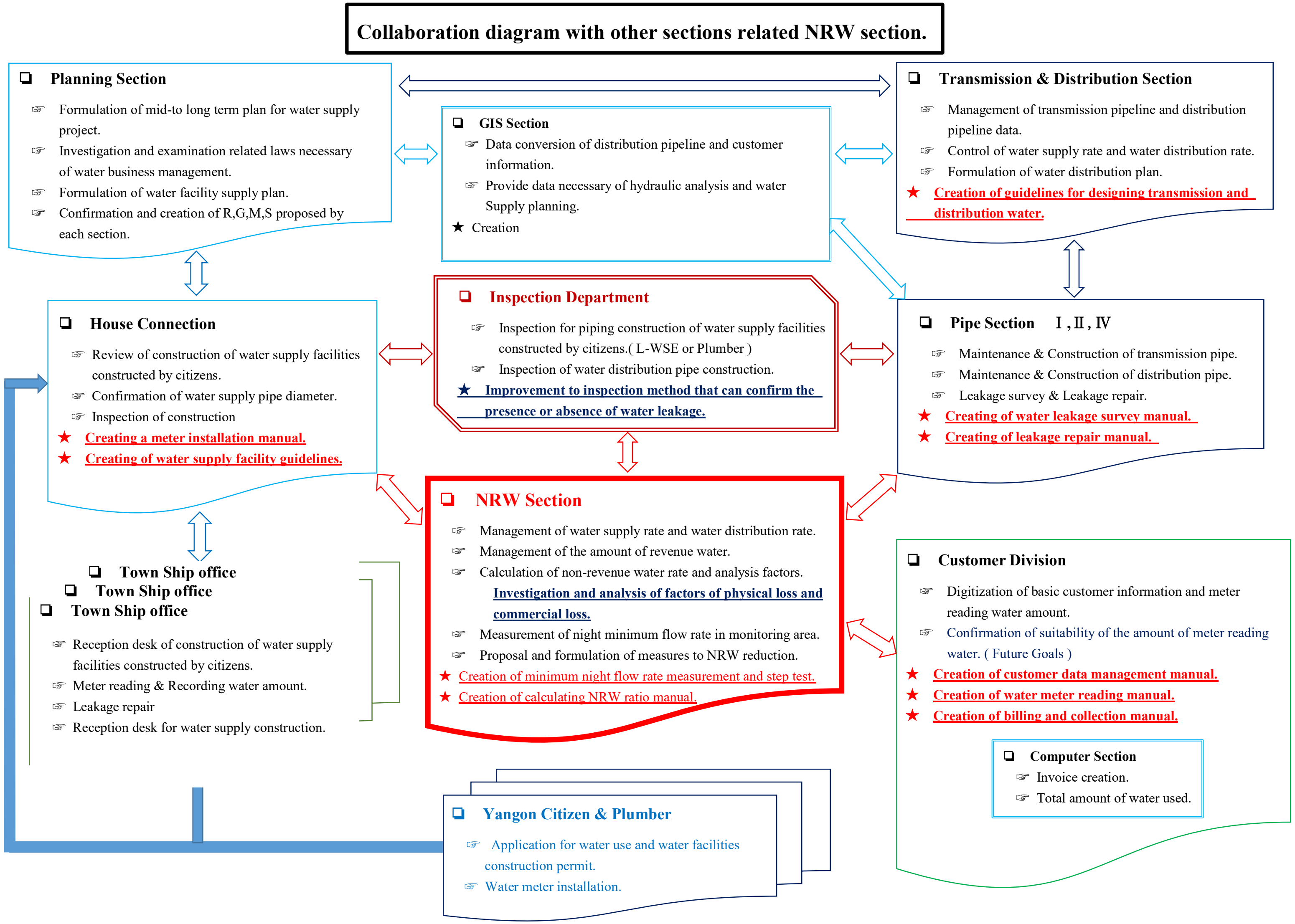


Figure 2-84: RGSMs related to NRW Management Section and relationship to the other sections

2-4-5 Conduct Off-JT by trainers
The activities are included in 2-3-5.

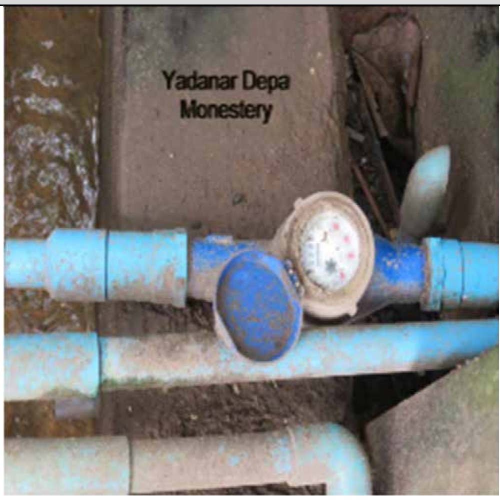
2-4-6 Prepare action plan and procure equipment for the countermeasures to be taken for reducing commercial loss in the pilot area
The activities are included in 2-3.

2-4-7 Conduct the countermeasures against commercial loss in the pilot area
(1) Water meter installation on proper position
Almost all existing meters in Yangon are placed where customers want to set the meters. Some of those meters are placed under the floor or narrow spaces because of renovation work in the customers' houses. Therefore, it is difficult for meter readers to read the water meters. Moreover, almost all meters do not have meter boxes, and it causes the meters to break due to external shock. The Expert taught the importance of meter installation position and decided to install meters near the entrance of customer houses in the pilot project. Steel meter boxes installed for all customers in pilot project were locally made. Improvement on meter installation positions in the pilot project is shown below.

- Improvement on customer meter

Current issues	Improvement
1) Meter position The position is difficult to read meter	Meters were installed near the entrance at a distance of 1-2 m from the road.
2) Current situation of meter installation Meter without meter box Put something on meter Buried meter	Meter box was installed for all meters.
3) Meter installation Meter installed vertically	All meters were installed horizontally.
4) Backflow prevention No check valve installed	Check valve was installed for all connections. Backflow prevention inside of a meter or from underground tank to service pipe.

Following pictures show meter situation before/after the pilot project.

<table>
<tr><th colspan="2">Before the pilot project</th></tr>
<tr><td>

Meter φ25mm (Before)</td><td>

Meter φ20mm (Before)</td></tr>
<tr><th colspan="2">After the pilot project</th></tr>
<tr><td>
Improved by the Project</td><td>
Improved by the Project</td></tr>
<tr><td>
Improved by the Project</td><td>
Improved by the Project</td></tr>
</table>

Photo 2-61: Situation of customer meter

(2) Install water meter with proper function

Since YCDC does not have any rules for water meter so far, almost all existing customer meters in the pilot area were procured by customers. Therefore, quality of those meters was not good. The meter function test we carried out three years ago showed that only 33 of 118 meters functioned with less than 5% error (Q≦±5%). The ratio of functioning meters was 28%. Based on that result, all existing meters were replaced with high-quality meters imported from Japan in the pilot project.

To grasp the value of commercial loss caused by water meter, we measured with existing meters once after the distribution pipes were replaced. Afterwards, all meters were replaced; and after one month reading was carried out with the new meters. Through this activity, we were able to grasp the influence of existing meters and water consumption estimated by meter readers of the pilot area on commercial losses. Water meter is the only way for YCDC to collect water tariff; therefore, lack of function checks and lack of periodic replacement of water meters contributes to commercial loss.

(3) Causes of broken meter and countermeasures
There are a lot of broken meters not only in Yankin T/S but also in the whole Yangon city. It is assumed that impurities such as shells in raw water from Hlawga reservoir or the other reservoirs causes the meters to break. Impurities such as seaweeds from Hlawga reservoir block the impellers of water meters and damage the meters.
To prevent these damages caused by impurities, distribution of raw water needs to be stopped and treated water is to be distributed. However, huge budget is needed to improve the treatment facilities so this will take a long time to be realized. Since these issues cannot be ignored to improve water supply management, YCDC should try to solve these issues actively.

2-4-8 Evaluate cost-benefit of countermeasures against commercial loss in the pilot area and formulate the optimal model of activities
This activity is included in 2-3-10.

2-4-9 Implement OJT by the trainers in the pilot area
This activity is included in 2-3-11.

2-4-10 Verify the manuals on commercial loss
This activity is the aame as 2-3-12.

2-5 Develop training yard for NRW management

2-5-1 Prepare training plan
(1) Preparing training plan
The objective of training yard is that engineers of WRAWSA obtain NRW management skills and basic knowledge through training in the yard. The Expert aims that engineers should well understand appropriate pipe materials and jointing skills to prevent leak and learn how to find leakage and carry out proper repair work as reactive measures. The training plan in the training yard is shown in the table below.

Table 2-101: Training plan of training yard

Training Item	Contents	Duration Seminar	Duration Training	Capacity	Remarks
Pipe Jointing (Jointing between different materials)	❏ Cutting and jointing pipe (DIP,RRVP,HDPE,PVC,PP, etc.)	○	◎	6 teams	☛ Two teams can train for every materials simultaneously
	❏ Jointing between different materials(DIP × RRVP, DIP × HDPE, RRVP × HDPE)	2.0H	0.5D×3	(2person/ team)	≫ Wrench(monkey,ratchet), Inserting machine
Pressure test & Pipe cleaning	❏ Pressure test on jointed pipe and service pipe branch. (connections made by "Jointing training")		◎	3 teams	☛ 0.5Mpa pressure test
	❏ Cleaning pipe after passing the pressure test. (Turbidity test on hydrant)	1.0H×3＋0.5H		(4person/ team)	≫ Manual test pump、engine pump
Saddle installation & Drilling	❏ Installing saddle with corporation stop and how to drill.	○	◎	12person	☛ 12person for every material
	Drilling on DIP, RRVP and HDPE pipe (φ20～φ50mm,under pressure drilling for φ 75mm)	1.0H	0.5D		≫ drilling machine 3nos. , drilling machine for under pressure 1nos.
Leakage repair	❏ Repairing leakage from joint point and corroded point by using repair crump.	○	◎	6 teams	☛ Three teams can train simultaneously × 2times
	❏ How to measure leak volume. (Grasp NRW rate by measuring leak volume per unit time)	1.0H	1.0H	(2person/ team)	≫ funnel, measuring cup
Leakage detection	❏ Sound detecting leak point by using detector.	○	◎	12person	☛ Four persons can train simultaneously(20min.×3)
	(Leak detector, Acoustic bar, correlation type leak detector)	2.0H	0.5D		For 2person/team (30min) ×6
Flow measurement & analy	❏ Measuring minimum night flow. (Ultrasonic flow meter + logger) ＆ Analysis	○	◎	12person	☛ Twelve persons can train simultaneously(20min.×3)
	❏ Measuring water flow variation by line	2.0H	0.5D		≫ Ultrasonic flow meter + logger, PC
Pressure monitoring	❏ Monitoring "dynamic water pressure" and "static water pressure"	○	◎	12person	☛ Twelve persons can train simultaneously(20min.×3)
	Monitoring dynamic water pressure when leak occur	1.0H	1.0H		≫ Pressure guage
Storage tank installation	❏ To understand how to keep water level of storage tank with ball tap and level regulating valve	○	◎	12person	☛ Twelve persons can train simultaneously(20min.×3)
	To understand how to prevent overflow from ground tank or high tank.	1.0H	1.0H		≫ level regulating valve + ball tap
Water meter installation	❏ Piping of service connection by meter diameter	○	◎	12person	☛ Twelve persons can train simultaneously(20min.×3)
	❏ To understand how to fill the bulk size meter (over φ75mm)	1.0H	3.0H		≫ Water meter, swan neck piping
Pipe threading	❏ Pipe threading and jointing on SGP. (φ20～φ100mm)	○	◎	12person	☛ Twelve persons can train simultaneously(20min.×3)
		1.0H	3.0H		≫ Pipe threading machine
Jointing service pipe	❏ Piping of PVC (TS-joint) and PP (metal joint with metal core)		◎	12person	☛ Twelve persons can train simultaneously(20min.×3)
			2.0H		≫ Glue for PVC, wood hanmer, tightning tool
Pipe locating	❏ Locating by using metal locator. (for CIP,DIP,SGP)		◎	12person	☛ Twelve persons can train simultaneously(20min.×3)
	❏ Locating by using non-metal pipe locator（PVC, HDPE）		0.5D		≫ Metal locator, locator for non-metal (D-305)
In-pipe inspection	❏ How to use in-pipe camera and check pipe condition.	○	◎	6 teams	☛ Twelve persons can train simultaneously(20min.×3)
		1.0H	3.0H	(2person/ team)	≫ φ50mm saddle crump, in-pipe camera

(2) Roles of training yard

Th main objective of training yard is that the engineers obtain knowledge and techniques for preventing leaks from occurring. To understand basic knowledge such as valves, and calculation of planned daily maximum demands for setting DMAs to grasp NRW volume measurement and conduct analysis is also one of the objectives of training yard.

Target trainees are not only YCDC engineers but also engineers of other water utilities or private companies related to water supply construction work in the future. Certification such as a license will be issued if the trainees finish the trainings.

(3) Roles of training yard in overall NRW management training plan

First trainers were developed through seminar by the Expert, NRW reduction project in North Okkalapa, and the pilot project in the Project. Those trainers will conduct training of basic knowledge and technical training in training yard and will also conduct practical training in daily work by OJT. Next trainers will be developed by those trainings and a sustainable training system will be established. The image of utilization of the training yard is as shown in Figure 2-85.

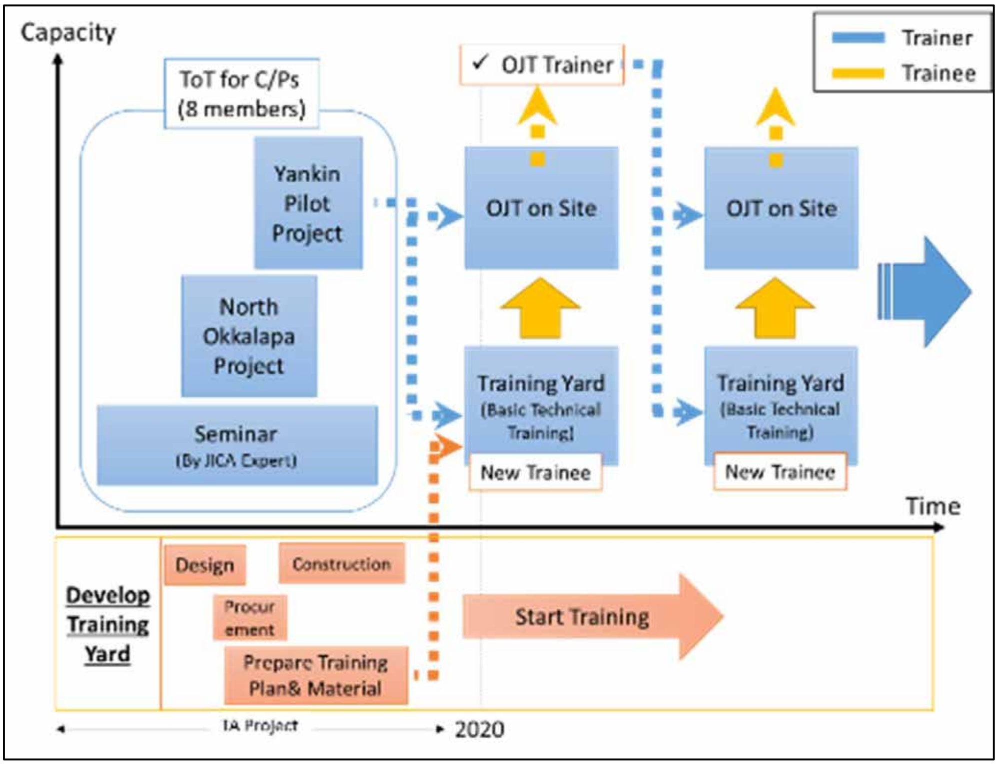


Figure 2-85: Image of utilization of training yard

2-5-2 Design training yard

(1) Location of training yard

The training yard was constructed as a "Training Center for NRW Management" placed in the southern area of the warehouse in Yegu pumping station. The training center consists of training yard for practical training such as leak detection and training house for seminar.

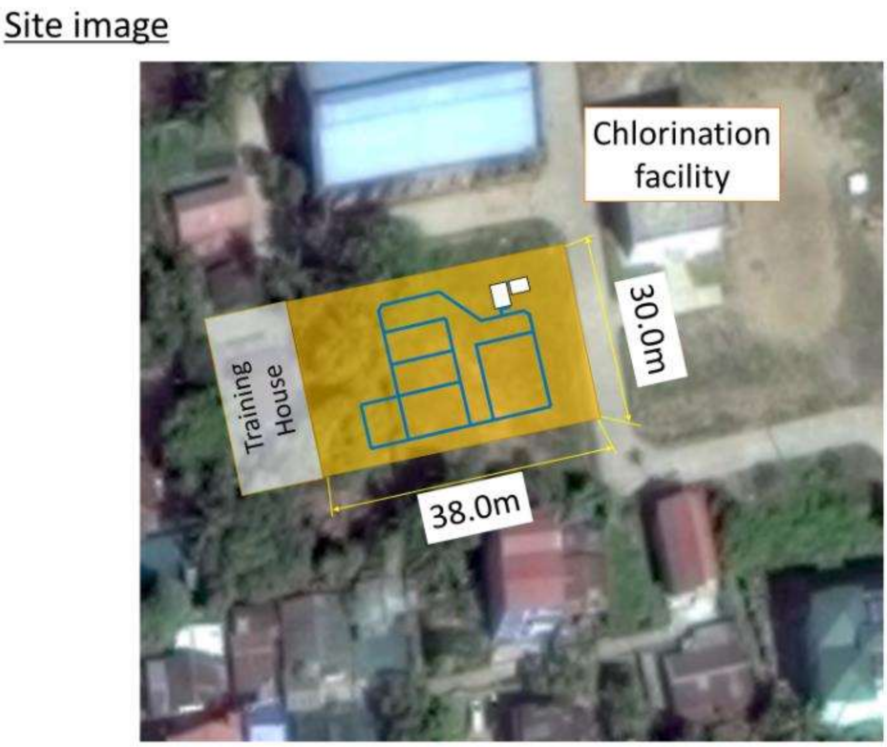


Figure 2-86: Location of training yard

(2) Frame of training yard

Facility: Training yard with roof (construct by WRAWSA)

Structural outline: Steel structure (Steel truss)＋Steel roof

Floor space = 30.0m×38.0m＝1,140m^2

(3) Accessories of yard

Accessories of yard were prepared and set by WRAWSA.

- Booster pump x 2 + control panel + tank x1
- Circulation pump x 1
- Storage tank x 1 FRP made: 2.0m×2.0m×2.0m H
- Basement for storage tank (RC)
- Water supply line: supply equipment for storage tank (φ40mm)

(4) Design and construction of frame

Piping work and yard facilities were designed by the Expert and frame of the yard and the lecture house including lecture room, warehouse, and trainer room were designed by WRAWSA. All facilities were constructed by WRAWSA.

(5) Installation of pipeline accessories

Piping work and pipeline accessories such as flow meter were implemented by the C/P after receiving instructions about objectives and construction methods by the Expert. Design of pipeline and pit are shown in Figure 2-87 and Figure 2-88.

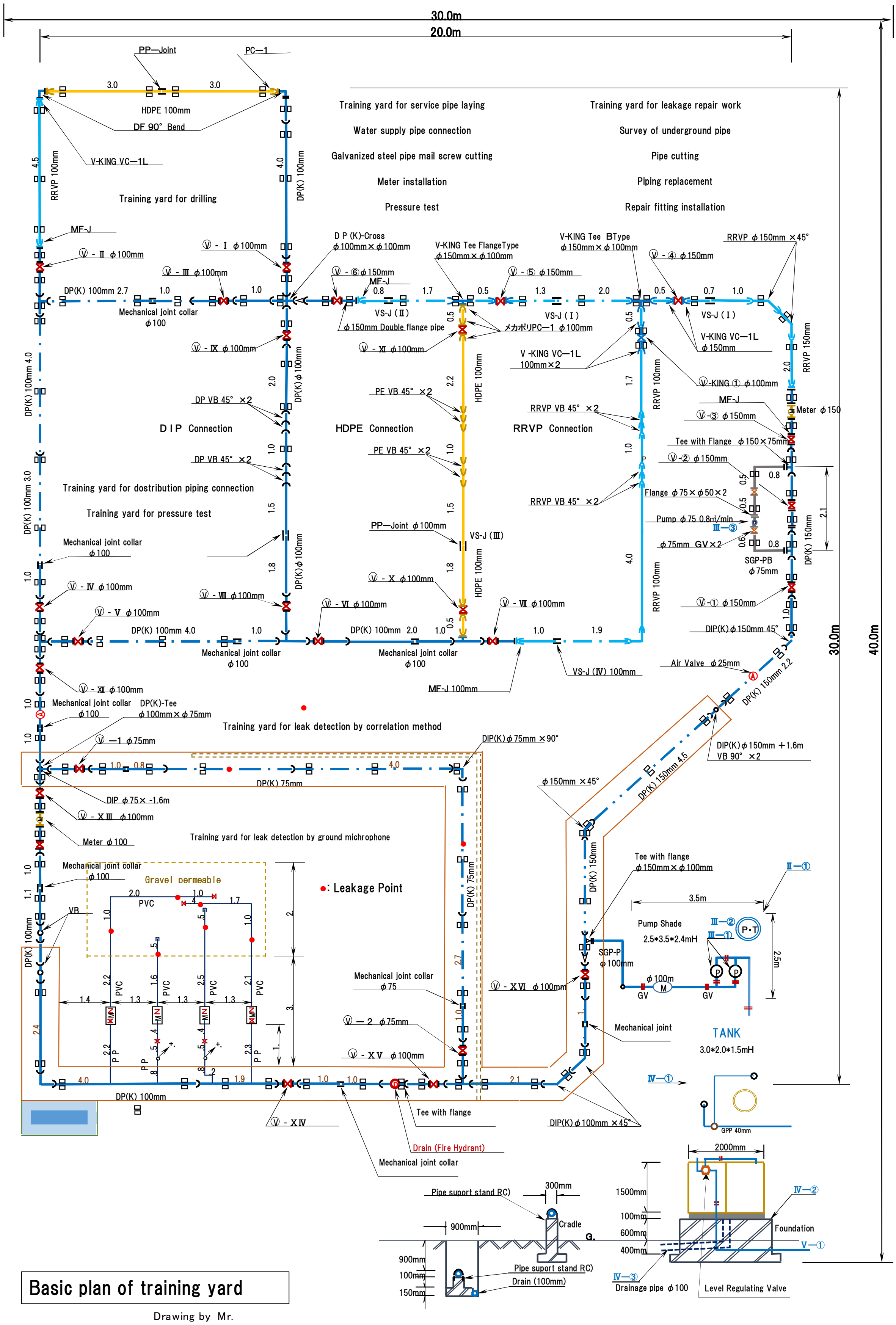


Figure 2-87: Pipeline design of training yard

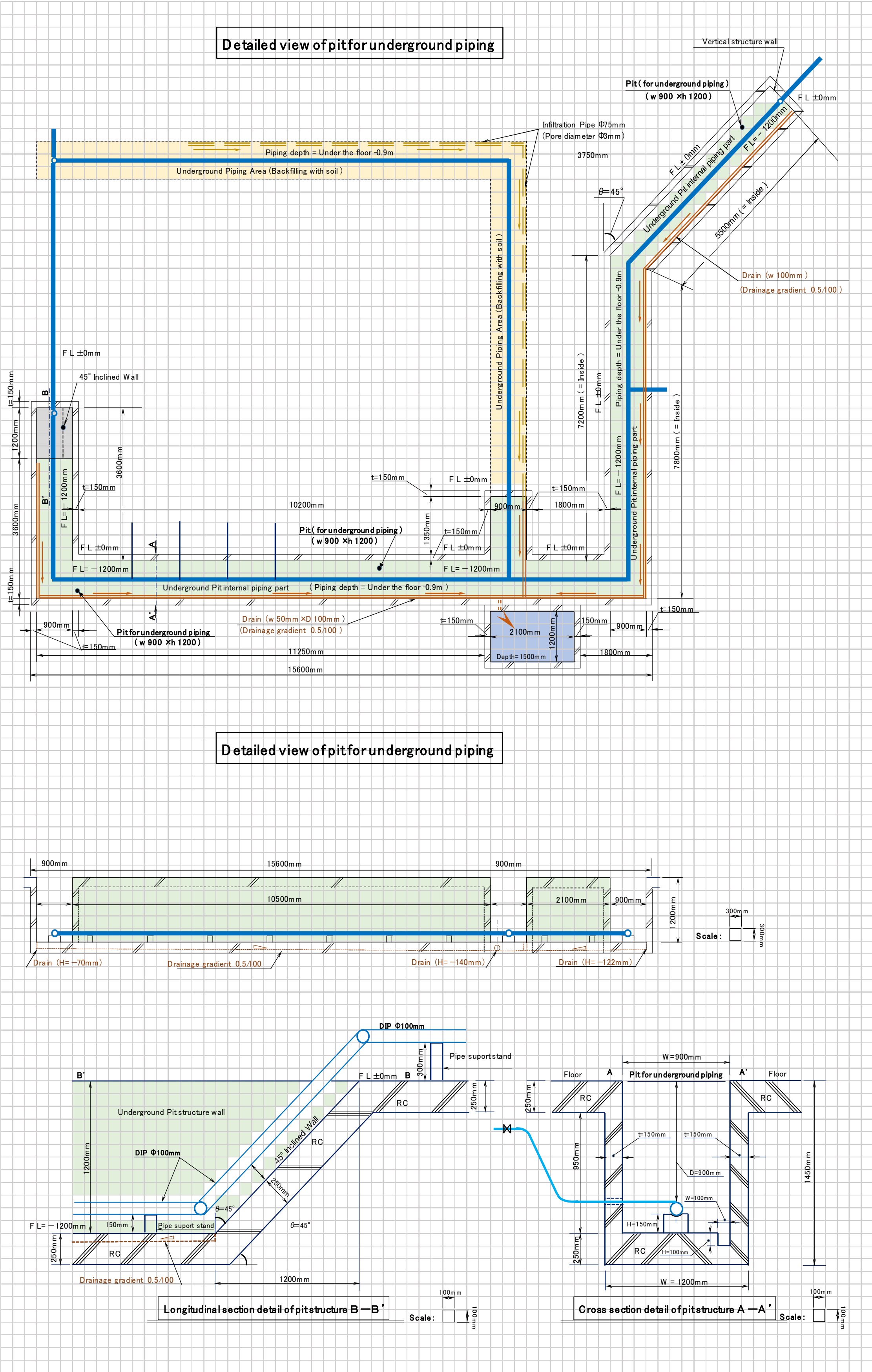


Figure 2-88: Detail drawing of pit

(6) Training center

WRAWSA constructed a training building next to the training yard. Training building enables WRAWSA to move seamlessly from classroom lecture to training in the training yard. The training building consists of lecture rooms, a warehouse for pipe materials and tools, and an office for NRW Management Section that is mainly in charge of training.

Photo 2-62: Lecture room

Photo 2-63: Training center (front view)

2-5-3 Prepare equipment and materials for training yard

Based on the design, equipment and materials for the training yard were procured by JICA. Frame of the training yard was the responsibility of YCDC so that pipes, fittings, accessories, leak detector, tools etc. were procured by JICA. Those equipment and materials arrived in Yangon in Sep. 2019.

2-5-4 Construct training yard

Training yard facilities were constructed as per the following schedule. Piping work of the training yard was implemented by the C/P of the pilot project. The facilities of the training yard are shown in Photo 2-64.

Date	Activities
2019/09/26 ～ 10/03	Start piping work Five members from the C/P started piping work as an OJT by the Expert DIPφ150mm (inside of pit) DIPφ75mm (leak correlation area), making leak point Piping at leak detection field (4 lines)
2019/11/18 ～ 11/20	Set inlet pipe and accessories for storage tank Inlet pipe to tank：Training for threading SGP-PB and jointing. Installation of water level regulation valve (40mm)
2020/1/21 ～ 1/29	First training in training yard Trainees are selected from last promoted staffs Seminar was carried out by the Expert, and practical training was carried out by the C/P Closing Ceremony was held on 30th Jan 2020
2020/1/27	Opening ceremony for NRW Management Center


Inlet of storage tank


Tank – booster pump


Piping inside of pit


Jointing training area


Circulation pump


Flow meter


pipeline inside pit


Leak detection field


Water meter

Photo 2-64: Facilities in training yard

(7) Opening ceremony for Training Center for NRW Management

Date：27th Jan, 2020 AM7:00～

Opening ceremony of Training Center for NRW Management was held with participation of the Mayor, the Secretary, and other committee members. After opening speech by the Mayor, introduction of training in training yard was carried out. The C/P showed the training to trainees as a first demonstration. The contents of training were as follows.

1. Leak detection
2. Piping work

3. Water pressure test
4. Setting saddle snap tap and drilling

2-5-5 Prepare training manuals and materials for training yard
Training materials were prepared based on training plan as shown in Table 2-83 and Table 2-84.

2-5-6 Conduct trainings of the trainers in training yard
(1) Launch NRW management training in training yard
The first training of NRW management was carried out for 7 days from 21st Jan 2020. Six trainers were selected from the C/P of the output 2 and 20 members of trainees were selected from the staff newly promoted to SAE.

This was the first training by the trainers. Before the start of the training, the Expert gave a training for trainers in training yard on the first day and practical training for trainees was given on 23rd and 24th Jan. 2020 by trainers. The trainers did not only instruct but also answered questions from the trainees. They carried out the training by fully utilizing their experience in the pilot project.

At the beginning, the Expert was worried that it may be difficult for lower-level staff to instruct higher level staff because some of trainers are of lower level than the trainees. However, the lower-level staff could teach well, despite being in lower grades, supported by the advice of the CE in the meeting at the start of the training. The trainers of training, the schedule, and the evaluation results of trainees are shown below. Some of the trainees were selected from a section or division which was not related to NRW management so that it made difference in activeness and comprehension in the result.

【Trainers】

Name	Section	Training in charge
U Aung Min Oo	NRW Management Sec.	Water pressure test
U Kaung Zaw Thet	NRW Management Sec.	Leakage survey
U Sithu Win	Yankin Pilot Counterpart	Pipe jointing
U Than Oo	Yankin Pilot Counterpart	Set saddle snap tap and drilling
U Myo Than Thun	NRW Management Sec.	Support
U Yan Naing Thun	NRW Management Sec.	Support

【Training schedule】

21/Jan	Tue	AM: Seminar (What is waterworks) PM: Seminar (What is waterworks), Instruction for the C/P in training yard
22/Jan	Wed	AM: Seminar (Planning waterworks) PM: Seminar (Hydraulic analysis)
23/Jan	Thu	Instruction for the C/P in training yard Pipe Jointing, Leak Detection, Drilling, Pressure Test
24/Jan	Fri	Instruction for the C/P in training yard Pipe Jointing, Leak Detection, Drilling, Pressure Test
25/Jan	Sat	-
26/Jan	Sun	-
27/Jan	Mon	AM7:00～ Opening ceremony PM13:00～ Seminar (Hydraulic analysis)
28/Jan	Tue	AM: Seminar (Outline of NRW、Hydraulic analysis) PM: Final Examination
29/Jan	Wed	AM: Lecture (Lecturer: U Zaw Win Aung, Daw Yu Yu Hla Baw)
30/Jan	Thu	Closing

【Trainees and results of exam.】

No.	Position	Section	Activeness	Obedience	Attendance	Exam	Score
1	SAE	JICA	26.25	5	5	48	84.25
2	Deputy Supervisor	Aung Da Gon Pump station	26.25	5	5	32.4	68.65
3	Deputy Supervisor	Reservoir	26.25	5	5	43.8	80.05

No.	Position	Section	Activeness	Obedience	Attendance	Exam	Score
4	Deputy Supervisor	Pipe-2	24	5	5	31.2	65.2
5	Skill-5	Pipe-4	25.5	5	5	39.6	75.1
6	SAE	GIS	27.75	5	5	53.4	91.15
7	Deputy Supervisor	GIS	28.5	5	5	51	89.5
8	Deputy Supervisor	Reservoir	24.75	5	5	35.4	70.15
9	Deputy Supervisor	Nyaung Na Pin	27	5	5	42.6	79.6
10	Skill-5	GIS	25.5	5	5	31.8	67.3
11	Deputy Supervisor	East District	24	5	5	31.8	65.8
12	Deputy Supervisor	Resarch	27	5	5	39.6	76.6
13	SAE	GIS	28.5	5	5	41.4	79.9
14	Deputy Supervisor	Nyaung Na Pin	24	5	5	37.2	71.2
15	Deputy Assistant Programmer	Tharkaeta	28.5	5	5	48.6	87.1
16	Skill-5	NRW	28.5	5	5	36	74.5
17	Deputy Supervisor	Lagonpyin	27	5	5	40.8	77.8
18	SAE	GIS	24.75	5	5	45.6	80.35
19	Deputy Supervisor	Reservoir	25.5	5	5	48	83.5
20	SAE	Design	25.5	5	5	39	74.5

(2) Developing trainers for online training

Trainings for online trainers were carried out through Zoom online meeting as follows.

Date: 24th Nov, 1,7,14 Dec 2020 (4 days)

Target staff (responsible training course):

1. U Aung Min Oo (Water supply plan)
2. Daw Mi Mi Khine (Commercial loss)
3. Daw Thander Htway (Leakage detection)
4. U Zayyer Tun (Water supply equipment)

Two assistant engineers (AE) who were assigned to the NRW Management Section after the completion of the pilot project were selected as trainer for the online training. There was a tendency to focus on job rank rather than work experience on trainers, and it was still difficult for the lower-level staff to teach the higher-level staff.

(3) NRW management online training

From 16th December to 30th December 2020, an online training was carried out for T/S deputy officers. Since it seemed there would be too many participants if all T/S participated at one time, this training was divided into two sessions. Deputy T/S officers from 11 T/S participated in the first online training.

NRW Management Section was in charge of the training. Not only was the training on practical or technical NRW management held, but also required works of T/S offices and the research results of the C/P in Tokyo University were presented in this online training. Moreover, some videos, which showed how to use leak detector etc., were added to training materials so that training materials on that day was improved than the first version.

Trainers and trainees of this online training are given below. After the training, trainees made a presentation and evaluation was conducted.

Trainers

No.	Name	Position	Subjects
1	U Thant Zin Oo	EE	(Utilization of NRW Management in Townships)
2	D Yu Yu Hla Baw	EE	(NRW Management) (DMA Monitoring and Commercial Loss Management)
3	U Zayyar Tun	AE	(Ls-10 Water Supply Equipment)
4	D Mar Mar Aye	AE	(Duty and Responsibility of Deputy Township

No.	Name	Position	Subjects
			Officers and Water Distribution Service), (Laws, Regulations SOPs for Township Staffs)
5	D Mi Mi Khine	AE	(Ls-11 Issues Caused By Meter)
6	D Thandar Htway	AE	(Ls-8 Leakage Detection Method)
7	U Aung Min oo	SAE	(Ls-1 Water Supply Plan)
8	U Myo Thant Tun	SAE	(SOPs for Pipe Installations)
9	U Yan Naing Tun	SAE	(NRW Reduction Projects)
10	D Khaing Khaing Soe	SAE	(Knowledge Sharing by Research Activities)
11	D Win Sandar Oo	Assistant Supervisor	(How to Use Meter Test Kit)
12	U Kaung Zaw Htet	Flat	(Ls-7 Minimum Night Flow and Night Step Test)

Trainees

No.	Name	Position	Offices
1	D. Su Su Maw	Dy Supv	Sanchaung
2	U. Kyaw Htay	Dy Supv	Tharkayta
3	D Zin Mar Win	Dy Supv	Mayangone
4	D Nweni Soe	Dy Supv	Insein
5	D Wah Wah Aung	Dy Supv	Insein
6	D Ei Ei Theint	SAE	North Okkalapa
7	U Htay Htay Aung	Asst: Supv	Shwe Paukkan
8	U Kyi Naing	Asst: Supv	Lathar
9	D Nweni Aung	Asst: Supv	Shwepyithar
10	D Nilar Win	Asst: Supv	Hlaing
11	U Nyi Nyi Aung	Asst: Supv	Mingalardone
12	D Chaw Sandar Kyaw	Asst: Supv	North District Office
13	D Zin Mar Than	Asst: Supv	Mingalardone
14	D Yamone Theint Theint Htay	Asst: Supv	Lanmadaw

Schedule

<table>
<tr><td>Date/Time</td><td colspan="2">13:00 - 14:30</td><td rowspan="11">Break Time (10 mins)</td><td colspan="2">14:40 - 16:10</td></tr>
<tr><td>2020/12/16</td><td colspan="2">Opening</td><td colspan="2">(NRW Management) (D Yu Yu Hla Baw)</td></tr>
<tr><td>2020/12/17</td><td colspan="2">(Ls-1 Water Supply Plan)
(U Aung Min Oo)</td><td colspan="2">(Ls-10 Water Supply Equipment)
(U Zeyyar Tun)</td></tr>
<tr><td>2020/12/18</td><td colspan="2">(Ls-10 Water Supply Equipment)
(U Zeyyar Tun)</td><td>(Ls-11 Issues Caused By Meter)
(Daw Mi Mi Khine)</td><td>How to Use Meter Test Kit)
(D Win Sandar Oo)</td></tr>
<tr><td>2020/12/21</td><td>(D Yu Yu Hla Baw)
(DMA Monitoring and Commercial Loss Management)</td><td>(D Khine Khine Soe)
(Knowledge Sharing By Research Activities)</td><td colspan="2">(Ls-8 Leakage Detection Method) (D Thandar Htwe)</td></tr>
<tr><td>2020/12/22</td><td colspan="2">(Ls-8 Leakage Detection Method) (D Thandar Htwe)</td><td colspan="2">(Minimum Night Flow and Night Step Test) (U Kaung Zaw Htet)</td></tr>
<tr><td>2020/12/23</td><td colspan="2">(Duty and Responsibility of Deputy Township Officers and Water Distribution Service) (D Mar Mar Aye)</td><td colspan="2">(Utilization Of NRW Management In Townships) (U Thant Zin Oo)</td></tr>
<tr><td>2020/12/24</td><td colspan="2">(Utilization of NRW Management In Townships)
(U Thant Zin Oo)</td><td colspan="2">(Laws,Regulations SOPs For Township Staffs) (D Mar Mar Aye)</td></tr>
<tr><td>2020/12/28</td><td colspan="2">(SOPs For Pipe Installations) (U Myo Thant Tun)</td><td colspan="2">(NRW Reduction Projects) (U Yan Naing Tun)</td></tr>
<tr><td>2020/12/29</td><td colspan="2">(Presentation by Participants)</td><td colspan="2">(Presentation by Participants)</td></tr>
<tr><td>2020/12/30</td><td colspan="2">(Presentation by Participants)</td><td colspan="2">Closing</td></tr>
</table>

2-6-1 Develop 5-year and 10-year NRW management plans

(1) Current NRW ratios in Yangon city

Flow measurement work was launched in Nov. 2019 by flowmeters installed in the Project. NRW Management Section calculated NRW monthly based on the data from the flowmeters. The NRW ratio of entire Yangon city until Sep 2020 is shown in the table below.

Table 2-102: NRW ratio of entire Yangon city

Item	2019		2020								
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
System input volume (MGD)	215.5	215.5	215.5	215.5	215.5	215.5	213.3	211.0	212.5	209.7	205.6
Revenue water volume (MGD)	80.7	79.7	78.8	83.9	75.3	78.0	73.1	76.5	73.7	72.3	73.1
Non-Revenue Water volume (MGD)	134.8	135.8	136.7	131.6	140.2	137.5	140.2	134.5	138.7	137.4	132.4
NRW ratio (%)	62.5	63.0	63.4	61.1	65.1	63.8	65.7	63.7	65.3	65.5	64.4

(2) Formulate improvement plan through the training in neighboring country

The third country training in PPWSA was carried out on NRW management and customer service management. After the training was finished, the C/P made an improvement plan for NRW management and customer management based on the training. PPWSA has many useful experiences for WRAWSA such as reduction of NRW ratio from over 70% to less than 7% in 25 years. At the discussion of the improvement plan, the C/P had a lively discussion. Table 2-103 shows improvement plan (Annex CD2) that the C/P made through the training in the neighboring country. This improvement plan was also utilized for formulating the action plan and management plan above.

Table 2-103: NRW improvement plan formulated through the training

Items	Improvement plan
NRW Reduction	➢ Establish NRW team in every T/S and carry out 24-hours leak management ➢ Replace damaged meter immediately ➢ Record leakage information ➢ Repair leakage immediately ➢ Install flowmeter in WTP and reservoir and grasp the distribution amount. Leak detection and repair will be carried out continuously to achieve the NRW ratio shown in M/P.
Organization	➢ Establish relationship between NRW Management Section and the other relating Division/Section
Countermeasures against NRW	➢ Use high-quality material ➢ Reduce physical loss by collaborating with leak detection team and repair team ➢ Eliminate illegal connection and install high-quality water meter to reduce commercial loss
Planned leak detection by detection team	➢ Make a leakage detection plan in every T/S and implement detection work.
Inspection	➢ Inspect leak repair work and construction work with check lists by inspection team when finishing works. (e.g. proper material is used or not, etc.)

(3) Formulating mid and long-term NRW management plan

Meeting for formulating NRW management plan was held for five days in Aug. 2018. The 21 objectives of NRW management in Table 2-104 were decided as an action plan through discussions with NRW Management Section and the other related sections. Before start of the discussion, the Expert showed NRW ratio of the Yangon city which is estimated on the basis of the design capacity of water supply facilities. At that time, flowmeters were not installed, and it was before the pilot project so that it was difficult to mention concrete target goals. Afterward, data such as water flowrate and meter function rate were accumulated, and the pilot project was completed. Therefore, NRW Management Section started updating the mid-term plan to make it more detailed from Feb 2020.

Date	Contents
3rd Aug 2018	Expert explained followings. • Review issues (4th S/C1 meeting) • Basic approach for formulating plans • Feasibility and priority from the viewpoint of budget, human resource, and time.
7-8th, 13-14th Aug 2018	NRW management plan was drafted. 5 categories and 21 objectives were formulated as shown in Table 2-104.

Table 2-104: NRW management action plan (draft)

Category	Policy	No	Objective
NRW Management	Improve information accuracy	1	Create and update pipeline map
		2	Collect basic data regarding NRW management
	Grasp actual NRW situation	3	Grasp NRW rate periodically by data collecting on distribution and effective water (revenue, non-revenue)
		4	NRW management in existing DMA
Physical Loss	Proactive leak prevention	5	Design/construct DMA system in pipe network
		6	Pipe laying at proper location to prevent leakage
		7	Prevent leakage at branch point
		8	Implement water pressure test to prevent leakage
	Reactive leak prevention	9	Efficient leak detection/repair on existing transmission/distribution pipe
		10	Repair leakage in proper repair method
		11	Record every leakage repair work
Commercial Loss	Measure exact water consumption	12	Grasp situation of existing meter function
		13	Install meter at proper location
		14	Water meter maintenance by WRAWSA
		15	Maintain measurement accuracy of water meter
		16	Solve non-metered customer
		17	Secure function of large size meter
		18	Proper meter-reading to get exact consumption
		19	Fairness in collecting water charge
		20	Eliminate illegal connections
		21	Decrease broken rate of new meter

(4) Formulate NRW management plan

After NRW action plan was formulated, NRW management plan was updated by NRW Management Section aiming to include more detailed mid- and long-term action plan (refer to Annex 5.C) since data was accumulated through activities such as flowmeters installation and meter function check. The table of contents of the plan is shown below.

1. Target Non-revenue Water Ratio
  1.1. Overall Service Level Targets of YCDC
  1.2. Target of NRW
2. Existing Situation of NRW Management
  2.1. Causes of NRW in Yangon by IWA table
  2.2. Estimation of NRW Ratio in Entire City
  2.3. Issue of Water Meters
  2.4. Current Human Resources Capacity of NRW Management
  2.5. Organization of NRW Management Section
3. On-going NRW Reduction Measures
  3.1. Distribution network rehabilitation and NRW management projects
  3.2. NRW Pilot Projects in Yankin in the Project
  3.3. Cost benefit analysis of NRW activities in Pilot Project
  3.4. NRW Management Model by DMA
  3.5. On-going NRW Reduction Projects
  3.6. Other related activities
4. NRW Management Plan
  4.1. Proposed NRW Management Measures
    4.1.1. Activities and components of NRW management
    4.1.2. Mid and long-term measures
    4.1.3. Short term measures
  4.2. Physical Loss Management Plan (rehabilitation or replacement)
    4.2.1. NRW reduction by on-going large donor projects
    4.2.2. NRW reduction roll-out plan by WRAWSA
    4.2.3. Maintenance work of pipe
  4.3. Commercial Loss Management Plan
    4.3.1. Status of existing meters in Yangon City
    4.3.2. Meter installation plan
    4.3.3. Meter replacement work
    4.3.4. Meter installation annual target
    4.3.5. New meter installation by ODA project and WRAWSA own project
    4.3.6. NRW reduction plan up to 2030
  4.4. Training Plan
    4.4.1. Mid- and long-term target
    4.4.2. Short term training plan (2021~2024)

2-6-2 Launch priority activities as a part of implementing the 5-year NRW management plan. The activities which have been already launched in the mid-term plan are shown below.

Table 2-105: Activities launched in mid-term plan

Policy	No.	Objective	Launched Activities
Improve information accuracy	1	Create and update pipeline map	• Creating as-built drawings of North Okkalapa NRW project by WRAWSA and other NRW project
	2	Collect basic data regarding NRW management	• T/S started to record leakage and meter function and NRW Management Section is collecting that data.
Grasp actual NRW situation	3	Grasp NRW rate periodically by data collecting on distribution and effective water (revenue, non-revenue)	• NRW calculation whole Yangon city with flow meter
	4	NRW management in existing DMA	• NRW calculation of existing DMA(ODA、YCDC)
Proactive leak prevention	8	Implement water pressure test to prevent leakage	• Water pressure test in Yankin Phase2 project or other WRAWSA project.

Policy	No.	Objective	Launched Activities
Reactive leak prevention	11	Record every leakage repair work	• Making leakage record with common format by T/S and submit to NRW Management Section (Mostly unsubmitted)
Countermeasures against Commercial Loss	12	Grasp situation of existing meter function.	• Meter function survey is carrying out in 6 T/S in downtown area.
	13	Install meter at proper location	• Implement in Yankin phase2 project or other WRAWSA project
	16	Solve non-metered customer	• Started by whole YCDC

2.2.3. Output 3: Capacity of Water Quality Management of YCDC is enhanced

3-1 Establish Water Treatment Section

3-1-1 Establish Water Treatment Section

WRAWSA supplies water from reservoirs and a water treatment plant. There was no section which was in charge of making a plan of systematic maintenance and renewal of these facilities, understanding and accumulation of appropriate water treatment technology and knowledge, and setting of source water quality conservation measures. Therefore, WRAWSA decided to establish the "Water Treatment Section" in July 2016 and address the issues above. The figure below shows the organization of the section.

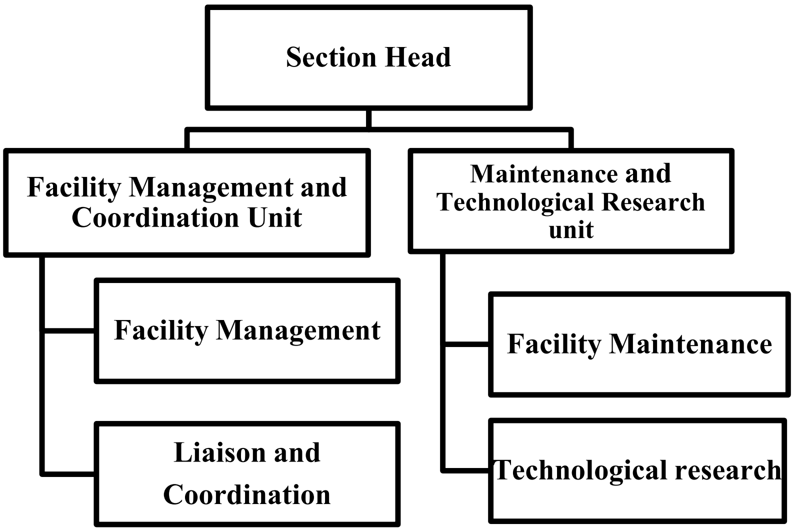


Figure 2-89: Organization of Water Treatment Section

3-1-2 Define the division of duties of Water Treatment Section

(1) Duties of Water Treatment Section

Duties of Water Treatment Section are shown below.

Table 2-106: Duties of Water Treatment Section

• Things on reservoirs, intakes, raw water transmissions, water treatment and clear water transmissions ✓ Management of facilities and equipment of reservoirs, intakes, raw water transmissions, water treatment plants and clear water transmissions. ✓ Liaison and coordination with relevant ministries, agencies and organizations about water use of reservoir and river water. ✓ Liaison and coordination with relevant ministries, agencies, and organizations about prevention of water quality pollution of reservoir, river, and open channel water. ✓ Liaison and coordination with water treatment plants and reservoirs about information of operation, maintenance, and water treatment technology. ✓ Management, control and collection of water treatment technology and information. ✓ Planning and research of the maintenance of the facilities and equipment. ✓ Making comprehensive improvement, renewal and maintenance program of the facilities and equipment.

(2) Outline of the work of Water Treatment Section

Water Treatment Section started to work on management of water treatment plant facilities, information collection on water treatment, information management, management of water treatment technology, and collection of technical information from the outside organizations. In addition, Water Treatment Section was in charge of a secretariat work for preparing standard operating procedure (SOP) and worked on the formulation of SOP system and determination of SOP format applied to water treatment plants, reservoirs, pumping stations and laboratories and held SOP preparation workshops. The activities for preparing SOP and formulation of SOP system were developed into the activities of the entire WRAWSA, and Water Treatment Section took over the secretariat duties of SOP development for the entire WRAWSA from Planning Section.

3-1-3 Hold a series of seminar for basic water treatment technology with study tours

The C/P and the Expert held a study tour at the water treatment plant, 9 seminars on basic water treatment technology (Table 2-107), 3 Task Force Team (TFT) seminars (Table 2-108), 6 joint seminars & meetings of Output 3 team (Table 2-109) and 6 seminars specialized in individual themes (Table 2-110). The target audience for the series of seminar for basic water treatment technology were technical staff of WRAWSA. The TFT seminars targeted the Output 3 C/P, whose purpose was application of basic water treatment technology to practical field. The joint seminars & meetings targeted the Output 3 C/P and the persons involved in each activity. The seminars specialized in individual themes were held at chlorine treatment working group meetings, SOP preparation workshops, and study meetings of new water treatment facility (Phase 3) at Nyaunghnapin water treatment plant.

Table 2-107: Date and outline contents of seminars for basic water treatment technology

No.	Date	Outline of Contents
1st	23rd, Dec, 2015	• About the Seminar • Basic Design Parameters • Coagulation • Observation of Water Treatment Plant
2nd	9th, Feb, 2016	• Quick Review of the First Seminar • Answer to the Questions shown in the Presentation Material of the First Seminar • Answer to the Questions from WRAWSA staff in the First Seminar • Flocculation
3rd	17th, Mar, 2016	• Requests and Questions from WRAWSA Staff through Questionnaire of the Second Seminar • Control of Coagulant dose

No.	Date	Outline of Contents
		• Sedimentation
4th	21st, Mar, 2016	• Coagulation, Flocculation and Sedimentation process in a beaker (Jar-Test) • Coagulation • Control of Coagulant dose • Flocculation • Sedimentation • Removal of Iron
5th	16th, May, 2016	• Water Treatment and Disinfection • Dosing of Chlorine and Residual chlorine • Requirement of Disinfection and Water Quality Test • Advantage and Disadvantage of Chlorination • New Chlorine Generator in Yegu Pumping Station
6th	17th, May, 2016	• Water Treatment and Disinfection • Advantage and Disadvantage of Chlorination • Chemistry of Chlorine • Consumption of Chlorine in Various Water • Residual chlorine • New Chlorine Generator in Yegu Pumping Station • Reaction of Chlorine and Ammonia • Old Chlorine Generator in Yegu Pumping Station
7th	8th, Jul, 2016	• Requests and Questions from WRAWSA Staff through Questionnaire of the Third and Forth Seminar • Rapid Sand Filtration
8th	6th, Sep, 2016	• Requests and Questions from WRAWSA Staff through Questionnaire of the seventh seminar • Questions in the seventh seminar from the Expert • Rapid Sand Filtration
9th	1st, Nov, 2016	• Requests and Questions from WRAWSA Staff through Questionnaire of the Eighth seminar • Ozonation • Ultraviolet Treatment

Table 2-108: Date and contents of seminars for task force team

No.	Date	Outline of Contents
1st	27th, Aug, 2016	• Basic Design Parameters on Design Standard • Functions Required to Filters • Rapid Sand Filtration
2nd	6th, Sep, 2016	• How to get yield, minimum and maximum diameter of a filter media from a sieve analysis
3rd	26th, Oct, 2016	• Review of the last TFT mini seminar • Exercise • Requirements to be considered in the filter improvement plan

Table 2-109: Date and contents of Joint seminar & meeting

No.	Date	Contents
1st	28th, June, 2017	• Reservoir water improvement (JICA Expert) ➢ What (parameter) should be improved? ➢ Which reservoir(s) should be the target to improve? ➢ Could the treatment facility of Gyobyu be useful for intended improvement? ➢ What (numerical target) is the goal of the improvement? ➢ To make improvement research plan

No.	Date	Contents
		➢ Schedule ➢ Contents of the research • Duties of Water Treatment Section (WRAWSA staff) ➢ To make periodical check regulation for all facilities belonging to the reservoir division ✧ Basic principles ✧ Guideline of the selection of instrument for periodical check ✧ Type of check ✧ Principles of making and keeping records ➢ To make a regulation of long-term facility maintenance and renewal plan of WTP and reservoirs. ✧ Basic principle of making facility and instrument management ledger at every site ✧ Basic principle of periodical maintenance, overhaul and renewal of facilities and instruments ✧ Basic principle of record making and keeping ➢ Drawing of design and document keeping ✧ To make basic principle for making design drawing records ✧ To make system for keeping and inheriting of design drawings and documents • Documents need to be store or made related to the Filter Improvement Activity (JICA Expert) ➢ Designs of the pilot filter basins. ➢ Completion drawings. ➢ Parameter decision and their calculation ➢ Filter media and their particle sizes ➢ Depth of both filter media. ➢ Making procedure of filter sand ➢ Sieve test result of the raw sand. ➢ Selection of mesh size (opening) of sieves ➢ Size and depth of supporting gravel ➢ Filter wash condition ➢ Backwash rate and surface wash rate ➢ Backwash time and surface wash time ➢ Filter wash sequence of backwash and surface wash. ➢ Size of the wash water drainage valve ➢ Mounting position of the surface wash nozzle (Phase 1 & Phase 2) ➢ Height of the weir height at filtrate side ➢ Repair of the false flow ➢ Repair of the underdrain system
2nd	23rd, Aug, 2017	• Activities of TFT (WRAWSA staff) ➢ Total plan of pilot filter basins ➢ What will be remodeled? (Anthracite, Sand, Drainage valve, Wash water rate, Ware height of effluent and so on) ➢ Evidence of all remodeling plans ➢ Research plan using pilot basins ➢ Total schedule of the research plan • Study and research about sludge removal method (WRAWSA staff) ➢ Research plan ➢ Result of the research • Duties and their schedule of Water Treatment Section (WRAWSA staff) ➢ Periodical check regulation ➢ Facility maintenance and renewal regulation ➢ Drawing of design and document keeping
3rd	3rd, Oct, 2017	• Technological information about ACH and PAC (WRAWSA staff) ➢ Jar-Test and Most appropriate dosage (MAD) ➢ Coagulation Efficiency of ACH and PAC ➢ Relation between Raw water turbidity and MAD

No.	Date	Contents
		➢ Advantage and disadvantage of using ACH and PAC • Study and research about sludge removal (WRAWSA staff, JICA Expert) ➢ Sludge pilling up speed in Phase1& 2 sedimentation basins. ➢ Water flow speed (rate) to scour deposited sludge in a sedimentation basin. ➢ Flocks (Sedimentation speed is used as a parameter of flock size.) intended to be removed in Phase1& 2 sedimentation basins. ➢ Relation between sludge depth/height and water flow speed. ➢ How deep/height of sludge pilling up in Phase1& 2 sedimentation basins is allowed. • Reservoir water quality improvement (WRAWSA staff) ➢ Plan of a pilot plant.
4th	28th, Nov, 2017	• Progress of the filter improvement TFT (WRAWSA staff) ➢ Improvement plan of the pilot filters ➢ Basic design parameter ➢ Comparison of the new and old parameter ➢ Drawing of the new pilot filters ➢ Process and procedures of the improvement ➢ Photos of improvement work ➢ Plan of the new pilot filters experiment ➢ Purpose ➢ Monitoring parameter ➢ Schedule • Study and research about sludge removal (WRAWSA staff) ➢ Summary of the research result ➢ Laying of desludging pipes ➢ Future plan of desludging research • Reservoir water quality improvement (WRAWSA staff) ➢ Plan of a pilot plant. ➢ Water quality of Gyobyu reservoir in the past. ➢ Schedule
5th	23rd, Jan, 2018	• Progress of the filter improvement TFT (WRAWSA staff) ➢ Progress of the improvement of the pilot filters ➢ All the process should be recorded ➢ All the process should be checked ➢ Making filter sand, laying down filter materials, rise of weir, wash water drainage valve, surface wash pipe, size of filter sand and anthracite, etc. ➢ Drawing of the new pilot filters ➢ Plan of the new pilot filters experiment ➢ Purpose ➢ Monitoring parameter ➢ Water level in the filter ➢ Frequency of backwash ➢ Filtrate water quality ➢ Schedule • Reservoir water quality improvement (WRAWSA staff) ➢ Final plan of a pilot plant. ➢ Schedule
6th	16th, March 2018	• Rapid Filter Improvement TFT; Pilot basin of Phase 2 ➢ Repair of water leak from pressure chamber wall at the point of backwash water pipe connection ➢ Set a countermeasure not to be involved air in backwash water. Or a countermeasure to remove air before backwash ➢ Procedure of the filter washing ✧ How many backwash pumps you will use after leak repair ✧ Procedure to set appropriate surface wash rate (10~20cm/min), opening degree of the valve ✧ Procedure to set appropriate backwash rate (40~45cm/min), opening

No.	Date	Contents
		degree of the valve, a countermeasure not to open the valve excessively. ✧ Research plan ● Purpose ● Monitoring parameter ➢ Water level in the filter ➢ Frequency of backwash ➢ Filtrate water quality ● Schedule • Rapid Filter Improvement TFT; Pilot basin of Phase 1 ➢ Production of the filter sand of which specification is as same as the Phase 1 pilot basin ➢ Repair and replacement of false floor and strainer ➢ Replacement of wash water drainage ➢ Schedule of the improvement of Phase 1 pilot filter basin • Sludge management in Nyaunghnapin WTP ➢ Long term cleaning plan and schedule ✧ Phase 1 ● Schedule, procedure ✧ Phase 2 ● Plan, procedure ✧ Research plan of No. 1 basin of Phase 1.

Table 2-110: Date and outline contents of seminars specialized in individual themes

No.	Date	Contents
1st	22nd, May, 2018	Meeting about chlorination & disinfection (JICA Expert) ➢ Introduction of Chlorine Disinfection Facility ➢ Introduction Schedule of the Chlorination (Disinfection) Facility ➢ Basic/Plan of chlorination (disinfection) of WRAWSA ➢ Summary and object of chlorination facility ➢ Details of chlorination facility ➢ Necessary information and plan for using sodium hypochlorite ➢ Water quality control of chlorination (disinfection) ✧ To make daily check of residual chlorine concentration at all facilities ✧ Monitoring of residual concentration and bacteria count in the distribution area ✧ To clarify a route of water supply and to illustrate it on a map ✧ Prevention and reduction of chlorine consumption in reservoirs and tanks in the distribution area ✧ Prevention and reduction of chlorine consumption in water pipes ➢ Requirement of Disinfection and Water Quality Test in Drinking Water Supply System
2nd	27th, Aug, 2018	Things necessary for the Chlorination WG Discussion and Activity (JICA Expert) ➢ Introduction Schedule of the Chlorination (Disinfection) Facility ➢ Details of chlorination facility ✧ To prepare necessary plans for O&M of facilities and water quality control ➢ To clarify a route of water supply and to illustrate it on a map ✧ To determine retention time (water age) of water in the distribution area ➢ Basic Plan of chlorination (disinfection) of WRAWSA ➢ Control method of Chlorine dosing ➢ Water quality management of chlorination (disinfection) ➢ To prevent reduction of chlorine concentration ➢ To clean the inside of pipes ➢ To eliminate area where water may stagnate
3rd	27th, Aug, 2018	Agenda for Nyaunghnapin WTP: Rapid Filter Improvement TFT and Procedure when power failure happens (JICA Expert) ➢ Pilot basin of Phase 2

No.	Date	Contents
		✧ Performance result ✧ Filter backwashing ➢ Pilot basin of Phase 1 ✧ Improvement of No.27 filter pilot basin ➢ Observe the present procedures at power failure and power recovery
4th	17th, Oct, 2018	Chlorine dosing house (JICA Expert) ➢ Chlorine Dosing House ➢ Plain Drawing of Chlorine Dosing Facility ➢ Dosing Room and Dosing pumps ➢ Example of dike in dosing house Basic Policy of chlorination in Japan (JICA Expert) ➢ Basic Policy of chlorination in Japan. Water Supply Act of Japan ✧ Water Supply Act of Japan ✧ Enforcement Regulations of the Water Supply Act ✧ Drinking Water Quality Standards in Japan ✧ MHLW Ordnance of Water Supply Facility Standards based on the Water Supply Act ✧ Notice of the director of the Water Supply Division, Health Service Bureau, MHLW (No. & place of sampling points for water quality test)
5th	17th, Oct, 2018	Relation between Amount of Water Supply, Amount of Raw Water Intake and WTP Capacity (JICA Expert) ➢ Basic Parameter of Flocculation Basin ➢ Basic Parameter of Sedimentation Basin ➢ Basic Parameter of Filter
6th	13th, Dec, 2018	Selection of water treatment process (JICA Expert) ➢ Factors Influencing Process Design ➢ Evaluating Process Options at Expansion or New Water Source of WTP ➢ Examples of Treatment Process Selection ➢ Available Water Quality Information

3-2 Review current situation and formulate phased countermeasures

The review of current situation and countermeasures of water quality monitoring and water treatment management (water treatment) are shown in 3-2-1 & 3-2-2 and 3-2-3 & 3-2-4, respectively.

3-2-1 Review of current situation of water quality monitoring

Water Quality Section was established in 2014. The water quality monitoring items at the beginning of the activity are shown in the following table. There were 19 items that could be measured and 11 of the 16 priority items of the Myanmar National Drinking Water Quality Standards (MNDWQS) could be measured. SOPs had been prepared for 9 items.

Table 2-111: Water quality monitoring items at the beginning of this activity

No.	Monitoring item	Priority item in MNDWQS	Measuring method	SOP
1	Coliform bacteria	○	IDEXX Test kit (Modified multi tube method)	○
2	Faecal coliform (e-coli)	○	IDEXX Test kit (Modified multi tube method)	○
4	Turbidity	○	Nephelometric method	
5	Arsenic	○	Simple test kit (Chromogenic method)	
6	Lead	○	HACH test kit	
7	Manganese	○	HACH test kit	

No.	Monitoring item	Priority item in MNDWQS	Measuring method	SOP
8	Chloride	○	Titration method	○
9	Total hardness	○	Titration method	○
10	Calcium		Titration method	○
11	Magnesium		Titration method	○
12	Iron	○	HACH test kit	
13	pH	○	Electrode method	
14	Total dissolved solid (TDS)	○	Electrode method	
15	Electric conductivity (EC)		Electrode method	
16	Salinity		Electrode method	
17	Total alkalinity		Titration method	○
18	Carbonate		Titration method	○
19	Bicarbonate		Titration method	○

A summary of the water quality monitoring plan at the start of this activity is given in the table below. The monitoring at water sources, water treatment plant, taps and tube wells started.

Table 2-112: Summary of water quality monitoring plan at the start of this activity

Category	Sampling location	Frequency	Monitoring items
Water source	Yegu PS, Kokkowa river	1 time / week	pH, TDS, EC, TDS, Turbidity, Total alkalinity, Carbonate, Bicarbonate, Chloride, Calcium, Magnesium, Iron, Manganese
	• Gyobyu, Phugyi and Hlawga reservoirs • Aungtagon PS and Barlar PS • Yangonpauk, Thaephyu, South Dagon No.54 and No.107 groundwater supply system • Lagunbyin canal	1 time / month	
WTP	Nyaunghnapin WTP	1 time / week	pH, TDS, EC, total hardness, Turbidity, Total alkalinity, Carbonate, Bicarbonate, Chloride, Salinity, Calcium, Magnesium, Iron, Manganese
Tap water	Pabedan TS, Kyauktada TS	1 time / week	Coliform bacteria, e-coli, Turbidity, EC, TDS
Tube well	Tube well in 33 TS	1 time / 4 months	pH, TDS, EC, Total hardness, Carbonate, Bicarbonate, Chloride, Salinity, Calcium, Magnesium, Iron, Manganese

Water Quality Section had started its activities, but the monitoring items were not in line with MNDWQS, and SOPs had been under development. The frequency of monitoring was once a month to once every four months; thus, it was necessary to increase monitoring frequency. In addition, regular reporting of water quality monitoring data was not made, and there was no established system for utilizing water quality data to improve water quality. The issues and their countermeasures in the Project are summarized below. The details of the activities for the countermeasures are shown in the next section.

Table 2-113: Issues and the countermeasures in the Project

Issue	Countermeasures in the Project
1) Addition of water quality monitoring items and development of SOPs	
• Addition of monitoring items to meet MNDQWS	Of the 16 priority items in MWDQS, 14 items can be measured excluding taste and odor (see 3-2-2(2)).
• Addition of necessary SOPs	SOPs for the operation, analysis and equipment management of the central laboratory and SOPs for mini laboratories were developed (see 3-4-1).

Issue	Countermeasures in the Project
2) Review of water quality monitoring plan	
• Increase frequency of monitoring	Frequency of water quality monitoring in the reservoirs and WTP increased to daily by establishment of mini laboratories (see 3-2-2 (3)).
• Expansion of the sample collection area and increase of the frequency of monitoring of tap water	In the 5-year and 10-year water quality management plan, tap water monitoring was planned using T/S offices or district offices (see 3-7-1).
3) Improvement of capacity to use water quality monitoring data	
• Prepare regular water quality reports • Improve capacity of water quality data analysis • Improve data utilization capacity	A system for reporting the results of water quality monitoring data and providing feedback has been established (see 3-2-2(4)). In addition, seminars on the accuracy control of water quality data were held (see 3-3-1).
4) Strengthening of water quality monitoring capacity in remote areas	
• Set up of mini-laboratories and establishment of water quality monitoring system	Mini laboratories (5 locations) were set up and technical guidance by the central laboratory started (see 3-2-2(1), 3-3-3 and 3-6-1).
5) Development of residual chlorine management capacity	
Since the operation of the chlorination facilities was started during the implementation of the Project, it was necessary to improve the management capacity of residual chlorine (determination of monitoring method and management indicators).	Residual chlorine concentration in water distribution system was measured. In addition, TFT to assess the disinfection effect was established and discussions started (see 3-2-4(5)).

3-2-2 Countermeasures for issues on water quality monitoring

(1) Water quality monitoring system

Water quality monitoring system was established in the Project. The central laboratory was established in the WRAWSA head office, and 5 mini laboratories were established in Nyaunghnapin WTP, Yegu Pumping Station, Hlawga Reservoir, Phugyi Reservoir and Gyobyu Reservoir. The role of laboratories is shown below.

Table 2-114: Organizations of water quality monitoring in WRAWSA

Laboratory	Role of laboratory
Central laboratory	• Water quality monitoring of waterworks facilities (Reservoir, pump station (PS), water treatment plant (WTP), groundwater supply facilities, tube well) and tap water. • Technical guidance for mini laboratories
Nyaunghnapin WTP mini laboratory	• Water quality monitoring of process of water treatment • Water quality monitoring of treated water
Yegu pumping station mini laboratory	• Water quality monitoring of service reservoir in Yegu PS
Hlawga reservoir mini laboratory	• Water quality monitoring of Hlawga reservoir
Phugyi reservoir mini laboratory	• Water quality monitoring of Phugyi reservoir
Gyobyu reservoir mini laboratory	• Water quality monitoring of Gyobyu reservoir

(2) Water quality monitoring items

Water quality monitoring items of the central laboratory are shown below. 26 water quality items have been monitored since March 2018. For the 16 priority items listed in the MNDWQS, 14 items are being monitored.

Table 2-115: WRAWSA Water quality monitoring items

No.	Monitoring item	Priority item of MNDWQS	Additional monitoring item by WRAWSA	Measuring method
1	Coliform bacteria	○		Multi tube method (Test kit)
2	Faecal coliform	○		Multi tube method (Test kit))
3	Colour	○		Spectro photometric
4	Turbidity	○		Nephelometric method
5	Arsenic	○		Simple test kit (Chromogenic method)
6	Lead	○		HACH test kit
7	Nitrate	○		HACH test kit
8	Nitrite		○	HACH test kit
9	Ammonia nitrogen		○	HACH test kit
10	Manganese	○		HACH test kit
11	Chloride	○		Titration method
12	Total hardness	○		Titration method
13	Calcium			Titration method
14	Magnesium			Titration method
15	Iron	○		HACH test kit
16	pH	○		Electrode method
17	Sulfate	○		HACH test kit
18	Total dissolve solid	○		Electrode method
19	Residual chlorine		○	DPD colorimetric method
20	Suspended solid		○	Gravity method
21	EC		○	Electrode method
22	Salinity		○	Electrode method
23	Phosphate		○	HACH test kit
24	Total alkalinity		○	Argent metric method
25	Zinc		○	HACH test kit
26	Dissolved oxygen		○	HACH test kit

Organoleptic test (Taste and odour)

WRAWSA began chlorination of tap water in December 2019. The list of new chlorination facilities is shown in Table 2-116. However, the safety of tap water cannot be guaranteed because the effectiveness of the chlorination has not yet been fully verified such as the distance downstream of the chlorine injection point where the residual chlorine remained and whether chlorination prevented the detection of coliform bacteria and faecal coliform. For this reason, a taste test of sample water by mouth has not been implemented.

On the other hand, the problem of odour caused by chlorine itself or the generation of combined chlorine may occur in the future as chlorination is started. Therefore, odour test will be started to secure the comfortableness of water use.

Table 2-116: New chlorination facilities

No.	Location	Chlorine injection point
1	Nyaunghnapin WTP Phase1	Pre-chlorination (Raw water) and Post-chlorination (treated water)
2	Nyaunghnapin WTP Phase2	Pre-chlorination and Post-chlorination
3	Lagunbyin WTP	Pre-chlorination and Post-chlorination
4	Hlawga reservoir No.1	Reservoir water (Transmission main from Hlawga No. 1 PS)
5	Yegu PS	Service reservoir (New tank and Old tank)

Remarks: All chlorination facilities use sodium hypochlorite.

(3) Water quality monitoring plan

In accordance with the decided monitoring plan, periodical water quality monitoring is implemented in the central laboratory and mini laboratories.

Table 2-117: Water quality monitoring plan of the central laboratory

Category		Sampling point	Frequency	Monitoring item
Water source	Reservoir	Gyobyu, Phugyi, Hlawga	1 time / month	pH, TDS, EC, Total hardness, Turbidity, Total alkalinity, Fe, Mn, Nitrate, SS
	Groundwater water supply system	Yangonpauk, Thaephyu South Dagon No.54 and No.107	1 time / month	pH, TDS, EC, Total hardness, Turbidity, Total alkalinity, Fe, Mn, Nitrate, Chloride
	Raw water PS	Aungtagon PS Barlar PS	1 time / month	pH, TDS, EC, Total hardness, Turbidity, Total alkalinity, Fe, Mn, Nitrate
Waterworks facility	WTP	Nyaunghnapin WTP (Raw water)	1 time / month	pH, TDS, EC, Total hardness, Turbidity, Total alkalinity, Fe, Mn, Nitrate, SS
		Nyaunghnapin WTP (Treated water)	1 time / week	pH, EC, Turbidity, Color
			1 time / month	TDS, Total hardness, Total alkalinity, Fe, Mn, Nitrate
	Pumping station	Yegu PS	1 time / week	pH, TDS, EC, Total hardness, Turbidity, Total alkalinity, Fe, Mn, Nitrate
	Tube well	Tube well in 33T/S (In 2020: 482 tube wells)	1 time / 4 months	pH, TDS, EC, Total hardness, Turbidity, Total alkalinity, Fe, Mn, Nitrate, Chloride
Consumer	Tap water	Service tap in 33T/S	1 time / month	pH, Fecal coliform, Coliform bacteria, TDS, EC
New water source	River water	Lagunbyin WTP raw water Kokkowa WTP raw water	1 time / month	pH, TDS, EC, Total hardness, Turbidity, Total alkalinity, Fe, Mn, Nitrate

Table 2-118: Water quality monitoring plan of mini laboratories

Laboratory	Sampling point	Monitoring item and frequency
Nyaunghnapin WTP	Raw water, End of sedimentation pond, End of sand filtration pond, Clear water tank	Daily: Water temperature, pH, Turbidity, Color Daily: Jar test (Raw water) 1 time / month: SS sampling (SS analysis is done in the central laboratory)
Gyobyu Reservoir	Water intake, Ingate of sedimentation pond, End of sedimentation pond	Monitoring items common to all facilities Daily: Water temperature, pH, Turbidity, Color 1 time / month: SS sampling (SS analysis is done in the central laboratory)
Phugyi Reservoir	Water intake	
Hlawga Reservoir	Water intake, Outlet of pumping station	
Yegu PS Service tank	New tank, Old tank	

(4) Reporting and utilization of water quality monitoring data

Information flow of water quality monitoring is shown below. Water quality monitoring data is reported to the ACE, the DYCE, and finally the CE. Reported data is utilised for the decision-making to improve supplied water quality.

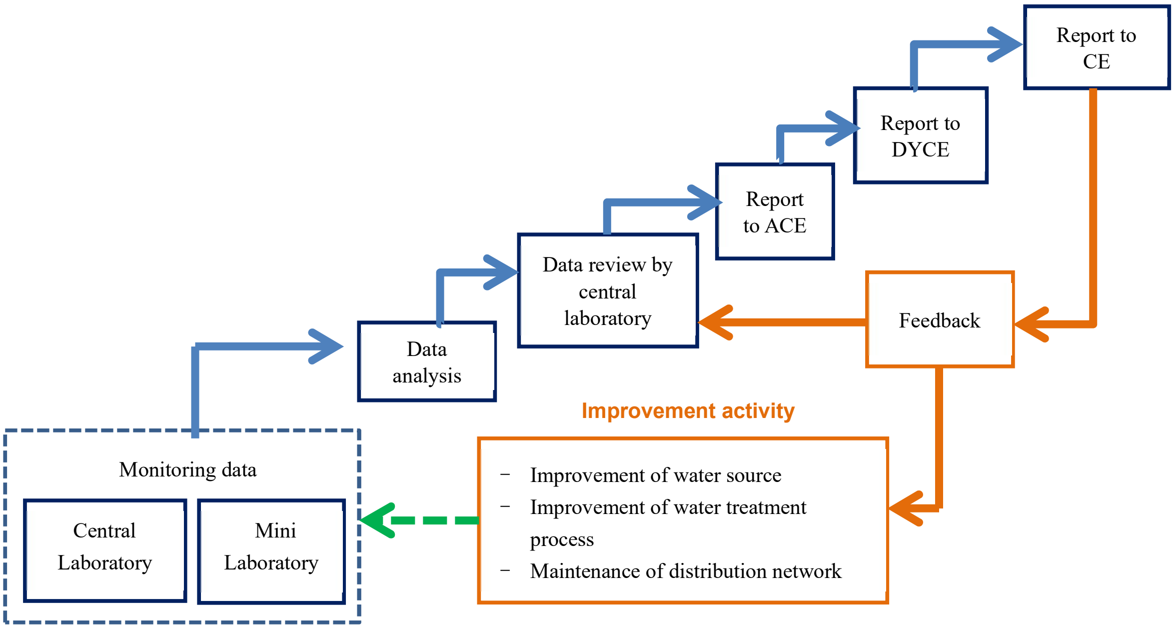


Figure 2-90: Information flow of water quality monitoring data

Examples of the water quality analytical data utilized for water quality management are as follows.

Table 2-119: Activity of tap water quality improvement based on water quality monitoring data.

Water quality data	Implemented action to improve water quality
Comparison of turbidity data of Gyobyu Reservoir, Hlawga Reservoir and Yegu service tanks ・Yegu service tanks shows higher turbidity than Gyobyu and Hlawga Reservoir except in December and January (Dry season)	Cleaning of Yegu service tanks
Water quality data of tube well ・High turbidity (over 5 NTU) or chloride (over 250mg/L)	Close of tube wells As of 2020, 115 of 597 tube wells were closed

(5) Preparation of water quality management for chlorination

New chlorination facilities (sodium hypochlorite injection facility) were constructed in Hlawga reservoir, Yegu PS and Nyaunghnapin WTP. Operation of chlorination facilities commenced in January 2020.

In advance of new chlorination facility construction, the central laboratory implemented a residual chlorin survey in Yegu PS supply area (Research No.1: Survey in Yankin T/S in 2018 while the Yegu old chlorination facility was operating)

After new chlorination facility started operation, an additional research was done in new Nyaunghnapin WTP chlorination facility supply area (Research No.2: Survey in Mingalardon T/S, North Okkalapa T/S and South Okkalapa T/S in 2020). The result of both research and data analysis by the central laboratory is shown below.

Research No.1: Yegu PS supply area

Research was done in July 2018 in Yankin T/S. The following figure shows a relationship between residual chlorine concentration and distance from Yegu PS. The residual chlorine began to decrease at 1.7km distance, and it decreased 0.07 ppm at 5.1km distance (red dotted line in the figure). At that time, Yegu PS old chlorination facility injected chlorine into untreated water from Gyobyu reservoir. Therefore, this rapid decrease of residual chlorine might occur due to the consumption of chlorine by the organic matter in untreated water. At the distance of 2.5 km-3.3 km, residual chlorine drops to 0.1-0.3 ppm (red circle in the figure). It was thought that the reduction of residual chlorine in these distances occurred due to the mixing of water from Hlawga reservoir (without treatment and chlorination) at these distances, or long water retention in pipeline or in water storage tanks of household.

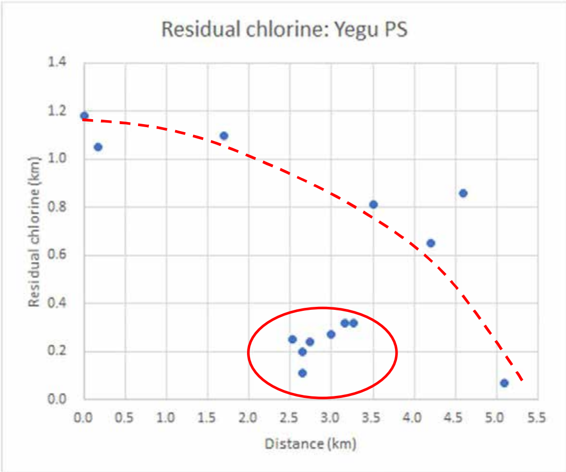


Figure 2-91: Relationship between residual chlorine and distance from Yegu PS

The following figure shows the monitoring data of turbidity, residual chlorine, coliform bacteria, and faecal coliform in Yankin DMA (constructed by Japanese ODA). Distance of monitoring points from Yegu PS were at 2.5 – 3.2 km. In this survey, residual chlorine levels ranged from 'Not Detected' to 0.32mg/L. Coliform group was 18 CFU/100mL to over 2,419 CFU/100ml and *E. coli* was under 1 CFU/100mL.

The number of coliform bacteria increased at No.7 and No.8. This increase of coliform group was assumed to be caused by pollution sources around No.7 or No.8. An assumed reason for pollution sources is intrusion of polluted water through breakage of pipeline or loose connections caused by poor construction of pipeline.

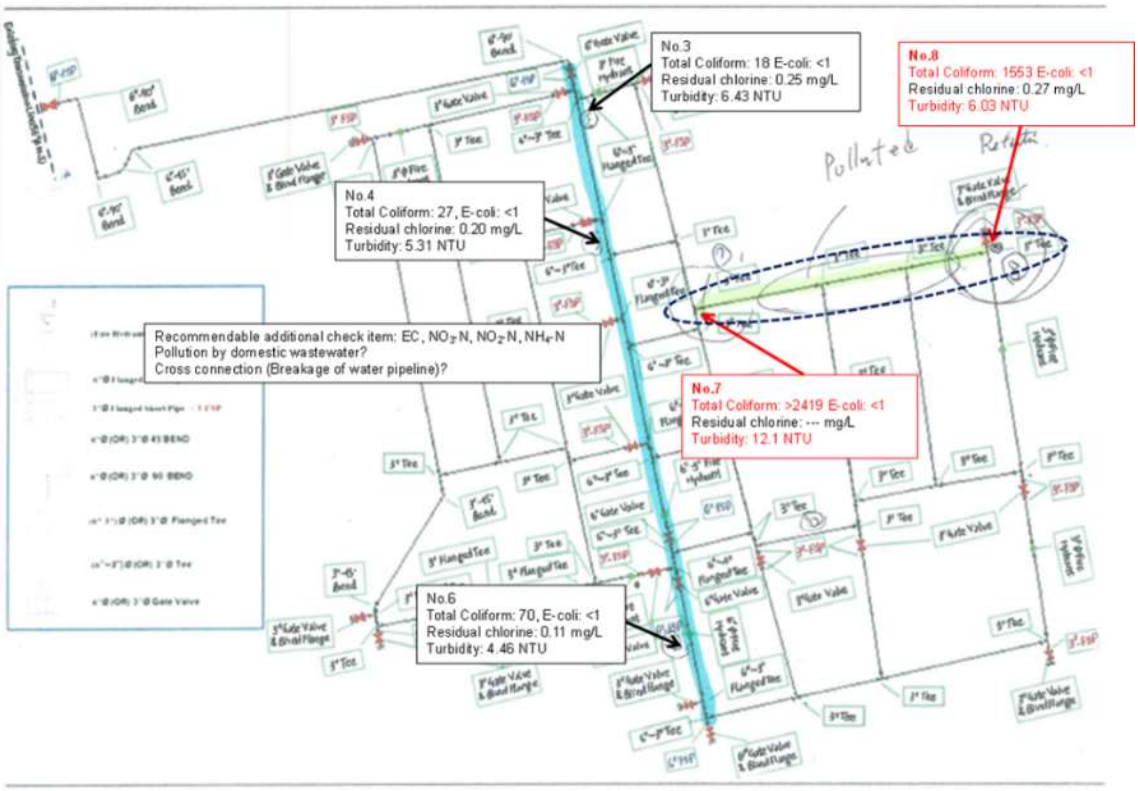


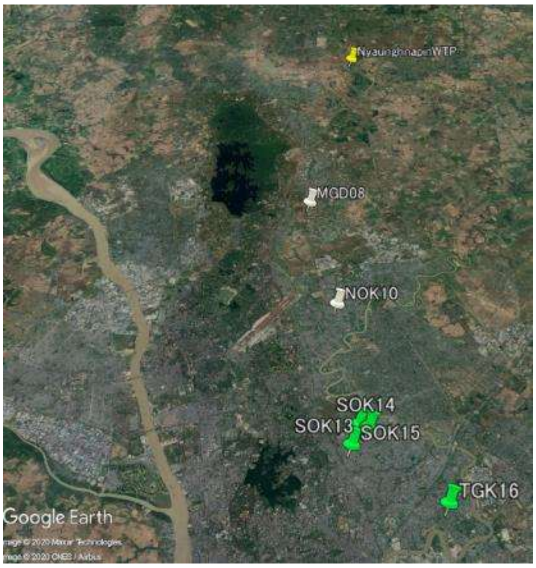
Figure 2-92: Residual chlorine, coliform group, and faecal coliform in Yankin DMA (Yankin T/S)

Research No.2: Nyaunghnapin WTP supply area

Residual chlorine survey was conducted in the supply area of Nyaunghnapin WTP in February 2020. Sampling points are shown in the following figure. Sampling points were selected near the transmission pipe and samples were collected at water taps without storage tank.

In the supply area, it seems that 2 transmission lines from Nyaunghnapin WTPs Phase 1 and Phase 2 are connected and treated waters of 2 WTPs are combined in South Okkalapa T/S (SOK 12 - 15) and Thingangyun T/S (TGK 16), and untreated reservoir water (from Yegu PS) is also combined in these areas.

Phase 1 WTP supply area



Phase 2 WTP supply area

Figure 2-93: Sampling points of residual chlorine survey

Summary of residual chlorine survey is shown in Table 2-120. Abbreviations of sampling points are given below.

MGD :	Mingaladon T/S	SOK :	South Okkalapa T/S
NOK :	North Okkalapa T/S	TGK :	Thingangyun T/S

Chlorine injection ratios in Nyaunghnapin WTP (Phase1 and Phase2) were 1.67 ppm for pre-chlorination and 1.67 ppm for post chlorination. Turbidity of treated water in both Phase 1 and Phase 2 was very high (Phase1: 11.8NTU, Phase2: 8.7NTU). Possible reason of this high turbidity was that Nyaunghnapin WTP was operated at an overload to produce the necessary amount of clear water.

Turbidity of Phase 1 supply area in MGD 06 – NOK11 showed nearly-constant value. On the other hand, MGD 08 in Phase 2 supply area showed lower turbidity. The reason of this difference of turbidity is assumed to be the deposition of turbidity in the branch pipeline around MGD 08.

South Okkalapa T/S, where water from Phase 1, Phase 2 and Yegu P/S is mixed, showed high variation of turbidity. In SOK 13, SOK15 and TGK 16, decrease of turbidity was observed. The detailed status of connections of transmission and distribution pipelines and the supply schedule in the water treatment plant supply area and reservoir water supply area were not known. However, this decrease in turbidity may be due to the mixing of reservoir water. Table 2-121 shows the average turbidity in February (2017 - 2019) at Yegu PS which delivers untreated reservoir water into urban area. Although this turbidity data was obtained before 2020, turbidity of Yegu PS in February was lower than that of Nyaunghnapin WTP water supply area (north of SOK 12 point). Therefore, the decrease in turbidity at SOK13, 15 and 16 is presumed to be due to the mixing of reservoir water with lower turbidity than the water supplied by Nyaunghnapin WTP.

Table 2-120: Summary of residual chlorine survey

Location	Sample No.	Turbidity (NTU)	Residual chlorine (ppm)	Distance from WTP (Approx. km)
WTP				
Nyaunghnapin Phase1 Clear water tank	-	11.8	1.73	0
Nyaunghnapin Phase2 Clear water tank	-	8.7	1.47	0
Phase1 Supply area				
No36, Myasabae street, Pareal (3) Ward, Mingalardon T/S	MGD06	10.5	1.50	12.2
No 195, Myasabae Street, Pareal (3) East Ward, Mingalardon T/S	MGD07	10.0	1.35	12.4
No 37, room 10, Thudamar Street, Htawonbae Ward, North Okkalapa T/S	NOK09	10.1	1.39	19.7
Kaymarthi Street, Zakae Ward, North Okkalapa T/S	NOK11	11.6	1.31	21.5
Phase2 Supply area				
No 131, Khaing Shwewar Street, Pareal (1) East Ward, Mingalardon T/S	MGD08	3.3	1.57	14.2
Maydarwei Street, Za market, Salein Ward, North Okkalapa T/S	NOK10	7.6	1.56	21.5
Phase1、Phase2 and Yegu PS water blending area				
Thila (10) Street, South Okkalapa T/S	SOK12	12.3	1.37	29.4
No 759, Bhyamaso street,5th Ward South Okkalapa T/S	SOK13	6.1	0.26	29.9
No 1, Bhyamaso street,7th Ward, South Okkalapa T/S	SOK14	10.7	1.07	30.0
Waizayandar Road,3rd Ward, South Okkalapa T/S	SOK15	5.9	0.20	29.6
Thanthumar Road,29th Ward, Thingangyun T/S	TGK16	2.8	1.08	35.3

Table 2-121: Monthly average turbidity in Yegu PS service reservoir (February)

Year	Old tank (NTU)	New tank (NTU)
2017	1.94	2.85
2018	1.71	1.98
2019	4.60	4.58

The following figure shows relationship between residual chlorine and distance from Nyaunghnapin WTP. After 21.5 km, there is a water mixing area of treated water from WTP and reservoir water from Yegu PS, but residual chlorine remained more than 1.0 ppm.

However, the residual chlorine at MGD 08 and NOK 10 (Phase 2 supply area) showed higher residual chlorine value than WTP. Possible reason was that colour of sample water raises apparent residual chlorine value.

On the contrary, the residual chlorine at SOK 13 and SOK 15 showed lower residual chlorine (red circle in Figure 2-94, SOK 13: 0.26ppm, SOK 15: 0.2ppm). The reason for this acute decrease of residual chlorine has not been explained clearly; however, one of the possible reasons is that consumption of residual chlorine was accelerated by organic matter or deposit in pipeline.

In addition, it was assumed that reservoir water might be mixed into this area. The reservoir water is chlorinated at Hlawga Reservoir and Yegu PS before distribution. The survey of residual chlorine in Figure 2-91 showed that residual chlorine disappeared at 5 km point from chlorine injection point. Therefore, there is possibility that the decrease of residual chlorine in SOK13 and SOK15 may be caused by the mixing of reservoir water in which no residual chlorine exists.

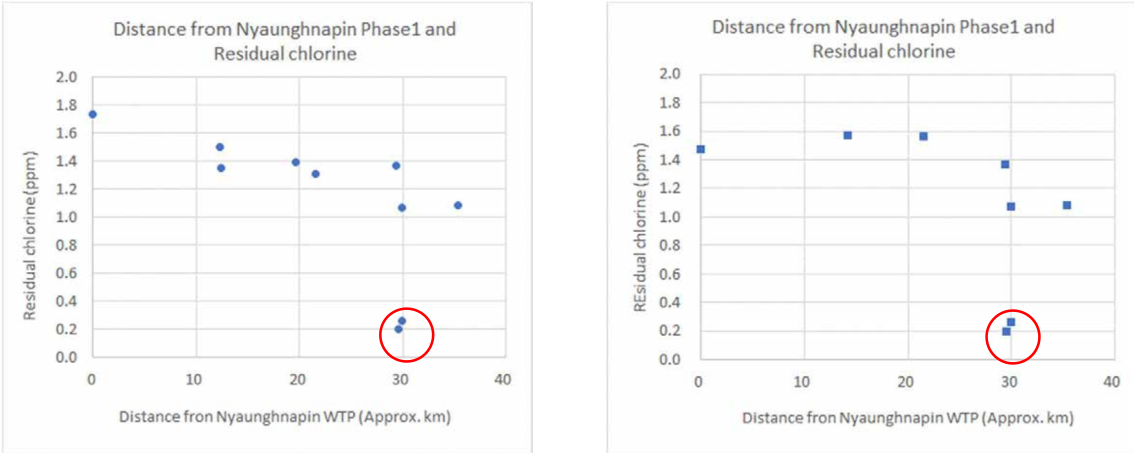


Figure 2-94: Residual chlorine by distance from Nyaunghnapin WTP

<u>Reduction of residual chlorine</u>
The reduction of residual chlorine was compared with the case of Japan. The results of <u>Research 1: Downstream of Yegu PS</u> and <u>Research 2: Downstream of Nyaunghnapin WTP</u> were compared with the simulated values using apparent velocity constant (k') obtained from the measured data of chlorinated water in Osaka City where middle point chlorination was adopted in WTP. The conditions of the simulation are as follows.

> **Calculation**: Residual chlorine concentration = Residual chlorine concentration at WTP x exp (-k' x Retention time (hr))
> **Retention time**: Distance from WTP (approx. km) / Estimated average frow rate (1m/s = 3.6km/hr), Frow rate is estimated data of Hlawga reservoir downstream.

Apparent velocity constant (k') is obtained from annual observed value of Mid- chlorinated water in Osaka City[1].

Max: 0.059, Min: 0.015

Figure 2-95 shows downstream of Yegu PS, and Figure 2-96 shows downstream of Nyaunghnapin WTP. In these figures, measured data is ■, simulation data with Min-k' is blue solid line and simulation data with Max-k' is red dot-line. In the downstream of Yegu PS (untreated reservoir water), decrease of residual chlorine after 1.7 km point is more rapid than in Japan (Osaka City). On the other hand, in the downstream of Nyaunghnapin WTP, except for two points (about 30 km from WTP, SOK13 and SOK15), which are thought to be inflow area of reservoir water, decrease of residual chlorine showed the same trend as the Japanese case up to 35 km.

As a result of this comparative study, it was found that the decreasing trend of residual chlorine in Yangon tap water was different between reservoir water and WTP treated water. That is, the decreasing trend of residual chlorine in WTP treated water was slower than that in the untreated reservoir water.

Turbidity of WTP treated water was higher than that of the reservoir water. However, the reason of the rapid decrease of residual chlorine of reservoir water was assumed to be the consumption of residual chlorine by the ingredients other than turbidity, such as soluble organic matter in reservoir water.

[1] Fuchigami and Terashima, Behavior and control of residual chlorine in advanced treated water in the distribution process of water in Osaka city, Journal of Japan Water Works Association, Vol.72, no.6, pp.12-24, 2003.

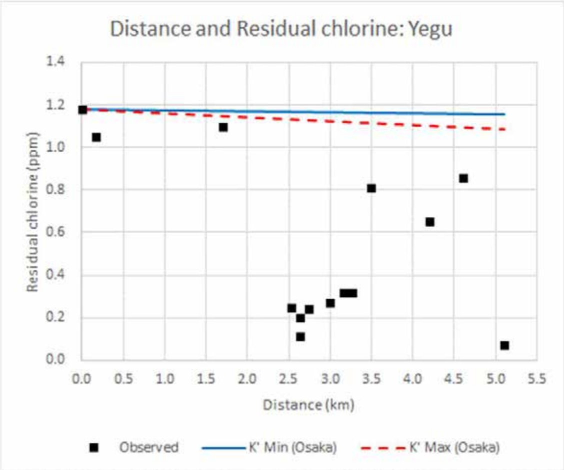
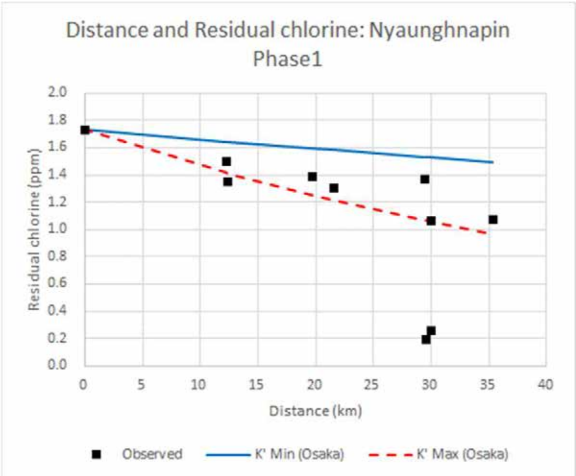
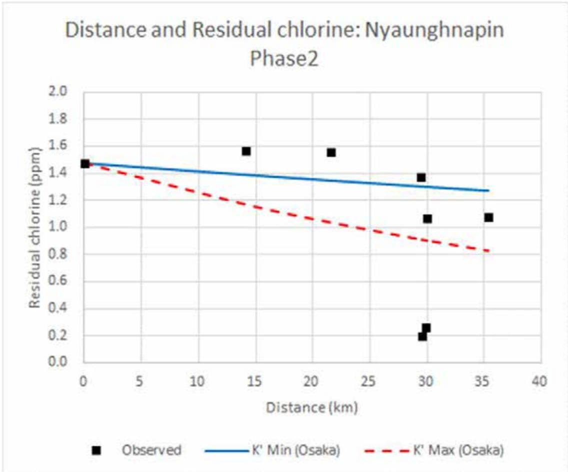


Figure 2-95: Decrease of residual chlorine in the downstream of Yegu PS



Phase1



Phase2

Figure 2-96: Decrease of residual chlorine in the downstream of Nyaunghnapin WTP

<u>Summary of residual chlorine survey</u>

- In the reservoir water supply area (water supply area of Yegu PS), residual chlorine decreases rapidly.
- In Nyaunghnapin WTP water supply area, decreasing speed of residual chlorine is relatively low and residual chlorine is maintained in the long distance.
- The border of supply areas is not clearly delineated between both supply areas. It was assumed that there are areas where water from both supply systems is mixed, where it is difficult to estimate the tendency of residual chlorine concentration accurately.

<u>Assessment index of effectiveness of chlorine disinfection</u>

Deciding a method for assessing the effectiveness of chlorination is a challenge for water quality management. In 2018, the C/P started discussions on this issue. A summary of the discussion by the C/P is given as a remark at the end of this section (the document was prepared by the C/P). The C/P decided following policies for chlorination management:

- The control parameters for the chlorine injection rate shall be determined by faecal coliform.
- The control of the chlorine injection rate shall be determined so that the residual chlorine is 0.2-1.0 ppm.

The following are issues on chlorine disinfection.

- To collect pipeline drawings from GIS Section.
- Cleaning of service reservoirs and water distribution pipelines before chlorination is commenced (Comment from the Expert).

The discussion about assessment index of chlorine disinfection is continued in TFT. However, based on the knowledge of the C/P as of the year 2018 and the results of the survey of residual chlorine mentioned above, the following items should be improved:

- Decide monitoring points of appropriate residual chlorine with accurate GIS information of the water distribution network.
- The water transmission and distribution schedule by valve operation and PS operation should be understood. Water quality monitoring schedule should reflect this operation schedule.
- Identify the water distribution area of WTP (treated water) and reservoir (untreated water) in the water distribution system.

The turbidity particles provide a shelter for micro-organisms to protect themselves from chlorination. For this reason, it is important to reduce turbidity to increase the effectiveness of chlorination. In the description of 4th WHO Drinking Water Quality Guideline, no more than 1 NTU should be maintained to ensure the effectiveness of disinfection[2]. Therefore, it is necessary to implement measures to reduce turbidity, such as improving operation and maintenance of WTP or appropriate management of service reservoir and pipeline.

The effect of disinfection was assessed by faecal coliform and residual chlorine. As shown in Research No.2, it is expected that residual chlorine will be detected over the WTP water supply area, but in the reservoir water supply area, even though chlorination facilities operate, detection of residual chlorine may be limited. Therefore, effectiveness of chlorination is assessed by:

- Residual chlorine and faecal coliform in WTP water supply area, and
- Faecal coliform in reservoir water supply area.

The target values for residual chlorine and faecal coliform are decided in accordance with the NMDWQS. It is important to reduce turbidity to maintain the effectiveness of chlorination.

- Residual chlorine > 0.2 mg/L
- Faecal coliform < 100 CFU/100mL

(6) Target value of turbidity

Based on turbidity measurement data, the target values of the overall goal of the Project in terms of turbidity is set. The water quality target values are considered for the areas where treated water is supplied; the water supply areas of Nyaunghnapin WTP and Lagunbyin WTP.

1) Nyaunghnapin WTP

a. Water quality target value
   - Outlet of WTP: 95% of the annual turbidity data should be less than 2 NTU.
   - Water distribution area: No target value defined.

b. Reason for deciding turbidity target value

The turbidity target value at the outlet of Nyaunghnapin WTP was set based on the turbidity data of filtered water in the pilot sand filtration basin at Nyaunghnapin WTP in 2018-2020. The analysis of turbidity measurement from October 2018 to September 2019 and October 2019 to September 2020 showed that 95% of the annual data is less than 2.0 NTU in both years. Based on this result, it is proposed that the turbidity target at the outlet of Nyaunghnapin WTP is set as "95% of the annual turbidity data should be less than 2 NTU".

A prerequisite for this target value is that the renovation of all sand filtration basins in Nyaunghnapin WTP must be completed as planned.

The water service area of Nyaunghnapin WTP is not clearly defined and reservoir water is mixed. Thus, untreated reservoir water may be distributed at the same time in the same area. Therefore,

[2] 4th WHO Drinking Water Quality Guideline, Chapter 10, Acceptability aspects: Taste, Odour and Appearance.

contamination of distribution pipeline with untreated water will be continued. Therefore, the turbidity target value in Nyaunghnapin WTP supply area is not set because improvement of water quality in Nyaunghnapin WTP supply area is not expected unless i) the supply areas of Nyaunghnapin WTP and reservoir water distribution area is separated, and ii) the distribution pipeline is cleaned and renewed completely.

2) Lagunbyin WTP and its water distribution area

a. Water quality target value

- Outlet of WTP: 75% of the annual turbidity data must be less than 1 NTU.
- Water distribution area: Same as “Outlet of WTP”

b. Reasons for deciding turbidity target value

Lagunbyin WTP started to supply water to Thilawa Special Economic Zone (Thilawa SEZ) on a priority basis. However, the distribution network in the areas outside the Thilawa SEZ is still under construction. In addition, because long-term turbidity data is not available, it is not possible to analyse the trend of turbidity throughout the year. Therefore, the turbidity target value at the outlet of Lagunbyin WTP was decided based on the turbidity data at trial operation, which showed less than 1 NTU.

Both Lagunbyin WTP and its water distribution network are newly constructed. Therefore, turbidity target value in water distribution network is set at less than 1 NTU.

However, there are parts of the WTP facilities (coagulation sedimentation basins, sand filtration basins, etc.) that are not yet in use, and pollution by the inflow and stagnation of raw water / rainwater to the WTP is assumed. In addition, water distribution network is still under construction and it will take several years more to complete the work and clean the pipes. There may be a temporary increase in turbidity over the next few years. Therefore, it is proposed that the turbidity target value for the outlet of Lagunbyin WTP and its distribution network is set as "75% of the annual turbidity data should be less than 1 NTU".

(7) Study on drinking water quality through international study program in Tokyo University

Ms. Ei Khaing Mon, an international student (2018-2020) at the University of Tokyo, conducted a study on groundwater in Yangon. Summary of this study is as follows:

1) Outline of this survey

- Number of samples: 3 Reservoirs, 3 Service reservoirs and PS, 3 WTPs, 25YCDC managed tube wells, 20 Personal tube wells and 29 Tap water. Total 83 samples.

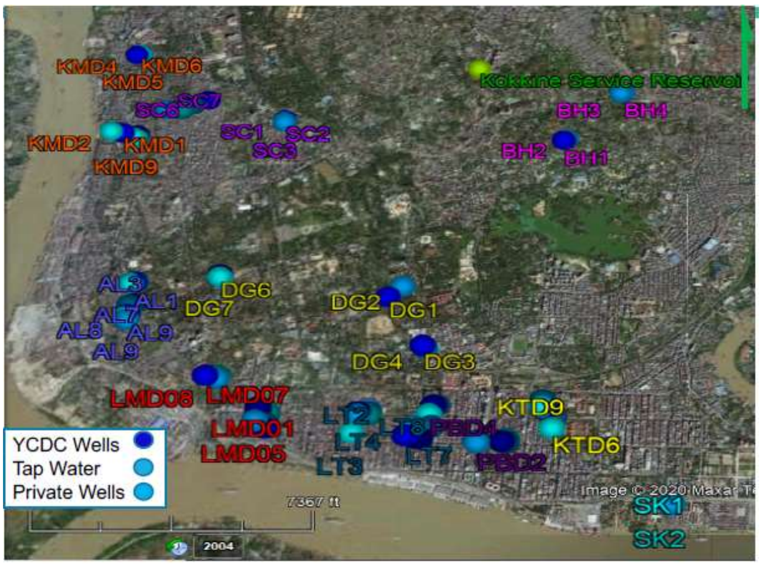


Figure 2-97: Sampling location of YCDC tube well, private tube well and tap water (Western district in Yangon city)

- Analysis items: pH, EC, Water temperature, Turbidity, Colour, Dissolved organic carbon (DOC), Nitrate, Nitrite, Ammonia nitrogen, Phosphoric acid, Sulfuric acid, Iron (total and 2+), Calcium, Magnesium, Sodium, Chlorine ion, Potassium, Bromine ion

2) Key findings

- Tap water is contaminated by groundwater.
- Groundwater and tap water are contaminated by faecal coliform.
- High concentration of ammonia nitrogen was detected in groundwater.
- Many groundwater samples had low pH (below 6)
- Groundwater contamination was not only of seawater origin but possibly anthropogenic pollution.

3) Recommendation

- Introduction of small-scale facilities for groundwater treatment is necessary.
- Introduction of rainwater recharge techniques for groundwater is necessary.
- More extensive groundwater survey and investigation of acid-sulfate soil (a possible cause of low pH) are necessary.

Reference: Ei Khaing Mon, Shinobu Kazama and Satoshi Takizawa, Estimation of Groundwater Pollution source in the Western District of Yangon city, Myanmar, Tokyo University master's thesis, 2020, JICA Water Engineering and Utility Management Future Leaders Program.

Remarks: Minutes of discussion of chlorination basic plan

Subject

Reporting on the results of working group meeting for drafting Chlorination Basic Plan.

1. Concerning with the matter mentioned above, Engineering Department (water & Sanitation) has been trying to supply clean & drinkable water to the city dwellers. To be able to improve/achieve supply works, it's planned to dose the chlorine and to implement it, we setup Working Group to be able to draft Chlorination Basic Plan on 8 July 2018.

2. The working group meeting to draft Basic Plan was held on 9 July 2018 and again in 14 August 2018, the meeting led by DYCE 1 was held and there were 10 participants including JICA TA Expert and discussed on the needs and things to be prepared to draft Chlorination Basic Plan.
   A) When in purchasing Sodium Hypochlorite Solutions which will be used for Chlorination, the specification of it should be the same as the one designed by Lagunbyin Water Supply Project Team & Consultant Team.
   B) When setting the control parameter for chlorine dosing, it's to set Fecal coliform value.
   C) The Operational Parameter of Chlorination Dosing Work, it's to set Residual Chlorine Amount as (0.2-1) ppm according to WHO Standard.
   D) The Initial Chlorine dosing amount should be set according to the proposed section (dosing amount for Lagunbyin WTP will be set by Lagunbyin WTP Project Consultant Team, Ngamoeyeik WTP, Hlawga Reservoir, Yegu Pumping Station will be used/dosed according to proposed amount) and after that the dosing amount will be adjusted based on Residual Chlorine Amount on ground.
   E) Setting the points along respective Transmission pipelines & Distribution lines to check/measure Residual Chlorine.
   F) Discuss with GIS Section & pipe sections to make/get a specific pipeline map.

3. Besides, JICA Expert also suggested that before starting chlorine dosing system, it's to clean Service reservoirs & pipelines. It's also to consider the water detention time in the pipeline when the power failure happens and it's needed to know the exact starting time of chlorination dosing works and more workshops will be held to be able to draft Chlorination Basic Plan.

4. Therefore, I would like to submit the discussed things by Working Group & JICA Expert for Chlorination Basic Plan and would like to receive further instructions.

Ei Khaing Mon, Section Head (Assistant Engineer)

3-2-3 Review of current situation of water treatment management (water treatment)

A summary of the current issues in the water quality management field (water treatment plant) including the problems found through the function analysis conducted by the staff of Nyaunghnapin water treatment plant as the main members, the observation with the C/P on the site, and the discussions at various seminars in the Project are described below.

Issues of treatment plant operation

- Floc carry over is observed in coagulation-sedimentation basins.
- Filtration functions of filters are extremely low.
- Wash method of filters is inadequate. (Wash water is retained above the top of trough, for instance, amount of wash water is excessive, or drainage capacity of drain valves is too small.)
- Backwash procedure of filters (Timing of valve opening/closing and adjustment of valve opening aperture of surface wash water valve, backwash water valve and wash water drainage valve) is not set properly.
- Operation procedures of each water treatment step are not standardized.

Issues of treatment plant maintenance

- Sludge has piled up in sedimentation basins.
- Most of the filter media in filters has washed out.
- Deficiencies of underdrain system are observed in some filters.
- There is malfunction of many valves and surface wash equipment.
- Periodical check of facilities, equipment and instruments are not practiced.
- Maintenance management plan of WTP is not prepared.

Issues of design for facilities

- Many basic design parameters of each treatment in WTP are not clear.
- There is a fall of water at the point between flocculation basin and sedimentation basin. There is possibility that it breaks flock created in the flocculation basin.
- Design of filter is inadequate.
  - Condition of filter wash cannot be set at the supposedly optimum condition.
  - Water level in filter basins is not maintained above the filter media.

Issues of record, information keeping and succession of information

- Some summary drawings kept by WRAWSA do not reflect the actual situation of the WTP.
- Some details of design are not clear.
- Fundamental records (operation procedures, check and repair records etc.) have not been made.
- There are no evaluation, reports and circulation of the water quality monitoring results.

Issues of acquisition and application of technical information

- Technical information and knowledge of water treatment facility design standards are not kept.
- Know-hows for preventive maintenance of water treatment facilities are not established.
- Necessity of coagulant dosing control is not understood.
- Necessary amount of filter media (Anthracite and Sand) indicated by the design have not been kept in filter basins.
- Particle diameters of filter media are not tested nor confirmed.
- Know-hows for making an intended diameter of filter media are not kept.

Issues of inspection system of procured materials

- Inspection procedures for specification of delivery products are not established.
- Corresponding method when specification of product purchased is wrong and inappropriate is not established.
- There is no decision code or standard defining necessity of inspection.
- Details of test procedures for checking quality and function of supplies are not prepared.

3-2-4 Countermeasures for issues of water treatment management (water treatment plant)

The goal of this technical project is "Improvement of WRAWSA water supply management capacity", and "To secure initiative of Myanmar side" is listed as one of the basic policies in the Project operation. Therefore, following items should be taken under utmost consideration in the course of the process of analysis on countermeasures and its decision making about issues and problems described in 3-2-3.

- To review and to decide solutions aiming at capacity development of the WRAWSA staff.
- To foster motivation of the WRAWSA staff to participate in analysis of solutions themselves and to act positively.
- To choose countermeasures that can be tackled and engaged by the WRAWSA staff themselves at an early stage, so improvement that requires a large amount of expenses and a long period, such as civil engineering structure renovation of the water treatment plant, should be avoided. This is because it is assumed that the C/P cannot directly engage in renovation works of large-scale facilities design and construction. In addition, it is assumed that the series of activities would not be completed within the Project period when it is considered the long period required for a technical investigation for a large budgetary request, preparing the basic documents for explanation of a large budgetary request, implementation of renovation work and an operation after renovation and evaluation of the renovation. Furthermore, if the requested budget cannot be obtained due to a large amount, it is necessary to reexamine the activities themselves from the beginning.

Also, when deciding countermeasures, following matters are taken into consideration to estimate the reasons, establish new measures and discover new knowledge, even if the countermeasure fails to achieve the anticipated results and the problems are not sufficiently resolved.

- The details of the countermeasures are understood by the staff of the WRAWSA, and they themselves are involved in the work to solve the problem.
- The technical base, evidence, technical standards, etc. of the countermeasures to be taken are clear and staff of WRAWSA understands them.

Meanwhile, it was needed to minimize disadvantages as much as possible by adopting the above-mentioned policy. The disadvantage includes (1) it is hard to expect a complete solution of problems without the renovation of civil engineering structures, and (2) it takes time to develop results of the countermeasure such as water quality improvement. The Expert gave a guidance to the C/P keeping these considerations in mind.

In addition, the Expert were required (1) to be able to advise timely about the technology applicable in Myanmar among the technologies that are used globally without concerning the technical standards in Japan, (2) to understand the technical level and knowledge as much as possible that are used and handled in Myanmar, and construction method used by WRAWSA.

The following are the results of an analysis conducted mainly by the C/P for each issue.

1) Issue of treatment plant operation
    - Floc carry over is observed in coagulation-sedimentation basins.

      Countermeasure

      ➢ To check whether the coagulant dosing system is adequate.
      Aluminum chloro-hydrate (ACH: aluminum content: 16% as Al_2O_3) is used as a coagulant and its appropriate injection rate is considered to be 6 ppm to 8 ppm. We investigated whether this injection rate is appropriate or not by jar test and the result shows that it is appropriate.

      ➢ To check whether the mixing condition of rapid mixing and slow mixing is adequate.
      Appropriate intensity of rapid mixing is assumed to be 100 S^{-1} or more as G value, and proper stirring condition of slow mixing is 23000 to 210000 as G · t value; those are one of the global guidelines. The Output 3 C/P measured those values and found that the G value of rapid mixing system of the Nyaunghnapin water treatment plant is about 1,700, while the G · t value of slow mixing system is 44,000, both of which are the appropriate value or the range.

- To check the surface loading rate of sedimentation basins.
  The appropriate surface loading factor is 15 to 30 mm, while the surface load factor of Phase 1 sedimentation basin is 30.6 mm, and Phase 2 is 23.5 mm. It is evaluated that Phase 1 sedimentation basin is a condition that a carryover easily occurs. The flow velocity in the sedimentation basin is 0.2 m / min to 0.28 m / min for Phase 1 and 0.17 m / min to 0.23 m / min for Phase 2, both of which satisfy the design guideline value (0.4 m / min or less).
- To check the actual desludging condition and the circumstances of sedimentation basins.
  All sedimentation basins have pipes for drainage of sludge in the former half of the basins, but they are not used to drain sludge from the sedimentation basins. In the interview survey, the reasons for not using sludge drainpipes for daily desludging are explained as follows, (1) it cannot be opened due to a valve malfunction and (2) many pipes inside the sedimentation basins are broken.
  The sedimentation basin is cleaned almost once a year. When it is recognized that sludge piles up and the function of the sedimentation basin is greatly impaired, a part of sludge is removed from the sedimentation basin, as an emergency measure, and efforts are made to improve the water treatment property.
  The C/P is aware that there are many situations where the sludge piling up height is more than half the height of sedimentation basins; therefore, it is clear that sludge has not been discharged properly from sedimentation basins. It is thought that this may be the main cause of carryover of flocs from the sedimentation basins.

- Filtration functions of filters are extremely low.
- Wash method of filters is inadequate. (Wash water has retained above the top of trough, for instance, which means amount of wash water is excessive or drainage capacity of drain valves is too small).
- Backwash procedure of filters (Timings of valve opening/closing and adjustment of valve opening aperture of surface wash water valve, backwash water valve and wash water drainage valve) is not set properly.

Countermeasure
Concerning with three filter issues mentioned above, the following items are confirmed from the design drawing and the appearance inspection of the filters.

Thicknesses of filter media layer
According to the stored design drawing, the thicknesses of the filter media of Phase 1 and Phase 2 sufficiently satisfies the international technical guidelines, as shown beow.

Table 2-122: Designed thicknesses of filter media

Filter media	Phase 1	Phase 2
Anthracite	45cm	30cm
sand	30cm	90cm
gravel	37.5cm	45cm

It seems that the filtration performance is low because the filter media laid at the time of the construction flows out in large quantities and the layer of the filtration media is remarkably thin.

Mounting position of surface washing pipe
Corrosion and breakage are observed in many surface washing pipes. It is not possible to evaluate whether the mounting position of the surface washing pipes is appropriate or not, since a large amount of the filter media hse flown out, therefore the length between the surface of the filter media and the attachment position of the surface washing pipe is impossible to know. It is necessary to decide an appropriate attachment position when filters will be improved in the future.

Particle size of filter media

Design drawings describing the particle size of filter media used in the present filter are not available. However, it is possible to judge from the stored surplus anthracite which is used at the improvement and construction of the Phase 1 & 2 filters that the particle size is inappropriate from appearance. The particle size of the filter sand being used is unknown.

Backwash rate

Backwash rate is unknown since a flow meter of backwash water for filters is not installed.

Washing water drain valve

In the design drawing, the diameter of the washing water drain valve is 30 cm, and when the speed of washing water passing through the valve is assumed to be 2 m/sec, then the filter wash water rate is about 25 cm/min. This washing rate is lower than the general washing rate adopted in water treatment plants in the world, which means that the filters and their media have not been cleaned effectively.

- Operation procedures of each water treatment step are not standardized.

  Countermeasure

  - Standardization of operation procedures for water treatment will be planned where functions are properly maintained or water treatment for which improvement has completed.

2) Issue of treatment plant maintenance

- Sludge has piled up in sedimentation basins.

  Countermeasure

  - To research the change and the actual condition of sludge piling up in sedimentation basins using the interface detector procured by JICA.

    In order to ensure good clear water quality, senior officials of WRAWSA, the C/P of the Output 3 and water treatment plant staff have recognized that it is important not to pile up sludge more than certain depth above the bottom of the sedimentation basins. They are going to plan to remove sludge systematically.
  - To study efficiency of desludging through sludge draining pipes using the interface detector.

    In the course of investigating the desludging efficiency through the sludge pipes, it is found that there are many sedimentation basins where sludge cannot be effectively removed because the desludging pipes are damaged.
  - To study effective desludging procedure.

    Theoretical investigations predict that the turbidity of the after-sedimentation water increases when the sludge piling up depth reaches 1.9 m or more in Phase 1 and 2.7 m or more in Phase 2 in the first part of the sedimentation basins. A method to control and manage the sludge depth below the aforementioned depth is studied.

- Most of filter media in filters has been washed out.
- Deficiencies of underdrain system are observed in some filters.
- There are some malfunctions of many valves and surface wash equipment.

  Countermeasure

  - To study about the maintenance plan of water treatment plant combined with the consideration of comprehensive countermeasures for three filter issues mentioned above.

    Filter improvement TFT was organized in the WRAWSA to commence initiatives to solve the issues comprehensively including the above issues and continue activities. In order to formulate solutions to those issues and to acquire appropriate knowledge and skills for the C/P on sand filtration and filters, the TFT decided to install total two pilot filters in each Phase 1 and Phase 2, respectively. By conducting the survey and improvement of the pilot filters, the C/P worked on the preparation of measures to solve a wide variety of filter issues.

- Periodical check of facilities, equipment and instruments are not practiced.
  Countermeasure
  - To prepare a periodical check plan as a SOP.

- Maintenance management plan of WTP is not prepared.
  Countermeasure
  - To prepare a periodical maintenance plan as a SOP.

3) Issue of design for facilities
   - Many basic design parameters of treatment processes in WTP are not clear.
     Countermeasure
     - To learn importance of basic design parameters in seminars for basic water treatment technology.
     - To encourage importance of confirming the basic design parameters of water treatment facilities and to report the research results at the seminars.
       Basic design parameters obtained by calculation and estimation, together with known basic design parameters are showed in Table 2-123.

Table 2-123: Basic design parameters of Nyaunghnapin water treatment plant

Treatment	Parameters	Values
Water quality	Raw water turbidity	6.9 – 69 Degree (2017) 9.3 – 116 Degree (2018) 6.5 – 820 Degree (2019)
Treatment plant	Planned treatment capacity	90MGD, 410,000 m^3/day Phase 1,2: 45MGD, 205,000 m^3/day, (each)
	Treatment process	Coagulation, sedimentation, Rapid filtration
Treatment unit	Size of flocculation basins	Phase 1,2: 22m×6.9m×3m
	No. of flocculation basins	Phase 1,2: 6 (each)
	Size of sedimentation basin	Phase1: 10.2m×36m×6.2～4.7m Phase2: 10.8m×45m×6.6～5.1m
	No. of sedimentation basin	Phase 1,2: 12 (each)
	Size of rapid filter	Phase1: 5.6m×7.2m×4.7m (Filtration area：4.5m×7.2m) Phase2: 5.6m×7.2m×5m (Filtration area：4.5m×7.2m)
	No. of rapid filter	Phase1: 28 basins Phase2: 32 basins
	Treatment chemical (at present)	ACH：Aluminum Chloro-hydrate
Coagulation	Standard coagulant dose rate	6～8ppm
	Control method of coagulant dosage	Fixed amount dosage
	Strength of rapid mixing (G value)	$1600S^{-1}$
	Strength of slow mixing (G・t value)	G value: $33s^{-1}$ G・t value: 44000
Sedimentation	Surface loading rate	Phase1: 30.6mm Phase2: 23.5mm
	Flow rate	Phase1: 0.20～0.28m/min Phase2: 0.17～0.23m/min
	Retention time	Phase1: 2.7hr Phase2: 3.9hr
Rapid filtration	Type of filtration rate control	Natural balance type
	Filtration rate	Phase1: 220m/day (28 basins) Phase2: 190m/day (32 basins)
	Specification of anthracite media	Unknown (No information)
	Thickness of anthracite media	Unknown (No information)

Treatment	Parameters	Values
	Specification of sand media	Unknown (No information)
	Thickness of anthracite media	Unknown (No information)
	Backwash rate	Unknown (No information) ca. 30cm/min (Estimation)
	Surface wash rate	Unknown (No information)
	Filter wash pattern	Surface wash → Surface & back wash
	Frequency of filter wash	1/day (Roughly)

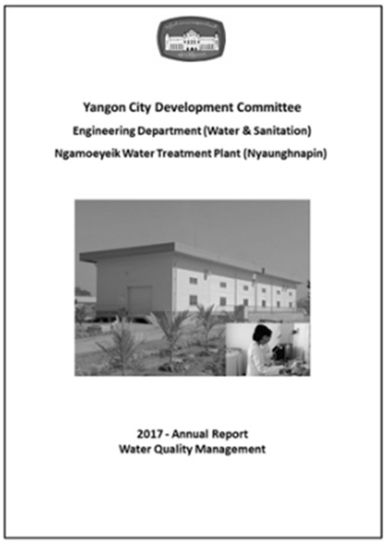
- There is a water drop at the point between flocculation basin and sedimentation basin. There is possibility that it breaks flock created in the flocculation basin.
  Countermeasure
  - ➢ Some officers of the WRAWSA recognized the issue, though, an improvement plan has not been prepared yet. In accordance with the development of the improvement work on the sedimentation in the Project, the drastic improvement of turbidity after sedimentation process was obtained by removing the sludge piled up in the sedimentation basins. Therefore, it was assumed that the adverse effect due to this water drop on sedimentation process was not fatal.

- Design of filter is inadequate.
  Countermeasure
  - ➢ The filter improvement TFT identified the problems in the design of the existing filtration basin and solved the problems when renovating existing filters to the pilot filters.

4) Issue of keeping and succession of records and information
- Some summary drawings kept by WRAWSA do not reflect the actual situation of the plant.
- Some details of the design are not clear.
  Countermeasure
  - ➢ Recognizing that the storage and inheritance of technical information and records are important, Water Treatment Section started storing the information / record as an electronic medium. It is desirable to formulate guidelines of the entire WRAWSA for creating technical drawings and storage methods, including design and completion drawings of the whole organization of WRAWSA.

- Fundamental records (operation records, check and repair records etc.) have not been kept.
  Countermeasure
  - ➢ The C/P develops a system related to the creation, storage and inspection of records, along with the creation of various SOPs.

- There are no evaluation, report, and circulation of the water quality monitoring results.
  Countermeasure
  - ➢ To prepare report and circulation system of water quality monitoring results.
    Daily, monthly and annual reports for water quality measurement were created and circulated to the relevant officers. Figure 2-98 shows a part of the Annual Report.



Annual Results of 2017

Phase 1	Raw	Water	Sedimentation Water		Clear	Water
Parameter	Max	Min	Max	Min	Max	Min
pH	8.44	6.48	8.05	6.52	7.99	6.07
Turbidity	69	6.9	22.37	0	16.01	0
Color	490	17	170	5	160	0
EC	154	60.1	153.2	61.6	128.2	62.3
TDS	77.6	30.1	77.2	30.8	63.3	31.1
Salinity	0.08	0.03	0.07	0.04	0.06	0.04

Phase 2	Raw	Water	Sedimentation Water		Clear	Water
Parameter	Max	Min	Max	Min	Max	Min
pH	8.44	6.48	8.07	6.56	8.03	6.59
Turbidity	69	6.9	20.99	0	9.15	0
Color	490	17	160	0	100	0
EC	154	60.1	128.1	61.6	126.6	62.3
TDS	77.6	30.1	64	30.8	63.2	31.2
Salinity	0.08	0.03	0.07	0.04	0.06	0.04

June လ (19.6.17) ေန႔တြင္ မိုးမၾကာခဏ ပ်က္ျဖင့္ ကန္မ်ားပိတ္ထားၿပီး Turbidity ႏွင့္ Color

2017-Annual report of Nyaunghnapin water treatment plant

A page of Annual Report excerpted (Summary of annual data)

Figure 2-98: Annual report

5) Issue of acquisition and application of technical information
- Technical information and knowledge of water treatment facility design standards are not kept.

  Countermeasure
  - ➢ To provide information and knowledge of design standards in the seminars for basic water treatment technology.
  - ➢ To provide literature and books (English version) about technological design standards of water treatment facility.

- Know-how for preventive maintenance of water treatment facility is not established.

  Countermeasure
  - ➢ In the third country training conducted in February 2018, "Maintenance of water purification plant based on preventive maintenance" was selected as a training theme.

- Necessity of coagulant dosing control is not understood.

  Countermeasure
  - ➢ To study the necessity, the present procedure, and the improvement plan of coagulant dosing control in the seminars for basic water treatment technology.

- Necessary amount of filter media (Anthracite and Sand) planned by the construction design have not been kept in the filter basins.
- Particle size of filter media are not tested or confirmed.
- Know-how for making an intended particle size of filter media is not kept.

  Countermeasure
  - ➢ To provide information and knowledge of above issues in the seminars for basic water treatment technology and seminars for the rapid filter improvement TFT. The C/P use procured instruments for particle size analysis of filter media and for making the pilot filter sand and test the size of purchased filter media including anthracite.

6) Issue of inspection system of procured materials
- A procedure of inspection of specifications of delivery products are not established.
- Response method is not established when the specifications of delivery product are wrong or inappropriate.
- There is no decision code or standard to define the necessity of inspection.

  Countermeasure

- The necessity of establishing the fundamental regulation for inspection for WRAWSA was discussed at the workshop in the 2nd Joint Advisory Committee seminar.

- Details of test procedure for checking quality and function of supplied materials and products are not prepared.
  Countermeasure
  - Examination test method of chemicals and materials for water treatment in WRAWSA was established.

3-3 Capacity development for water quality improvement

3-3-1 Conduct training of trainers on the water quality management
(1) Water quality monitoring
1) Training of trainer
Because water quality monitoring requires expertise and know-how, the candidates of trainers and lecturers need special knowledge in the related field. Therefore, the leaders of each field (physicochemical analysis, microbial analysis, or data analysis) in the central laboratory were selected as candidates of trainers of training. The main target of training of water quality monitoring is the staff of the central laboratory and mini laboratories, and that of training of basic water quality monitoring is the staff of WTP and chlorination facilities and new staff of WRAWSA as well.

Table 2-124: Contents of training and expected trainers and trainees

Water quality monitoring

Training item	Expected trainees	Expected trainers
1-1Basic of water quality monitoring − Water quality monitoring plan of WRAWSA − Water quality monitoring item and sampling point, and the purpose of each monitoring − Knowledge about water quality monitoring item: Meaning of water quality monitoring item and monitoring method	− New staff of Water Quality Section − Staff of WTP and chlorination facilities − New general staff of WRAWSA − Candidates of water quality monitoring / management staff	Central laboratory staff − Leader of physicochemical analysis − Leader of biological analysis
1-2 Water quality data analysis − Data analysis using Excel − Water quality data analysis using graphic − Preparation of water quality report	− New staff of Water Quality Section − Staff of mini laboratories − Candidates of water quality monitoring / management staff	Central laboratory staff − Leader of water quality data analysis
1-3 OJT of water quality monitoring in central laboratory − Training of sampling and water quality analysis − Training of maintenance and calibration of water quality analysis equipment − Training of water quality data analysis	− New staff of Water Quality Section	Central laboratory staff − Leader of physicochemical analysis − Leader of biological analysis − Leader of water quality data analysis
1-4 OJT of water quality monitoring in the mini laboratories − Training in central laboratory or traveling guidance by central laboratory staff − Training of sampling and water quality analysis − Training of maintenance and calibration of water quality analysis equipment − Training of water quality data analysis	− Staff of mini laboratories	Central laboratory staff − Leader of physicochemical analysis − Leader of water quality data analysis

2) Seminars for capacity development of water quality monitoring

To develop basic knowledge of water quality monitoring and to develop the capacity for trainers, seminars for capacity development of water quality monitoring was implemented. The contents of seminar are shown in Table 2-125.

Table 2-125: Contents of seminars for water quality monitoring

No.	Month and Year	Contents
1	February 2016	• Schedule of seminars • Concept of development of monitoring plan • Case example of monitoring plan in Japan (Osaka City and Fukuoka City) • Review of existing monitoring plan of WRAWSA
2	February 2016	• Proposal of new water quality monitoring plan by the Expert
3	May 2016	• Safety handling of Sodium Hypochlorite
4	June 2016	• Validation of analysis method • Example of DPD residual chlorine analysis method • Based on the experimental result of WRAWSA laboratory
5	June 2016	• Practical training: Statistic calculation of water quality monitoring data
6	October 2016	• Preparation of mini laboratories
7	December 2016	• Operation training of mini laboratory equipment
8	December 2016	• Operation training of SS measurement
9	February 2017	• Water quality monitoring item
10	October 2017	• New chlorination facility
11	December 2017	• Water quality monitoring item (Joint implementation with the central laboratory and mini laboratory)
12	March 2018	• Review mini laboratory data (Joint implementation with the central laboratory and mini laboratories)

3) Seminars for capacity development of data quality management

To develop the capacity of analysis data quality management, seminars for the central laboratory and mini laboratory were implemented. The contents of seminars are shown in Table 2-126.

In these seminars, RPD (Relative Percent Difference) index was introduced to evaluate data precision. Both central laboratory and mini laboratories have used this index to validate daily water quality data. If the RPD index is more than 20%, the Expert instructed them to clarify the reason for reduction of data precision and reflect the result in the revision of SOP.

Reference: RPD

RPD (Relative Percent Difference) = Absolute (Difference of data) / Average (%)

RPD is an index of data validation. Usually, RPD within 10 – 20% is required for field water quality monitoring.

Table 2-126: Contents of seminars for data quality management

No.	Month and year	Trainee	Contents
1	September 2019	Central laboratory	• Introduction QA/QC system • Practical method of Data quality management
2	September 2019	Mini laboratories (Yegu, Hlawga, Phugyi and Gyobyu)	• Introduction QA/QC system • Practical method of Data quality management
3	January 2020	Nyaunghnapin WTP	• Data quality management (Part2) • Improvement of color measurement
4	February to March 2020	Mini laboratories (Yegu, Hlawga, Phugyi and Gyobyu)	• Data quality management (Part2) • Improvement of color measurement

(2) Water treatment plant

Training was completed through seminars for basic water treatment technology, seminars for the rapid filter improvement TFT, joint seminars & meetings, seminars specialized in individual themes described in 3-1-3 with study tours", and on-the-job training at chlorination facilities, etc. and the activities was completed.

3-3-2 Prepare the training plan and training materials by the trainers

(1) Water quality monitoring

Central laboratory staff provided a new staff training of WRAWSA in accordance with new staff training plan of WRAWSA.

At present, water quality laboratory staff (both central laboratory and mini laboratories) have not been transferred. When new staff are assigned to laboratories, training will be provided to new staff using SOPs as training materials.

(2) Water treatment plant

The training materials are prepared by the training instructors as SOPs at water treatment plant, pumping stations, and reservoirs, and the activity was completed. Table 2-127 shows the number of SOPs created.

Table 2-127: Number of standard operation procedures (training materials) created at water treatment plant, etc.

No.	Office name	No. of SOPs
1	Nyaunghnapin WTP	19
2	Yegu P/S	70
3	Hlawga reservoir & P/S	16
4	Phugyi reservoir	28
5	Gyobyu reservoir	27
6	Heavy Maintenance	11

3-3-3 Conduct Off-JT by the trainers

(1) Water quality monitoring

Central laboratory staff provided training for new staff in WRAWSA in new staff training course of WRAWSA. In addition, the central laboratory provided technical seminars and visit training for mini laboratory staff.

Photo 2-65: Technical training of mini laboratory staff at the central laboratory

(2) Water quality management

The C/P has conducted trainings using SOP one after another and will continue to provide training. Trainings in the WTP is shown below.


Photo 2-66: Trainings using SOPs in Nyaunghnapin WTP

3-4 Develop SOPs for water quality management

3-4-1 Develop SOP on water quality test and monitoring

(1) Third country training

In February 2018, the third country training of output 3 teams was conducted at Phnom Penh Water Supply Authority (PPWSA) in Cambodia. In this training, the C/P decided to focus on utilization of the SOPs and had trainings for the preparation of SOPs, the actual situation of application, creation and storage of records, establishment, and continuation of SOP system etc. The staff of Water Treatment Section, the water treatment plant, the chlorine disinfection facility, and Water Quality Section participated in the training. The fruits of the training were reflected in the creation of SOPs and the establishment of SOP system at the various sections including the water treatment plant. In the report (Action Plan) prepared after the training, the C/P reviewed the outline of the SOPs and its preparation procedure in Reservoir Division of WRAWSA. Training program of the third country training at PPWSA is shown in Table 2-128.

Table 2-128: Training program of the third country training

Programs
Overall Water treatment and water quality management
Introduction of PPWSA
Visit Nirodh WTP and intake
Visit Phum Prek WTP and intake
Water treatment and water quality management
Water sampling and monitoring in WTP
Water quality monitoring system in WTP (Process monitoring in WTP)
Facilities and operation of Chlorination
Summary of chlorination in PPWSA
SOP management system
SOP management system
O&M System with SOP in WTP and reservoir
O&M System with SOP in WTP and reservoir
O&M System with SOP in coagulation, flocculation (OJT at site)
O&M System with SOP in sedimentation, and sludge removal (OJT at site)
O&M System with SOP in sedimentation, and sludge removal (OJT at site)
Visit CCW WPT
O&M System with SOP in chlorination (OJT at site)
Contingency plan
Plans for Maintenance
Maintenance Plan

Programs
Maintenance Plan (OJT)
Long term facilities and equipment renewal plan
Internal Discussion
Water sampling and monitoring in water distribution area
WTP water sampling and water quality monitoring (OJT at site)
Data processing and reporting (OJT at site)
Reporting & Utilization of water quality monitoring data
Quality control of water quality monitoring data

(2) Holding workshops for SOP creation

The C/P organized a SOP preparation workshop with the aim of promoting the creation of SOPs and applying those smoothly. The workshop was held led by Water Treatment Section. The Section arranged the contents, the style, the approval procedure, the code system, etc. of SOPs, and it was decided to supervise the trial application of the prepared SOPs.

The basic ideas on operation and maintenance using SOPs were explained in the workshop. Other things, such as the explanation of the SOPs, the purpose to create SOP system, the reasons, the target person using the SOPs, and how to utilize the SOPs are systematically explained. Details of them were presented as "SOP Regulation", "Master SOP" showing the rules concerning the creation, application, style, revision, recording and storage of SOPs shown in Figure 2-99. All of SOP operations and management were considered to be based on this system and process.

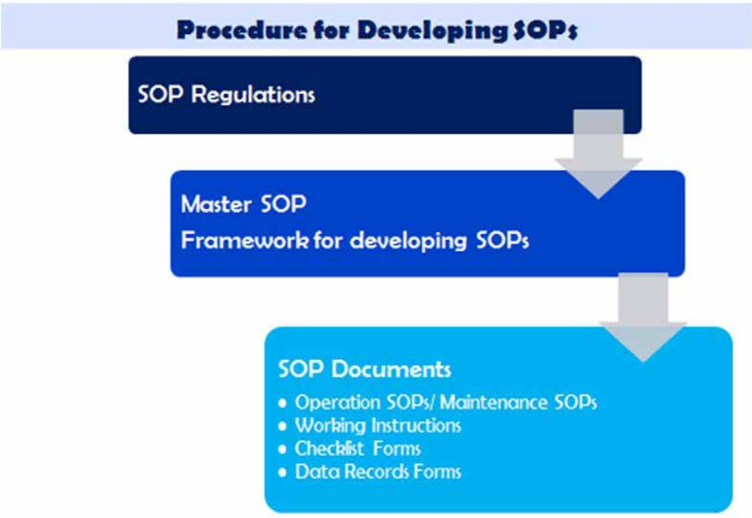


Figure 2-99: SOP system

In the workshop, it was decided to prepare SOPs for not only Nyaunghnapin WTP and the disinfection facilities of Yegu pumping station, which were the target to create SOPs in the Project, but also other WTP, reservoirs and pumping station. The person in charge of the facilities where SOPs are to be created, sequentially creates the SOPs, and the contents of the SOPs were confirmed by all the participants in the workshop. Furthermore, based on the SOPs, all the documents created such as "Working Instruction", "Recording Form", "Checklist", etc., which subdivided the work contents into each section were mutually confirmed.

Facilities and sections that completed the SOPs tried to apply the SOP. Then after reviewing the trial results, they were applied officially.

(3) Develop SOP on water quality test and monitoring

List of the SOPs established in the Project is shown in Table 2-129 (for the central laboratory) and Table 2-130 (for mini laboratories). These SOPs are utilized for training materials. The SOPs have been revised periodically according to improvement in capacity and technology of water quality analysis. The SOPs created are attached in Annex 6.A.

Table 2-129: SOPs for central laboratory

Number	Title
Administration	
EDWS-LAB-OP1	Water Quality Monitoring
EDWS-LAB-OP1-W1	Daily Duty
EDWS-LAB-OP1-W2	Weekly Duty
EDWS-LAB-OP1-W3	Monthly Duty
EDWS-LAB-OP1-W4	Sampling & Storage
EDWS-LAB-OP1-W5	Instruction for Laboratory (Dos & Don't)
EDWS-LAB-OP1-W6	Chemical Handling
EDWS-LAB-OP1-W7	Meter Operation
EDWS-LAB-OP1-W8	Safety
Analysis SOPs	
EDWS-CL-AP-W-2	EC (Electrical Conductivity)
EDWS-CL-AP-W-3	TDS
EDWS-CL-AP-W-4	Salinity
EDWS-CL-AP-W-5	Color
EDWS-CL-AP-W-6	Turbidity (HANNA)
EDWS-CL-AP-W-6	Portable Turbidity (HANNA)
EDWS-CL-AP-W-7	Suspended Solid
EDWS-CL-AP-W-8	Jar Test
EDWS-CL-AP-W-9	Total Hardness
EDWS-CL-AP-W-10	Calcium
EDWS-CL-AP-W-11	Total Alkalinity
EDWS-CL-AP-W-12	Chloride
EDWS-CL-AP-W-13	Manganese
EDWS-CL-AP-W-14	Iron (Fe)
EDWS-CL-AP-W-15	Nitrate-Nitrogen (NO^3-N)
EDWS-CL-AP-W-16	Nitrate-Nitrogen (NO^2-N)
EDWS-CL-AP-W-17	Ammonia (NH^3-N)
EDWS-CL-AP-W-18	Sulphate (SO_4^{2-})
EDWS-CL-AP-W19	Phosphorous (PO_4^{3-})
EDWS-CL-AP-W20	Lead (Pb)
EDWS-CL-AP-W21	Zinc
EDWS-CL-AP-W22	Arsenic (Portable Test)
EDWS-CL-AP-W23	Phosphorous (Total LR)
EDWS-CL-AP-W24	Phosphorous (Total HR)
EDWS-CL-AP-W25	Nitrogen, Total LR (0.5 to 25 mg/L)
EDWS-CL-AP-W26	Nitrogen, Total LR (1 to 16 mg/L)
EDWS-CL-AP-W27	Nitrogen, Total LR (2 to 150 mg/L)
EDWS-CL-AP-W28	Residual Chlorine
EDWS-CL-AP-W29	Quanty Tray
EDWS-CL-AP-W30	Total Coliform & Fecal Coliform
Equipment SOPs	
EDWS-SuD-EP-WI-1	pH Calibration for Mettler Toledo Brand
EDWS-SuD-EP-WI-2	EC Calibration for Mettler Toledo Brand
EDWS-SuD-EP-WI-3	Balance
EDWS-SuD-EP-WI-4	Oven
EDWS-SuD-EP-WI-5	Desiccator
EDWS-SuD-EP-WI-6	Measurement of Turbidity (HANNA)
EDWS-SuD-EP-WI-7	DO Meter
EDWS-SuD-EP-WI-8	U-50 Meter
EDWS-SuD-EP-WI-9	Jar Test (Laboratory Flocculator)
EDWS-SuD-EP-WI-10	DR-6000 (UV Spectrophotometer)

Number	Title
EDWS-SuD-EP-WI-11	Fume Hood
EDWS-SuD-EP-WI-12	DRB 200 Reactor (Digester)
EDWS-SuD-EP-WI-13	Burette
EDWS-SuD-EP-WI-14	Quantity-Tray Sealer Plus
EDWS-SuD-EP-WI-15	UV-Viewing Cabinet
EDWS-SuD-EP-WI-16	Incubator
EDWS-SuD-EP-WI-17	Auto Clave

Table 2-130: SOPs for mini laboratories

Number	Item
EDWS-LAB-OP2	Mini Lab's SOP
EDWS-LAB-OP1-W1	pH measurement instruction
EDWS-LAB-OP1-W2	EC measurement instruction
EDWS-LAB-OP1-W3	Salinity measurement instruction
EDWS-LAB-OP1-W4	Total Dissolved Solid measurement instruction
EDWS-LAB-OP1-W5	Jar Test measurement instruction
EDWS-LAB-OP2-W1	pH measurement instruction for mini lab
EDWS-LAB-OP2-W2	Turbidity measurement instruction for mini lab
EDWS-LAB-OP2-W3	Color measurement instruction for mini lab
EDWS-LAB-OP2-W4	Chlorine measurement instruction for mini lab
EDWS-LAB-OP2-W5	Daily activities instructions in the lab.
EDWS-LAB-OP2-W6	Instruction for taking water sample
EDWS-LAB-OP2-F1	Computer form

3-4-2 Develop SOP on operation and maintenance of water treatment plant and disinfection facility

As shown in Table 2-131 and Table 2-132, the preparation of SOPs were completed at the Nyaunghnapin WTP and Yegu pumping station where the disinfection facility (Electro chlorinator) was installed. The SOPs in the tables below are the latest version at present. In addition to the above facilities, the SOP preparation activities was continued to the preparation activities of the whole Reservoir Division including three reservoirs and pumping stations. This activity furthermore led to the creation activities of SOPs in all WRAWSA, and the activities in the Reservoir Division were applied to all sections and facilities in the entire WRAWSA.

Table 2-131: List of SOPs of Nyaunghnapin WTP

No.	Title	Document Code
1	Dosing rate adjusting table	EDWS-NWTP-OP1-A1
2	Low-lift pump operation record	EDWS-NWTP-OP1-F1
3	Dosing pump operation record	EDWS-NWTP-OP1-F2
4	Aluminum Chlorohydrate (ACH Ledger book)	EDWS-NWTP-OP1-F3
5	Booster pump operation point (1st Phase)	EDWS-NWTP-OP1-F4
6	Booster pump operation point (2nd Phase)	EDWS-NWTP-OP1-F5
7	Power failure/recovery (times, duration & frequency)	EDWS-NWTP-OP1-F6
8	Water Quality in NWTP (1st Phase)	EDWS-NWTP-OP5-F1
9	Low-lift pump operation	EDWS-NWTP-OP1-W1
10	ACH Dosing Pump Operation Instruction	EDWS-NWTP-OP1-W2
11	Instruction for Pre-sedimentation pond	EDWS-NWTP-OP1-W3
12	Instruction for Sedimentation basin	EDWS-NWTP-OP1-W4
13	Instruction for Rapid Sand Filter	EDWS-NWTP-OP1-W5
14	Instruction for backwashing process in Rapid Sand Filter	EDWS-NWTP-OP1-W6
15	Duties of Ngamoeyeik Water Treatment Plant	EDWS-NWTP-OP1
16	Daily maintenance work in Ngamoeyeik WTP	EDWS-NWTP-MP1
17	Operation of Booster pumps	EDWS-NWTP-OP1-W3
18	Activities to carry out when in power failure	EDWS-NWTP-OP1-W4
19	Activities to carry out when the power is recovered	EDWS-NWTP-OP1-W5
20	PI Data record	

Table 2-132: List of SOPs of Yegu PS (Electro chlorinator)

No.	Title	Document Code
1	Duties of Yegu Pumping Station	EDWS-YPS-OP
2	Maintenance of Electro chlorinator	EDWS-YPS-MP3
3	Maintenance of Electro chlorinator	EDWS-YPS-MP3-W1
4	Operation of Electro chlorinator	EDWS-YPS-OP3
5	Operation of Electro chlorinator	EDWS-YS-OP3-W1
6	Daily Check Sheet (Electro chlorination Plant)	EDWS-YPS-MP3-F1
7	Monthly check sheet (Electro chlorination Plant)	EDWS-YPS-MP3-F2
8	Annual Check sheet (Electro chlorination Plant)	EDWS-YPS-MP3-F3
9	Dosing pump control chart	EDWS-YPS-OP3-A1

3-5 Conduct OJT on water quality management at the pilot treatment plants and disinfection facility

3-5-1 Procure water quality analysis and water quality management equipment

Procurement of equipment was done in 2016 and 2017. The list of procured equipment and allocation of each equipment is shown below.

(1) The 1st procurement

The 1st procurement was carried out in September 2016. The list of procured equipment is shown in Table 2-133.

Table 2-133: Procured equipment list (1st procurement, 2016)

No.	Item	Model No.	Manufacturer	Qty.
1-1	Turbidity meter (Tabletop)	HI 88703	Hanna	1 set
1-2	Turbidity meter (Portable)	HI 93703	Hanna	5 sets
1-3	Color meter (Portable)	HI 96727	Hanna	6 sets
1-4	pH meter	HI 98128	Hanna	5 sets
1-5	Residual chlorine meter	2470	HACH	1 set
1-6	Magnetic stirrer with hot plate	TM-14SB	JeioTech	1 set
1-7	Magnetic stirrer	MS-12B	JeioTech	4 sets
1-8	Magnetic stirrer rotor	Nil	TGK	15 pcs.
1-9	Burette stand	561-51-54-01	TGK	2 sets
1-10	Grass ware	Assorted	TGK	1 set
2-1	Jar tester	PB-900	Phipps & Bird	1 set
2-2	Sieve shaker	Analysette 3	Fritsch	1 set
2-3	Sieve (for sieve shaker)	Assorted	As One	2 sets
2-4	Electric Scale	SJ-1200	Shinko Denshi	1 set
2-5	Sludge level detector	Check Boy	Central Kagaku	1 set
3-1	Grass desiccator	371-07-23-05	TGK	1 set
3-2	Filter funnel	KG-47	Advantec	3 sets
3-3	Vacuum Bell (Bell Jar)	VT-500	Advantec	2 sets
3-4	Aspirator (Vacuum pump)	DAP-6D	Ulvac	1 set
3-5	Porcelain pan 60mm (Evaporation dish)	129-31-51-21	TGK	30 pcs.
3-6	Grass filter paper 47mm (100 filters / 1 nos)	GS-25	Advantec	2 boxes

The procured equipment was placed at the locations listed in Table 2-134. Equipment from No. 2-1 to 2-5 were placed in the Nyaunghnapin WTP and used to improve the water treatment process. The rest of the equipment were placed in the central laboratory and mini laboratories for water quality monitoring.

Table 2-134: Installation location of monitoring equipment

No.	Item	Installation location
1-1	Turbidity meter (Tabletop)	Central laboratory
1-2	Turbidity meter (Portable)	Mini Laboratory: Gyobyu Reservoir, Phugyi Reservoir, Hlawga Reservoir, Yegu pumping station, Nyaunghnapin WTP
1-3	Color meter (Portable)	Central Laboratory Mini Laboratory: Gyobyu Reservoir, Phugyi Reservoir, Hlawga Reservoir, Yegu pumping station, Nyaunghnapin WTP
1-4	pH meter	Mini Laboratory: Gyobyu reservoir, Phugyi reservoir, Hlawga reservoir, Yegu pumping station, Nyaunghnapin WTP
1-5	Residual chlorine meter	Mini Laboratory: Yegu pumping station
1-6	Magnetic stirrer with hot plate	Central laboratory
1-7	Magnetic stirrer	
1-8	Magnetic stirrer rotor	
1-9	Burette stand	
1-10	Grass ware	
2-1	Jar tester	Nyaunghnapin WTP
2-2	Sieve shaker	
2-3	Sieve	
2-4	Electric Scale	
2-5	Sludge level detector	
3-1	Grass desiccator	Central laboratory
3-2	Filter funnel	
3-3	Vacuum Bell (Bell Jar)	
3-4	Aspirator (Vacuum pump)	
3-5	Porcelain pan	
3-6	Grass filter paper	

(2) The 2nd procurement

The 2nd procurement was carried out in November 2017. The list of procured equipment and allocation of each equipment are shown below. All procured equipment were placed in the Nyaunghnapin WTP and utilized for improvement of water treatment process.

Table 2-135: List of procured equipment: Portable ultrasonic flow meters

No.	Item	Model No.	Manufacturer	Qty.
1-1	Portable ultrasonic flowmeter	UF801P	Ultraflux	2 set
1-2 to 1-10	Accessory	UF801P accessory	Ultraflux	2 set
2	Sensor extension cable 95m	--	Ultraflux	2 set
3	Sensor for large diameter pipe	SE1595	Ultraflux	2 set

Table 2-136: List of procured equipment: Drier and desiccator

No.	Item	Model No.	Manufacturer	Qty.
1	Desiccator	4201407	TGK	1set
2	Drier	DRS420DB (220V)	Advantec	1set

(3) Procurement equipment by WRAWSA

WRAWSA procured Atomic Absorbance Spectrometer (AAS) for heavy metal analysis in August 2018.

- Manufacturer: Analytikjena (Germany)
- Model: contrAA 800
- Measurement item: Iron, Manganese, Arsenic (As), and other heavy metal

The central laboratory staff attended the manufacturer's seminar of AAS and the seminar organized by Hiroshima Prefecture to learn how to operate AAS. They are now preparing SOPs for AAS operation.

Measuring As standard

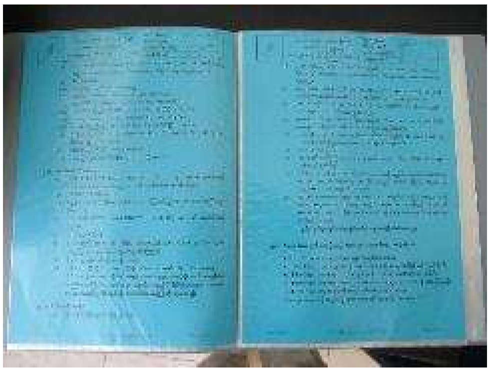
Data analysis for As calculation curve

Photo 2-67: Operation of AAS

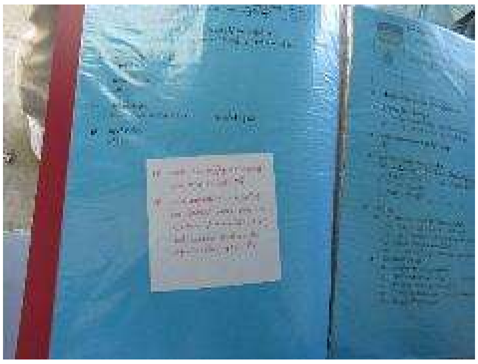
3-5-2 Conduct OJT on water quality test and monitoring

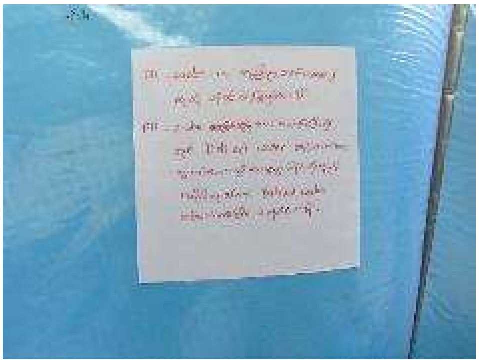
The central laboratory and mini laboratories implemented periodical water quality monitoring in accordance with decided SOPs. SOPs used in the central laboratory and the mini laboratories are given in Annex 6.A.

The SOPs used in the mini laboratory in Hlawga is shown in Photo 2-68. Problems noticed during daily measurement operation are recorded and these records are reflected in the revision of SOPs.



SOP of mini laboratory in Hlawga





Record of notice on daily measurement operation by mini laboratory staff in Hlawga

Photo 2-68: SOP of Hlawga mini laboratory

3-5-3 Diagnose function of treatment processes of Nyaunghnapin water treatment plant

Functional diagnosis was conducted and completed. Based on the diagnostic results, improvement activities such as sedimentation basins and rapid sand filters are being implemented.

(1) Comparative survey of coagulants

Aluminum chloro-hydrate (ACH: 16% as aluminum oxide concentration) is used as a coagulant in

Nyaunghnapin WTP. On the other hand, liquid poly-aluminum chloride (PAC: 10% as aluminum oxide concentration) and aluminum sulfate (8% as aluminum oxide concentration) are widely used in water purification plants in Japan and around the world. The C/P in charge of water treatment plant had the idea to reevaluate the coagulant used in Nyaunghnapin WTP by comparing the ability of coagulation of ACH and PAC and they carried out the research. The result was that the performance of coagulation and economy of ACH and PAC were evaluated as almost equal. Therefore, ACH is used in Nyaunghnapin WTP. The result of the research was compiled by the C/P as a report. It was confirmed from the actual measurement of the amount of the coagulant consumed that the coagulant corresponding to the above dosing rate was injected in the WTP.

(2) Investigation of effective desludging method

As a new sludge removal method, new desludging pipes were laid in No.1 sedimentation basin of Phase 1. (Photo 2-69 - Photo 2-71). The new drainage pipes are three pipes in total, and they were laid in the bottom of the sedimentation basin along the downstream part of the three baffled walls in the sedimentation basin. Simultaneously, with the addition of the new desludging pipe work, the existing drainage pipes were also replaced and repaired, and the effects of these additional, replaced and repaired desludging pipes were investigated.

Photo 2-69: New desludging pipes equipped in No.1 sedimentation basin of Phase 1

Photo 2-70: New desludging pipes equipped in No.1 sedimentation basin of Phase 1 (Outside of the basin)

Photo 2-71: Replaced desludging pipes in No.1 sedimentation basin of Phase 1

Figure 2-100 shows the change of the sludge depth measured by the C/P. The data of the No. 1

sedimentation basin with the sludge removing pipe installed is shown by the solid line and the data of the other 11 sedimentation basins is shown by the dotted line. As can be seen from this data, it could not be said that the speed of sludge piling up in the No. 1 sedimentation basin was slow compared to other sedimentation basins. The C/P found that the installed pipes had only limited effect of promoting sludge discharge. On the other hand, it was proved that by installing new sludge removing pipes in addition to the existing sludge removing pipes, cleaning of the settling basin can be done in a shorter time.

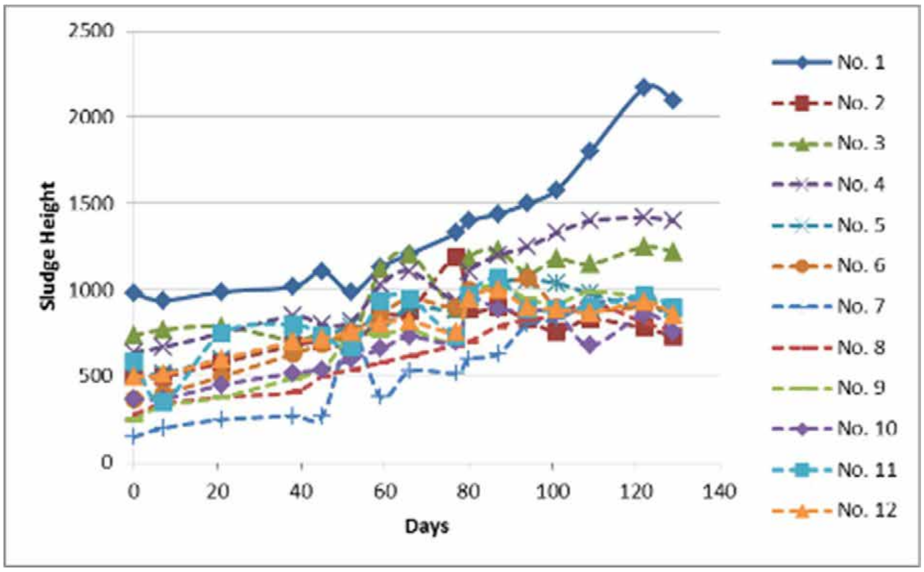


Figure 2-100: Increase of sludge depth in Phase1 sedimentation basins

(3) Acceptable sludge depth in a sedimentation basin and making annual sludge removal plan

The depth at the inflow part of the sedimentation basin is about 5.6 m in Phase 1 and about 6.2 m in Phase 2, which is a sufficient depth to accumulate sludge. As the accumulation of sludge progresses and the effective depth of the sedimentation basins becomes shallow, the flow velocity in the sedimentation basins become faster. It would eventually cause the settled sludge to be scoured and sludge would not settle. We examined this depth. For the study, a reference was made to the literature (“Unit Treatment Processes in Water and Wastewater Engineering”, T J Casey, AQUAVARRA RESEARCH LIMITED, 22A Brookfield Avenue Blackrock Co. Dublin., October 2006) that describes the relationship between sludge scouring and flow velocity. In this report, the concept of the critical flow rate at which the sedimented sludge is rolled up is shown. The depth obtained by the calculation, shown in Figure 2-101 and Figure 2-102 are almost in agreement with the relationship between the measured sludge depth of the sedimentation basins and the measurement result of treated water quality. We decided to operate the sedimentation basins with the depth of sludge below these depths.

In order to control the sludge depth of the sedimentation basins below the above depths, we made a plan to remove sludge completely from the Phase 1 sedimentation basins twice a year. The existing drainage pipes of Phase 2 sedimentation basins had a certain level of drainage capacity. We planned to carry out partial sludge removal using drainage pipes twice a year, and a complete sludge removal once a year. Also, we decided to create and store sludge removal records.

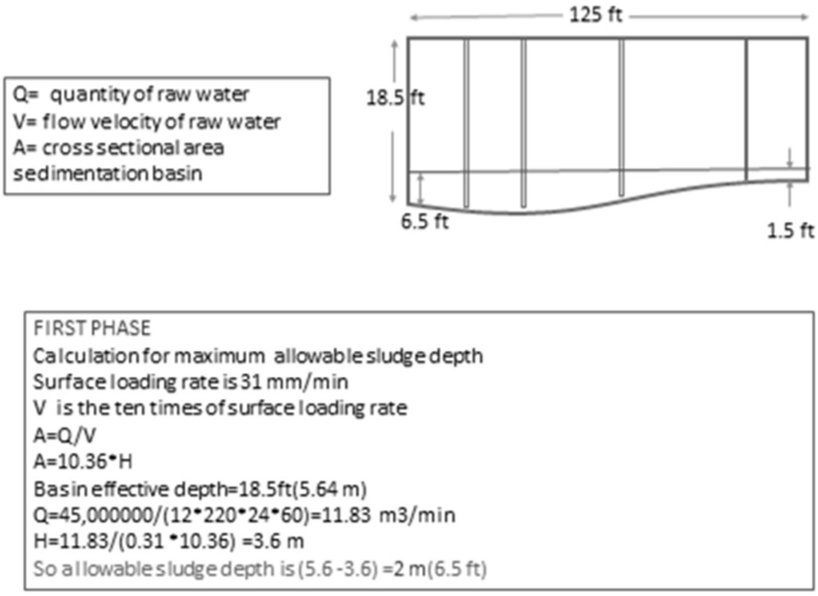


Figure 2-101: Calculation result of critical flow rate at which the sedimented sludge was rolled up at Phase 1

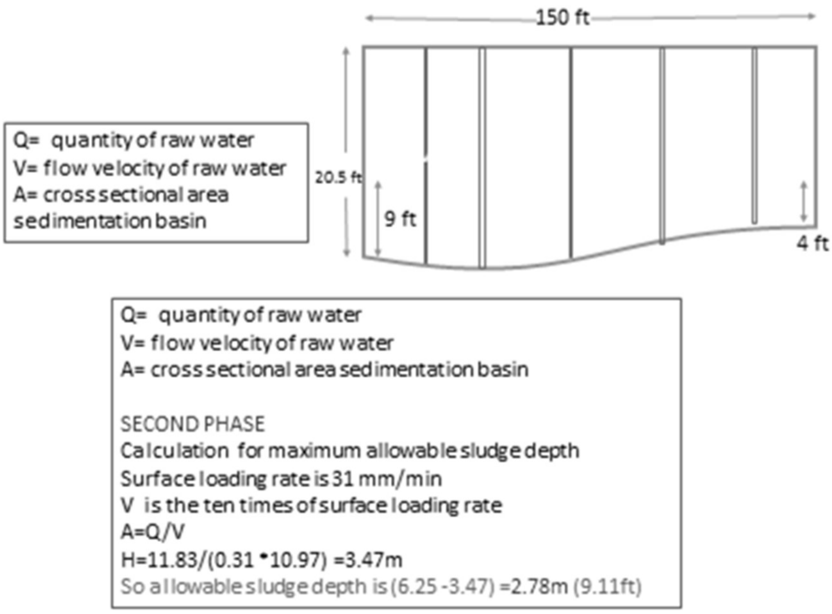


Figure 2-102: Calculation result of critical flow rate at which the sedimented sludge was rolled up at Phase 2

(4) Efficient removal of sludge from the sedimentation basin by modifying the bottom of the sedimentation tank or using a mobile submersible pump

The C/P installed mobile submersible pump for sludge removal at the inlet section of the sedimentation basin to study a more efficient method for sludge removal. The pump was installed on a pedestal that was able to move in a direction perpendicular to the flow direction of the treated water, and the entire inlet section of the sedimentation basin was designed to allow sludge removal. The pump was also used for draining the process water in a sedimentation basin in a short time when it was required to clean a sedimentation basin. This method was adopted in all 22 sedimentation basins except the two sedimentation basins in which the bottoms are modified, and pump pedestals are installed in these 22 basins. (Photo 2-72)

It was also decided to study a method of setting a one-way slope and installing a groove at the bottom of a sedimentation basin for sludge removal in the actual basins. The bottom of the sedimentation basins was modified in Phase 2 No. 11 and No. 12 of which the side wall of the basins was to be rebuilt, and these basins were put into service after the modification work was completed. (Photo 2-72)

	
Pedestal of mobile submersible pump for sludge removal	Construction to provide a one-way slope on the bottom of the sedimentation basin

Photo 2-72: Improvement work for efficient sludge removal

3-5-4 Develop improvement measures of function of Nyaunghnapin WTP through pilot basins

(1) Improvement of pilot filters

One existing filter was improved as a pilot filter in both Phase 1 and Phase 2. These pilot filters were used for real filtration treatment after improvement of necessary functions, then monitoring the filter performance and evaluating the effect of function improvement measures. We set up a filter improvement investigation TFT in WRAWSA aiming to comprehensively solve the problems related to rapid filters and started the investigation on it. To improve a pilot filter for use in the survey, we decided to improve and repair as many problems shown in Table 2-137 as possible, while avoiding repair that costs high. This intended to avoid blank activities during the period required to obtain large budget for improvement costs, and to avoid the impact on the Project activities if the budget was not approved.

Table 2-137: List of problems on sand filtration basin

1	**Issues of design for facilities**	
	1.1	Records relating to the process and evidence of calculations and decisions of basic design parameters are not available
	1.2	Sufficient amount of filter wash water flow cannot be obtained due to too small diameter of wash water drainage valve
	1.3	There is no way to know the amount of wash water flow
	1.4	While the filter is natural balance type, water is not kept above the filter media; therefore, upper part of filter media is exposed to air due to insufficient height of outlet weir when an operation of filter is stopped, for example
	1.5	Nozzles of surface wash are placed 30cm above the top of filter media
	1.6	Causes and evidence of design change are not available
2	**Issues of record and information keeping and succession of information**	
	2.1	Only summary figures and drawings of filters are kept
	2.2	Some summary drawings of filters kept by WRAWSA do not reflect the actual situation of the plant
	2.3	There is no drawings of modification and completion of filters after a change of the design
3	**Issues of acquisition and application of technical information**	
	3.1	Issue of acquisition and application of technical information
	3.2	Inadequate specification (particle size, outside) of anthracite is used
	3.3	Inadequate specifications of sand are used
	3.4	Sieving method of sand is inadequate
4	**Issues of treatment plant operation**	
	4.1	Almost all anthracite has flown out
	4.2	Most filter sand have flown out

	4.3	Standards and conditions for filter wash are not established
	4.4	Procedures and conditions of filter wash process are not established
	4.5	Amount of filter wash water (backwash water, surface wash water) is controlled by the site operator's judgement
5	**Issues of treatment plant maintenance**	
	5.1	Routine check system such as particle size of filter media and their depth are not established
	5.2	Routine checks and repair system of all parts of filter basin such as surface wash equipment, valves, principal concrete structural parts are not established
6	**Issues of inspection system of procured materials**	
	6.1	Inspection system for goods imported from foreign country (e.g., anthracite) is not established nor inadequate
	6.2	Confirmation method of technical specification in inspection is not established

Specific and technical improvement and refurbishment points extracted from the issues are shown below.

Table 2-138: Improvement and refurbishment points of the filters

Improvement and refurbishment points	Corresponding numbers in the above table
Specifications and amount of procurement of anthracite to be used	3-1,4-1,6-1,6-2
Specifications of filter sand to be used	3-2,4-2
Production of filter sand, amount of sand to produce and its procedure by the WRAWSA	3-3
Layer thickness of filter media (gravel, filter sand and anthracite)	1-4,1-5
Mounting position of surface wash pipes	1-5,4-3
Diameter of wash water drainage valves in filters	1-2,4-3,4-4
The height of the weir on the outflow side of filters	1-4
Repair of the false floor	4-1,4-2
Installation of flow restricting device for filter washing water	4-1

At first, Phase 2 pilot filter was refurbished after the start of its operation; then Phase 1 pilot filter was refurbished. The refurbished works of Phase 2 filter are shown in Photo 2-73 and the works of Phase 1 filter are shown in Photo 2-74.

Replaced gravel
(Phase 2 pilot filter)

Replaced filter sand
(Phase 2 pilot filter)

Replaced anthracite
(Phase 2 pilot filter)

Newly set surface wash nozzle
(Phase 2 pilot filter)

Replaced wash water drainage valve
(Phase 2 pilot filter)

Raised outflow weir
(Phase 2 pilot filter)

Photo 2-73: Improvement work of Phase2 filter

Replaced effluent valve
(Phase 1 pilot filter. The weir is before improvement)

Raised outflow weir
(Phase 1 pilot filter)

Replacement work of filter sand
(Phase 1 pilot filter)

Replaced anthracite
(Phase 1 pilot filter)

Photo 2-74: Improvement work of Phase1 filter

(2) Issues of Phase 1, 2 pilot filters before and after operation for research
During the Phase 2 pilot filter research operation, the following issues were identified. It was thought that all these would be the issues of not only the pilot filter, but the issues of all filters in Phase 2, and these issues needs to be addressed in refurbishment of all Phase 2 filters in the future.

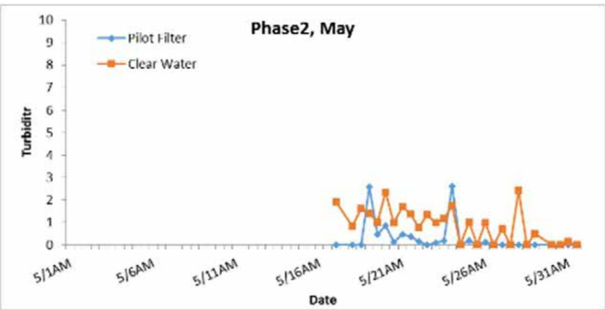
A. Mixing of air into backwash water
B. Leakage of the backwash water at the backwash pipes installation parts at the bottom of the pilot filter
C. Leakage from filter outflow valve (It cannot be closed up completely.)

Regarding the mixing of air into the backwash water, the air mixing route could not be identified. Then, replacement of the seals of the flange parts, confirmation of the function of the check valves (backflow prevention valves) of backwash water main pipe, installation of air valve to backwash water main pipe, which were the cause of the presumption, were carried out, but mixing of air could not be prevented. Therefore, in the washing of the pilot filter, it was premised on the assumption that backwash water included air, and a procedure was set up to prevent anthracite flowing out from a filter by the air. Water leakage from the backwash water pipe installation parts on the bottom of the pilot filter was repaired and measures were taken to prevent leakage. It was judged that replacement of the filter outflow valve was necessary. The above issues were not observed in the Phase 1 pilot filter, and it is thought that these are issues related to construction and used parts specialized for Phase 2.

When we introduced filter sand into the Phase 1 pilot filter, sand after sieving was introduced for 40 cm of the depth of the filter, and after backwashing, 5 cm of the surface was removed to remove fine sand. After that, 5 cm plus several cm of sand were added for compensation of 5 cm of scraped off sand. Then, extra sand of several centimeters was scraped to get a layer thickness of 40 cm. In the measurement of the C/P, the effective diameter of the introduced sand at first, was 0.371 mm, the 60% diameter was 0.665 mm, and the uniform coefficient was 1.793. After scraping, the effective diameter was 0.439 mm, the 60% diameter was 0.691 mm, and the uniformity coefficient was 1.582. From observation of the Phase 1 pilot filter, it was presumed that the amount of scraping was insufficient, as fine sand was observed on the surface of anthracite after filter washing.

(3) Filter improvement study using pilot filters and water quality of their filtrated water
Research operation of Phase 2 pilot filter started from May 2018. Turbidity after filtration was measured. The object to be compared with turbidity of the pilot filter was turbidity of clear water (Control water), which was the water of all Phase 2 filters. Research operation of Phase 1 pilot filter started from October 2018.

Phase 2 pilot filter turbidity and control water turbidity measurement results measured twice a day are shown in Figure 2-103. The turbidity of the pilot filter is shown in blue color line and the turbidity of the control water is shown in red color line.



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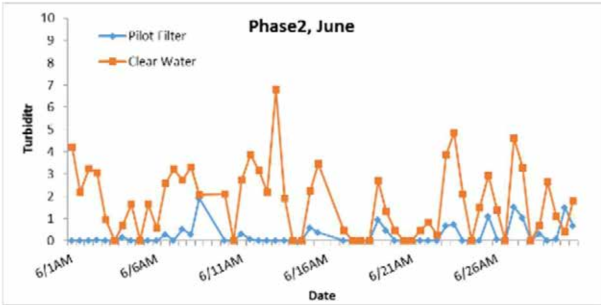
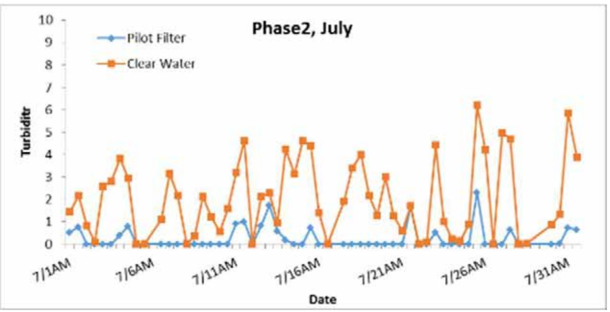
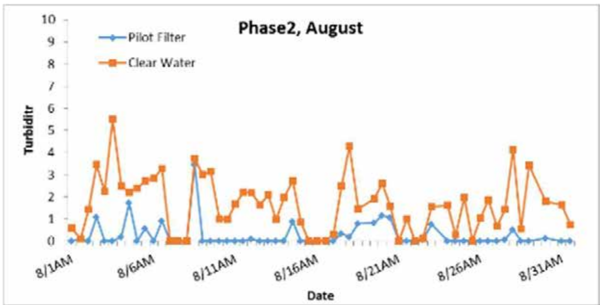


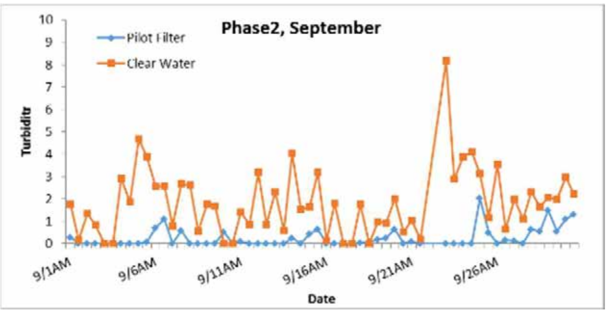
June, 2018



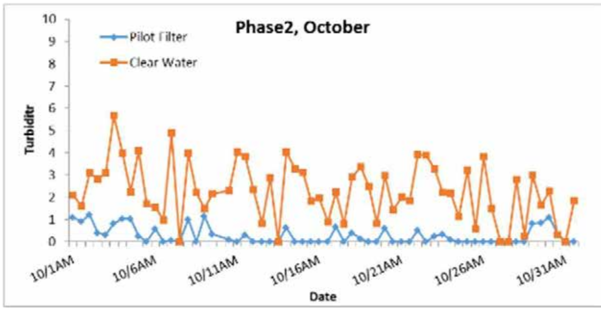
July, 2018



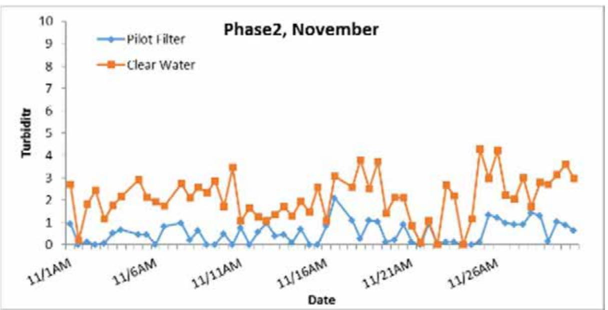
August, 2018



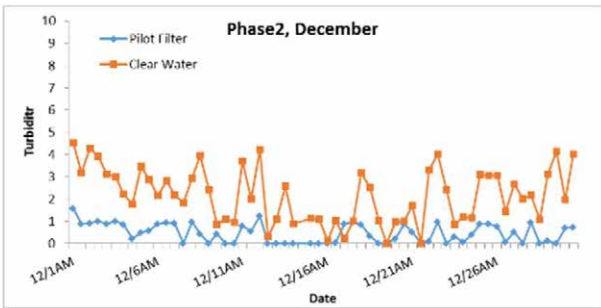
September, 2018



October, 2018



November, 2018



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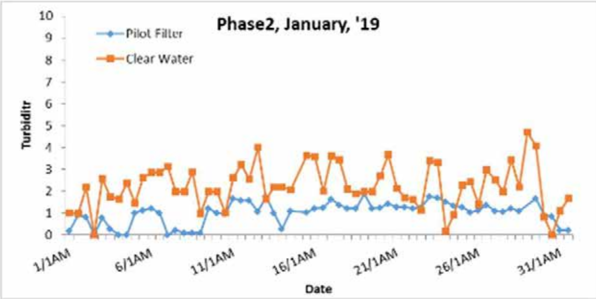
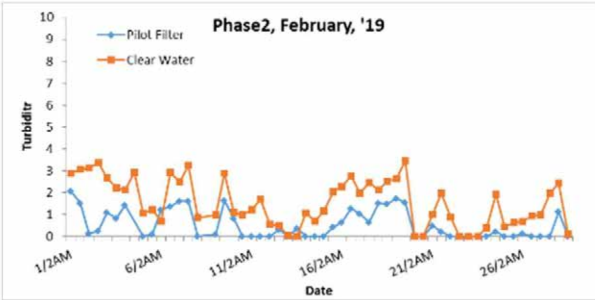


January, 2019



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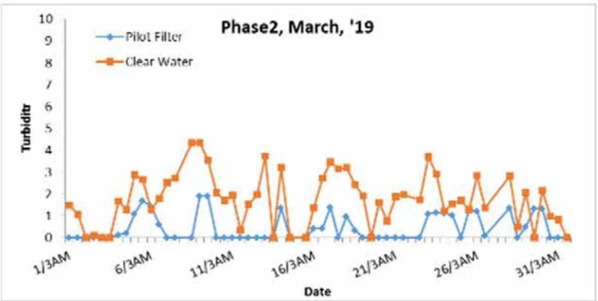

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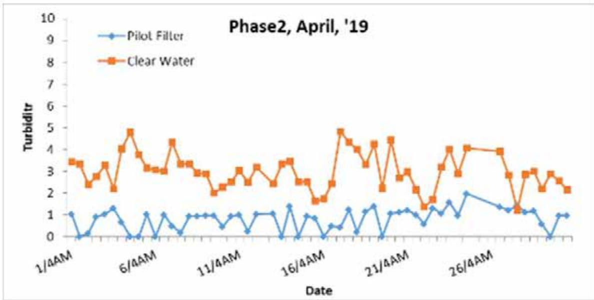

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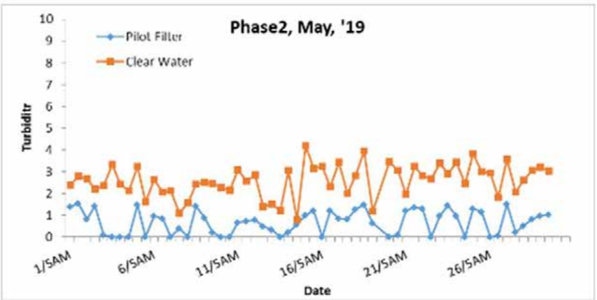

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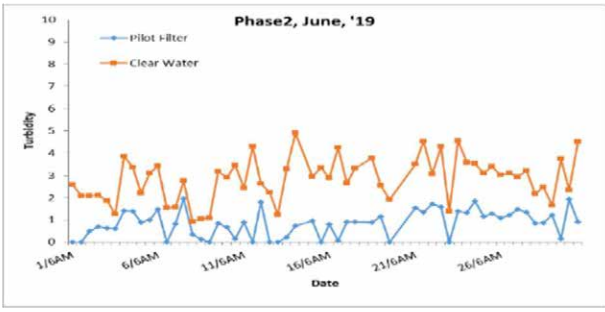

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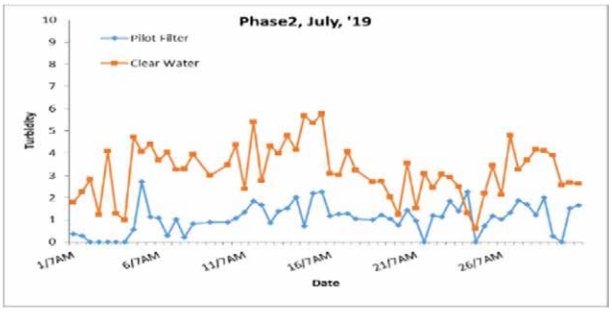

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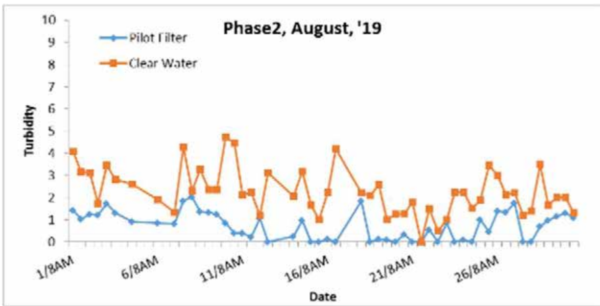
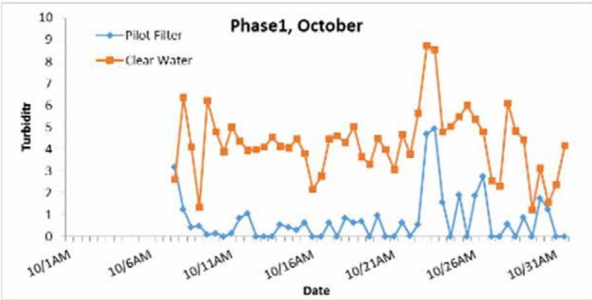


August, 2019

Figure 2-103: Turbidity change in Phase2 pilot filter

The turbidity of Phase 2 pilot filter was much lower than the control water turbidity, which was the water quality of existing filters, indicating that the turbidity removal capability of the pilot filter was recovered. Phase 2 pilot filter was in operation for more than 15 months since the start of survey operation, during which the pilot filter has been able to remove the turbidity in a stable manner.

Figure 2-104 shows the turbidity of Phase 1 pilot filter and the control water (Clear water of Phase 1), from the same it was clear that the turbidity removal capability of the pilot filter was also recovered like Phase 2.



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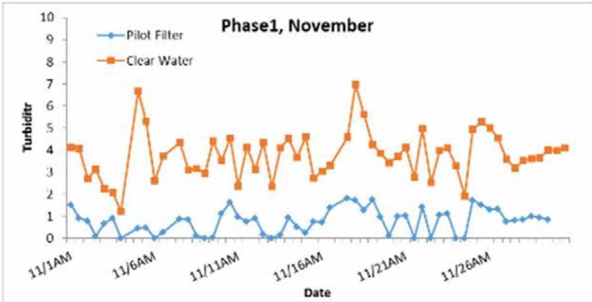
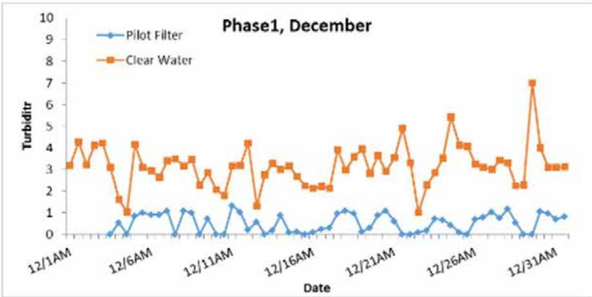


November, 2018



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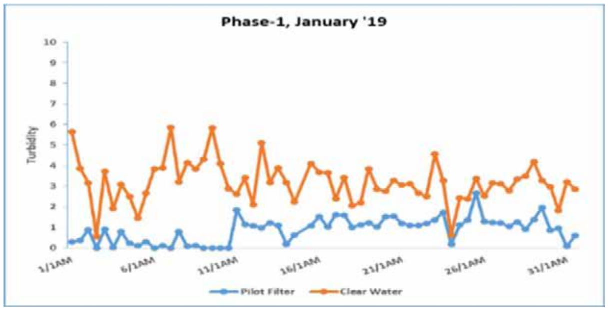

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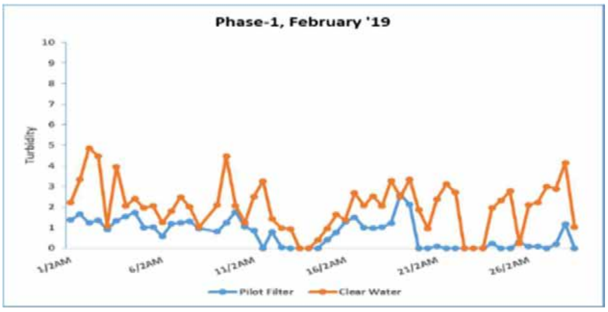

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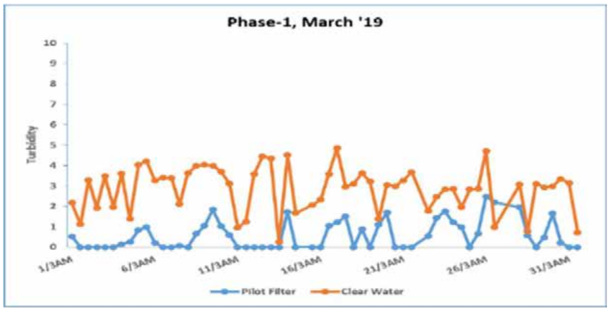

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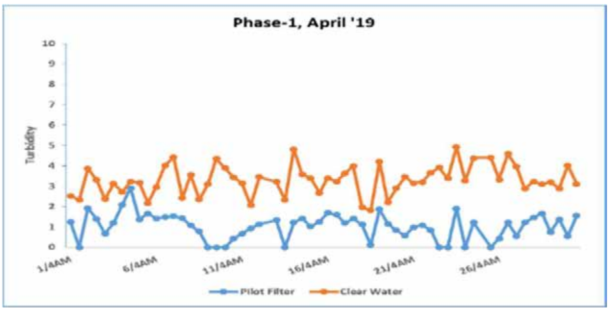
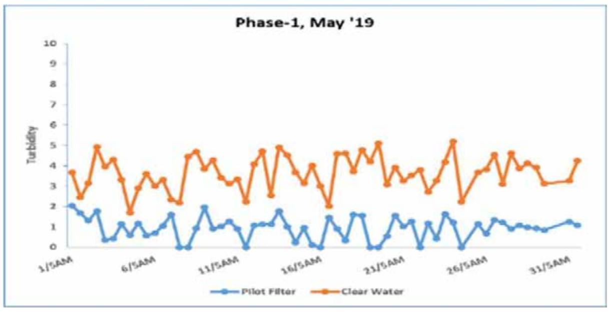
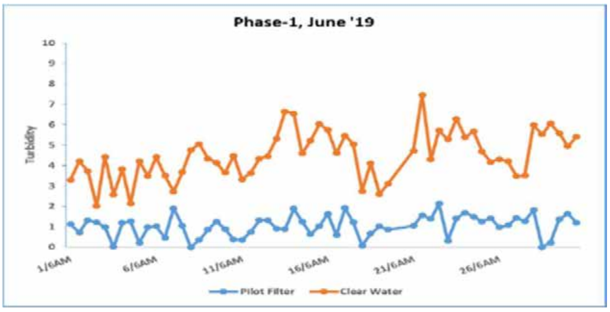


April, 2019



May, 2019



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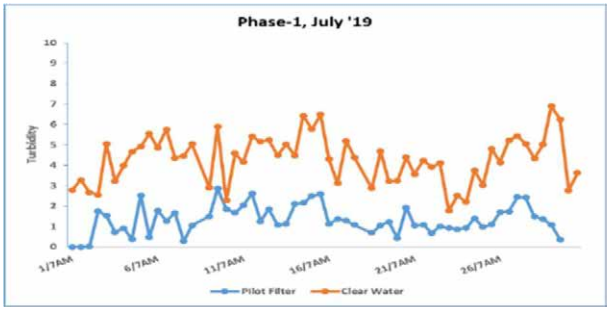

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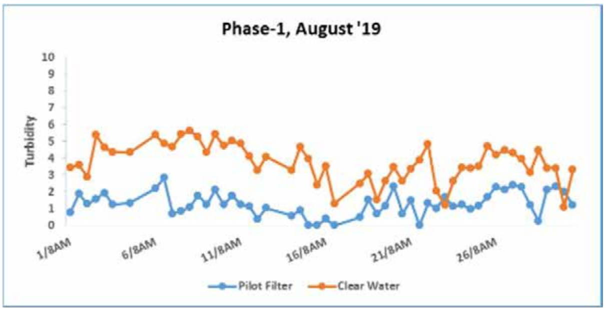


August, 2019

Figure 2-104: Turbidity change in Phase1 pilot filter

Turbidity measurement results of Phase 2 and Phase 1 pilot filters by month are summarized in Table 2-139 and Table 2-140. It also shows the number of measurements, the number of times the turbidity exceeds 1 NTU, the monthly average turbidity and the monthly maximum turbidity of the pilot filters and the control water (Clear water).

The average turbidity of the Phase 2 pilot filter by month ranged from 0.24 to 1.00 NTU, on the other hand, the same for control water ranged from 0.88 to 3.20 NTU. This result means that the turbidity decreased largely compared to the control water. The turbidity of the Phase 1 pilot filter was also lower than that of the control water.

The above-mentioned survey results up to August 2019 using the pilot filters by TFT were summarized as a report entitled "RESEARCH REPORT OF FILTER IMPROVEMENT" and submitted to WRAWSA.

Table 2-139: Summary of turbidity reduction of the Phase 2 pilot filter

Phase2 (2018)								
Month	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
No. of Meas.	28	56	58	58	58	61	57	61
No. of > 1 NTU	2	5	3	5	5	6	9	3
Ave. (Pilot basin)	0.29	0.24	0.26	0.26	0.25	0.28	0.53	0.49
Ave. (All basin)	0.88	1.75	2.03	1.65	1.81	2.25	2.10	2.18
Max. (Pilot basin)	2.62	1.92	2.30	3.46	2.02	1.21	2.08	1.57
Max. (All basin)	2.42	6.79	6.20	5.52	8.17	5.65	4.27	4.50

Phase2 (2019)								
Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
No. of Meas.	60	54	57	56	59	56	59	54
No. of > 1 NTU	38	16	16	22	17	21	36	20
Ave. (Pilot basin)	1.00	0.54	0.45	0.81	0.68	0.84	1.06	0.73
Ave. (All basin)	2.21	1.53	1.76	2.99	2.59	2.84	3.20	2.26

Phase2 (2018)								
Max. (Pilot basin)	1.88	2.05	1.90	1.96	1.54	1.96	2.72	2.03
Max. (All basin)	4.68	3.44	4.33	4.80	4.17	4.89	5.76	4.72

Table 2-140: Summary of turbidity reduction of the Phase 1 pilot filter

Phase1 (2018,2019)											
Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.
No. of Meas.	49	55	57	61	55	58	58	59	58	58	55
No. of > 1 NTU	11	16	10	32	23	16	35	31	34	42	38
Ave. (Pilot basin)	0.75	0.78	0.53	0.88	0.73	0.58	1.04	0.94	1.04	1.33	1.28
Ave. (All basin)	4.26	3.78	3.15	3.20	2.05	2.87	3.30	3.65	4.50	4.28	3.73
Max. (Pilot basin)	4.94	1.82	1.35	2.67	2.61	2.48	2.91	2.05	2.13	2.85	2.82
Max. (All basin)	8.72	6.95	7.00	5.85	4.85	4.85	4.92	5.20	7.46	6.90	5.62

3-5-5 Prepare an improvement plan of Nyaunghnapin water treatment plant

The improvement plan of the Nyaunghnapin WTP was created for the purpose of strengthening the water treatment function and performing stable water treatment. The purpose of the plan was to restore and improve the treatment function at the beginning of WTP construction. The improvement contents of the plan in terms of facilities were aligned with the contents of the water quality management plan described later. Table 2-141 shows the outline of the improvement plan.

Table 2-141: Summary of Nyaunghnapin WTP improvement plan

No.	Strategic approach	Initiatives	Improvement target	Expected effect
1	Recovery of filtration function	Improvement of a filter	Replacement with an appropriate filter media	Lowering turbidity of filtered water
2		Maintenance and repair of filter	False floor, Surface washing device, Leak of washing pipe installation point, Inlet valve, Outlet valve	Making filtered water quality constant
3		Optimization of filter washing method	Replacement with large size of washing water drain valve	Maintaining cleanliness of filter media
4		Retention of filtration function	Raising height of filter outflow weir	Retention of water level in filter basin
5	Recovery of sedimentation function	Enhancement of sludge discharge function	Installation of sludge discharge pipe	Lowering turbidity of settled water
6		Prevention of excessive sludge accumulation	Formulation of sludge removal annual plan	Making settled water quality constant
7		Prevention of excessive sludge accumulation	Periodic measurement of sludge depth	Making settled water quality constant
8	Optimization and making intake water volume constant (prevention of frequent changes in water intake amount and prevention of excessive water treatment)	Increase of clear water storage capacity	Expansion of clear water tank	Making clear water quality constant
9	Ensuring cleanliness of clear water tank	Introduction of structure that can perform periodic cleaning of clear water tank	Enabling split operation of clear water tank	Prevention of water quality deterioration

No.	Strategic approach	Initiatives	Improvement target	Expected effect
10	Conducting chlorine disinfection of tap water with sodium hypochlorite	Construction of sodium hypochlorite injection facility	Disinfection of tap water suppling from water treatment plants	Securing tap water safety
11	Appropriate injection of chlorine disinfectant (sodium hypochlorite)	Establishment of O&M procedure	Creation of O&M SOPs and establishment of SOP system at chlorine disinfection facilities	Ensuring inactivation of pathogenic bacteria in tap water
12	Proper O&M of chlorine disinfection facilities	Ensuring implementation of O&M procedure	Training of O&M work procedures for chlorine disinfection facility workers	Stable execution of chlorine disinfection
13	Establishment of SOPs system	Establishment of SOP creation method, documentation of work procedures (creation of SOP) and preparation of work record and storage method	Documentation of existing work procedures, study of validity of the existing procedures and creation of records	Making work procedures appropriately, confirmation of technical base, prevention of work errors and ensuring traceability
14	Maintaining, inheriting and developing appropriate and necessary O&M technical level	Operation of SOPs system at facilities of water treatment plants, etc.	Proper application of SOPs, conducting training at water treatment plants etc., and confirming these activities at site	Stable and permanent operation and maintenance of water treatment plants including reservoirs
15	Increase of Nyaunghnapin water treatment plant capacity	Review of existing facilities and study of treatment method of new facility	Planning and design of new facility reflecting the review results of existing facilities	Stable operation of existing facilities of Nyaunghnapin water treatment plant

3-5-6 Conduct OJT on operation and maintenance of water treatment plant and disinfection facility

At Nyaunghnapin WTP and Yegu pumping station where the disinfection facility was installed, the staff officers conducted OJTs on the basis of the created SOPs for the workers who were in charge of operation and maintenance of the facilities. Table 2-142 shows the number of times each training is conducted.

Table 2-142: Number of OJTs conducted at Nyaunghnapin WTP and Yegu pumping station

Nyaunghnapin WTP	Yegu pumping station
4	3

3-5-7 Verify SOP for water quality management

Yegu PS started SOP trial in January 2019. In the trial, the consistency between the actual operation or maintenance procedure and the contents of the SOPs was confirmed, and it was also confirmed whether all SOPs required for the operation and maintenance were prepared. Based on these studies, the SOP trial results were verified (reviewed) in July 2019. Since it was determined in this verification that the SOPs were being used appropriately, the C/P decided to apply the SOPs officially and systematically.


Photo 2-75: SOP trial verification (review) at Yegu pumping station

The Nyaunghnapin WTP started SOP trial in February 2019 and confirmed the suitability of the SOPs. As a result, the C/P revised the description format and contents of some SOPs and started trial application of the final SOPs in October 2019.

The organizations of the operation and maintenance system of Lagunbyin WTP is shown in Table 2-143. The organization charts of disinfection facilities of Yegu PS, Hlawga PS and Nyaunghnapin WTP are shown in Figure 2-105, Figure 2-106 and Figure 2-107, respectively.

Table 2-143: Organization of the operation and maintenance system of Lagunbyin WTP

Lagunbyin Water Treatment Plant Task Force Team

No.	Name	Position	Duty
1	U Than Han	ACE	Team Leader
2	U Htin Lin Kha	Project Manager	Deputy Team Leader
3	U Soe Kyaing	EE	Electrical Work
4	U Aung Htut Lin	AE	Electrical Work
5	U Aung Moe Kyaw	SAE	Electrical Work
6	U Bhone Thet Naing	SAE	Electrical Work
7	U Zaw Min	EE	Civil Work
8	U Phone Naing	AE	Civil Work
9	U Tint Zaw	AE	Civil Work
10	U Zaw Oo	AE	Mechanical Work
11	U Soe Paing	AE	Preparation work to operate the plant
12	U Ye Tint	AE	Preparation work to operate the plant
13	U Tin Htut	AE	Preparation work to operate the plant
14	U Tun Tun	Supervisor	Preparation work to operate the plant
15	U Yan Naing	Supervisor	Preparation work to operate the plant
16	U Zin Min Latt	SAE	Preparation work to operate the plant
17	U Maung Maung Aye	SAE	Preparation work to operate the plant
18	U Kyaw Swar Min	SAE	Preparation work to operate the plant
19	U Aye Min	Deputy Supervisor	Preparation work to operate the plant

Lagunbyin WTP Trial Test Operation & Maintenance Organization

No.	Responsibilities	Name	Position	Remark
(A)	Intake Facilities	**(1) U Soe Paing** (2) U Aye Min (3) U Kyi Thaung (4) U Aung Soe Kyaw (5) U Than Soe (6) U Kyaw Ye Aung Htoo (7) U Win Tun	**AE** Deputy Supervisor Daily WA WA WA	Trial operation & maintenance, opening channel cleaning, controlling raw water pipeline & recording data

No.	Responsibilities	Name	Position	Remark
(B)	Purification Facilities	**Process Operation & Control for all**		WTP operation & maintenance, Reporting
		(8) U Tin Htut	**AE**	
		Lift Pump, Dividing & Pre-sedimentation Pond		
		(9) U Mg Mg	SAE	Operation & maintenance, valve control, cleaning for pre-sed, L.P, DW recording data & reporting
		(10) U Thet paing Aye	Flat	
		(11) U Ye Kyaw Kyaw	WA	
		(12) U Myint Aung	WA	
		(13) U Ye Htwe Kyaw	WA	
		(14) U Kyaw Zin Win	WA	
		Coagulation, Mixing & Sedimentation		
		(15) U Tun Tun	Supervisor	Dosing for pre-chlorine, dosing for coagulation, cleaning for sedimentation, recording data & reporting
		(16) U San Aung	Skill (4)	
		(17) U Kyaw Zay Ya	Flat	
		(18) U Shine Ko	WA	
		(19) U Kyaw Htay	WA	
		RSF & Clear Water Reservoir		
		(20) U Zin Min Latt	SAE	Operation & maintenance, valve control, cleaning for pre-sed;, L.P, DW recording data & reporting
		(21) U Kyaw Myo Aung	Flat	
		(22) U Ohn Than	Daily	
		(23) U Than Tun Min	WA	
		(24) U Kyaw Swar Hein	WA	
		(25) U Myo Zin Oo	WA	
		(26) U Aung Myo Tun	WA	
		M & E Work		
		(27) U Si Thu Htun	WA	Checking & maintenance
		(28) U Zaw Ye Htike	WA	
		(29) U Min Htet Aung	WA	
		(30) U Wai Phyo Aung	WA	
		(31) U Ko Oo	WA	
		Office Work		
		(32) U Myo Min Htike		Attending, reporting, keeping & recording all data & documents
		(33) U Win Naing		
		(34) U Hla Myin		
(C)	**W.Q.C & Test Bench**	**Water QC & Test for all**		
		(35) U Ye Tint	AE	Operation for meter test bench, water sampling & jar test, maintenance & record data keeping, reporting & safety
		Water QC & Test Bench		
		(36) U Yan Naing	Supervisor	
		(37) U Kyaw Swar Min	SAE	
		(38) U Tun Kyaw	WA	
		(39) U Nay Lin Aung	WA	
		(40) U Zin Min Ko Ko	WA	
		(41) U Htet Aung Kyaw	WA	
		(42) U Aung Myo Ko Ko	WA	

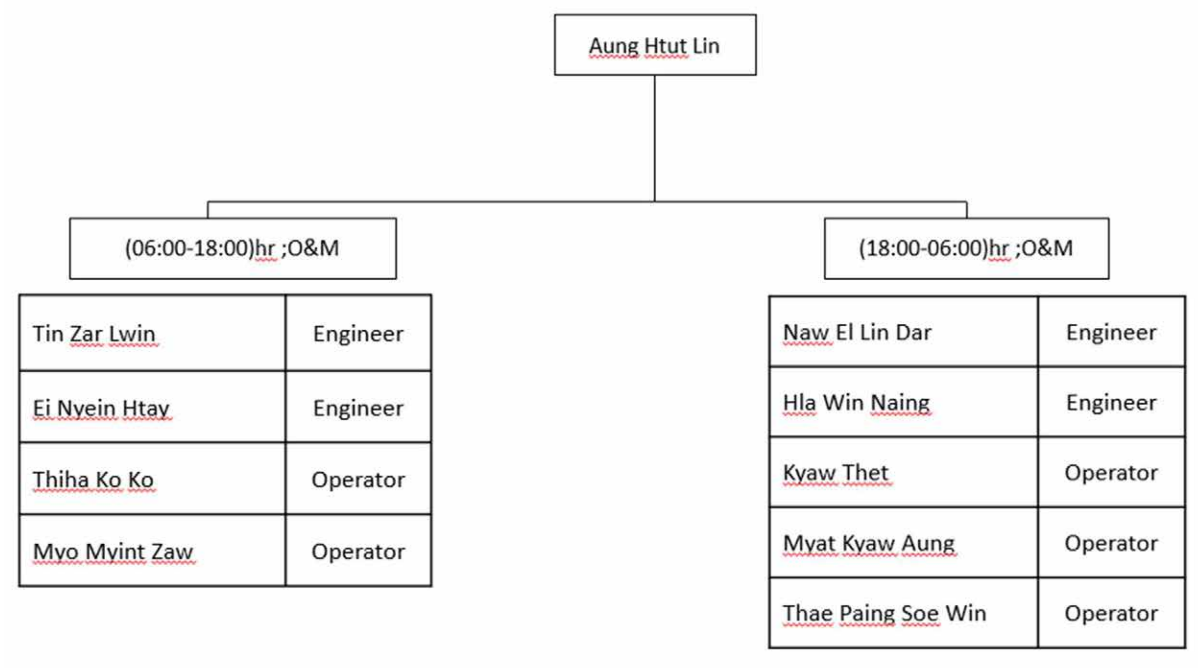


Figure 2-105: Organization chart of disinfection facilities of Yegu P/S

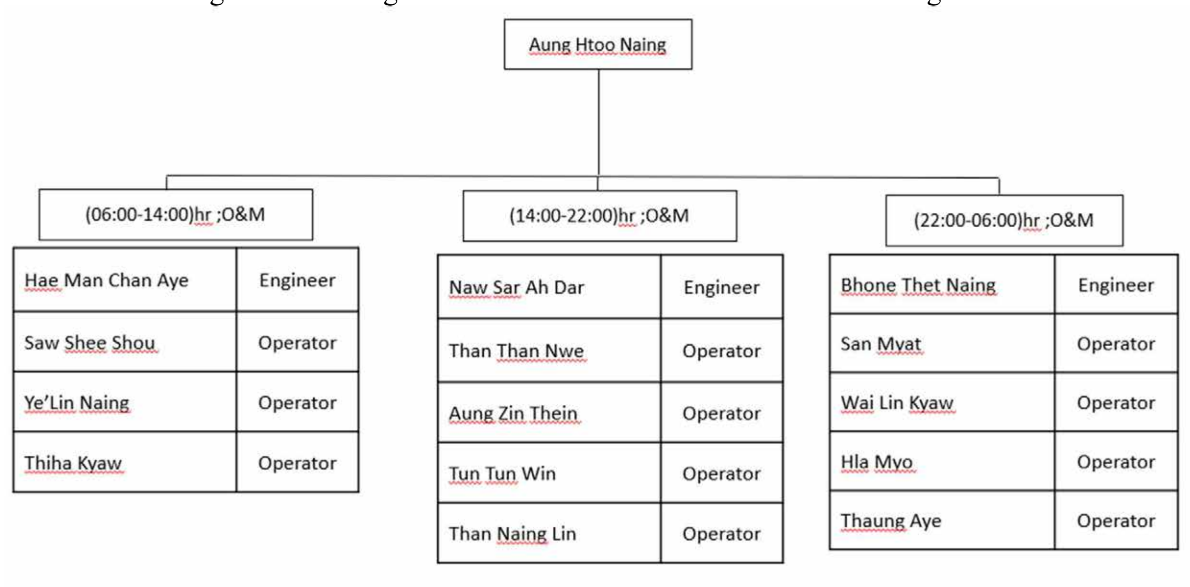


Figure 2-106: Organization chart of disinfection facilities of Hlawga P/S

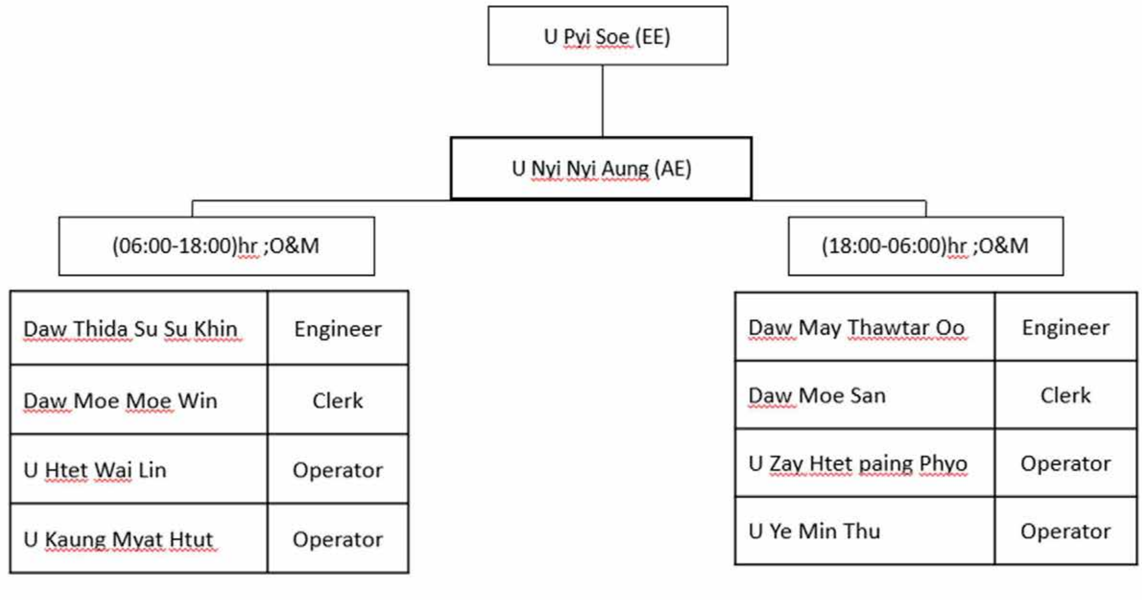


Figure 2-107: Organization chart of disinfection facilities of Nyaunghnapin WTP

3-6 Conduct OJT on improvement of water quality supplied from reservoirs

3-6-1 Review water quality problem of reservoir water

(1) Installation of mini laboratories

The mini laboratories were installed in Gyobyu Reservoir, Phugyi Reservoir, Hlawga Reservoir and Yegu PS in January 2017, and began daily water quality monitoring of turbidity, color, and pH. In addition, periodical (monthly) SS monitoring of reservoir water was started in the central laboratory. Photos of all mini laboratories are shown below.

Gyobyu Reservoir

Phugyi Reservoir

Hlawga Reservoir

Yegu PS

Photo 2-76: Photos of mini laboratories

pH meter Color meter

Photo 2-77: Water quality measurement equipment in mini laboratory (Hlawga Reservoir)

(2) Technical training for mini laboratory

To enhance technical capacity of the staff of the mini laboratories, the staff of the central laboratory conducted travelling technical trainings. The Expert also provided visiting trainings to the mini laboratories on analytical data accuracy management and solving technical problems (e.g., especially for the occurrence of negative values in color measurement).

Photo 2-78: Technical guidance of the central laboratory staff to mini laboratories at sites

Gyobyu Reservoir Hlawga Reservoir

Photo 2-79: Experts' visit training for mini laboratory staff

3-6-2 Research water quality improvement measure of reservoir supply water

(1) Outline of water treatment facility of Gyobyu reservoir

WRAWSA has strongly requested the improvement of water quality in supplied water from Gyobyu reservoir. The water supply capacity of Gyobyu reservoir is 27 MGD (123,000 m^3/day), and supply of water was started in 1940. There is a water treatment facility constructed in 1940s in the area of the reservoir. The facility includes fountain-like aeration, coagulant injection facility and sedimentation basins, which are still in operation. A plan view of the facility is shown in Figure 2-108, and an outline of the flocculation basin and the sedimentation basin is shown in Photo 2-80 and Table 2-144, respectively.

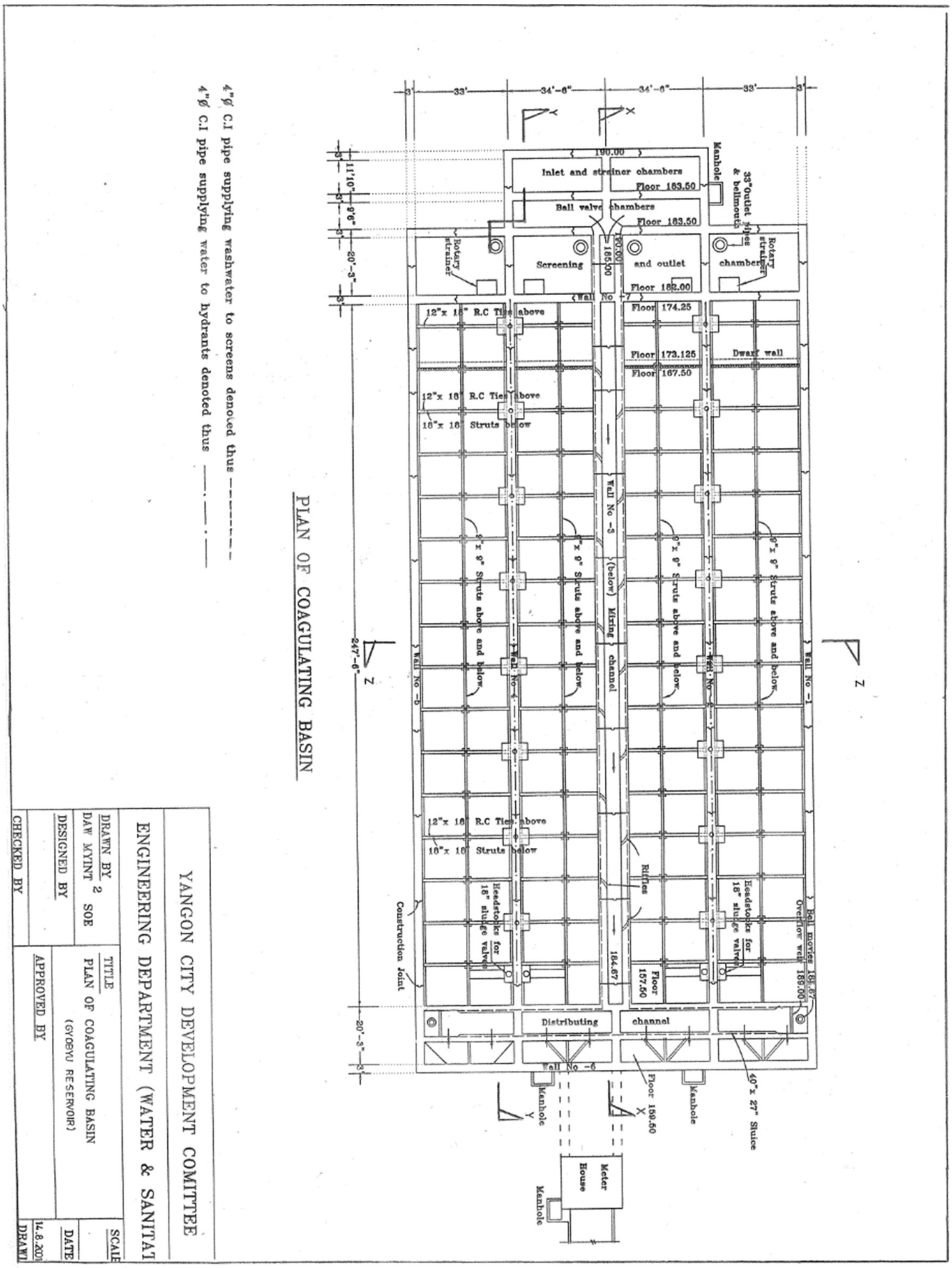


Figure 2-108: Plan view of Gyobyu reservoir treatment facility

Photo 2-80: Gyobyu reservoir treatment facility

Table 2-144: Summary of Gyobyu reservoir treatment facility

Mixing channel

Length	Width	Depth	Volume	Cross section area	Velocity	Retention time
81.7m	2.86m	1.5m	350m^3	4.3m^2	33cm/sec.	4.1min.

Coagulation basin

Length	Width	Depth	No. of basins	Surface area	Surface lord	Retention time
75.5m	10m	4m	4	9966m^2	8.6mm/min.	7.8hour

As described later, the C/P constructed the direct filtration (also referred to as a micro floc method) experimental facilities (hereinafter referred to as a direct filtration apparatus), installed them in Gyobyu reservoir and started experiments in May, 2018. Because of the good results of this treatment experiment, WRAWSA decided to carry out the same experiments in Hlawga reservoir. One of the two experimental devices installed in Gyobyu reservoir was transferred to Hlawga reservoir. After setting up the experimental facility and setting various experimental conditions, the experiments started from October 2018.

Hlawga reservoir also supplies reservoir water without any treatment like Gyobyu reservoir and has similar water quality problems to Gyobyu reservoir. The amount of water resources that Hlawga reservoir can supply is 14 MGD (64,000 m^3/day). In addition, water of 54 MGD (245,000m^3/day) flows into the reservoir from the Phugyi reservoir; therefore, Hlawga pumping stations take 68 MGD (309,000 m^3/day) in total and supply to the downstream part of Hlawga reservoir. Intake and water supply are carried out by two pump stations. No. 1 pump station supplies 14 MGD (64,000 m^3/day) of water under gravity flow without operating the pumps. No.2 pump station supplies 54 MGD (245,000 m^3/day) by operating pumps.

(2) Study of a treatment method

For the treatment of water being supplied from the reservoirs, the direct filtration method was decided to be installed as an experimental apparatus from the following viewpoint.

- A treatment method applicable for any of these reservoirs will be selected.
- Since Gyobyu reservoir area has less flat land, it is impossible to introduce large-scale treatment facilities.
- It is better to have a method that can be converted to coagulation-sedimentation and rapid sand filtration in the future.

The direct filtration method involves filtering the suspended solids in raw water by injecting coagulant and filtering without flocculation. The direct filtration method has advantages including that a settling basin (which need a lage facility) is not required and the injection rate of flocculant can be reduced. This method has been evaluated in the world as a processing method suitable for the case where the turbidity of raw water is low. The outline of the experimental apparatus is shown in Photo 2-81 and Photo 2-82. The experimental filter with a small bore in the photograph was used at Hlawga reservoir. All of these experimental devices are made by the staff of WRAWSA.

The Expert provided some reference papers on direct filtration published in Journal of American Water Works Association when conducting a study on direct filtration with the C/P. The C/P also referred to the paper when they prepared a experiment plan, evaluated and compiled the result. The experimental report was compiled and submitted to WRAWSA. The title of the report is “RESEARCH REPORT OF DIRECT FILTRATION, ENGENERING DEPARTMENT OF WATER AND SANITATION, YCDC”.

References:

1. “Pilot Plant Test of Direct Filtration”, C. A. Tate, J. S. Lang, H. L. Hutchinson, Jour.A.W.W.A., Vol.69, p.375 (July 1977)
2. “Direct Filtration”, R. L. Culp, Jour.A.W.W.A., Vol.69, p.379 (July 1977)
3. “Plant-Scale Comparison of Direct Filtration Versus Conventional Treatment of a La,e Erie Water”, G. P. Westerhoff, A. F. Hess, M. J. Barnes, Jour.A.W.W.A., Vol.72, p.148 (March 1980)

Photo 2-81: Experimental apparatus at Gyobyu reservoir

Photo 2-82: Experimental apparatus at Hlawga reservoir

(3) Experiment at Gyobyu and Hlawga reservoirs

At the start of the experiment, the C/P set up the appointment of site staff for conducting the survey, established the organizational structure, manuals for operation of the direct filtration device and backwash procedures at both reservoirs, and then the survey was started. The C/P listed the following items shown in Table 2-145 as the confirmation and check points of the experiment.

Table 2-145: Confirmation and check points of the experiment

Check Points
Flow Rate
Water Quality(turbidity, color, pH, temp)
Visual inspection (filtered water & air Bubbles)
Filter sand sieve analysis

In Gyobyu reservoir, power outage occurred on a daily basis, so in order to avoid the influence on the experiment, in-house power generation equipment was installed. The experiment was continued once or twice a week steadily from late May 2018.

An experiment at Hlawga reservoir started in October 2018. As a result of analyzing and examining the data obtained from the experiment, it turned out that there was a problem with turbidity measurement. Therefore, the data up to that time was abandoned. The experiment started again from December 2018 after obtaining a new turbidity meter. The experiment conditions of two filters are shown in Table 2-146.

Table 2-146: Experiment conditions of two filters

No.	Parameter	Gyobyu Filter	Hlawga Filter	Remarks
1	Type of filter	Gravity type	Gravity type	
2	Filter diameter	Ø 600 mm	Ø 300 mm	
3	Filtration velocity	150 m/day – 200 m/day	150 m/day – 200 m/day	
4	Filter media	Sand	Sand	
5	Size of media, U.C. & thickness	1 mm, U.C.=1.2, 1 m	0.86 mm, U.C.=1.1, 0.85 m	
6	Filter gravel &depth	2-5 m m= 50 mm 5-9 mm = 100 mm 9-16 mm = 100 mm 25 mm = 50 mm	2-5 m m= 50 mm 5-9 mm = 100 mm 9-16 mm = 100 mm 25 mm = 50 mm	
7	Available water height	1.2 m	1.2 m	
8	Type of washing	Air + Water	Air + Water	
9	Wash condition (water rate& washing time)	0.4-0.9 m/min & 15 min	0.4-0.8 m/min & 12 min	ACH = 3 ppm

1) Gyobyu reservoir

The experiment was conducted hundred and eleven (111) times at the Gyobyu reservoir and the summary of the results are shown in Table 2-147 and Table 2-148. Turbidity of raw and clear water in the table is their measured average turbidity during each experimental run. One cycle of experiment of direct filtration was completed when water flows into the pilot direct filter and the water level in the pilot direct filter reaches 1.2 m (available water level or available head loss) above the filtration sand surface where the overflow pipe was installed. Some experiments might finish at the discretion of the person in charge of the experiments before the water level on the sand surface reached 1.2 m.

Table 2-147: Result of experiment at Gyobyu reservoir (1)

Date	Run	Turbidity (NTU)		Head	Running time	Head loss Increase Rate	Filtration Rate	Head loss Increase
		Raw	Clear	(Final)	(hr)	(m/hr)	verage (m/h	Coefficient
25.5.2018	R1	2.1	0.25	0.95	14.00	0.068	5.167	0.013
26.5.2018	R2	3.62	0.3	1.12	7.50	0.149	4.708	0.032
28.5.2018	R3	2.1	0.25	0.62	11.50	0.054	4.708	0.011
31.5.2018	R4	2.45	0	1.1	6.50	0.169	4.292	0.039
4.6.2018	R5	1.75	0	1.1	8.83	0.125	4.042	0.031
7.6.2018	R6	3.55	0.63	1.1	13.50	0.081	4.125	0.020
13.6.2018	R7	1.3	0.17	0.54	4.50	0.120	4.271	0.028
16.6.2018	R8	0.87	0	1.3	6.50	0.200	3.875	0.052
22.6.2018	R9	1.18	0	0.75	14.58	0.051	4.292	0.012
28.6.2018	R10	0.69	0	1.3	15.92	0.082	4.708	0.017
3.7.2018	R11	1.1	0	1.3	13.67	0.095	4.292	0.022
5.7.2018	R12	0.6	0	1.3	12.67	0.103	5.33	0.019
9.8.2018	R13	1.56	0	1.21	36.00	0.034	5.33	0.006
15.8.2018	R14	2.36	0.08	1.21	18.00	0.067	5.33	0.013
21.8.2018	R15	2.07	0	1.21	25.00	0.048	5.33	0.009
24.8.2018	R16	1.67	0	1.21	23.00	0.053	5.38	0.010
27.8.2018	R17	1.36	0	1.21	22.50	0.054	5.04	0.011
30.8.2018	R18	1.5	0	1.21	27.00	0.045	5.25	0.009
3.9.2018	R19	2.28	0	1.21	26.00	0.047	5.25	0.009
7.9.2018	R20	2.53	0	1.21	28.00	0.043	5.50	0.008
10.9.2018	R21	1.3	0	1.21	28.50	0.042	5.38	0.008
14.9.2018	R22	1.9	0	1.21	25.00	0.048	5.54	0.009
17.9.2018	R23	1.3	0	1.21	16.00	0.076	5.42	0.014
21.9.2018	R24	1	0	1.21	24.00	0.050	5.67	0.009
26.9.2018	R25	2.88	0	1.21	15.50	0.078	8.98	0.009
4.10.2018	R26	2.97	0	1.21	9.00	0.134	8.83	0.015
7.10.2018	R27	2.45	0	1.21	13.50	0.090	7.25	0.012
8.10.2018	R28	3	0	1.21	12.00	0.101	6.84	0.015
11.10.2018	R29	1.91	0	1.21	9.00	0.134	7.17	0.019
14.10.2018	R30	1.47	0	1.21	9.33	0.130	6.94	0.019
17.10.2018	R31	1.8	0	1.21	12.00	0.101	6.88	0.015
21.10.2018	R32	1.67	0	1.21	8.00	0.151	7.00	0.022
24.10.2018	R33	2.5	0	1.21	13.50	0.090	6.83	0.013
27.10.2018	R34	2.67	0	1.21	12.50	0.097	6.33	0.015
30.10.2018	R35	2.33	0	1.21	11.50	0.105	6.46	0.016
2.11.2018	R36	2.27	0	1.21	12.00	0.101	6.29	0.016
5.11.2018	R37	3.11	0	1.21	10.00	0.121	7.04	0.017
11.11.2018	R38	2.97	0	1.21	13.50	0.090	5.96	0.015
17.11.2018	R39	2.16	0.26	1.21	12.50	0.097	6.33	0.015
20.11.2018	R40	2.26	0	1.21	10.50	0.115	6.58	0.018
23.11.2018	R41	2.5	0	1.21	9.00	0.134	6.88	0.020
26.11.2018	R42	2.16	0.26	1.21	9.00	0.134	6.88	0.020
4.12.2019	R43	4.7	0	1.21	10.00	0.121	6.63	0.018
7.12.2018	R44	3.2	0	1.21	10.00	0.121	7.25	0.017
10.12.2018	R45	4.62	0	1.21	10.50	0.115	6.96	0.017
14.12.2018	R46	1.76	0	1.21	10.50	0.115	7.00	0.016
18.12.2018	R47	1.5	0	1.21	11.00	0.110	6.96	0.016
22.12.2018	R48	0.98	0	1.21	10.00	0.121	6.79	0.018
25.12.2018	R49	0.9	0	1.21	10.00	0.121	6.75	0.018
28.12.2018	R50	1.66	1.45	1.21	11.00	0.110	6.56	0.017
31.12.2018	R51	2.01	0	1.21	11.00	0.110	6.75	0.016
12.1.2019	R52	0.95	0	1.21	12.00	0.101	6.67	0.015
18.1.2019	R53	0.86	0	1.21	12.00	0.101	7.08	0.014
19.1.2019	R54	0.93	0	1.21	12.00	0.101	6.88	0.015
21.1.2019	R55	0.73	0	1.21	11.50	0.105	6.88	0.015
24.1.2019	R56	1.49	0	1.21	12.00	0.101	7.25	0.014
27.1.2019	R57	1.57	0	1.21	12.00	0.101	7.15	0.014
30.1.2019	R58	2.54	0	1.21	12.00	0.101	7.15	0.014
3.2.2019	R59	1.26	0	1.21	12.00	0.101	7.15	0.014
6.2.2019	R60	1.31	0	1.21	12.00	0.101	7.15	0.014

Table 2-148: Result of experiment at Gyobyu reservoir (2)

Date	Run	Turbidity (NTU)		Head	Running time	Head loss Increase Rate	Filtration Rate	Head loss Increase
		Raw	Clear	(Final)	(hr)	(m/hr)	verage (m/h	Coefficient
9.2.2019	R61	1.59	0	1.21	12.00	0.101	7.15	0.014
13.2.2019	R62	1.91	0	1.21	12.00	0.101	7.15	0.014
16.2.2019	R63	1.86	0	1.21	12.00	0.101	7.15	0.014
19.2.2019	R64	3.74	0	1.21	12.50	0.097	7.15	0.014
22.2.2019	R65	3.21	0	1.21	11.50	0.105	7.15	0.015
25.2.2019	R66			1.21	11.00	0.110	6.64	0.017
28.2.2019	R67			1.21	14.00	0.086	6.96	0.012
6.3.2019	R68	3.39	0.3	1.21	12.50	0.097	6.88	0.014
9.3.2019	R69	2.9	0.44	1.21	13.25	0.091	6.72	0.014
12.3.2019	R70	3.9	0	1.21	11.00	0.110	6.67	0.016
15.3.2019	R71	3.49	0.49	1.21	12.00	0.101	6.44	0.016
18.3.2019	R72	2.73	0.05	1.21	11.50	0.105	6.710	0.016
21.3.2019	R73	2.393	0.08	1.21	13.00	0.093	6.300	0.015
25.3.2019	R74			1.21	12.00	0.101	6.590	0.015
28.3.2019	R75			1.21	11.00	0.110	6.350	0.017
31.3.2019	R76			1.21	12.50	0.097	6.547	0.015
3.4.2019	R77	5.43	1.49	1.21	11.00	0.110	6.480	0.017
6.4.2019	R78	4.93	1.25	1.21	11.00	0.110	6.700	0.016
10.4.2019	R79	5.88	1.16	1.21	13.00	0.093	6.500	0.014
13.4.2019	R80	6.01	1.26	1.21	12.50	0.097	6.540	0.015
17.4.2019	R81	5.84	1.12	1.21	12.50	0.097	6.550	0.015
20.4.2019	R82	4.79	1.14	1.21	13.00	0.093	6.830	0.014
23.4.2019	R83			1.21	11.50	0.105	4.920	0.021
24.4.2019	R84			1.21	13.00	0.093	6.375	0.015
27.4.2019	R85			1.21	12.00	0.101	6.580	0.015
30.4.2019	R86			1.21	12.00	0.101	6.670	0.015
4.6.2019	R87	2.21	0.12	1.21	11.00	0.110	5.796	0.019
7.6.2019	R88	2.72	0.17	1.21	7.50	0.161	5.846	0.028
10.6.2019	R89	2.47	0.12	1.21	10.50	0.115	6.083	0.019
13.6.2019	R90	1.61	0	1.21	11.00	0.110	6.271	0.018
16.6.2019	R91	1.95	0.06	1.21	11.50	0.105	6.142	0.017
19.6.2019	R92	1.51	0	1.21	11.50	0.105	5.888	0.018
22.6.2019	R93	2	0	1.21	11.50	0.105	6.104	0.017
25.6.2019	R94	3.16	0	1.21	11.50	0.105	5.885	0.018
28.6.2019	R95	1.37	0.01	1.21	14.50	0.083	7.354	0.011
1.7.2019	R96	1.51	0	1.21	13.50	0.090	5.917	0.015
4.7.2019	R97	2.77	0	1.21	14.00	0.086	6.129	0.014
7.7.2019	R98	2.2	0.03	1.21	13.50	0.090	6.117	0.015
10.7.2019	R99	2.14	0	1.21	14.50	0.083	5.8375	0.014
13.7.2019	R100	1.8	0.04	1.21	14.50	0.083	5.9125	0.014
16.7.2019	R101	1.88	0	1.21	14.50	0.083	6.175	0.014
19.7.2019	R102	2.9	0.04	1.21	14.00	0.086	6.292	0.014
22.7.2019	R103	2.27	0.07	1.21	14.00	0.086	5.9875	0.014
25.7.2019	R104	1.72	0	1.21	14.00	0.086	6.1167	0.014
28.7.2019	R105	1.84	0.03	1.21	14.50	0.083	6.1333	0.014
31.7.2019	R106	2.79	0.06	1.21	14.50	0.083	6.0875	0.014
3.8.2019	R107	1.35	0	1.21	14.00	0.086	5.9375	0.015
6.8.2019	R108	2.51	0.03	1.21	14.50	0.083	6.3425	0.013
8.8.2019	R109	2.22	0.09	1.21	14.00	0.086	6.0000	0.014
10.8.2019	R110	2.85	0.11	1.21	13.50	0.090	6.0583	0.015
13.8.2019	R111	1.44	0.39	1.21	15.50	0.078	5.9833	0.013

Figure 2-109 shows the raw water turbidity and filtered water turbidity of each experiment. The raw water turbidity increased in April, the second half of the dry season, and high turbidity in raw water was detected continuously at several times. After that, it decreased to the value before the turbidity increase started. A phenomenon was observed in which the turbidity of the filtrate increased simultaneously with the increase of the raw water turbidity.

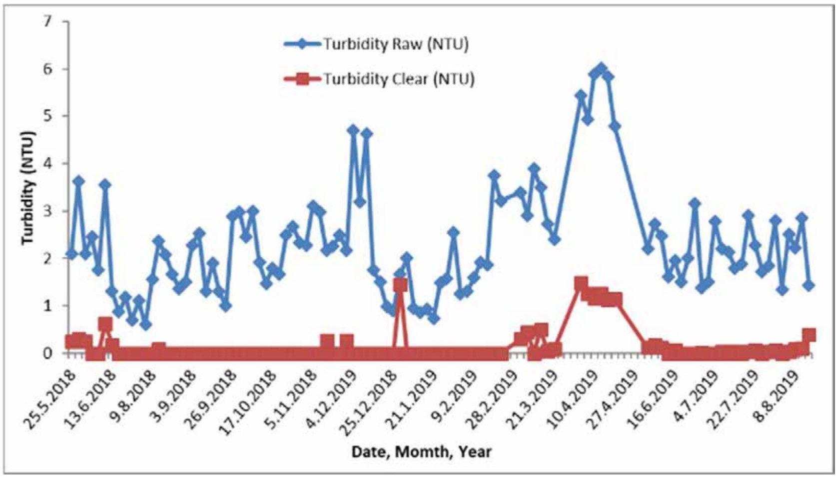


Figure 2-109: Average turbidity of raw and clear water of all experiment run in Gyobyu

2) Hlawga reservoir
The experiment was conducted from October 6, 2018 to April 30, 2019. One cycle of experiment of direct filtration was completed when the water level in the pilot direct filter reached 1.1 m (available water level or available head loss) above the filtration sand surface where the overflow pipe was installed. Some experiments were stopped at the discretion of the person in charge of the experiments before the water level on the sand surface reached 1.1m. 47 experiments were conducted during the research period. All experimental results of Hlawga are summarized in Table 2-149. The turbidity values shown in the table are the average of the turbidity measured during each experiment for both raw and filtered water.

Figure 2-110 shows the raw water turbidity and filtered water turbidity of each experiment. The raw water turbidity was less than 4 during this experimental period, and large change of raw water turbidity was not observed. As shown here, turbidity increase in April, which was observed in Gyobyu raw water, was not confirmed in Hlawga raw water.

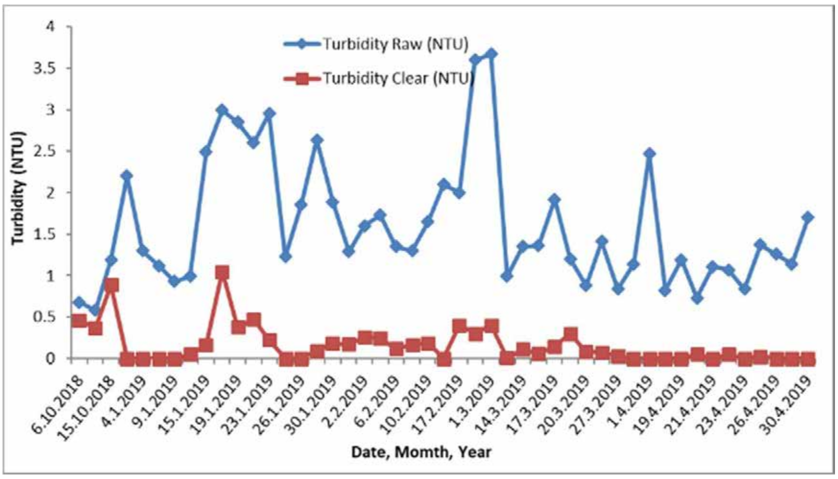


Figure 2-110: Experimental result at Hlawga reservoir

Table 2-149: Result of experiment at Hlawga reservoir

Date	Run	Turbidity (NTU)		Head	Running time	Head loss Increase Rate	Filtration Rate	Head loss Increase
		Raw	Clear	(Final)	(hr)	(m/hr)	verage (m/h	Coefficient
6.10.2018	R1	0.68	0.46	1.2	32.00	0.038	7.417	0.005
12.10.2018	R2	0.58	0.37	1.2	45.00	0.027	7.000	0.004
15.10.2018	R3	1.19	0.89	1.2	18.00	0.067	8.042	0.008
1.1.2019	R4	2.2	0	1.2	40.00	0.030	7.687	0.004
4.1.2019	R5	1.3	0	1.2	20.00	0.060	7.617	0.008
7.1.2019	R6	1.12	0	1.2	22.00	0.055	5.167	0.011
9.1.2019	R7	0.93	0	1.2	28.00	0.043	7.770	0.006
12.1.2019	R8	0.99	0.05	1.2	26.00	0.046	7.898	0.006
15.1.2019	R9	2.49	0.16	1.2	31.00	0.039	8.180	0.005
17.1.2019	R10	2.99	1.05	1.2	30.00	0.040	7.833	0.005
19.1.2019	R11	2.85	0.375	1.2	24.00	0.050	7.839	0.006
20.1.2019	R12	2.6	0.475	1.2	34.00	0.035	7.82	0.005
23.1.2019	R13	2.95	0.22	1.2	27.00	0.044	7.68	0.006
25.1.2019	R14	1.23	0	1.2	22.00	0.055	8.09	0.007
26.1.2019	R15	1.86	0	1.2	33.00	0.036	8.11	0.004
28.1.2019	R16	2.64	0.095	1.2	31.00	0.039	7.42	0.005
30.1.2019	R17	1.89	0.179	1.2	36.00	0.033	8.04	0.004
1.2.2019	R18	1.29	0.17	1.2	21.00	0.057	8.13	0.007
2.2.2019	R19	1.6	0.26	1.2	28.00	0.043	8.13	0.005
5.2.2019	R20	1.73	0.241	1.2	33.00	0.036	8.02	0.005
6.2.2019	R21	1.35	0.12	1.2	22.00	0.055	7.93	0.007
9.2.2019	R22	1.3	0.167	1.2	29.00	0.041	7.27	0.006
10.2.2019	R23	1.65	0.186	1.2	17.00	0.071	7.83	0.009
12.2.2019	R24	2.1	0	1.2	21.00	0.057	7.27	0.008
17.2.2019	R25	2	0.4	1.2	26.00	0.046	7.75	0.006
1.3.2019	R26	3.6	0.3	1.2	30.00	0.040	7.99	0.005
1.3.2019	R27	3.67	0.4	1.2	31.00	0.039	7.99	0.005
13.3.2019	R28	0.99	0.004	1.2	22.00	0.055	7.36	0.007
14.3.2019	R29	1.35	0.11	1.2	33.00	0.036	7.49	0.005
16.3.2019	R30	1.36	0.06	1.2	20.00	0.060	7.54	0.008
17.3.2019	R31	1.92	0.145	1.2	23.00	0.052	8.11	0.006
18.3.2019	R32	1.2	0.3	1.2	37.00	0.032	8.00	0.004
20.3.2019	R33	0.88	0.077	1.2	19.00	0.063	7.66	0.008
21.3.20199	R34	1.41	0.075	1.2	36.00	0.033	7.91	0.004
27.3.2019	R35	0.84	0.025	1.2	34.00	0.035	7.87	0.004
29.3.2019	R36	1.14	0	1.2	18.00	0.067	7.88	0.008
1.4.2019	R37	2.47	0.0025	1.2	12.00	0.100	8.00	0.013
4.4.2019	R38	0.82	0.002	1.2	13.00	0.092	7.69	0.012
19.4.2019	R39	1.19	0	1.2	10.00	0.120	7.69	0.016
20.4.2019	R40	0.73	0.05	1.2	20.00	0.060	7.70	0.008
21.4.2019	R41	1.11	0	1.2	23.00	0.052	7.59	0.007
22.4.2019	R42	1.07	0.05	1.2	14.00	0.086	7.62	0.011
23.4.2019	R43	0.84	0	1.2	19.00	0.063	7.63	0.008
24.4.2019	R44	1.37	0.02	1.2	34.00	0.035	7.52	0.005
26.4.2019	R45	1.26	0	1.2	27.00	0.044	7.88	0.006
29.4.2019	R46	1.14	0	1.2	27.00	0.044	7.78	0.006
30.4.2019	R47	1.7	0	1.2	19.00	0.063	7.60	0.008

3) Manganese concentration in raw water of Gyobyu and Hlawga reservoirs

Total manganese concentration and soluble manganese ion concentration in raw water were measured in March and April, 2019 when the water level in the reservoir decreased. Water quality standard of manganese is 0.4 mg/L. It is known that the color of tap water is increased by chlorine disinfection when manganese ions are contained at around 0.05 mg/L or more.

In both months, raw water from each reservoir was sampled and filtered using a membrane filter with a pore size of 0.45 μm. This sample water contained manganese dissolved in water and the measured manganese concentration was soluble manganese (manganese ion). Moreover, the manganese concentration of the test water which was not filtered was measured. This is the total manganese concentration, which was the total of insoluble and soluble manganeese. All measured results are shown in Table 2-150. About 0.38 mg/L total manganese and about 0.31 mg/L manganese ion were detected in Gyobyu raw water sampled in April 29. That is, insoluble manganese concentration was 0.07 mg/L, and dissolved concentration was 0.31 mg/L.

Total manganese concentration in the raw water of both reservoirs in March and the raw water of the Hlawga reservoir in April were 0.1 mg/L to 0.13 mg/L. The maximum manganese ion concentration that develops color in water by chlorine disinfection was 0.045 mg/L and it was low. Manganese that is not dissolved in water can be removed by a direct filtration treatment, so there is no problem even if the concentration is high. On the other hand, dissolved manganese cannot be removed by a direct filtration method, and it develops color by subsequent chlorine disinfection.

The cause of the high concentration of dissolved manganese in the reservoir raw water is unknown. April, when manganese is detected, is the end of the dry season and this is the time when the water level in the reservoir is lower than usual. When water level is low, a lower layer of water in the reservoir is taken as raw water. It is well known that in a reservoir at a certain depth, the water in the reservoir is stratified. Dissolved oxygen concentration in the water in the lower part of the stratified reservoir decreases because dissolved oxygen is not supplied. Therefore, the oxidized metal compounds such as manganese and iron contained in a sediment are reduced and dissolved into water in the form of ions. In the future, it will be necessary to monitor the soluble and insoluble manganese concentration in the raw water of both reservoirs, especially Gyobyu reservoir, to understand the behavior in manganese concentration throughout the year. Since April 2019, the central Laboratory of WRAWSA has regularly measured the soluble and insoluble manganese concentrations in raw in water all reservoirs.

Methods to avoid or prevent the problems caused by soluble manganese that may occur when chlorinated include, (1) method to prevent the generation of high-concentrated soluble manganese in the reservoir, (2) method of avoiding intake of raw water containing high concentration of soluble manganese in reservoir, (3) method of removing soluble manganese contained in raw water, and (4) controlling residual chlorine concentration for disinfection of tap water so as not to develop color in water. It is required to comprehensively study the monitoring results of manganese, etc., to determine whether countermeasures for soluble manganese are necessary or not, and what methods are to be adopted when countermeasures are necessary.

Table 2-150: Concentration of manganese in Gyobyu and Hlawga reservoirs

	25th, March		**29th, April**	
Reservoir	Gyobyu	Hlawga	Gyobyu	Hlawga
Dissolved	0.045 mg/L	0.003 mg/L	0.307 mg/L	0.002 mg/L
Total	0.106 mg/L	0.127 mg/L	0.379 mg/L	0.129 mg/L

4) Checking the washing condition of the pilot direct filter

The pilot direct filter used in the direct filtration experiment was washed by air backwash and water backwash. Washing conditions are shown in Table 2-146, and it was examined whether the pilot direct filter was effectively washed under these conditions. In the survey, wash water drainage was sampled at regular intervals and its turbidity was measured.

The method of washing was as folows. The water level at 20 cm was lowered above the surface of the filter sand, and then air backwashing for 2 minutes was performed, followed by air backwashing and water backwashing at the same time for 5 minutes, and finally only water backwashing was continued. Sample of drainage water was collected every 1 minute from the time when the water level in the pilot direct filter rose after the start of water backwashing and the wash water drainage began to flow out from the drainage pipe. An example of the turbidity measurement results of the wash water drainage is shown in Figure 2-111 and the appearance of the samples are shown in Photo 2-83. The turbidity of the drainage increased to over 700 NTU, then decreased rapidly to about 2 NTU after 8 minutes. From this result, it was found that the washing condition were appropriate, and the pilot direct filter was washed appropriately.

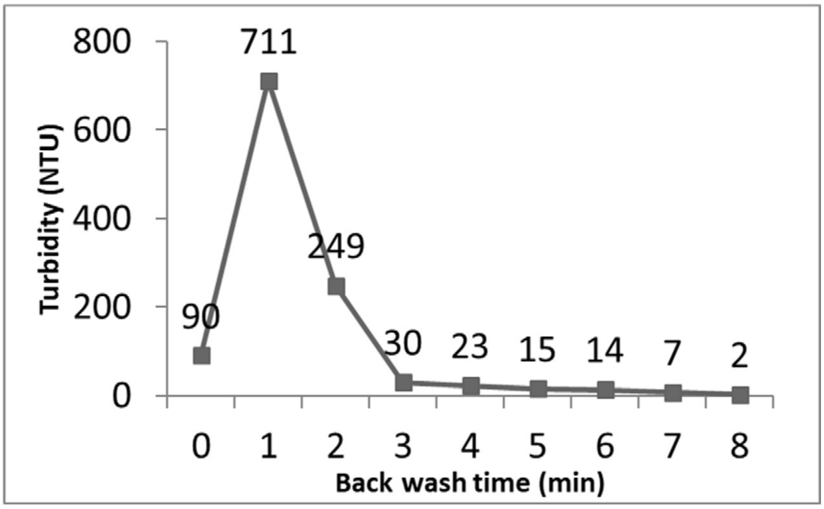


Figure 2-111: Change of turbidity of wash water drainage

Photo 2-83: Appearance of backwash drainage

As described in this section, it was evaluated that the direct filtration method could be used for the treatment method of raw water of the reservoirs used by WRAWSA as a water source. On the other hand, there are still some issues such as treatment of manganese ions contained in raw water and confirming the basic design parameters necessary for designing the actual facility. The results of this research using the pilot direct filter were compiled into a report including future issues and this activity was completed.

3-7 Develop and support implementation of the water quality management plan

3-7-1 Develop 5-year and 10-year water quality management plan

Water quality management plan (draft) with 2 sections: water quality monitoring and water treatment, was prepared. The detailed plan is shown in Annex 6.C and the outline of the plan is as follows.

(1) Water quality monitoring

Implementation items

The implementation items in water quality management plan (water quality monitoring) are as follows:

- ✓ Establishment of water quality monitoring organization for urban tap water monitoring
- ✓ Enhancement of water quality management capacity in water source area
- ✓ Capacity enhancement of the central laboratory
- ✓ Support of new WTP laboratory

For each implementation items, the following will be done:

1. Establishment of water quality monitoring organization for urban tap water monitoring
- ✓ Establishing a monitoring organization in collaboration with the central laboratory and township or district office
- ✓ Procurement of equipment for residual chlorine monitoring
- ✓ Preparation of SOPs
- ✓ Establish training methods and conduct training for township or district offices staff
- ✓ Develop tap water monitoring plan including monitoring items, monitoring points and monitoring frequency

2. Improving water quality management capacity in the water source area
- ✓ Capacity enhancement of minilab’s staffs
- ✓ Revision of minilabs' SOPs
- ✓ Provide technical guidance to minilab’s staffs

3. Enhancement of the capacity of the central laboratory
- ✓ Implementation of heavy metal measurement by AAS and development of SOPs
- ✓ Introduction of standard measurement methods

4. Support of new WTP laboratory
- ✓ Review of water quality monitoring items and monitoring plan
- ✓ Establishment of water quality monitoring organization for Lagunbyin WTP and Kokkowa WTP laboratories in corporation with the central laboratory
- ✓ Training of laboratory staff of Lagunbyin WTP and Kokkowa WTP

Long-term capacity building

For the above implementation items, following continual capacity building is implemented.

1. Continuation of tap water monitoring in urban area
- ✓ Continuing implementation of urban tap water monitoring
- ✓ Continuing training to township or district office staff
- ✓ Using tap water quality monitoring data to improve tap water quality

2. Continuing enhancement of water quality management capacity in the water source area
- ✓ Continuing technical enhancement of minilab’s staffs
- ✓ Using water quality monitoring data to improve water quality of water sources

3. Capacity enhancement of water quality data analysis and ability to disseminate information
- ✓ Preparation of regular water quality reports and enhancement of their content
- ✓ Publication of water quality information in collaboration with PR section
- ✓ Participation in seminars and conferences

4. Capacity enhancement of new WTP laboratory

- ✓ Continuing to enhance technical capacity and implement technical guidance for new WTP laboratory.
- ✓ Using water quality monitoring data to O&M of WTP

(2) Water quality management (Water treatment)

1. Improvement of Nyaunghnapin WTP water quality
   1) Replacement of the filter media used in the present filters with filter media of adequate specifications
   2) Optimization of the filter backwash function
   3) Recovery of sludge discharge function of sedimentation basins
   4) Optimization and making constant the intake water volume (prevention of frequent changes in water intake amount and prevention of excessive water treatment)
   5) Ensuring cleanliness of clear water tanks
   6) Securing the processing capacity margin in Nyaunghnapin water treatment plant (Increase of Nyaunghnapin water treatment plant capacity)

2. Improvement of water quality supplying from reservoirs
   1) Study on water purification treatment method
   2) Water quality preservation of the reservoirs

3. Disinfection of tap water
   1) Conducting chlorine disinfection of tap water with sodium hypochlorite (Appropriate injection of chlorine disinfectant)

4. Establishment and execution of standard O&M work procedures at disinfection facilities, water purification plants, etc.
   1) Establishment of standard operating procedure (SOPs) system, succession of technical information in EDWS and developing appropriate and necessary O&M technical level

5. Prevention of water quality deterioration in distribution tanks in the distribution area
   1) Ensuring cleanliness of distribution tanks

3-7-2 Launch priority activities as a part of implementing 5-year water quality management plan

During the implementation period of the Project, following activities were started:

(1) Water quality monitoring

- Improvement of water quality analysis equipment
  AAS was introduced by WRAWSA in 2018 to enhance capacity of metal analysis. The Expert implemented necessary technical support to enhance the capacity of AAS analysis. Furthermore, the central laboratory staff participated in a training course in Japan (Hiroshima Prefecture) and acquired the necessary knowledge.
- Expansion of the monitoring area for residual chlorine to address new chlorination facilities
  In cooperation with chlorine disinfection TFT, the central laboratory started to study the residual chlorine monitoring method. To obtain basic data for this purpose, the residual chlorine was investigated downstream of the Yegu PS (reservoir raw water supply area) and downstream of the Nyaunghnapin WTP (treated water supply area).

(2) Water quality management

- Priority was given to modifying the sedimentation basins and improving the rapid sand filters in Nyaunghnapin WTP. The WTP has 24 sedimentation basins in total, and 2 of them were remodeled. The modification was designed to efficiently remove sludge accumulated at the bottom, and other sedimentation basins will be dealt with after evaluating the modification.

- Improvement of the rapid sand filters
  The plan for the improvement of the rapid sand filters was prepared as shown in Figure 2-112.

No.	Items	First Year	Second Year	Third Year
1.	Filter Sand purchase	⟶		
2.	Gravel purchase	⟶		
3.	Anthracite purchase	⟶	⟶	⟶
4.	Nozzle purchase		⟶	⟶
5.	Valves purchase			
	(A) Raw water Valves – 24”	⟶	⟶	
	(B) Clear water Valves – 24”	⟶	⟶	
	(C) Drain valves – 18”	⟶		
6.	Surface washing pipes		⟶	⟶
7.	Filter sand sieving		⟶	⟶
8.	Gravel sieving		⟶	⟶
9.	Valves replacement		⟶	⟶
10.	Structure repairing work		⟶	⟶
11.	Filter media replacement		⟶	⟶
12.	Test run & Data Record			⟶

Figure 2-112: Plan for filter improvement in Nyaunghnapin WTP

2.3. Other Activities

2.3.1. JICA Advisory Committee (AC) and Joint Coordinating Committee (JCC) Meeting

(1) JICA Advisory Committee

JICA Advisory Committee was organized by JICA, Bureau of Waterworks of Tokyo Metropolitan Government and Fukuoka City Waterworks Bureau. The members were dispatched in Myanmar once a year and participated in Joint Coordinating Committee meeting and Myanmar Japan Joint Seminar (MJJS) until the 3rd JCC. The activities of AC members in Myanmar were separated from JCC activities since the JCC in fiscal year (FY) 2017. The dispatch of AC members was suspended in FY2018 and resumed in FY2019.

Table 2-151: List of advisory committee members

Affiliation	Department	Name	Assignment
Bureau of Waterworks, Tokyo Metropolitan Government	Director, Construction Section I, West Area Construction Office	Mr. Hiroshi TANIGUCHI	Management plan and human resources development
	Director, Water Supply Section, North Area Branch Office,	Mr. Nobukazu IBARAKI	
	Director, Construction Section I, West Area Construction Office	Mr. Naoki HAMANAKA	
	Manager of Nerima Service Station	Mr. Noriaki NAGANUMA	Finance and waterworks management
	Manager of Setagaya Service Station	Mr. Naoyuki TAKAHASHI	
	Manager of Sumida Service Station	Mr. Toru SUGIYAMA	
	Director, Water Distribution Section, East Area Branch Office	Mr. Takao MATSUNO	NRW management technology (Training plan, Manuals, Lectures for physical loss)
	Director, Construction Section II, East Area Construction Office	Mr. Osamu MATSUBA	
	Director, Water Distribution Section II, East Area Branch Office	Mr. Yuji AOKI	
	Supervisor for Accounting Investigation, Finance Section	Mr. Naoki INAGAWA	Assistance
	Deputy Director for International Affairs Team, Planning and Coordination Section, General Affairs Division	Mr. Takao HOSHINO	
Fukuoka City Waterworks Bureau	Chief, Management & Planning Section, General Affairs Department	Mr. Masaru MATSUOKA (Mr. Yuki TOKUTOMI as replacement)	NRW management technology (Pilot project, DMA, and practical training for physical loss)
	Chief, Administration Section, Water Purification Department	Mr. Kohei IKOUGA	NRW management Technology (Non-physical loss) and Public Awareness
	Management & Planning Section, General Affairs Department	Mr. Keizo WATANABE	
	Chief, Takamiya Water Purification Plant, Water Purification Department	Mr. Noriyuki HAYASHI	Water treatment and disinfection technology
	Director, Water Quality Center, Water Treatment Department	Mr. Yoshinobu KIUCHI	Water quality management

Affiliation	Department	Name	Assignment
	Director, Water Quality Center, Water Treatment Department	Mr. Kenji KIMURA (Koichi AKAGI as replacement)	
	Director, Water Quality Center, Water Treatment Department	Mr. Kenji KIMURA	

(2) Schedule and main theme of Joint Coordinating Committee

The outline and main themes of JCC and the implementation image are shown below. The minutes of meeting of JCC are given in Appendix 6.

Table 2-152: Outline of JCC

S.N	Date	AC participation	Main theme	Participants
1st JCC	27~29, Jan. 2016	1st ACS	Establish **Future Vision of Water Utility Management of YCDC** (Utility Financial Management, NRW and Water Quality Management)	Day1=67 Day2=78 Day3=70
2nd JCC	25, Aug. 2016	No	Establish **New Organization**	108
3rd JCC	30, 31 Jan, 1 Feb. 2017	2nd ACS	Overview of **Planning and Rules** to guide actions of new organization for achievement of future vision	Day1=95 Day2=88 Day3=75
4th JCC	7 Sept, 2017	No	Good **Governance**/ Sustainable Utility and Management Improvement Plan	93
5th JCC	26 Feb 2018	3rd (separate)	Follow-up of **Improvement Actions** on-going	105
6th JCC	10 Oct 2018	No	Finalization of **Mid-term plan** (2018-2020) of WRAWSA	116
7th JCC	1 Mar 2019	No	Toward the Project Success and further growth to achieve WRAWSA Vision	137
8th JCC	24 Oct 2019	No	Toward Sustainable **Human Resource Management**	103
9th JCC	30 Jan 2020	4th (separate)	The Result of **Terminal Evaluation** (Achievements, Evaluation, Recommendations and Lessons Learned of the Project)	91

Rules=Regulations, standards, guidelines, and manuals

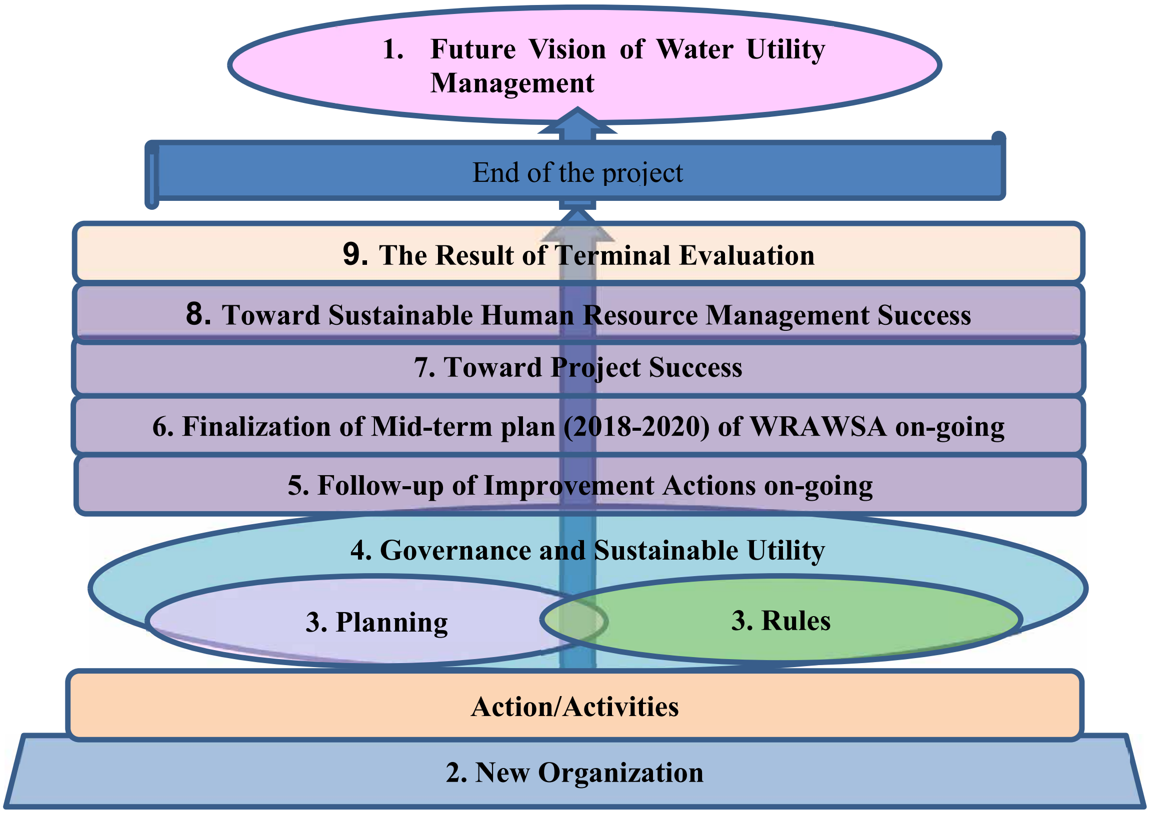


Figure 2-113: Outline and main themes of JCC and implementation image

Table 2-153: Record of implementation of JCC

JCC and AC meeting	Period
1st JCC and 1st MJJS (Myanmar Japan Joint Seminar)	27th to 29th Jan 2016
2nd JCC	25th Aug 2016
3rd JCC and 2nd MJJS	30th Jan to 1st Feb 2017
4th JCC	7th Sept 2017
5th JCC	26th Feb 2018
3rd AC meeting part 1 (Output 2)	2nd to 6th Feb 2018
3rd AC meeting part 2 (Output 1)	21st to 23rd Feb 2018
3rd AC meeting part 3 (Output 3)	21st to 23rd Mar 2018
6th JCC	10th Oct 2018
7th JCC	1st Mar 2019
8th JCC	24th October, 2019
9th JCC	30th January, 2020
4th AC meeting part 1 (AC members of Fukuoka city)	21st to 24th October 2019
4th AC meeting part 2 (AC members of Tokyo Metropolitan Government)	15th to 17th January, 2020

(3) Record of dispatch of AC members

The record of dispatch of AC members is shown below.

Table 2-154: Record of dispatch of AC

Affiliation	Department	Name	Affairs	Dispatch
JICA	JICA Senior Advisor Deputy Director General, Global Environment Department (GED)	Mr. Shigeyuki MATSUMOTO	Chief of JICA Advisory Committee Team Leader of Terminal Evaluation Team	Jan 2020 (9th JCC)
	Director, Water Resources Management Team 1, GED	Mr. Makoto IWASE	Team Leader of Monitoring Mission	Oct. 2019 (8th JCC)

Affiliation	Department	Name	Affairs	Dispatch
	Water Resources Management Team 1, Global Environment Department	Mr. Hiroaki HASHIMOTO	Project management	24th to 29th Jan 2016
		Mr. Koji NAKASHIMA	Project management	21st to 26th Jan 2016 26th Jan to 2nd Feb 2017
	Water Resources Team 1, Global Environment Department	Ms. Risa ARAMAKI	Project management	Oct. 2019 (8th JCC)
Bureau of Waterworks, Tokyo Metropolitan Government	Director, Construction Section I, West Area Construction Office	Mr. Hiroshi TANIGUCHI	Water supply management planning, Human resources development	24th to 29th Jan 2016
	Director, Water Supply Section, North Area Branch Office,	Mr. Nobukazu IBARAKI		24th to 29th Jan 2016
	Director, Construction Section I, West Area Construction Office	Mr. Naoki HAMANAKA		21st to 23rd Feb 2018 15th to 17th Jan 2020
	Manager of Nerima Service Station	Mr. Noriaki NAGANUMA	Financial management	24th to 29th Jan 2016 29th Jan to 1st Feb 2017
	Manager of Setagaya Service Station	Mr. Naoyuki TAKAHASHI		21st to 23rd Feb 2018
	Manager of Sumida Service Station	Mr. Toru SUGIYAMA		15th to 17th Jan 2020
	Director, Water Distribution Section, East Area Branch Office	Mr. Takao MATSUNO	NRW reduction (Physical Loss)	24th Jan 2016 – 29th Jan 2016 29th Jan 2017 – 1st Feb 2017
	Director, Construction Section II, East Area Construction Office	Mr. Osamu MATSUBA		21st to 23rd Feb 2018
	Director, Water Distribution Section II, East Area Branch Office	Mr. Yuji AOKI		29th Jan 2017 – 1st Feb 2017
	Supervisor for Accounting Investigation, Finance Section	Mr. Naoki INAGAWA	Assistant advisor	24th to 29th Jan 2016 29th Jan to 1st Feb 2017
	Deputy Director for International Affairs Team, Planning and Coordination Section, General Affairs Division	Mr. Takao HOSHINO	Assistant advisor	29th Jan 1st Feb 2017
Fukuoka City Waterworks Bureau	Chief, Management & Planning Section, General Affairs Department	Mr. Masaru MATSUOKA	NRW reduction (Physical Loss)	24th to 29th Jan 2016 29th Jan to 1st Feb 2017
		(Mr. Yuki TOKUTOMI as replacement)		2nd to 6th Feb 2018
	Chief, Administration Section, Water Purification Department	Mr. Kohei IKOUGA	NRW reduction (Commercial Loss)	24th to 29th Jan 2016 29th Jan to 1st Feb 2017
	Management & Planning Section, General Affairs Department	Mr. Keizo WATANABE		2nd to 6th Feb 2018 21st to 24th Oct 2019
	Chief, Takamiya Water Purification Plant, Water Purification Department	Mr. Noriyuki HAYASHI	Water treatment /disinfection	24th to 29th Jan 2016 29th Jan to 1st Feb 2017
	Director, Water Quality Center, Water Treatment Department	Mr. Yoshinobu KIUCHI	Water quality management	24th Jan 2016 - 29th Jan 2016 26th Jan 2017 – 1st Feb 2017
	Director, Water Quality Center, Water Treatment Department	Mr. Kenji KIMURA (Koichi AKAGI as replacement)		21st Mar to 23rd 2018
	Director, Water Quality Center, Water Treatment Department	Mr. Kenji KIMURA		21st to 24th Oct 2019

The contents of presentations by JICA AC are shown below (January 2016 - January 2020).

Table 2-155: Contents of presentations by JICA AC

Title of the presentation	Municipality/ Member name	Implementation Date
1. Public enterprise accounting of water utility in Tokyo (WB-TMG)	Bureau of Waterworks, Tokyo Metropolitan Government (TMG) Mr. Noriaki NAGANUMA	January 2016
2. Transition of management plan/policy of water utility in Tokyo (WB-TMG)	Bureau of Waterworks, TMG Mr. Hiroshi TANIGUCHI	January 2016
3. Transition of NRW management measures in Tokyo and benefits of NRW management in Tokyo (WB-TMG)	Bureau of Waterworks, TMG Mr. Takao MATSUNO	January 2016
4. Considerations in planning, designing, and operation and maintenance of pipeline and water supply equipment from view point of leakage control (WB-FC)	Fukuoka City Waterworks Bureau Mr. Masaru MATSUOKA	January 2016
5. Transition of non-physical loss (commercial loss) and countermeasures (WB-FC)	Fukuoka City Waterworks Bureau Mr. Kohei IKOUGA	January 2016
6. Transition of water quality monitoring and treatment in Japan and Fukuoka city according to development of water supply service (WB-FC)	Fukuoka City Waterworks Bureau Mr. Noriyuki HAYASHI	January 2016
7. Water safety plan in Fukuoka city and suggestion for YCDC's plan (WB-FC)	Fukuoka City Waterworks Bureau Mr. Yoshinobu KIUCHI	January 2016
8. Success case and lessons learnt from JICA NRW technical cooperation project 9. Lessons and recent trend of JICA Technical Cooperation Projects on NRW reduction	JICA Mr. Hiroaki HASHIMOTO	January 2016
10. Implementation of fair waterworks and financial autonomy	Bureau of Waterworks, TMG Mr. Noriaki NAGANUMA	January 2017
11. Necessity, planning and implementation process of Mid-term Management Plan and Water Supply Regulation	Bureau of Waterworks, TMG Mr. Nobukazu IBARAKI	January 2017
12. (NRW) Plans and Rules for NRW Management (Physical loss)	Bureau of Waterworks, TMG Mr. Takao MATSUNO	January 2017
13. (NRW) Plans and Rules for NRW Management through Pilot Project	Fukuoka City Waterworks Bureau Mr. Masaru MATSUOKA	January 2017
14. (NRW) Plans and Rules for NRW Management (Non-physical loss)	Fukuoka City Waterworks Bureau Mr. Kohei IKOUGA	January 2017
15. (Water Quality) Plans and rules related to water treatment (design and O&M)	Fukuoka City Waterworks Bureau Mr. Noriyuki HAYASHI	January 2017
16. (Water Quality) Plans and rules related to water quality monitoring	Fukuoka City Waterworks Bureau Mr. Yoshinobu KIUCHI	January 2017
17. (Overall) Outputs related to plans and rules in other JICA TA projects	JICA Mr. Koji NAKASHIMA	January 2017
18. Development of mid-term management plan Development process, Selection of priority activities, Budget allocation and etc.	TMG Tokyo Mr. Hamanaka	February 2018
19. Water Supply Regulations Introduction of examples in Tokyo, Importance, necessity and details of each clause and etc.	TMG Tokyo Mr. Hamanaka	February 2018
20. Implementation structure of human resources development Introduction of examples in Tokyo, Plan of human resources development, Development of training instructors, Identifying training needs, License system for specialists and etc.	TMG Tokyo Mr. Hamanaka	February 2018
21. Duties of Finance Section in an autonomous water supply utility, Fixed asset management and accounting Introduction of examples in Tokyo regarding the work considering financial autonomy, budgetary control, water tariff setting, fixed asset management and accounting	TMG Tokyo Mr. Takahashi	February 2018
22. Duties and responsibilities, Key points of the work, Work	TMG Tokyo	February 2018

Title of the presentation	Municipality/ Member name	Implementation Date
efficiency, Improvement of services, and Complaints handling Duties and responsibilities in a head office and branch offices, Relationship between their duties and annual activities, Key points of the work, Work efficiency, Improvement of services, and Complaints handling (to customer/ to WRAWSA), Accumulating and analyzing of Complaints etc.	Mr. Takahashi	
23. Public relations (Delivery programs, School programs etc.) Introduction of examples in Fukuoka City about School programs, other PR activities and etc.	Fukuoka City Mr. Watanabe	February 2018
24. Operation and safety management for chlorination facility Operation management for chlorination facility, Operation structure (relevant organizations for operation & management and its responsibilities), Process and procedures to install disinfection facilities and etc.	Fukuoka City Mr. Hayashi	March 2018
25. Water management monitoring Methods of reflecting water management monitoring results to water source management, operation management of WTP, maintenance of distribution facilities and etc.	Fukuoka City Mr. Akagi (Act.)	March 2018
26. Finalization of water supply regulation of WRAWSA ・ Session-A: Service pipeline and water meter ・ Session-B: Water tariff billing and collection ・ Session-C: Other issues in the regulation ・ Summarization of discussion results and preparation of report and reporting to top management and discussion	Fukuoka City Mr. Kimura Mr. Hayashi Mr. Watanabe Mr. Matsuoka	October 2019
27. Output 1 Planning and monitoring (Business plan), Regulations, standards, guidelines and manuals (RSGM), Human resource development	TMG Mr. Hamanaka (Mr. Sugiyama, Mr. Aoki)	January 2020
28. Output 1 Finance, Customer service/PR	TMG Mr. Sugiyama	
29. Output 2 NRW management	TMG Mr. Aoki (Mr. Hamanaka)	
30. Output 3 Water treatment and water quality management	TMG Mr. Aoki (Mr. Hamanaka)	

Note: ( ) indicates support member.

2.3.2. Record of Seminars, Trainings and Periodical Meetings

(1) Seminars and trainings conducted as project activity

The record of all seminars and trainings are summarized in the table below. The detailed contents of seminars and trainings are shown in Appendix 3.I and 3.II, respectively.

In addition to the above seminars and trainings, taking opportunities of regular meetings of the Project, a lot of presentations such as mini seminars by the Expert, briefings of the Expert's seminars by the C/P, and action plans of foreign training by training participants were made in periodical meetings with many counterparts. Those efforts contributed to strengthening the broad knowledge of YCDC staff. A list of those presentations is shown in Appendix 3.III.

Table 2-156: Summary of seminars and trainings conducted as project activity

Related outputs	Seminars		Trainings	
	Times	Accumulated number of participants	Times	Accumulated number of participants
Output 1-1 New organization	-	-	5	66
Output 1-3 Customer service	19	292	3	42
Output 1-4 Monitoring	1	50	24	658
Output 1-5 Regulations	4	57	29	1192

Related outputs	Seminars		Trainings	
	Times	Accumulated number of participants	Times	Accumulated number of participants
Output 1-6 Financial management	27	685	2	19
Output 1-7 Public relation	1	6	1	68
Output 1-8 HRD	23	500	48	1481
Output 1-9 Mid-term management plan	1	73	11	230
Output 2 NRW management	19	465	34	420
Output 3 Water quality management	24	483	7	91
Output 3 Water quality analysis	20	295	-	-
Overall subjects (including good governance, 5S)	17	1010	-	-
Total	156	3,919	164	4,267

(2) Trainings in foreign countries

The summary of the trainings in the foreign countries is as shown in the table below. The contents and participants of each training are given in Appendix 3.IV. As a result of each training, the training participants compiled an improvement plan of each course including proposals for future WRAWSA improvement and submitted to the CE after returning to Yangon.

Table 2-157: Summary of training courses in foreign countries implemented by the Project

Output	Training course	Host organization	Time	No. of participants
Output 1	1. Water Supply Management	MWA, Thailand	Nov. 2016	10
	2. Water Supply Management	PPWSA, Cambodia	Jan. 2017	10
	3. Water Supply Management	Tokyo Waterworks Bureau	Jan 2018	9
Output 2	4. Distribution and NRW Management, and Billing and Collecting Management	PPWSA, Cambodia	Oct. 2017	12
Output 3	5. O&M of Water Treatment Plant and Water Quality Management	PPWSA, Cambodia	Mar. 2018	5

<u>Training in third country (Term 1)</u>

Training course on “Water Supply Utility Management” was implemented with following two courses in Thailand and Cambodia. It aimed at studying experiences and collecting information of highly performing utilities in the neighboring countries. Training subjects of the two courses were same so that the results of two cases could be easily compared by topic. This comparison was referred to in promoting the improvement of management in the future. The training program was designed as research training so that the participants can study good practices and consider how to apply them for improvement of their workplace. They needed to prepare their research issues before the training and compile the results as an improvement plan submitted to the Mayor after the training. The plan included comparison with YCDC, recommendations to their business operation, and improvement proposals. The outline of the third country training (Schedule and Contents) is shown as below.

i) Training providers: Metropolitan Waterworks Authority (MWA), Provincial Waterworks Authority (PWA), Thailand

Training subjects

“Overview of water supply management” (4 days)

Including institutional Governance & Organization of water utility, overall activities as water supply utility, role and function of planning section, Practices of waterworks management/ planning by using PIs and PDCA cycle, HRD activities, corporate accounting system and fixed asset management, Whole structure of standards/ guidelines/ manual /SOPs, actions for problem solving (such as leadership), utilization of PPP.

"Details of water supply management" (2 ~ 5 days) Including financial management, business plan of water supply utility, Standard/ guidelines/ manuals, human resource development. ***Training Period***: from 21/11 to 01/12/2016 ***Participants:*** 10 participants (DYCE. ACE, EE and staff members in charge) ***Cost***: Appx. USD 9,200 for training provider, and travel expenditures
ii) Training providers: Phnom Penh Water Supply Authority (PPWSA), Ministry of Industry and Handicraft (MIH), Cambodia ***Training subjects*** ***"Overview of water supply management" (4 days)*** Including institutional Governance & Organization of water utility, overall activities as water supply utility, role and function of planning section, Practices of waterworks management/ planning by using PIs and PDCA cycle, HRD activities, corporate accounting system and fixed asset management, whole structure of standards/ guidelines/ manual /SOPs, actions for problem solving (such as leadership), ***"Details of water supply management" (2 ~ 3 days)*** Including financial management, business plan of water supply utility, Standard/ guidelines/ manuals, human resource development. ***Training Period***: from 15/01 to 26/01/2017 ***Participants***: 10 participants (CM, CE, ACE, EE and staff members in charge) ***Cost***: USD 10,700 for training provider, and travel expenditures

<u>Training in third country (Term 2)</u>

Training courses of "Distribution Management, NRW Management/ Revenue Collection" and "Water Quality Monitoring/ O&M of WTP" were carried out in Cambodia. The main purpose was to learn the good practices of PPWSA as high-performance utility and to collect relevant information. The training program was designed as research training for the participants to apply the training results to their works proactively for problem-solving. The participants prepared presentations for the issues in the training topics before the training. After they returned to Myanmar, they compiled the training results into a proposal report for improvement plan including comparison to YCDC, recommendation for regular works, improvement proposal etc., and submitted it to the Mayor. The outline of the third country training in Term 2 is shown below.

Training institution:	Cambodia, Phnom Penh Water Supply Authority (PPWSA)
Training course and period:	Distribution Management, NRW Management/ Revenue Collection 25 Sep – 7 Oct 2018 (including travel days)
Participant:	Executive members and the relevant staff of WRAWSA, YCDC
Contents:	1) NRW counter measures (NRW management strategy, history, organizational system, NRW reduction plan, action plan, inspection system of pipeline works, GIS, RSGM) 2) Revision of water tariff 3) Field training (leakage management and detection, OJT training of NRW reduction) 4) Meter reading, revenue collection, countermeasure for non-payers, customer management 5) Specification of water meter, meter reading method, revenue collection process, importance of leadership, illegal connection 6) Site visit (customer data center, branch and service station)

Training institution:	Cambodia, Phnom Penh Water Supply Authority (PPWSA)
Training course and period:	Water quality monitoring/ O&M of WTP 13 Feb – 22 Feb 2018 (including travel days)
Participant:	Executive members and the relevant staff of WRAWSA, YCDC
Contents:	1) Water treatment and water quality monitoring (SOPs, chlorination

	treatment, sampling, data management and report, monitoring process, quality management) 2) O&M (SOPs and plan on WTP, reservoir, floc formulation, coagulation and sedimentation, filtering, sludge management) 3) A long-term plan on facilities and equipment 4) Site visit (WTP and laboratory)

Training in Japan

Training course on "Water Supply Utility Management" as a country training course was implemented in Japan. The concept of the course was to input the image of financial autonomy targeting executive members of WRAWSA. Under the public enterprise law in Japan, the trainees were made to understand the appropriate management cycle of waterworks in the mega city. It was expected that this course provided an opportunity to consider necessary actions for WRAWSA. Same as the third country training, the training program was designed as research training so that the participants can study good practices and consider how to apply them for improvement of their workplace. The participants prepared presentations for the issues in training topics before the training They had discussion time for the review and made a presentation on the last day of the training. When they returned to Myanmar after the training, they compiled the training results into a proposal report for improvement plan and submitted it to the Mayor. The outline of training in Japan is shown below.

Training institution:	Bureau of Waterworks Tokyo Metropolitan Government
Training period:	23 – 31 Jan.2018 (including travel days)
Participant:	Executive members of WRAWSA, YCDC
Contents:	1) Organizational system and type of water utility, role and responsibility of a head office and branch offices, role and function of each section of water department, staffing, cooperation and coordination with other department. 2) Planned waterworks management, development process of short-, mid- and long-term business plan, linkage between the national development plan and the municipal development plan 3) Structure of financial autonomy under the public enterprise law, authority of the municipal government, role of the central government (subsidy, bond), assets management 4) Water administration and regulatory frameworks, (Ministry of Health, Labor and Welfare Ministry, municipal government, water association) vision and mission, policy, major RSGM 5) Human resource development, personnel management, HRD plan, role of each section, training system, incentives, OJT, personnel evaluation system, awarding system. 6) Method for problem-solving (case study of Tokyo)

(3) Support for participation in foreign seminars and conferences

The Project also supported counterpart's participations in foreign seminars and conferences as listed below. Presenting project results and activities on such occasions presented valuable opportunities for the C/P to confirm the significance of their activities. The presentation materials are as attached in Appendix 3.V.

Table 2-158: Summary of seminar and conference participation in foreign countries

No	Time	Seminar/Conference	Place	Presented by
1	Aug. 2017	Executive Forum for Enhancing Sustainability of Urban Water Service in Asian Region	Yokohama, Japan	Ms. Hlaing Maw Oo (YCDC Secretary)

No	Time	Seminar/Conference	Place	Presented by
2.	Sep. 2018	IWA World Water Congress	Tokyo, Japan	Mr. Myo Thein (DYCE)
3.	Oct. 2018	Japan Waterworks Association Research Conference	Fukuoka, Japan	Mr. Zaw Oo (AE)
4.	Nov. 2019	Japan Waterworks Association Research Conference	Hakodate, Japan	Ms. Khin Zin Mar Myint (Assistant Officer), Mr. Zin Min Latt (SAE)
5.	Feb. 2020	Project to Project Meeting	Phnom Penh, Cambodia	Ms. Thin Thin Soe (ACE), Ms. Yu Yu Hla Baw (EE)

(4) Periodical meetings

In Term 1, monthly meetings were held in addition to weekly meetings. In Term 2, the activities of each outcome were able to be effectively implemented by the C/P, so the opportunities for presentations and discussions were optimized, and regular meetings were held twice a month. The records of meetings are shown below. The detailed records are given in Appendix 4.

- Weekly meeting: 35 times, (total participants 1,682)
- Monthly meeting: 16 times
- Half monthly meeting: 27 times, (total participants of monthly and half monthly 2,121)

2.3.3. Steering Committee (S/C)

The activities of three types of Steering Committees (S/C) are continuously being implemented. The responsible sections and the C/P are shown as below.

Table 2-159: List of S/C members

S/C 1: NRW management	Chairperson: CE Deputy Chairperson: DYCE2 Executive member: (Physical loss): ACE Executive member: (Commercial loss): ACE Executive member: (RSGM): EE, Daw Aye Aye Mar Leading sec.: NRW sec. Member: Representative of the relevant sec. (NRW sec., House connection sec., Research/Design sec., Customer service sec., Finance sec., Pipeline O&M sec., District offices), other persons recommended by CE
S/C 2: Planning & Monitoring	Chairperson: CE Deputy chairperson: DYCE1 Executive member: ACE, Daw Thawe Naing Oo, EE, U Zaw Min Leading sec.: Planning sec. Member: Representative of the relevant sec. (Planning sec., NRW sec., House connection sec., Research/Design sec., Finance sec., Water treatment sec., District offices, Reservoir sec., Water quality monitoring sec.), other persons recommended by CE
S/C3: Regulation, Standards, Guideline, Manuals	Chairperson: CE Deputy chairperson: DYCE3 Executive member: ACE, EE, Daw Aye Aye Mar Leading sec: Planning sec. Member: Representative of the relevant sec. (Planning sec., NRW sec., House connection sec., Pipeline O&M sec., District offices, Reservoir sec.), other persons recommended by CE

The record of S/C is shown below.

Table 2-160: Record of Steering Committee (S/C)

Date	Agenda	Number of participants
17.7.2017	S/C 2	24
25.7.2017	Planning + S/C 3	20
21.8.2017	S/C 1 (Kick-off Meeting)	12
13.9.2017	S/C 2	19
21.9.2017	S/C 1 (NRW Management Meeting)	12
20.10.2017	S/C 3 (S/C3, WG3.1)	-
14.12.2017	S/C 1	17
1.12.2017	S/C 3, Water Supply Regulation (WG3-1)	13
15.12.2017	S/C 3 (WG3-1)	-
19.2.2018	S/C 3 (WG 3.1)	-
6.3.2018	S/C 3 (WG 3.1)	-
28.3.2018	S/C 1	25
19.6.2018	S/C 2	22
26.6.2018	S/C 3+ Finance	24
2.8.2018	S/C 2+ Planning & Monitoring	20
10.8.2018	S/C 3 (SG A&B)	-
16.8.2018	S/C 1	27
31.8.2018	S/C 3 (WG, SG A&B)	-
5.9.2018	S/C 3 (SG B)	-
7.9.2018	S/C 3 (SG A)	-
20.9.2018	S/C 2	22
5.10.2018	S/C 2	20
12.12.2018	S/C 3 (SG A&B)	-
5.3.2019	S/C 3 (WG 3.1, SG A&B Meeting)	13
12.3. 2019	S/C 3 Meeting	24
7. 6. 2019	S/C 3 (WG – 3.1, SG A&B Meeting)	12
26. 8. 2019	S/C 3 (SG A&B Meeting)	16
12. 9. 2019	S/C 3 Meeting	17

2.3.4. Baseline and End-Line Survey

(1) Baseline Survey

The baseline survey result by output was given in Annex CD5. Capacity assessment (CA) was implemented in the baseline survey. Capacity assessment was conducted from the following four aspects and carried out in 5 grades and the evaluation results were quantified and visualized.

Level	Technical Capacity	Core Capacity
Organization	Assessed through discussions among the C/P and the Expert according to assessment items prepared by each output team. • Organization • Information management • Manuals and SOPs	Assessed according to the unified assessment items. At most targeted sections, section heads conducted discussions with the Expert to make assessment. • Planning, monitoring • Budget management • Staffing • Communication
Personnel	Assessed through individual interview or filling questionnaire by each C/P according to assessment items prepared by each output team. • Required technical items specified by each output team	Assessed according to the unified assessment items by self-assessment. All counterparts were requested to assess their own capacity according to the questionnaire and describe their "advantages" and "points to be improved" on each item. After self-

Level	Technical Capacity	Core Capacity
		assessment, his/her supervisor confirmed to settle the results. • Awareness, leadership • Management • Problem solution

Regarding the results of the capacity assessment, each output team organized and analyzed the current situation at the start of the project, together with the results of the baseline survey. As a result, the baseline survey report with the capacity assessment report was compiled in Annex CD5.

1) Technical Capacity: Organizational Level

Organization:	Present organizational structure of WRAWSA seems not to be the most efficient. Corresponding to current workflow, and demand of issues to be solved urgently, WRAWSA needs to rearrange its organization including setting up new sections which specialize in planning, HRD, NRW management, water treatment etc.
Information management:	Information on existing facilities and assets are not managed well. Specifications and as-built drawings of facilities are lacking, which are quite important for daily O&M. In addition, operation records are sometimes kept individually, but not accumulated or compiled as periodic report properly as a whole organization.
Manuals and SOPs:	Manuals, SOPs and technical standards are limited and need to be set in many fields. In case there is any standard or manual, staff members of WRAWSA are unaware or do not understand its contents, so cannot apply the same to their work.

2) Technical Capacity: Individual Level

Senior officers have higher core capacity with rich experience of the concerned work. S/he can accumulate experiences and practical knowledge through working. However, in many fields, many staff members seem not to have enough theoretical knowledge on their works and wide knowledge related to their works.

3) Core Capacity: Organization Level

In general, WRAWSA has set procedures and means of planning and budgeting and its execution monitoring. However, these are not committed and shared well at section level, and the authority is too concentrated on top management level. It would be more effective if section level would be empowered with authority to be involved in planning and budgeting.

Planning and monitoring:	In WRAWSA, annual implementation plan and budget plan are set annually, but these are not well committed and shared by section and branch level. For monitoring the progress of the plan, monthly and biweekly meetings are held. However, section level does not know how the reporting and progress is reflected with respect to the plan. Although the progress of the activities is regularly compiled, quality of reporting is needed to be improved to show and analyze the data.
Budgeting and monitoring:	Budgeting and monitoring of its execution is done regularly, and procedures are set firmly. However, the authority is concentrated at the higher positions; few activities can be managed by section level. Decision making may take longer time, and it makes difficult to reflect real situations into consideration. In addition, budget execution is monitored but requires such complicated documents that staff members consume too much time in documentation.
Staffing:	In most sections the number of staff members is insufficient to implement the assigned duties, staff members do not possess enough knowledge related to the duties, and skilled labor is retiring, and WA and Flat resign easily. Moreover, most sections do not have clear job descriptions for staff of both section level and staff member level.
Communication:	Important information is shared in the regular meetings, but the annual plan is not distributed in writing but reported orally to each section (Hierarchal communication). －Communication within section: While small sections tend to have close communications among section members, in larger sections, information cannot be conveyed properly to lower staff members than SAE level. －Communication with related sections: Information is shared only in the regular meetings. Except that, information sharing is not

	officially established. In particular, branch offices, not located in the head office, face difficulties in communicating with other sections.

4) Core Capacity: Individual Level

Individual core capacity generally corresponds to job position of the C/P. The C/P in higher position has experiences and capacity of management.

Awareness, leadership:	Most staff members were awarded higher marks regardless of the position. Some younger staff member feel difficulty in applying what they learned to their job because they did not seem to have enough experience to be able to link the theory learnt to practice.
Management:	Staff members in higher positions have higher capacity. Younger staff members seem to be unfamiliar not only with making and working as per work plan but working closely with other sections. Even higher-level officers have difficulties in preparing reports of sufficient quality. The quality of reporting is needed to be improved at personal level and at organizational level.
Problem solution:	At present, the discretion is not well delegated to the worksite. Therefore, staff members are not familiar with making plans by themselves. This type of capacity is limited in younger staff members especially in grasping and understanding the problems. Ordinary staff members do not have sufficient opportunities to consider approaches for problem-solving. Once the direction to solve the issues is shown as work plan or order of a supervisor, most staff members have the self-confidence to implement it.

(2) End-Line Survey

Capacity Assessment (CA) for the end-line survey was conducted at the end of 2019, using the same methodology as the CA for the baseline survey at the end of 2015 when the project started. By comparing with the baseline CA, the development of counterpart's capacity during the project period was confirmed and analyzed. As for individual-level CA, there were many areas that individual-level CA could not be conducted at the end-line survey because many counterparts assessed during the baseline survey were replaced or retired since then. The result of End-line survey is given in Annex CD6.

1) Core Capacity Levels

Total	
Planning and monitoring	Significant improvements were observed in almost all areas. Due to the impact of creation of mid-term management plan and institutional improvement plan, the capacity to formulate annual action plans improved significantly (from 1.6 points to 3.6 points) from the low score at baseline. The capacity for plan monitoring of implementation, and periodical reporting also enhanced. This might be due in large part to presentations at regular meetings and the submission of data for KPIs.

Budget management	Planned budget request (2.0 points → 3.3 points) and budget execution management (2.4 points → 3.3 points), which have existing standardized procedures regulated by YCDC, scored relatively high even at the baseline. On the other hand, there are challenges in securing budgets for the implementation of the medium- and long-term plans. This system of YCDC makes it easy for the newly established sections to obtain budgets for related works during the Project period.
Staffing	All sections improved in terms of both items, 'Adequate Staff' and 'Clear Duties'. Newly established sections were staffed with clear duties and responsibilities, and those sections has been well established to carry out regular work in the course of the Project. On the other hand, some issues remain, such as the limited number of permanent staff, concentration of work on a few staff and offices, and less improvement for optimizing the workload.
Communication	There has been a general improvement in capacity and no significant problems were identified. The use of the annual plan as a tool for information sharing within each section, data management using KPIs, and the introduction of 5S to activate on-site activities, might have contributed to this improvement.

To achieve further development, the followings are recommended as possible measures.

- ✓ To allocate more institutional discretion to each section to strengthen institutional capacity to execute their own measures
- ✓ To indicate a clear job description for each staff to promote the level of fundamental competence of each section
- ✓ To promote the coordination with other relevant sections with strong and clear initiatives from the top management to support the efforts for data collection and monitoring of implementation and progress of important institutional decisions such as Mid-term Management Plan and Financial Plan, etc.

2) Technical Capacity Levels

In all eight technical areas where the end-line survey was conducted, significant capacity building is observed in the following three technical capabilities.

Organization	In many areas, especially in the newly established sections, the capacity was greatly increased by assigning staff with clear duties and responsibilities, accumulating technical knowledge and experience in the field, and improving the work by applying the same. On the other hand, further enhancement of capacity is needed for operations that require coordination and cooperation with other sections.
Office management	Many sections have made significant improvements in their management of annual plans, budget requests, business reports and various types of data in each section. In particular, the maintenance of data for KPIs and the introduction of PCs were factors in establishing regular data management in each section. On the other hand, improvements are still needed mainly in areas that are strongly influenced by upper management, such as budget securing and personnel management.
Working procedures	The most significant improvement is confirmed in working procedures. As all sections have formulated SOPs, working procedures have been defined, enabling efficient and unified operations. This has resulted in a significant improvement in the capacity to perform regular works. On the other hand, it is pointed out that continuous capacity building is necessary for further revision of SOPs and strategy formulation, which will require advanced knowledge and judgment which is different in nature from regular routine works.

As a result of the above evaluation, it is recommended to strengthen Technical Capacity as follows.

- ✓ For regular works, ensure the firm implementation of SOPs, and in the future, revise SOPs and examine the detailed description.
- ✓ Continue to make suggestions to top management on how to improve operations to ensure the necessary budget and personnel allocation and to strengthen information sharing among sections within WRAWSA.
- ✓ In addition to regular works, continue to improve technical capacity by studying for the realization of the future vision, planning future strategies, and committing to more specialized works.

2.3.5. Public Relations

1) Local Mass Media

The organization of JCC and Advisory Committee Meetings were posted in the City News in several times.

ရေပေးဝေမှုစနစ် ပိုမိုကောင်းမွန်ရေး

မြန်မာ-ဂျပန် ပူးတွဲပြုလုပ်သော အလုပ်ရုံဆွေးနွေး

(29 January 2016 in City News)

မြို့တော်စည်ပင်နှင့်ဂျပန်အပြည်ပြည်ဆိုင်ရာပူးပေါင်းဆောင်ရွက်ရေး အေဂျင်စီ (JICA)

ဒုတိယအကြိမ် ပူးပေါင်းညှိနှိုင်းရေး ကော်မတီ အစည်းအဝေးကျင်းပ

(25 August 2016 in City News)

ရန်ကုန်မြို့ ရေပေးဝေရေးစနစ်ပိုမိုဖွံ့ဖြိုးတိုးတက်ရေးနှင့်

ရေအရည်အသွေးပိုမိုကောင်းမွန်ရေးလုပ်ငန်းများ ဆွေးနွေး

(23 March 2018 in City News)

Photo 2-84: Articles in Newspaper related to JCC and Advisory Committee Meeting

The articles related to school program were published in City News.

သောက်သုံးရေ စနစ်တကျသုံးစွဲစေရေး ပညာပေးဆောင်ရွက်

1st: 21 December 2017

အခြေခံပညာကျောင်းများတွင် ရေလေလွင့်ဆုံးရှုံးမှုမရှိစေရေး ဟောပြော

2nd: 11 January 2018

ရေကိုချွေတာသုံးစွဲတတ်စေရန်
ငမိုးရိပ်ရေသန့်စက်ရုံသို့ လေ့လာရေးခရီးသွားရောက်

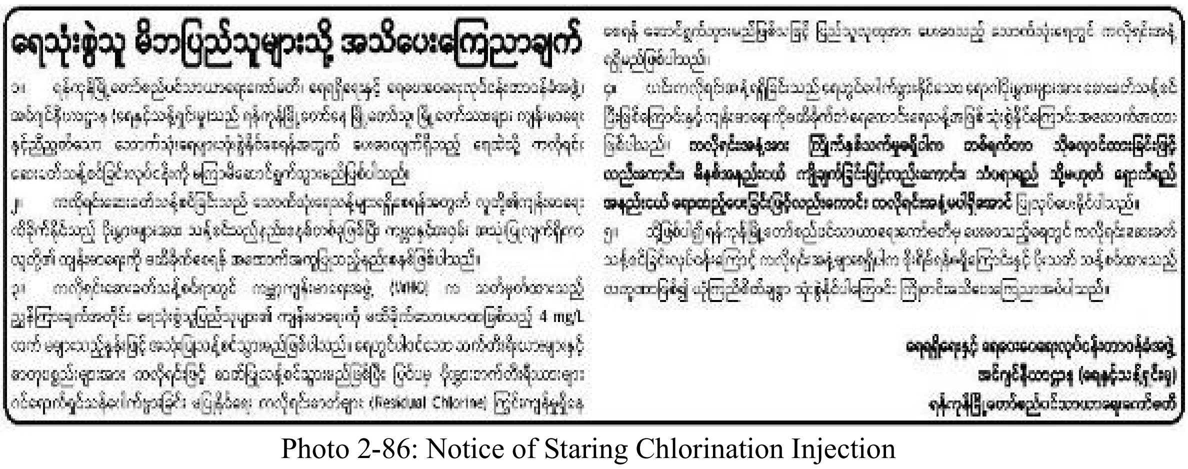
3rd: 14 January 2019

သောက်သုံးရေစနစ်တကျချွေတာသုံးစွဲတတ်စေရေး ပညာပေးဆောင်ရွက်

4th: 31 January 2019

Photo 2-85: Articles related to school program in City News

To inform the public of the chlorination of water supply, the article was posted in City News on 17 December 2019, and message was delivered through City FM several times.



ရေသုံးစွဲသူ မိဘပြည်သူများသို့ အသိပေးကြေညာချက်

Photo 2-86: Notice of Staring Chlorination Injection

In addition, the opening ceremony of NRW training center was posted in City News on 28 January 2020.

မြို့တော်သတင်း CITY NEWS ၂၈-၁-၂၀၂၀ အင်္ဂါနေ့။ ပြည်တွင်း ၂၁

စာမျက်နှာ (၁) ရေလေလွင့်ဆုံးရှုံးမှုလျှော့ချရေး စီမံခန့်ခွဲမှု

"ဒီသင်တန်းက သင်ကြားပေးလိုက်တဲ့ စာတွေ၊ လက်တွေ့ သင်ကြားမှုများကို အချင်းချင်းအပြန်အလှန်မျှဝေမှုမှတစ်ဆင့် ရရှိသွားတဲ့ အတွေ့အကြုံ၊ ဗဟုသုတနဲ့ ပညာရပ်များကို မိမိလုပ်ငန်းခွင်တွင် ပြန်လည်ပြီး အကျိုးရှိရှိအသုံးချဖို့နဲ့ ရန်ကုန်မြို့နေပြည်သူများ သန့်ရှင်းကြည်လင်တဲ့ သောက်သုံးရေကို လုံလောက်စွာပေးဝေနိုင်ရန် ဝိုင်းဝန်းကြိုးပမ်းဆောင်ရွက်ဖို့ လိုပါတယ်"ဟု ကော်မတီဝင် ဦးစိန်အုန်း ကပြောသည်။

ဖွင့်ပွဲအခမ်းအနားသို့ ရန်ကုန်မြို့တော်ဝန် ဦးမောင်မောင်စိုး၊ ဒုတိယမြို့တော်ဝန် ဦးစိုးလွင်၊ အတွင်းရေးမှူး ဒေါ်လှိုင်မော်ဦး၊ တွဲဖက်အတွင်းရေးမှူး ဦးသန်းနှင့် ကော်မတီဝင်များ၊ ဌာနမှူးများ၊ ရေရရှိရေးနှင့် ရေပေးဝေရေးလုပ်ငန်းတာဝန်ခံအဖွဲ့မှ တာဝန်ရှိသူများ၊ JICA မြန်မာမှ တာဝန်ရှိသူများနှင့် ဖိတ်ကြားထားသူများတက်ရောက်ကြသည်။

(မိုးမြင့်မောင်)

Photo 2-87: Articles related to Opening Ceremony of the NRW Training Centre in City News

2) Website of Project

The website of the Project was opened in JICA's website and the Project News and Newsletter were posted shown as below.

Project News

6 May 2016: Organization of kick-off meeting
6 June 2016: Implementation of new staff training of WRAWSA
28 September 2016: Implementation of new staff training of WRAWSA
30 September 2016: Implementation of 5S Kaizen seminar

Newsletter

Highlight of activities in 2015
Organization of first Joint Workshop / JCC
Organization of second JCC

3) JICA Project Brief Note

JICA Project Brief Note was prepared.

2.3.6. Major Output Materials/Reports Prepared in the Project

The main project output materials and reports are listed below and given in Annex.

Table 2-161: Major output materials and reports

No.		Title	Language	
			English	Burmese
1.	Manual for Monitoring Performance Indicators (PIs)		O	O
2.	Regulations, Standards and Guidelines for Water Utility Management			
	2.1	Water Resources and Water Supply Regulation (Draft)	O	O
	2.2	Guidebook for Water Tariff Setting	O	O
	2.3	Maintenance of Fixed Assets Lists	O	O
	2.4	Customer Management Manual (Draft)	O	O
	2.5	Standard Operating Procedures (SOP) of All Sections of WRAWSA	O	
3.	Organization Management Plan			
	3.1	Future Image of WRAWSA	O	
	3.2	Report on Institutional Re-Arrangement of WRAWSA	O	
	3.3	Report on Institutional Improvement Plan	O	O
	3.4	Mid-term Management Plan	O	O
	3.5	Human Resource Development Plan (Draft)	O	O
	3.6	Future Vision of Customer Service Section (Draft)	O	
4.	SOP of Data Management of Pipeline Drawings		O	
5.	Non-Revenue Water Management			
	5.1	SOP for Non-Revenue Water	O	O
	5.2	Guidelines and Manuals for Non-Revenue Water Management	O	O
	5.3	Improvement Plan for NRW Management (Third County Training in PPWSA)	O	O
	5.4	Non-Revenue Water Management Plan (Provisional)	O	
	5.5	Training Plan of NRW Training Center	O	
6.	Water Quality Management			
	6.1	SOP for Water Quality Monitoring	O	O
	6.2	SOP for Water Treatment Plants and Chlorination Facilities	O	O
	6.3	Water Quality Management Plan (Provisional)	O	
7.	Operation Manual for Customer Data Management System			O
8.	Baseline and End-line Survey			
	8.1	Report on Baseline Survey & Capacity Assessment	O	
	8.2	Report on Capacity Assessment – At the Project End -	O	
9.	Teaching Materials			
	9.1	Training materials for Data Management of Pipeline Drawings	O	
	9.2	Training Materials for NRW Management (On-Line Training)	O	
	9.3	Teaching Materials for Public Relations Activities	O	
	9.4	Teaching Materials for Management of Water Utility in YCDC	O	
	9.5	Teaching Materials for PPP and Organization Structure of Water Utility in YCDC	O	
	9.6	Technical Handouts by the Advisory Committee	O	
10.	Records of Project Activities		O	

3. Issues, Measures and Lessons Learned in Implementing and Managing the Project

Issues, Measures and Lessons Learned in Implementing and Managing the Project were extracted as listed below.

(1) Implementing Project with common understanding of capacity development (CD)
(2) Toward a target-oriented project by adhering to high targets (vision)
(3) Ensuring exchange with counterpart and reinforcing integrity of project by holding meetings regularly (weekly, monthly)
(4) Meetings, seminars, preparation of reports and reporting on activities are always with the participation of the counterpart
(5) Understanding of operation is being improved by demonstrating familiar examples in detail and implementing pilots
(6) Make clear themes at the Myanmar-Japan Joint Seminar (MJJS) and Joint Coordination Committee (JCC) meeting and make it purpose-oriented and outcome-focused
(7) Share clear goals and show the roadmap to improve and achieve the goals
(8) Implementation of overseas training as study and research training focusing on results and target oriented
(9) Enhancement of basic technical capacity by lectures and exercises, in which theory and practice is combined using universities and academic institutions
(10) Improvement of efficiency of office works starting by holding “5S Improvement” seminars
(11) Change in the procedure for preparing SOP (first improve facilities, improve operating method and then prepare SOP)
(12) Expand and unify SOP development activities from partial to entire departmental activity
(13) Clarify topics and activities that the C/P should implement when the Expert is not present, and follow up
(14) Make the results of the activities visible
(15) Raise awareness about HRD through pilot training and expand training program
(16) Develop problem-solving skills through pilot activities
(17) Mid-term evaluation by the C/P
(18) Utilize JCC to confirm YCDC executives’ ideas on human resource development plan
(19) CD should be implemented for organization but not for individuals (establish a proper organization for CD)
(20) Proposal to set up S/C (committee for promoting the implementation of important policies)
(21) JICA long-term expert assigned as Deputy Chief Adviser to promote implementation of more continuous activities

(22) Development of waterworks ordinances based on verification of domestic legal systems and research of overseas examples
(23) Technical cooperation for local materials and equipment for NRW management
(24) Review of a system of PDM indicators for the purpose of achieving the project overall goal

(1) Implementing Project with common understanding of capacity development (CD)

a. Issues

The experts themselves did not have a clear understanding of the significance and methods of CD. Accordingly, the CD project needed to be implemented after the expert team themselves fully understood the definition of CD.

b. Measures

After studying JICA's CD handbook and other materials, firstly, an easy-to-understand, simple CD hand-out was prepared for the expert team. The content was re-confirmed by the team, and common awareness and understanding on the CD in the team was developed. The items in the CD hand-out were as follows:

- What is CD?
- What are the kinds of capacity?
- What is capacity assessment?
- Relationship between capacity (C), performance (P) and impact (I)
- Roles of the expert

In addition, the expert was requested to thoroughly follow the following:

- Capacity refers to the ability of a developing country to identify and resolve issues by themselves (ability to solve problems), but not mere transfer of skills and technologies.
- The Project is a "Capacity Development" Project inclusive of "transfer of technology."
- The final objective of the Project is improvement and development of capacity (ability to solve problems).

c. Results and lessons learned

The Project was carried out bearing in mind improvement in the ability to resolve issues. As far as possible, practical issues were found, and methods to acquire technology required for solving those issues were applied, rather than merely transferring the required technology.

Consequently, the training and activities in each output became more practical in that the C/P was able to improve skills and abilities that can actually be used in the workplace. The trainings in Cambodia and Thailand and the training in Japan were also designed as problem-solving trainings, and the improvement plans were prepared by the training participants after their return. The pilot activities on NRW management and water quality management became practical activities to solve actual problems.

(2) Toward a target-oriented project by adhering to high targets (vision)

a. Issues

It was assumed that by merely implementing project activities, sustainable and target oriented participation of the C/P was not expected.

b. Measures

To promote sustainable participation in activities with the target in mind for the counterpart, PCM workshop was conducted with the counterpart by subgroup and by output team. While sharing awareness of problems and confirming the issues, the project activities were confirmed, and the vision of the Project was set. Such actions established the sequence, namely:

Understand existing conditions → Implement project activities → Achieve target

After guiding the C/P, seven visions of the Project at the initial stage were identified as given below. These visions have now become the visions of the WRAWSA, and the counterpart has been using these visions in their training. The name of the document is "Ideal Future Vision of WRAWSA" and it includes "Achievement status at the end of the Project." (Annex 3.A)

1. The waterworks is managed as an independent and financially self-sufficient utility.
2. Waterworks is managed in a planned manner based on performance indicators.
3. Waterworks is managed based on the developed regulations, standards, guidelines and manuals.
4. The waterworks has a continuous improvement structure of human resource capacity.
5. Waterworks enhances effective and efficient customer service.
6. A NRW management system is firmly established and the activities to reduce NRW are continuously carried out by instruction of the trainers and based on NRW management plan.
7. Safe and clean water is supplied to customers by identifying water quality problems and solving them by own staff and based on water quality management plan.

"The waterworks is managed as an independent and financially self-sufficient utility" was included in the vision as a future objective going beyond the existing objectives of the Project. Under normal circumstances, although it may be considered premature, unless a start is made, nothing can be achieved; with this thought, financial experts delivered seven lectures in the two series mentioned below to establish the concept at the initial stage of the Project (Annex CD8). The idea was to make the counterpart perform activities with higher targets, and to push them forward at every opportunity.

- Sustainable management and organization in water supply series
- Basics of water supply utilities series

c. Results and lessons learned

The results of these measures have not been expected to appear directly and in short-term. However, with clear financial targets in mind, the counterpart has understood the importance of preparing financial statements and asset management and was working toward achieving the higher targets.

This resulted in the implementation of a governance seminar with the aim of strengthening the governance of WRAWSA and its independent management in the future. Furthermore, based on the results of the training in Japan and the third countries, the C/P developed a Management Improvement Plan of WRAWSA (Annex CD1).

There was a change in the political regime in December 2016. The nominated Secretary of YCDC had been thinking in depth about the autonomy of the WRAWSA and of the YCDC itself. The probability was high that this vision would be pushed forward earlier than anticipated.

However, due to the political change in February 2021, the government became a military government, and the promotion of this vision became unclear.

(3) Ensuring exchange with the counterpart and reinforcing integrity of project by holding meetings regularly (weekly, monthly)

a. Issues

If regular meetings were not held, the integrity of the Project with the counterparts could not be assured because information such as what the results each team had been doing, what targets of the Project had been achieved, and so on, could be shared with the counterpart.

b. Measures

Weekly and monthly meetings were established as regular meetings. Weekly meetings were considered as a platform for mini seminars by the Expert and for presentations by trainees of the counterpart. Monthly meetings were meant for checking the progress and issues of the Project and for discussing and deciding issues.

No minutes of the meeting were recorded during the meetings before. Once discussed, they tended to be neglected. Accordingly, it was decided that YCDC side would prepare minutes of the meeting, review previous meetings, and process the agenda of the meetings under the guidance of the Expert.

c. Results and lessons learned

In principle, meetings were being held when the Expert was present in the country. By the end of the project, 35 weekly meetings, 16 monthly meetings and 27 half-monthly meetings were held. Mini seminars were also held during the meetings, and the number of lectures (training) and participants was large. Although direct measurement of the effects is difficult, the counterpart has absorbed various kinds of new knowledge, and these meetings have contributed to developing human resources. The topics in each meeting are shown in Appendix 4.

At the stage when the project activities had been firmly established, it became unnecessary to report the activities on a weekly basis, and thus the meeting was changed to be held on a half-monthly basis, combining weekly and monthly meetings.

The YCDC side took the initiative in preparing the meeting minutes, reviewing and confirming the previous meetings, and facilitating the meeting agenda. In Term 2 of the project, the Expert rarely reported on their activities, and the counterparts mainly reported and discussed. The role of the Expert in meetings became advisory only.

At the early stage, only the executive officers of WRAWSA made comments, but gradually more and more participants began to speak out, and it was assumed that the capacity to improve the operation from the bottom has been improved.

(4) Meetings, seminars, preparation of reports and reporting on activities are always with the participation of the counterparts

a. Issues

Even if the counterparts learned from the seminars, there was no plan to actually use what had been learned. Just listening to lectures from the Expert would not help in mastering skills and developing capacity.

b. Measures

It was decided that the counterparts would make use of the monthly and weekly meetings, summarize the lessons learned and the description of activities, and present the summary in the counterpart's own words. The language of the presentation would be Burmese, so that the understanding of other staff members of the counterparts listening to the presentation would also be enhanced.

Most of all, reports were also prepared and edited by the counterparts and supervised by the Expert for finalization. It was aimed that organizing these meetings and writing reports would eventually become routine work in YCDC.

c. Results and lessons learned

Making presentations in front of large audiences in their own words would help the counterparts develop their motivation to learn. This is also a method to keep the content in their memory. Since the presentations were made in Burmese and not in English, the counterparts listening to the presentations must have fully understood it. Initially, lectures and presentations were made only by the Expert; but in Term 2, more presentations were made by the counterparts. Some counterparts also took initiative to make presentations. The spontaneity of the C/P seemed to be developed.
These regular meetings have evolved to various improvement meetings within WRAWSA (SOP developing meetings for all sections, Steering Committee (S/C) improvement meetings). These meetings are now being held spontaneously.

(5) Understanding of operation is being improved by demonstrating familiar examples in detail and

implementing pilots

a. Issues

There were issues related to drawing counterpart's interests and encouraging them to participate in activities not experienced before. Specific examples are as follows:

- (Output 1: Human resource development) The staff members of WRAWSA were less interested in and lacked awareness in human resource development as there was no responsible section for human resource development within WRAWSA. If plan for human resource development was formulated without much interest from top management, there was a concern that it will take too much time, commitment would not be obtained, starting human resource development activities and training which were urgently needed would be delayed, and there would be insufficient time for the activities to become established in the organization.
- (Output 1 Finance) The accounting of WRAWSA is a part of the accounting of YCDC general accounting and is not independent. That is why it was difficult to make the counterparts understand the independent accounting principles of water supply business and asset management methods. Case studies of Japan or other countries were difficult to understand since the conditions of each country are quite different.
- (Output 2: NRW management) Due to the delay in the progress of the pilot project, it was difficult to start practical training activities.
- (Output 3) Because of the inadequacy of education and research systems related to water treatment in Myanmar, WRAWSA staff did not have practical knowledge on water treatment. Use and application of technology and knowledge on real treatment facilities was inadequate.

b. Measures

- (Output 1: Human resource development) In PDM, plan for human resource development was to be formulated after baseline survey. However, the interest and commitment within WRAWSA for human resources development was not high. Therefore, it was decided to prioritize training of new staff as part of showcasing activities.
- (Output 1: Finance) We visited YESC, a governmental organization that had applied corporate accounting system, studied as a specific case in Myanmar, and tried to deepen counterpart's understanding.
- (Output 2: NRW management) By providing guidance and support to WRAWSA's own NRW management project in North Okkalapa, the counterparts could deepen their understanding of NRW management through practices.
- (Output 3) Sufficient technical ability and knowledge are indispensable for the proper implementation of functional diagnosis of water treatment process and formulation of functional improvement measures. Therefore, we decided to utilize the implementation of this diagnosis and functional improvement as a place for human resource development and aimed at the direct involvement and voluntary capacity development of the staff of WRAWSA.

c. Results and lessons learned

- (Output 1 Human resource development) As training for new employees was implemented as pilot training, the development activities of human resources could be visualized; this led to heightened interest of the counterpart and the management of WRAWSA. As a result, the startup of the HRD Section and the assignment of full-time staff members proceeded smoothly. Firstly, efforts are made to enhance awareness by visualization of activities in the relevant field in the organization. When the awareness has grown, plans are formulated so that high commitment can be anticipated.
- (Output 1 Finance) The example of a power supply utility, a similar service utility in the same country, is probably easy to understand. Even if some points need to be studied further, it is easier to do so within the country. It was also a good opportunity to exchange information on common points as a public utility.

- (Output 2: NRW management) In the counterpart's own NRW management project, the counterparts understood what the appropriate NRW management method was. On the other hand, it was found that despite understanding its necessity, the counterparts could not improve construction works because of budget and material procurement. These should be improved in the future.
- (Output 3) As existing functions were diagnosed and improvement measures were formulated, the feeling of satisfaction and achievement of many staff members has increased. Activities were also accelerated further. Through a series of such activities, more practical knowledge and technology required for water supply were acquired by the counterparts.

At first, by visualizing the activities in the related field, raising awareness and stimulating the organization lead to understanding of the activities, raising awareness of the activities, and formulating specific plans.

(6) Make clear themes at the Myanmar-Japan Joint Seminar (MJJS) and Joint Coordination Committee (JCC) meeting and make it purpose-oriented and outcome-focused

a. Issues

In some cases, the main purpose of a seminar is to hold a seminar and make a presentation, and that of meeting is to carry out discussions and hold the event. After it is held, there may be no result of seminar and meeting.

b. Measures

To avoid such results, every seminar or JCC meeting was implemented with one clear target. That is, the idea was not merely to hold lectures or meetings with Advisory Committee members, but to produce fruitful results for WRAWSA through seminars and JCC activities. For each MJJS or JCC, an important theme was decided and implemented each time for WRAWSA. Furthermore, a series of seminars and JCC themes were created so as to have one story of themes. In addition to the building up of capacity from the bottom through transfer of technology, this story of themes was designed to realize reforms from the top. The themes are given below.

Figure 3-1: Main themes of 9 JCC meetings and roadmap for stage organizational strengthening

c. Result and Lesson

For the achievement of the overall goals of the Project and the vision of the WRAWSA, the counterparts were able to understand the positioning of the Project and its current standpoint. The themes of the meetings were set for WRAWSA to develop gradually, and the counterparts were able to approach the goals without much awareness, leading to the achievement of the project goals and vision.

(7) Share clear goals and show the roadmap to improve and achieve the goals

a. Issues

At the project start, WRAWSA did not have a clear image of the future they were aiming for. Furthermore, there was no roadmap on how to improve and achieve it. Without a clear goal for the organization and an approach to achieve it, the fruits of capacity development would not be obtained.

b. Measures

At MJJS and JCC, the goals of the organization and how to achieve them were shared with the counterparts. The themes are given below.

1. **1st MJJS and 1st JCC**
   - Based on Japanese experience, overview of future vision of water utility management of YCDC on utility financial management, NRW and water quality management.
   - Setting the mission and future image of EDWS
2. **2nd JCC**
   - Re-organization of EDWS
3. **2nd MJJS and 3rd JCC**
   - Overview of planning and rules to guide the actions / activities for achievement of future vision of EDWS.

The discussing and setting the future vision of WRAWSA was selected as the theme for the 1st MJJS and the 1st JCC. Aiming at this future vision, WRAWSA will improve and implement its management and operation.

Next, the organization of WRAWSA was not appropriate enough to operate the water utility properly. An appropriate organization setup is required to aim for the future vision. Accordingly, the theme of the 2nd JCC was to reorganize WRAWSA and create an appropriate organization that is required to achieve the future vision.

Now, as the vision of the future and the appropriate organization to aim for the vision are ready, next approach would be for the organization to act accordingly for the future vision and start activities for the same; however, WRAWSA did not know what the required activities are and what policies should be referred to. These questions were set as the themes for the 2nd MJJS and the 3rd JCC. That is, the plans and the various rules to guide the actions / activities for achieving the future vision of WRAWSA were discussed. The required plans and the various rules were selected in the MJJS and JCC. The structure of the above themes is illustrated in the sketch below.

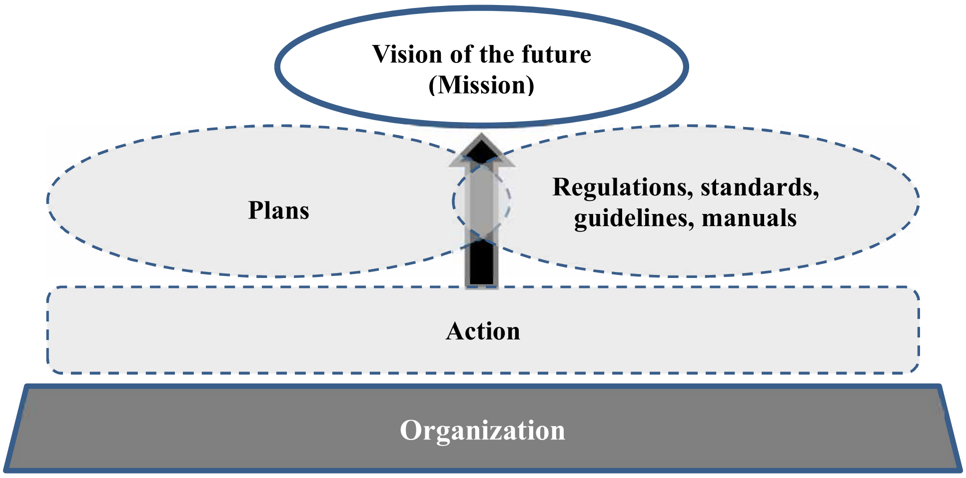


Figure 3-2: Sketch related to future vision, organization, action, plans and rules

c. Results and lessons learned

In addition to just transfer of technology, organizational targets, and organizational implementation system, plans, and rules were developed. In Term 2 of the Project, institutional development was expanded and practiced in detail in addition to transfer of technology. According to the JICA Capacity development (CD) Handbook, the meaning of CD is as given below; it is considered that the capacity to solve problem at individual, organizational and institutional level has been enhanced, by management of the Project guided by the roadmap mentioned above.

✧ **Meaning of capacity development (CD)**

- Development of comprehensive capacity for solving problems without being limited to specific knowledge and technology
- Understanding of capacity of the developing countries to solve problems proactively from comprehensive perspective, and offering indirect assistance to its spontaneous development.
    - ➢ Comprehensive perspective: Process for improving the ability to solve problems of developing countries as a group of multiple levels, such as individuals, organizations, institutions and society
        - a. To improve the knowledge and skills of individuals and organization
        - b. To develop the system (process) of the organization
        - c. To change and reinforce the institutional framework

(8) Implementation of overseas training as study and research training focusing on results and target oriented

a. Issues

The trainees tend to feel that they acquire knowledge during overseas training, through site tour and explanations on the content of work done by the visiting organization. WRAWSA had already participated in many overseas training programs; however, the output of such training could not be seen in their workplace. It is not merely learning that needs to be considered, but also how to apply and put into practice what has been learned. Even action plans formulated in each training program were not in line with the actual condition of WRAWSA or included too wide a scope which exceeded the authority of the participants to implement in their workplace and the effectiveness was poor.

b. Measures

For training in a third country, study and research training were adopted with focus on results and target oriented. The concept of training in a third country is as given below. Based on this concept, training was implemented in a third country. The improvement action report was required to be submitted to the Mayor after training completion. This concept was notified to the participants at the series of preparatory workshops for the training.

Concept of implementing training in a third country and in Japan

- Avoid short-term overseas training that starts and ends with mere sight-seeing. (Since training expenses are high, the aim should be to learn lessons that are worth of the expenses.)
- During short-term overseas training, aim for more practical training. Take basic lectures in Yangon in advance.
- Participants should at least possess basic knowledge related to the training. After returning to the country, they are expected to become trainers for internal training in the relevant field.
- Before dispatch, the participants should receive basic training.
- Participants should be aware of the issues related to the relevant sections for which they are responsible. Accordingly, training topics should be studied before departing for the training program. Either issues or topics should be found by themselves, or the Expert should list out the issues.
- The concept is that training should be carried out to actively use the results of research in one's work and study to solve issues rather than passive training (without learning what you will never use).
- After returning to the country, the trainees should not merely give a presentation of sightseeing results, but submit lessons learned in detail (reports compared to YCDC, proposals for practical use, improvement proposals, etc.). Reports should be evaluated by the Expert, top management or superiors, and the Expert in each field should follow up in the realization of subsequent activities.
- HRD Section should prepare the training record related to training participation.

c. Results and lessons learned

Upon returning to Myanmar, the participants prepared improvement plans and submitted to the Mayor/management of YCDC. It is assumed that the submission motivated the participants because they thought that the training results could actually be implemented.

Overseas training results were presented in the weekly meetings as well. In presentations, presenters prepared their presentations after carefully considering how best to utilize what they had learned in the actual work of WRAWSA. The result was that the presentations included more practical contents and proposals. The training results came to be utilized more concretely.

(9) Utilization of the university to enhance the basic technical capacity through lectures and exercises that combine theory and practice

a. Issues

Myanmar does not have universities or academic institutions that specialize in water supply and sewerage systems; therefore, there are not many engineers that have proper basic knowledge on water supply and sewerage technology in WRAWSA. All related engineers of WRAWSA needed to be re-educated by giving basic technical education of water supply, and their technical capacity needed to be enhanced.

b. Measures

With the cooperation of Yangon Technology University (YTU), a series of lectures were prepared for the related engineers in WRAWSA. The eight sessions covered the basic topics in water supply technology including hydrodynamics, water treatment, water quality, demand projection, and distribution network design. The lectures were given to about 70 civil, chemical and mechanical engineers ranging from new staff to new management staff level. After completion of the course, written tests were conducted to confirm their understanding. During the course, lectures on the theoretical part were given by university faculty, while the practical sessions were provided by WRAWSA senior engineers. This aimed to enhance the understanding both of theory and practice well, and to develop trainers who can teach in the relevant fields.

c. Results and lessons learned

After all sessions were completed, a questionnaire was distributed to the participants to obtain their opinions on the lecturers, the content and depth of the lectures, and the possibility of conducting future courses. The evaluation of the participants was generally high. However, last minute schedule changes on YTU side indicated the necessity of coordination between two sides to continue the program in the future.

By jointly holding the course with YTU and YCDC, it was expected that the collaboration between government and academia would be deepened and that the level of university education related to water in Myanmar would be raised. However, since Myanmar does not have a well-developed department that teaches water supply technology, it is necessary to strengthen the level of the university itself. In order to achieve this, further collaboration between government and academia will be necessary.

(10) Improvement of efficiency of office works starting by holding “5S Improvement” seminars

a. Issues

In general, there were a lot of inefficient working procedures such as labor-intensive activities, manual calculations, manual work, and records on paper in WRAWSA. It was necessary to improve them for increasing efficiency in the operations of work.

b. Measures

It is necessary to improve the efficiency of a wide range of operations, but first, we decided to implement 5S Kaizen in the office, which is easy to improve at each section and T/S level. With the cooperation of the Myanmar-Japan Human Resource Development Center, a lecturer was invited and “5S Improvement” seminar was held. After that, each section and T/S made improvements within a month, the results were presented at a workshop to share the practices, and awards were also given to excellent presentations.

Computers were installed in all offices including T/S offices, and generation of electric data related to PIs was started. Besides, computer training room was established, where computer training courses have been regularly provided.

c. Lessons learned

Many noticeable improvements in efficiency were found in office work in “5S Improvement” result workshop. In the workshop, each office became audience as well as presenter, and each office could refer to the improvement examples of others that they could apply in their own office. There were also offices that started improvement circles in their own office, so that sustainable improvements could be made through bottom-up discussions. Since such bottom-up discussions were rare in WRAWSA, the experience was fruitful for WRAWSA. Hence, such circle activities are expected to be expanded throughout WRAWSA.

(11) Change in the procedure for preparing SOP (first improve facilities, improve operating method, and then prepare SOP)

a. Issues

The original project description included “Preparation of Standard Operating Procedure for Operation and Maintenance of Water Treatment Plant and Disinfection Facility.” However, the water treatment functions in the WTP were inappropriate, and the operators in charge were not conversant with the workings of the WTP; as a result, the operation was improper. If treatment functions are inappropriate, even if a current SOP is prepared, its usage may not be effective, and the resulting treated water quality will be inadequate.

b. Measures

As a result of involving the officers in charge of O&M of WTP in diagnosing and improving water treatment functions, they gained an understanding of the mechanism of water treatment. After that, SOPs were developed for each of treatment process that had been improved and could function appropriately.

c. Lessons learned

The improvement of the treatment process improved the water quality. Then, the C/P created their own SOPs. The C/P could develop an appropriate SOP because they understood well why the water quality improved. Since the C/P has good understanding, they can provide training on O&M for the operators.

In addition, pumping stations and reservoirs were added to the scope of SOP development, and SOPs were prepared with a uniform format and rules. As a result of these activities and the learning of SOP development methods obtained from the training in third countries, the development of SOPs was expanded to entire WRAWSA.

When treatment functions are inappropriate, the resulting treated water quality may be inadequate. Therefore, it may be difficult to see the effectiveness of developing and applying SOPs. SOPs should be prepared after the functions have been improved.

(12) Expand and unify SOP development activities from partial to entire departmental activity in WRAWSA

a. Issues

The preparation of SOPs started in each output team in Term 1; however, the progress in preparing them was not so satisfactory.

b. Measures

The development of SOPs for O&M of WTP had been progressing well. Furthermore, the officer in charge of developing the SOPs for WTP learned the entire picture of the Phnom Penh Waterworks Supply Authority's SOP system during training in the third country. Based on this, he proposed that the SOP system be established as an activity of entire sections of WRAWSA. This proposal was presented at the monthly meeting, and agreed by the CE who decided to develop SOPs in entire WRAWSA with a unified format.

c. Result and Lesson

The development of SOPs started in all sections (T/S offices, head offices, and site offices), and by the end of the Project, almost all SOPs were created and being applied. The SOPs are also being used as training materials. It is effective to implement SOP development activities as an organizational activity under the leadership of top management, rather than as a project or output team activity.

(13) Clarify the activities that the C/P should implement when the Expert is not present, and follow up them

a. Issues

Activities stopped when the Expert was absent for a long period. It was difficult to provide timely guidance, check progress, etc., although homework was responded by the counterparts.

b. Measures

The Expert clarified the activities to be made by the counterparts when they were absent. In the course of the Project, in addition, the situation was improved by follow up by a long-term expert. The counterparts were also requested to make presentations about the progress of the activities at the future regular meetings.

c. Lessons learned

The follow-up activities of the long-term expert and the presentation of homework at the regular meetings were successful. Furthermore, it would be effective to position the activities to be carried out not as activities for the Project but as activities necessary for the section and roles of the section.

(14) Make the results of the activities visible

a. Issues

Objective data, which was the basis of organizational decisions, was not centrally managed in the operation of water utility.

b. Measures

Emphasis was placed on making improvements visible by grasping the water supply business as numerical values, such as creating PIs for all operations, accumulating water quality data, installing flow meters, and assessing capacity of water utility numerically.

c. Results and lessons learned

The Project conducted activities to improve the accuracy of performance indicators (PIs) of T/S. A mid-term management plan was formulated, and the PDCA cycle was carried out based on the plan. It is necessary to further visualize the results of the PDCA cycle through reporting and sharing the results with the entire organization.

(15) Raise awareness about HRD through pilot training and expand training program

a. Issue

It was revealed that awareness raising about HRD and needs survey was crucial to develop inclusive training from a long-term perspective.

b. Measures

It was decided to implement a pilot training course prior to the discussion for a comprehensive training system, which aimed at raising the awareness of those related to HRD activities by starting with activities where results are easily realized. In the existing training system, there were few training programs in fields specific to the water utility or targeted at young staff and workers; therefore, the Project prioritized these as pilot trainings and gradually expanded the trainings. Participants in the training were evaluated and presented certificates of completion, and the outstanding performers received a plaque from the WRAWSA top management.

c. Result and Lesson

The newly established HRD Section and its training activities have been recognized by WRAWSA top management. Through the implementation of the pilot training, training materials were improved in quality by revising the contents and adding updated information. In addition, an annual training cycle was well established, and a system was developed to ensure that training can be conducted continuously and independently within WRWASA in the future. Utilizing the training system established in this pilot training program as a core, further training can be expanded to include technical and management fields to increase the efficiency and overall organizational capacity.

(16) Develop problem-solving skills through pilot activities

a. Issue

How to develop problem-solving skills at both individual and organization level.

b. Measures

The Expert made efforts to develop WRAWSA's problem-solving skills by providing knowledge through guidance and seminars and letting the counterparts identify issues and think solutions by themselves through pilot activities. In the meantime, making SOP was one of these efforts so that WRAWSA can apply the same in actual practice. Pilot activities are shown below. These activities are not necessarily addressed at a large scale.

- Start-up training activity by HRD Section (pilot training)
- Improve water quality at WTP (improving trial as pilot project)
- Select water treatment method for reservoir and decide design criteria (pilot water treatment experiment)
- Improve water tariff collection management in Kyauktada T/S (pilot trial)
- NRW reduction in Yankin T/S (pilot project with DMA)

c. Result and Lesson

Through those pilot activities, trainings and seminars were implemented by the counterparts who understood the issues and the methods of problem-solving, which contributed to expanding the capacity development from individual level to organization level. The capacity at individual and organizational level was considered to be enhanced accordingly.

(17) Mid-term evaluation carried by the counterparts

a. Issue

It was unclear whether the counterparts understood PDM and what they needed to do by the end of the Project. There was a concern that some project activities might not be completed, and project purpose not achieved.

b. Measures

The counterparts' side evaluated progress, achievement level and future vision in the 7th JCC in which the theme was "Toward Project Success", which aimed to ensure that the counterparts had a clear understanding of what they needed to do by the end of the Project in a year and a half before the end of the Project. The counterparts prepared evaluation results by themselves and presented these in JCC.

c. Result and Lesson

Evaluation work was started for each outcome about three weeks before the JCC, detailed presentations were made for each outcome in the morning of the day of the JCC, and the outline of evaluation was announced and discussed in the afternoon summary session. It was considered that the counterparts evaluated the results by themselves and announced the results at the JCC, so that not only the person in charge of each outcome but all counterparts understood the progress of the current activities, the degree of achievement of the outputs, and the remaining activities.

(18) Utilize JCC to confirm YCDC executives' ideas on human resource development plan

a. Issues

In the JCC, YCDC executives usually left after a coffee break set after the opening remarks, hence the C/P could not confirm the executive's views on important issues. It was also difficult for staff members to ask the executives directly.

b. Measures

In order to hear the opinions of the executives on human resource development that had emerged as an important issue, the theme of the 8th JCC was set as Sustainable Human Resource Development. The C/P made a presentation and confirmed the ideas of the YCDC executive (Secretary) before her leaving the meeting.

c. Result and Lesson

The C/P confirmed one of the views of the executives on human resource development. Based on this, the C/P revised the human resource development plan (draft) and explained it again to WRAWSA executives and finalized it.

(19) CD should be implemented for organization but not for individuals (establish a proper organization for CD)

a. Issues

Initially, the counterparts were assigned as a part-time counterpart having other regular duties. Taking the example of a counterpart in the NRW team, the awareness for participating in NRW activities was low since the regular duties took priority. The counterparts also did not have the responsibility to achieve results; moreover, the technology learned had no place for use. Consequently, the technologies learned from donor projects implemented in the past and from the training in Japan were not being used. If the Project was continued in such a manner even when all the activities were completed, there would be no hope that the ability to manage NRW of the organization would improve.

b. Measures

Request was made to the CE to make the NRW counterpart assigned as full time. This request was made repeatedly since 2015; finally on 30th January 2017, eleven persons were assigned as full-time counterparts in NRW Management Section, which was newly set up. Moreover, all part-time counterparts belonging to the newly established sections / division were advised to transfer to a full-time position. This advice was accepted as one of the conclusions of the 3rd JCC.

c. Results and lessons learned

After the counterparts in NRW Management Section was transferred to a full-time position, all counterparts were united and worked for the NRW project in North Okkalapa. A system for accumulating as well as using techniques and management methods was developed in the organization.

A lesson learned from past donor projects and overseas training programs was that the problem-solving ability of the organization did not improve even after transfer of technology to individuals without any responsibility nor without the organization-in-charge. Technology needs to be transferred, accumulated and used for the benefit of the organization-in-charge.

Additionally, it was more effective to develop the capacity of the existing organization currently in operation. To develop and enhance the new capacity, an organization to use the capacity must be set up first and the activities should then be implemented in the organization. The counterparts would not have any interest in activities other than the organizational activities for which they are responsible, nor would these activities be implemented organizationally. Therefore, we believe that the transferred technology and activities will not take root in the absence of an organization that utilizes the enhanced capabilities.

The construction of the organizational structure was completed, and capacity development activities have been carried out for the organization. The number of full-time staff has increased in the counterparts. In particular, the counterparts for Output 2 used to be a part-time staff member, but now it has 16 full-time staff members.

(20) Proposal to set up S/C (committee for promoting the implementation of important policies)

a. Issues

At the early stages of the project period, activities were implemented through output team by the counterparts. However, important policies related to several sections / divisions become issues because an output team or one section in-charge could not solve the issues related to the policies. For instance, NRW management was not only an issue of NRW Management Section, but an overall response by several sections such as the Design Section, GIS Section, Customer Service Section, Computer Section and Water Supply Division was necessary.

b. Measures

The Expert proposed establishing following three steering committees (S/C) to promote the implementation of important measures across multiple sections with the key points: needs, composition of each S/C (Chairman, executive members, members, etc.), roles, how to hold meetings and frequency.

(1) NRW Management S/C

(2) Planning and Monitoring and Kaizen (Improvement) S/C

(3) Regulations, Standards, Guidelines and Manuals S/C

c. Results and lessons learned

The proposal was approved by the CE, and S/Cs were put into practice. S/Cs were held 28 times, of which many S/Cs were conducted by the C/P on their own initiative without participation of the Expert, and the direction of activities was decided. The autonomous activities of WRAWSA were enhanced. Furthermore, monthly meetings were held to discuss similar issues. It is important to create a place for systematic and regular discussions and decisions.

(21) JICA long-term expert assigned as Deputy Chief Adviser to promote implementation of more continuous activities

a. Issues

Consultant experts had intermittent assignments and at certain times all consultants were absent in Yangon. For this reason, the activities of the Project also became intermittent.

b. Measures

JICA long-term expert (organizational capacity building / human resource development) was dispatched to the site at Yangon continuously and fulfilled this role. The JICA long-term expert was given the responsibility of Deputy Chief Advisor of the project other than those under her own terms of reference, to promote implementation of continual overall activities of the Project.

c. Results and lessons learned

If an expert stays at site for a long period, the Project has the benefit of activities being implemented continually and effectively. Generally, communication with counterpart got held up when the Expert was absent. Sometimes, communications that included instructions, requests, etc., from the Expert from Japan to the counterpart got suspended, but the Deputy Chief Advisor could act independently to some extent and confer judgment, thus ensuring continuity of the Project.

(22) Development of water supply regulation based on verification of domestic legal systems and research of overseas examples

a. Issue

The development of a draft water supply regulation for Yangon city was added to the project scope in the course of the project period. Since many of the counterparts were technical staff, it could be said that their understanding was not high enough to understand that laws and regulations should be consistent with the legal system of the entire country, and that the regulation should be considered as one that defines the rights and duties of citizens. On the other hand, Myanmar does not have a water supply law at the national level, which is different from Japan's legal system, and it was assumed that it would be difficult to adopt Japan's case directly. Therefore, it became a challenge how to develop a consistent water supply regulation while enhancing the understanding of the counterparts.

b. Measures

In many countries around the world, water supply services started as a local public service. When looking into laws and governance, understanding how water supply services are structured within the local administration is often the easiest way to understand the key frameworks. Therefore, it was decided to first find out the positioning of the water supply business in Myanmar's local administration, make an assumption about it, and then try to make it consistent. In addition, the contents of water supply regulations of countries other than Japan were also studied and referred to in an effort to enhance counterpart's understanding of the laws and regulations.

c. Result and Lesson

It was assumed that there was a basis for water supply related laws and regulations in the Constitution, which stipulated the general framework of local administration, but we found there was no clear provision. On the other hand, the Municipal Law and other laws issued during the British colonial period defined the operations and authority of municipalities, including water supply services; thus, it was assumed that this old law had been inherited in a certain way. In fact, the YCDC Law, which succeeds the Municipal Law, stipulates that the YCDC shall be responsible for water services. Therefore, it was clarified that the region or state that has the authority to enact the YCDC Law has the authority to determine the framework of the water supply services, and the position of the water supply regulation that was planned to be developed. The water supply regulation of Yangon differs from that of Japan and can be regarded as a kind of enforcement regulations for the YCDC Law. By starting at studying the local administration, it was believed that the counterparts have acquired a deeper understanding of the position of the water supply regulation in line with the local legal system.

In addition, because of studying and researching water supply regulations of Japan and other countries, the counterparts were able to deepen their understanding of the similarities in which a regulation must include water supply equipment and water tariff, and the counterparts were able to utilize this understanding in drafting their regulation.

(23) Technical cooperation about local materials and equipment in NRW management

a. Issues

Countries with advanced waterworks technology such as Japan have a very high-quality level of technology related to pipe-laying and the construction of waterworks facilities as well as the quality of the materials that support this technology. The water supply infrastructure is maintained by many technologies including the use of appropriate materials. However, there were significant challenges in Myanmar in terms of the quality of locally procured materials and the types of products. The counterparts were faced with the lack of crucial materials and low quality, even if they tried to implement NRW measures by using the technical skills that they learned during the Project in their daily work afterwards.

b. Measures (and proposals)

With regard to the guidance and technical transfer of the measures against NRW in developing countries in the future, in addition to the direct technical technology, it is necessary to promote technical guidance on the local production of materials which is essential to maintain the transferred technology, with the cooperation of Japanese manufacturers.

(24) Review of a system of PDM indicators for the purpose of achieving the project overall goal

1) Issues

It was unclear about the initial PDM whether the overall goal could be achieved if the objectively verifiable indicators (OBIs) of the project purpose and the outputs could be achieved. In the initial OBIs system, the path leading to the achievement of the overall goal was unclear.

2) Measures (Recommendations)

The OBIs system was reestablished by examining the path to achieve the overall goal by creating the impact from the achievement of the project goal.

a. Method to achieve the overall goal

The overall goal will be achieved in 3 to 5 years after the completion of the Project by implementing the established PDM cycle using the capacities acquired in the achievement of the outputs and project purpose.

b. Set comprehensive targets of project purpose to be achieved
    - Achievement of all targets of the outputs
    - Operation of monitoring system
        - Are the indicators to achieve targets monitored periodically?
    - Establishment of an official system for taking improvement actions
        - Is there any driving force to implement PDCA cycle?
    - Creation of mid-term action plan to achieve the overall goal
        - What actions are made and how many years PDCA cycle will be implemented to achieve the overall goal?

c. Contents to be achieved in targets of the outputs
    - There are responsible organizations to achieve targets.
    - Internal business procedure has been improved or established. (e.g., creation of rules, standards, guidelines and manuals, improved internal processes)
    - The individual staff have leadership, ability to continuously develop human resources, and/or technical and administrative capacity to improve business process (e.g., development of leaders, Professional and trainers)

d. Image of the concept to achieve the overall goal

The image of the concept to achieve the overall goal is shown in the figure below. In this concept, PDCA is managed by Planning Section.

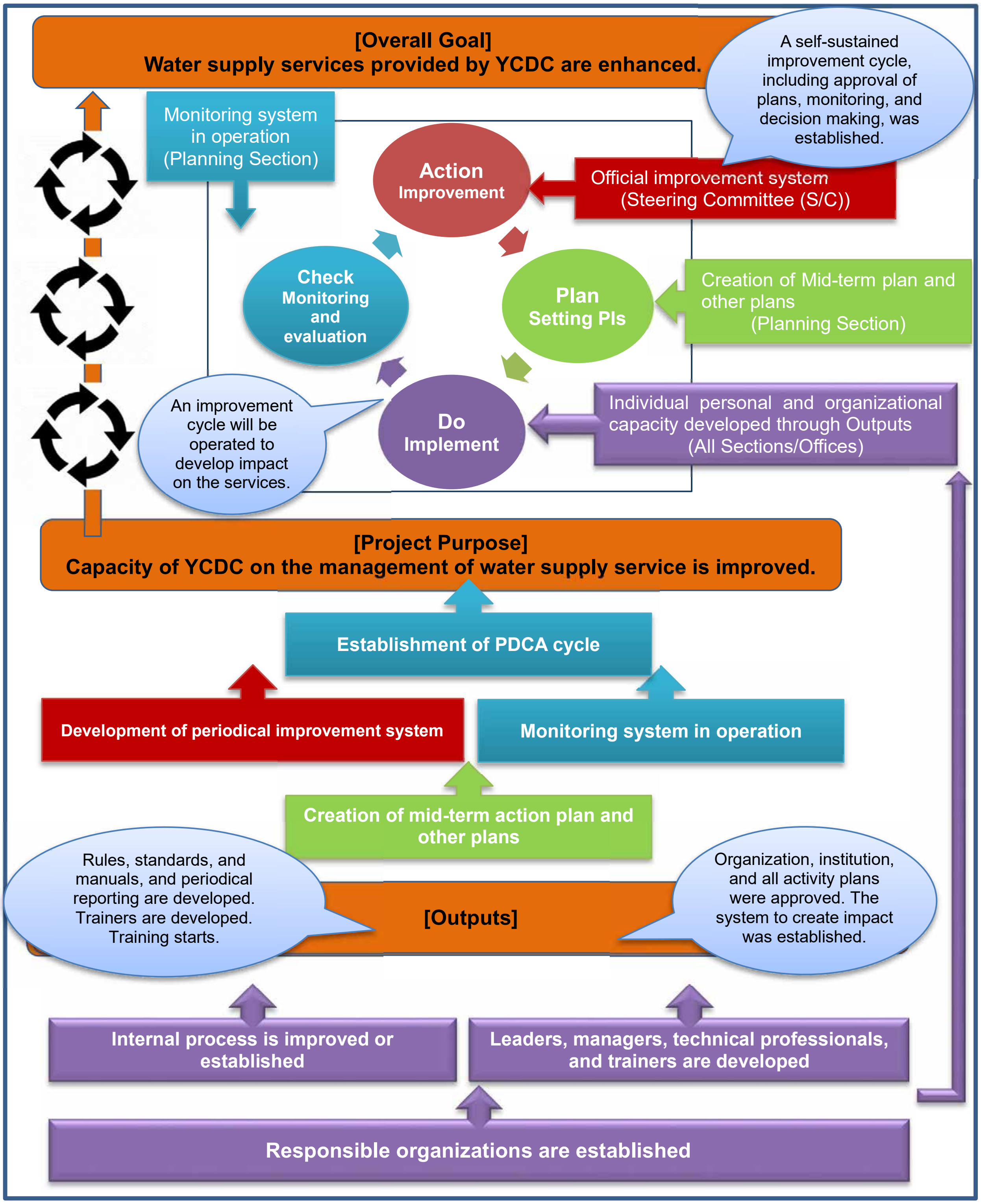


Figure 3-3: Image of the concept to achieve the Overall Goal

4. Achievement Status of the Project

4.1. Status of achievement based on PDM

4.1.1. Achievement Status of Outputs

The indicators of the outputs and achievement status are shown below. Most of the indicators have been achieved, although some indicators have been affected by COVID-19 pandemic and the political instability.

(1) Output 1: Capacity of YCDC on institutional management of water supply utility is improved

Indicators	Activities and Achievement Level
1-1 Plan for improvement of water bill collection is approved by WRAWSA.	The indicator 1-1 was fulfilled. The Project elaborated the plan for improvement of water bill collection and already gained approval of the plan from the CE of WRAWSA. The plan aims at developing a new customer management system on water bill collection. The new system completed in 2019 with functions of "search and registration of customers", "meter reading", and "water billing". The trial application is now under process in pilot T/Ss. The preparation to add more functions of "collection system of water tariff", "management of unpaid customers", and other statistical data treatments are in progress. The functionality and effectiveness of the first version system were already confirmed in the pilot township.
1-2 Plan for human resources development is approved by WRAWSA.	The indicator 1-2 was practically fulfilled. The Project has been working on development of an integrated plan that includes not only human resources development but also human resources management. The plan was already presented at JCC in October 2019. Priority measures have already been initiated to address the turnover of young and non-permanent staff as a key issue. The content of the plan has been agreed by WRWSA top management, and meetings to review and proofread the final draft have been ongoing since January 2021 for final confirmation of the plan prior to submission to YCDC, but the activity has been suspended due to political instability.
1-3 Drafts of regulations, standards and guidelines for water supply services in Yangon is approved by WRAWSA.	The indicator 1-3 was mostly fulfilled. Two guidelines regarding customer management such as "meter reading" and "bill collection" as well as a guidebook for water tariff setting have been developed. In addition to Standard Operating Procedures, SOPs, for NRW management and water quality management, SOPs have been elaborated at 33 divisions/sections of WRAWSA. As of January 2021, 12 of them are now being introduced after approvals, seven of them are under revision after trial, 13 of them are under trial, and one of them is at completion stage of final version. However, the progress was suspended due to political instability. Water supply regulation (draft) was elaborated. The final draft is almost complete and awaiting approval as it has been refined by legal advisor of YCDC and heard comments from all officers.
1-4 New organization structure is approved by Mayor.	The indicator 1-4 was virtually fulfilled. Based on the proposals presented in the "Report on Institutional Reorganization of Engineering Department (Water and Sanitation) of YCDC" in July 2016, the following divisions/sections were newly established with fulltime and part-time staffs, namely, Water

	Treatment Section, NRW Management Section, Transmission and Distribution Management Section, Planning Section, Human Resource Development Section, and Customer Service Division. WRAWSA is now under final approval process transferring to an "Authority" body. This newly developed organizational structure is included in the proposal of Authority establishment, and already submitted to Mayor.
1-5 2 Full time staff members in Planning Section can give direction of PDCA cycle to WRAWSA staff.	The indicator 1-5 is almost fulfilled. Two (2) staffs in Planning Section have participated in the Project since the beginning that included trainings on how to analyze and utilize PI data and to formulate mid-term management plan. After the training period, they started giving instructions and trainings to other divisions/sections and township offices as internal trainers of WRAWSA on these planning issues in the context of PDCA cycle. Their technical capacity and knowledge are almost reaching a reliable level to instruct PDCA cycle. In addition, another three (3) younger staff were assigned in Planning Section. They are also candidates to be internal trainers of PDCA cycle in the mid-run perspective.

(2) Output 2: Capacity of YCDC on NRW management is improved

Indicators	Activities and Achievement Level
2-1 Manuals and training materials on NRW management are utilized by YCDC staff.	The Project has been progressing towards fulfillment of the indicator's requirement. Based on observations and lessons learned through the pilot project since January 2019, the Project made 26 SOPs related to NRW management. In addition, another training material specifically for the Training Center for NRW Management; 12 training materials for lectures, and 4 technical documents for field practice have been developed. These were utilized at the training course on NRW management (online) conducted in Dec. 2020. From now on, the C/P is expected to continuously utilize these SOPs and training materials during providing training courses to YCDC staff.
2-2 Information of customers and pipes for the pilot areas is compiled and updated.	The indicator 2-2 was fulfilled. The Project started making the customer list in the pilot area, Yankin in January 2019 and finished in December of the same year. In parallel with making the list, information update on the list has also been conducted according to the change and/or move of customers. Information of distribution pipeline has also been compiled in WRAWSA.
2-3 The number of trainers for NRW management becomes 8.	The indicator was mostly fulfilled. A series of trainings on NRW has continued by use of the pilot project, which widely covers the training topics such as pipe laying, leakage detection and fixing of pipe. In addition, even before the pilot project commencement, the Project had conducted trainings on how to calculate service coverage rate, the mechanism of NRW occurrence and others. Although technical transfer has continued through such a series of trainings in integrated manner to create internal trainers, the Project faced frequent changes and/or leaves of counterparts, which resulted in less counterparts as internal trainer candidates than originally expected. As the Project continuously tried to increase the number of candidates, six C/Ps had been trained as internal trainers by January 2020.

	Furthermore, in preparation for the online NRW management training conducted in Dec. 2020, three new staff of NRW Management Section were trained as trainers and these staff were able to provide lectures with the assistance of the C/P implementing the Yankin pilot project. This training was conducted by 12 trainers (including 9 from NRW Management Section).
2-4 WRAWSA staff participates in training based on training plan for NRW management.	The indicator was mostly fulfilled. Most of training activities for the planned subjects have been completed although, the number of WRAWSA staffs participating in the NRW management training was rather limited at the time of the project completion compared to the originally expected number. First, trainings were provided to the C/P in survey related to NRW management, planning, drawing, hydraulic analysis in the pilot project area. Next, a total of 16 counterparts of newly established NRW Management Section and other offices were trained on technical management methods to prevent NRW through the pilot project, which included acquisition of techniques for selection of distribution materials, jointing and branching of service pipes from distribution pipes using branch saddles, and installation and function check of customer water meters. In addition, through pilot project, the C/P conducted a training session as trainers for T/S officers on water pressure testing, methods of pipe jointing (DIP, RRVP, HDPE (Electro-fusion)), installation of saddle snap tap and branching service pipes with drilling machine under pressure. In Jan. 2020, a comprehensive training course on NRW management was conducted for newly promoted staff (20 people) at the newly constructed Training center for NRW management. Thereafter, since group training could not be held due to COVID-19 pandemic, a 10-day online NRW management training course was held for 14 deputy T/S officers in Dec. 2020. As for other trainings, the Expert provided guidance on making construction completion drawings of pipeline networks in some areas. The C/P continued this work, but the final version has not been confirmed. Also, the guidance on step-test has been completed, but step-test in pilot area has not been conducted due to curfew in pilot area. It is necessary to continue training at NRW training yards and other facilities, but activities were suspended due to political instability.
2-5 NRW ratio is decreased to 25% in the pilot area.	The indicator 2-5 was fulfilled. NRW ratio of the pilot project area was calculated as 86% on the basis of water flow test in February 2019. The Project renewed the distribution pipes, service pipes and meters at the area. Owing to these renewals, NRW ratio dropped to 51.1% after pipe renewal, and reached to 5.5% with meter replacement. Further monitoring showed an increase in NRW ratio to 19.9% in June 2020. It is needed to investigate the cases and take actions in this field, but activities were suspended due to political instability.

(3) Output 3: Capacity of water quality management of YCDC is enhanced

Indicators	Activities and achievement level
3-1 Manuals and training materials on water quality management are fully	The indicator 3-1 was fulfilled. • Water quality management The Project finished elaborating SOPs on WTP and on chlorination

utilized by YCDC staff.	facilities as technical manuals as well as training materials on water quality management in February 2019. The SOPs have been well utilized for operation of WTPs. • Water quality monitoring The water quality monitoring has been conducted by use of SOPs on water quality analysis, the first version of which was completed in 2016. The SOPs have been effectively utilized not only at the central laboratory but also at other on-site mini laboratories.
3-2 Result of the water quality test by the central laboratory and on-site mini laboratory is recorded and monitored periodically.	The indicator 3-2 was fulfilled. Following monthly water monitoring plan, the central laboratory has conducted water quality tests of the samples collected from the monitoring points. As for reservoirs and WTPs, water quality tests are conducted every morning and afternoon. The data has been recorded since 2015 at the central laboratory and since 2017 at on-site mini laboratories.
3-3 The number of trainers for water quality management becomes 4.	The indicator 3-3 was fulfilled. • Water quality management Through a variety of trainings such as classroom trainings, OJTs and seminars, the Project has transferred technical knowledge and skills to develop internal trainers. Two (2) staffs are now qualified as internal trainers. • Water quality analysis Three (3) staff members are considered as internal trainers, judging from the fact that they already conducted younger staff trainings as trainers and are giving technical instructions to the on-site mini laboratory staff in their daily works.
3-4 WRAWSA staff participates in training based on training plan for water quality management.	The indicator 3-4 was fulfilled. All the staff working at laboratories has already participated in the trainings on water quality management. The participants are 10 from the central laboratory and 10 from the on-site mini laboratories. The trainings were conducted on the basis of the timing when the SOPs were elaborated and revised, and not based on the fixed training schedule and/or plan.
3-5 The turbidity of treated water in pilot sand filter in Nyaunghnapin water treatment plant is controlled less than 1 NTU.	The indicator 3-5 was fulfilled. The turbidity of treated water in Nyaunghnapin WTP has been well controlled less than 1 NTU nearly all the time. The turbidity surpassed 1 NTU at only three (3) times in 11 months at Phase 1 facility and one (1) time in 16 months at Phase 2 facility until Jan. 2020.
3-6 The operation and maintenance system of Lagunbyin water treatment plant is prepared.	The indicator was mostly fulfilled. Administrative order was issued to set up Task Force Team and to allocate 19 staffs for trial operation of Lagunbyin WTP. In addition, organizational structure for O&M of WTP and duties and responsibilities of each section were also determined. After establishing O&M structure, WTP started partial operation in Mar. 2020, however, new challenges were identified including seawater contamination in raw water, optimization of the size of the generated floc, and degradation of the water quality at the end of water supply area. With advice by Expert, the C/P handled these issues. The C/P will have to deal with the problems related to the start of operation of Lagunbyin WTP at the field, as well as prepare SOPs.
3-7 The operation and maintenance system of chlorination facilities is	The indicator was mostly fulfilled. Chlorination facilities were newly constructed in Nyaunghnapin WTP, Hlawga reservoir, Yegu pumping station, and Lagunbyin WTP, and

prepared.	after organization structure of the facilities was determined, the trial operation was started in January 2020. Although the organizational structure was established for O&M of the chlorine disinfection facilities, as with indicator 3-6, on-site guidance and explanation is necessary, and it was difficult to conduct effective support remotely. In the future, it is necessary to develop SOPs for these facilities by the C/P.

4.1.2. Achievement Status of Project Purpose

The indicators of the project purpose and achievement status are shown below.

(1) Project Purpose: Capacity of YCDC on the management of water supply service is improved

<table>
<tr><th>Indicators</th><th>Activities and Achievement Level</th></tr>
<tr><td>1. Steering Committees (S/C) are organized and improvement actions are implemented.</td><td>The indicator 1 was fulfilled.
The CE of WRAWSA approved establishment of Steering Committee, S/C, with appointment of members for each S/C in July 2017. The organized S/C and the number of meetings is as follows:
In June 2018, S/C 3 additionally formed two (2) sub-groups, one of which takes care of installation of water supply equipment and another is in charge of water billing and collection.
<table>
<tr><th>S/C</th><th>Primary field(s) of S/C</th><th>Number of S/C meetings as of January 2021</th></tr>
<tr><td>S/C 1</td><td>NRW management</td><td>5</td></tr>
<tr><td>S/C 2</td><td>Planning and monitoring</td><td>6</td></tr>
<tr><td>S/C 3</td><td>Regulations, standards and guidelines</td><td>17</td></tr>
</table></td></tr>
<tr><td>2. Mid-term management plan is approved by WRAWSA.</td><td>The indicator 2 was fulfilled.
The Mid-term management plan shows the current situation/challenges and their action plans with corresponding targets for their improvements in the mid-term perspective. The plan covers issues such as water supply services, water resource development, NRW management, water quality, water billing collection, financial management, and human resources development/management.
The plan was approved at the S/C 2 meeting in October 2018 and received an official letter in February 2019 from the CE of WRAWSA.</td></tr>
<tr><td>3. The implementation of mid-term management plan is monitored based on MKPIs.</td><td>The indicator 3 was fulfilled.
The Project selected 15 types of primary indicators such as service coverage rate, NRW ratio and total number of connections as “Management Key Performance Indicators” as MKPIs from Key Performance Indicators (KPIs). All the data has been collected since 2016 through the data monitoring system that the Project elaborated. All the monitored figures of MKPIs for the year of 2018/19 were compiled in 2020, and the monitoring work has been regularly carried out.</td></tr>
<tr><td>4. The NRW ratio is grasped in the water supply service area of YCDC and monitored.</td><td>The indicator 4 was fulfilled.
Before starting its operation of flow monitoring system, which was established by the project, the NRW ratio was about 50%, calculated on the basis of operation hours of pumping stations.
The water flow monitoring system was introduced in September 2019. The NRW ratio of October 2019 by use of the system is 65.3%. The NRW Management Section has continued to monitor NRW ratio. NRW ratio in September 2020 was 64.4%.
*The ratio will turn out only after three months due to the time necessary to gather water billing.</td></tr>
</table>

5. Plan for NRW reduction is approved by WRAWSA.	The indicator 5 was fulfilled. Mid-term plan for NRW reduction which has three major categories: NRW management, physical loss, and commercial loss was approved in October 2018 at JCC. NRW reduction is placed as the highest priority issue in the Mid-term management plan. Furthermore, the detail action plan was formulated.
6. Water quality is grasped in the water supply service area of YCDC and monitored.	The indicator 6 was fulfilled. The water quality monitoring plan exactly specifies the monitoring points in the water supply service area of YCDC, frequency, monitoring items, and methods. Each township sends samples to the central laboratory every month, and the monitoring results are presented to the CE on monthly basis. Since the technical capacity of the laboratories has almost reached a technically reliable level, it can be judged that water quality is being grasped much more accurately than before.
7. Plan for improvement of water quality is approved by WRAWSA.	The indicator 7 was fulfilled partially. Water quality management improvement plan is being developed; however, the counterpart activities were suspended due to the political instability and unrest since February 2021. A draft plan has been compiled, but approval is considered doubtful.

4.2. Self-Evaluation from 6 Evaluation Perspectives

(1) Evaluation perspectives

Relevance	Examines the extent to which the Project activity is suited to the priorities of donor and counterpart country. • Does the goal of the Project meet the needs of beneficiaries? • Is the Project approach appropriate for solutions of problems and challenges? • Are the Project activities consistent with the policies of counterpart country?
Coherence	• Consistency with the development cooperation policies of the Government of Japan and JICA • Collaboration with other projects and support within JICA (synergistic effects / synergies) • Cooperation with other domestic and foreign organizations, cooperation with international frameworks, etc.
Effectiveness	Measures the extent to which a program or a project attains its objectives and benefits the target society and the beneficiaries.
Efficiency	Measures the outputs in relation to the inputs to determine whether the aid uses the least costly resources possible to achieve the desired results.
Impact	Examines positive and negative changes as a result of the Project. This includes direct and indirect effects and expected and unexpected effects.
Sustainability	Sustainability relates to whether the benefits of the Project are likely to continue after the closure of the Project.
Non-core items	
Adaptation / contribution	Analysis of the process from an objective and independent perspective on the roles and contributions that JICA and other related parties played during planning, examination, and project implementation in order to achieve the project purpose.
Added value / creative value	Confirmation of the unique efforts of JICA, the values and element inputs that only JICA could provide, and the innovative efforts. Confirmation of dissemination and sharing of new knowledge acquired through the project.

(2) Evaluation

The evaluation results as of the end of the Project are shown as below. The evaluation results are described based on the results of terminal evaluation implemented in January 2020. The underlined parts are major updated parts after the terminal evaluation. In addition, Coherence, Adaptation/contribution and Added value/creative value were added to the evaluaton perspectives after the terminal evaluation based on the new evaluation scheme in JICA.

Relevance	The Project is consistent with the priority of development policies of Myanmar and Yangon city, the needs of YCDC, and the assistance of policy of Japan. The relevance is evaluated high. 1. Consistency with the policy and/or plan of Myanmar The national five-year development plan as of the Project commencement had three pillars, 1) renovation in policy, economy, administration, private sector development, 2) development by initiatives of Myanmar nationals, and 3) prioritized ten (10) development fields. Water supply services is placed as one of the 10 prioritized development fields. The Myanmar Sustainable Development Plan 2018-2030 as of the Terminal evaluation has five (5) goals, one of which is “access to safe water” as Strategy 5.3. It is confirmed that the Project has been consistent with the national policy since the beginning of the Project until now. As to the sector policy viewpoint, YCDC has been working on the basis of the “Yangon city water supply M/P”. The Project is regarded as one of the important inputs to realize the M/P. Overall, the Project is in line with the national policy as well as the sectoral plan of Yangon city. 2. Consistency with the needs Before the Project started in 2015, the ratio of NRW in Yangon city had reached 66% due to improper NRW management (2013). Yangon city also faced challenges in water quality, proper operation and maintenance of various water supply facilities and equipment. Under such challenging situation, YCDC had strongly recognized the necessity to develop staff’s capacity in wide range from institutional to technical aspects including topics such as NRW and water quality management. The Project has been providing technical assistance activities in various fields in accordance with the necessities of YCDC. The contents and targets of the activities have been determined through mutual consultation with YCDC counterparts and the Expert at the beginning of the Project. The Project has been meeting the needs of Yangon city and YCDC in this context.
Coherence	1. Coherence with development cooperation policies of Japanese government and JICA Japan's "Economic Cooperation Policy with Myanmar" announced in April 2012 specifies the development of infrastructure as one of its assistance goals. The assistance for water supply services in Yangon is positioned as one of the major projects to achieve this goal. The project is in line with the direction of Japan's aid policy. 2. Synergistic effects with other JICA projects (technical cooperation, grant aid, yen loan, etc.) • This project is designed to strengthen the capacity necessary for the implementation of the master plan formulated through the "Preparatory survey report on the project for the improvement of water supply, sewerage and drainage system in Yangon city” and for the implementation of various projects such as yen

	loans based on the master plan. The contents of this project were conceptualized based on the feasibility study of YCDC's capacity development plan conducted during the same preparatory study. The project dealt with a wide range of contents from the basic level and built the foundation of an organization to realize modern water supply services. • The project has achieved the synergistic effects as below in the yen loan assistance "Greater Yangon Water Supply Improvement Project " (hereinafter referred to as "Phase 1") and "Greater Yangon Water Supply Improvement Project (Phase 2)" (hereinafter referred to as "Phase 2"). ➢ Operation and maintenance system was established for Lagunbyin WTP and chlorine disinfection facilities of Phase I, which commenced the operation. The staff trained in this project at the existing WTP are in charge of the operation of the Lagunbyin WTP and chlorination facilities, and the transferred technologies are being utilized at the facilities constructed by the loan project. ➢ The knowledge and experiences on NRW management obtained in this project was used as a reference for the design of DMA construction in Phase 2. ➢ By utilizing the strengthened capacity of water quality monitoring in this project, C/Ps analyzed water quality of the water source of Phase 2 WTP, and confirmed its acceptability as a source of drinking water. • The project worked in close cooperation and information exchange with JICA Expert for Water Supply and Sanitation Improvement in Yangon City. In particular, with regard to the flow monitoring system provided by the project, it was expected that the system would be utilized even after the completion of the project, thus, the project worked in coordination with the expert in setting up Water Transmission and Distribution Section, and utilizing the collected data. • Three of main C/Ps of the project participated in the long-term scholarship program “Water Engineering and Utility Management Future Leaders Training” during the project period. In addition to facilitating the selection of candidates in line with the purposes of the program, the project provided advice on their research activities and support for the utilization of their knowledge in work after returning to YCDC, thereby enhancing the effectiveness of both the project and the program. 3. Complementation and harmonization with other projects of Japan or other development partners, alignment with international frameworks (international development objectives, initiatives, protocols, and standards) • WRAWSA had not had any office in charge of NRW management projects, and as a result, documents and technical reports provided by each donor have not been compiled and utilized within WRAWSA. NRW Management Section established in the project is assigned the task of collecting and organizing such kind of information. Furthermore, this section centrally manages the donors’ NRW management projects, which includes Japanese assistance projects such as “The Project for Reduction of Non-Revenue Water in Mayangone Township in Yangon (grant assistance for grassroots human security project)”, “the Project for Urgent Improvement of Water Supply System in Yangon City (grant aid project)”, and “The Project for Reduction of Non-Revenue Water in Mayangone Township in Yangon City” (grant aid with operation and maintenance) • The project of laying conveyance pipeline from Ngamoeyeik Reservoir to Nyaunghnapin WTP is underway by ADB. In this connection, a plan for the construction of Nyaunghnapin WTP Phase 3 has been developed. The design of the WTP is being studied using the direct filtration system, which has been experimented in the project and has shown good results.

	• In the course of the implementation of the project, the development of PPP application in the water supply sector in Yangon was initiated and a pre-feasibility study (hereinafter referred to as "Pre F/S") on PPP options was conducted by IFC. In response to this, the project carried out additional activities to study the options for PPP application.
Effectiveness	Effectiveness of the Project is high. 1. Progress of Project purpose • The Project purpose "capacity development of YCDC on management of water supply service" has been almost achieved as of the Terminal evaluation. The Project took approaches from three (3) aspects for capacity development, which are 1) organizational and institutional aspect, 2) operational aspect, and 3) technical aspect. As the achievement status of the Outputs show, positive outcomes are observed in each aspect. Essential knowledge and skills for water supply services, which had not been identified despite their importance, and/or had not been trained in spite of such requests before the Project, have been successfully accumulated step by step in YCDC staff. <u>In terms of "improvement" and "development" of capacity, the Project has been satisfactorily progressing towards full achievement of the purpose. The degree of its achievement has further progressed by the end of the Project.</u> • <u>The project purposes are mostly achieved as of the end of the Project.</u> 2. Contribution factors The Project has been progressing owing to these contribution factors. 1) Effect of the third-country training The Project provided third-country trainings in Thailand and Cambodia in addition to Japan. Since both countries achieved development and improvement of water supply services relatively recently, the trainings not only gave the counterparts technical knowledge but also raised their mind-set for improvement and motivation from learning their development experiences. <u>In addition, the concept of the training was a research-style training in which the trainees identified the main training challenges in advance and connected the training results with problem-solving. After the training, the C/P submitted a report including an improvement plan.</u> Looking at the tangible outputs on technical aspects, learnings from PPWSA of Cambodia were particularly effective. The C/P utilized their learnings especially on performance monitoring by PIs data, preparation of SOPs and development of various plans. The major plans they made are as follows: • Management Improvement Plan of WRAWSA • Improvement Plan for NRW Management and Customer Service • Improvement Plan for Management of Water Treatment and Water Quality 2) Application of knowledge and skills of local governments in Japan The Project effectively introduced knowledge and skills that have been accumulated in local governments in Japan owing to participation of the Expert from local government group/line companies. Their knowledge and skills contributed to enriching the Project activities particularly in water quality management, customer services, methodology and/or processes to set water tariff, NRW management and others. In addition, Advisory Committees comprised Tokyo metropolitan and Fukuoka city also assisted in the Project activities during the Project period. Their advices and information also enhanced the effectiveness of the Project activities.

	3) Process of designing the Project contents The detailed planning survey of the Project in 2014 determined the basic fields to deal with in the project, but intentionally did not determine detailed activities contents as well as PDM indicators. The detailed planning survey encouraged the C/P and the Expert to consider and determine the activities through discussion, workshops such as problem analysis and/or capacity assessment after the Project started. Such relatively open-styled planning enabled to avoid mismatch of the technical needs and the Project plan. Also, the initial process of workshops and capacity assessment contributed to deepening mutual understanding as well as creating ownership mind in the C/P. 4) Prompt decision making and actions by top management The top management strata of YCDC, Yangon city, and YRG has high recognition of the importance of the Project activities. Their recognition and leadership gave support to the Project in terms of personnel assignment and necessary budget securement. They also led to commencement of their own projects and/or equipment procurement in addition to the Project's support. 5) Synergetic effects of YCDC's spontaneous and prompt actions with the Project In the course of the Project implementation, YCDC initiated many projects with their own budget as mentioned above such as NRW management pilot project in North Okkalapa, introduction of the customer management system, and the small-scale direct pilot filter project of untreated water from Hlawga and Gyobyu reservoirs. These YCDC's activities produced synergetic effects with the Project activities. For example, prior to the start of the pilot project in Yankin, the Project could utilize the North Okkalapa pilot project as the venue for their training. From the viewpoint of the organizational aspect, YCDC promptly introduced new organizational structure proposed by the Project. Such quick adaptation made the Project focus on the Project activities and contents more clearly with more specified counterparts. Overall, it is highly evaluated that YCDC's spontaneous and prompt actions brought synergy effects within the Project and enhanced the effectiveness of the Project. 6) Assignment of a long-term expert stationed in Myanmar The Project dispatched a long-term expert in Myanmar in addition to the shuttle-style consultant expert team. Besides the original technical tasks, the long-term expert enhanced bridging information and relationship between the C/P and the Expert and contributed to improving management and follow-up of the Project activities.
Efficiency	Efficiency of the Project is moderate. Expert's assignment was flexibly adjusted not only in assignment timing but also in the variety of the Expert's assignment fields in accordance with the Project progress and necessity. Manpower input by Japanese side is evaluated to be efficient and effective. Component of the expert team comprising of various organizational backgrounds is also evaluated to be high. Myanmar side also made an effort to assign counterparts and to keep them stay, though, there were actually frequent changes and/or leaves of counterparts especially in NRW management, which had an influence on seamless technical transfer.

	The delay in equipment procurement also had influence on a series of activities of NRW management. On the other hand, the third-country training was an efficient and effective input contributing to the Outputs and the Project purpose. Overall, the efficiency is evaluated to be moderate. <u>In the terminal evaluation, the efficiency was evaluated to be moderate. With regard to the assignment of the C/P, however, WRAWSA continuously kept following up. For instance, the NRW Management Section expanded and became a large section with 16 staff members, which compared with no section of NRW at the beginning of the Project. In the pilot project, in addition, 21 staff members participated.</u> <u>Also, the activities were mostly completed by making up for the delay in procurement of equipment, and the outputs have been achieved. In addition, the efficiency of other activities was mostly high.</u> 1. Manpower inputs 1) Japanese side Japanese side flexibly adjusted the Expert's assignment in accordance with the Project progress and other needs identified in the course of Project implementation. It is evaluated that the manpower inputs are efficient and effective. The Project added experts on "customer services/water billing collection", "Design and supervision for flow meter chamber" responding to the necessities arisen during the Project implementation. Assignment period of the Expert also flexibly adjusted according to the progress of the NRW pilot project. In addition, it should be evaluated highly that components of the expert team which are made of a consulting company, local government group/line companies, a manufacturing company, and a stationed long-term expert enabled to enrich the Project activities. 2) Myanmar side It is evaluated highly that Myanmar side made an effort to assign counterparts as much as possible under the strict employment rule. However, as pointed out in the inhibition factor, there were actually many cases of job resignations, which caused negative effects in technical transfer to counterparts. In addition, there was a tendency to concentrate job assignment on middle age/class staffs, which are not only assigned to the Project but are also assigned to their original tasks in their sections and divisions. Such fully occupied working environment sometimes made it difficult to complete the Project activities. It is, however, necessary to point out the positive prospects as well. Staff still working as counterparts are all highly committed to the Project with ownership mindsets. They are expected to continue working and will play key roles in water supply services in YCDC. Only focusing on the counterparts remaining till now, the efficiency of technical transfer is satisfactorily confirmed. 2. Physical inputs: Equipment/Facility Equipment provided by the Project are all necessary items for the Project activities. They have been well utilized and have contributed to the achievement of the Outputs and the Project purpose. The variety of equipment covers not only the ones required for field works but also for office work. Equipment for office work created noteworthy effects as follows. At the time the Project started, the number of computers at township offices as well as YCDC headquarters was quite limited. A lot of works had to be done on manual basis, which brought challenges in efficiency of works and accuracy of data inputs. Owing to installation of computers and continuous training in computer skills in the newly established computer training room in the Project, they are now able to manage

	data on PIs, customer services and others. It is evaluated that this input contributed to achievement of the Output 1 and accordingly the Project purpose. Selection of equipment is also evaluated as reasonable. Myanmar side recognized advantages of the functions and usability of some items, for example, ultrasonic flowmeter and portable test meter. YCDC has already purchased them additionally from their own budget. On the other hand, there was a delay in procurement of NRW equipment. The negative effects caused by this event was abovementioned in the inhibition factor. <u>On the other hand, YCDC decided to build a training center for NRW management to continuously carry out NRW training without relying solely on pilot projects. The equipment to be installed there was procured by the Japanese side, but YCDC was in charge of the construction of the lecture building and training yard of the training center.</u> 3. Training in Japan and the third country Training in the third country created immense effects as mentioned in the contribution factor. Training in Japan was also effective for counterparts to learn water supply utility management at a global standard level and to have picture of the future in the mid-long run perspective. 4. Budget JICA flexibly increased budget amount allocated to the Project from the original estimate in response to additional needs recognized in the course of the Project. Though the entire request from the Project was not met due to the limitation of the JICA's budget, budget amount and the disbursement timing from both YCDC and JICA did not cause major negative effects for the Project activities. YCDC disbursed budget as planned in general, and sometimes quickly did, responding to decision by top management strata. 5. Supplementary effects and duplication activities Mapping information made by JICA "Yangon Mapping Project" made supplementary effects on the Project especially for development of NRW management plan of the pilot site. Close communication with a long-term expert "water supply supervisor" in YCDC also made positive and supplementary effects in terms of information sharing especially related to other donors' projects. Information sharing helped the Project avoid unnecessary duplication.
Impact	Impact of the Project is high. Achievement of the Overall goal "improvement of water supply services by YCDC" is highly prospected, considering the YCDC's proactive development efforts with corresponding budget, plans of donor projects and assets of the Project including technical knowledge and skills. Ripple effects are also observed in organizational and technical aspects as well. The impact is evaluated as high. 1. Ripple effects The following ripple effects by the Project are observed. 3) Organizational and technical aspects • Further and/or supplementary development actions by YCDC's initiative Using technical knowledge and skills gained through the Project, YCDC is now newly promoting development efforts for better water supply services

		with their own budget. Primary examples are as follows: ➢ YCDC initiated an NRW management pilot project in North Okkalapa with their own initiative and budget, applying the skills and knowledge learned in the Project such as setup of District Metered Area (DMA), analysis and design of distribution pipeline network, and others. ➢ Confirming the effectiveness of the pilot project in Nyaunghnapin water treatment plant, which tested the modified design of rapid sand filter, sedimentation tank and others, YCDC is determined to apply the design and the way of operation to entire Nyaunghnapin water treatment plant. Construction of hoppers and some modification has already started as of the Terminal evaluation. Necessary budget is already secured. ➢ Small scale pilot project of untreated water from Hlawga and Gyobyu reservoirs has shown positive results. YCDC is determined to proceed to the next step to enlarge the test scale. ➢ In addition, the Training Center for NRW Management was opened in January 2020. This center equips a training yard and a training building for lecture classes. <u>Training courses for newly promoted staff were implemented just after opening, and online NRW training courses were implemented in spite of the COVID-19 pandemic.</u> ➢ The training center is expected to provide training not only for Yangon areas under the YCDC's coverage, but also for other regions in Myanmar. In addition, YCDC recently opened the Training center for NRW management in January 2020, which has training yard and building for classroom training. It is expected for this center to provide trainings to not only YCDC coverage area but also to the rest of Myanmar. <u>Technical aspects</u> • Recognition as a leading laboratory in water supply organizations The central laboratory received a visit from Mandalay City Development Committee, MCDC, and provided technical instructions in response to their requests in October 2019. YCDC laboratory staff gave introduction of analytical method of coliform bacilli, SOPs currently in use, and brief instructions on the analytical equipment. In addition, Myanmar Border Development Committee also visited the central laboratory. The reputation of the central laboratory has been gradually extended within Myanmar as one of leading laboratories in water supply organizations, which would entail the roles of instructors such as they did to MCDC. • Formulation of SOPs Divisions and sections not directly involved in the Project in WRAWSA have also formulated their SOPs, following the SOP formulation exercises by the C/P. • Organizational aspects ➢ 5S and Kaizen The Project invited all the divisions and sections to the seminars of 5S and Kaizen. The effect of the seminars is now observed in many divisions and sections. The environment of the offices is now much more organized in terms of document storage/sorting and others. ➢ Staffs moved to Wastewater and Drainage Department Many counterparts who received technical transfer were moved to Wastewater and Drainage Department in April 2019 under reorganization process to an Authority. The staff transferred to the Department have been

	working with higher quality and skills they gained through participation in the Project. The effect of the Project has been spreading to other organizations through such personnel transfer. Negative impacts are not observed.
Sustainability	Sustainability of the Project is moderate. It is highly likely for Myanmar and Yangon local government to continuously stress importance on water supply services. The policy aspect has high sustainability. On the other hand, development and enforcement of legal and regulation aspects need to be accelerated including Water Supply Regulation. As to sustainability of organizational aspect, high sustainability is confirmed on organizational structure, while there are challenges in the form of shortage of permanent staffs and job leave. Technical sustainability has been upgraded significantly through the Project, though, there are still untouched technical fields and shortage of internal trainers. Financial sustainability from macro viewpoint depends on whether the water tariff can be increased or not as planned. Considering these aspects, the sustainability is evaluated as moderate. 1. Policy and legal/regulation aspects Improvement of water supply services is one of the top priorities in the national and Yangon city local governments. The importance is highly prospected even after the Project. Sustainability of policy aspects is evaluated as high. As for legal aspects, law and regulation related with water supply services have been developing step by step until now. However, in order to realize stable and reliable water supply services, further efforts to develop law and regulation are strongly required. 2. Organizational aspect WRAWSA has a reasonable organizational structure to engage in their tasks, which defines roles and responsibility that each division/section has. There are no concerns from the viewpoint of organizational structure. Contrary to the reasonable structure, challenging issues are shortage of staffs at some divisions/sections, and large portion of non-permanent staffs. Employment condition of non-permanent staffs, who may have narrow chances to promote to permanent staffs under the severe employment rule, is possibly affecting their motivation and sometimes leading to job resignation. It is noted that transition of WRAWSA to Authority which is now under official approval process does not create a significant change in their roles and operation for the time being. 3. Technical aspect It is confirmed that the skills and knowledge of WRAWSA/YCDC have significantly upgraded during the Project period. However, questioning if WRAWSA/YCDC can independently offer stable and reliable water supply services, their technical capacity has to be evaluated as it is still in developing stage. The background of this judgement is, firstly, that there are some facilities that are not yet commissioned, such as chlorination facilities and Lagunbyin water treatment plant. WRAWSA/YCDC staff themselves expressed their concerns on whether they will be able to deal with their technical requirements in these new facilities. Secondly, completely new issues may appear such as PPP, which the Project has not addressed yet. Technical concerns from financial management, legal setup and others may need to be addressed in the near future. Another issue of technical sustainability is securing of human resources as internal trainers. Water quality management field has already targeted a number of staffs,

	while other fields including NRW management have not reached the target. This is another concern for technical sustainability. However, the target was achieved by the training for trainers implemented after January 2020. It is also noted that enrichment of hardware aspect including the Training center for NRW management where systematic trainings can be offered, and that of software aspect such as training materials and SOPs formulated in all the divisions/sections, is a crucial asset which can function as technical development infrastructure and/or system. Using these assets, it is expected to enhance technical sustainability. 4. Financial aspect Myanmar's initiative and strong will to improve water supply services can be confirmed in new facilities construction including the Training center for NRW management, purchase of equipment such as ultrasonic flowmeter, and commencement of the NRW pilot project in North Okkalapa. Considering these examples of actual implementation, a certain degree of budget allocation by Myanmar side is prospected even after the Project ends. On the other hand, looking at the financial sustainability from much more macro viewpoint, it may depend on whether water tariff could be increased up to the level where necessary costs can be accommodated. In order to realize necessary investments and/or budget allocations for improvement of water supply services, proper level of water tariff is one of the most important conditions. If the gradual increase in water tariff is realized, the financial sustainability would possibly be enhanced as well. 5. Conclusions The Project made an approach to capacity development from three aspects: 1) Organizational, 2) Operational, and 3) Technical. In every aspect, steady progress can be seen, and the project purposes were mostly achieved as of the terminal evaluation. After that, further progress was seen in the achievement status of project purpose and outputs. The Project faced some challenges such as the delay of equipment procurement and frequent transfer/quitting of the staff members which influenced the training for trainers and technical transfer. While it is a quite remarkable that the Project has had various effects on the proactive development efforts of YCDC for water supply service, and organizational and technical aspects. Overall, the Project itself made a steady progress toward the achievement of the project purposes according to YCDC's development needs. The implementation of the Project can be evaluated as very significant and effective one. On the other hand, the activities of WRAWSA and its operation has been largely influenced by political instability and unrest which occurred in February 2021. Under the military regime, the management and institutional system of WRAWSA has been largely changed. It is feared that it may have a large influence on the sustainability of the Project depending on the succeeding movement.
Flexibility and contribution	In the project, various flexible actions were taken during the implementation process, which enabled activities to be carried out depending on the actual situations and led to scaling up of project outcomes and enhancing sustainability and impact. These efforts within the project are described in "3. Issues, Measures and Lessons Learned in Implementing and Managing the Project". Major contributions by Japanese stakeholders are as follows. • In the project preparation stage, PDM was made more flexible, and the first six months were devoted to assessing the existing situation, identifying issues, and formulating a detailed plan for the project, so that activities could be more fit to actual issues.

	• By taking the opportunities of JCC meetings to seek the YCDC side's requests for the projects, Japanese side was able to flexible respond to the request by adding activities and inputs as needed and utilize other programs such as group training in Japan.
Added values and innovations	In the project, some activities that were not included in the original plan were carried out in cooperation with university, and external organization such as the Myanmar-Japan Human Resource Development Center aiming at improving the capacity of the staff and promoting to produce the project outcomes. As described in "3. Issues, Measures and Lessons Learned in Implementing and Managing the Project", the main items are as follows. • In collaboration with Yangon Technological University (YTU), lectures on the basics of water engineering were planned and implemented at WRAWSA head office to improve the capacity of staff. This also provided the water supply sector with opportunities for exchange between public operators and academia. • With cooperation of Myanmar-Japan Human Resources Development Center, the project conducted a series of seminars on "5S and Kaizen" and provided guidance on its implementation. In WRAWSA, where top-down administration has been typical and bottom-up discussions have been limited, this program provided opportunities for new discussions at every office and improved the efficiency of workplace by staff participatory approach.

5. Recommendations to Achieve Overall Goal

5.1. Setting of Overall Goal

Three indicators are prepared for the overall goal. However, the setting of target values for the NRW ration and water quality management was delayed due to the delay in the calculation of the NRW ratio for the entire city and the delay in the operation of the Lagunbyin WTP and chlorination facilities, by which most of the capacity development activities related to these facilities has not been carried out. In addition, due to the COVID-19 pandemic and political instability which occurred in February 2021, it was not possible to set target values with the C/P. Therefore, based on the activities and discussions made with the C/P, the target values of NRW ratio and water quality management were provisionally prepared by the Expert as follows. The target year for achieving the overall goals is assumed as 2025.

<table>
<tr><th>Indicators</th><th>Contents of setting (provisional)</th></tr>
<tr><td>1. The management key performance indicators (MKPIs) are improved compared to the data at the Project commencement.</td><td>It has been set. An activity plan was formulated in the mid-term management plan, in which MKPIs were selected and target values were set.
<table>
<tr><th>Symbol</th><th>Indicators</th><th>Unit</th><th>FY2020/21
MTP Targets</th></tr>
<tr><td>S2</td><td>Total connections</td><td>Nb.</td><td>383,259</td></tr>
<tr><td>Q7-1-1</td><td>Compliance ratio of monthly water test in water facilities -treated water- (turbidity)</td><td>%</td><td>76</td></tr>
<tr><td>C20-2</td><td>Collection ratio in amount</td><td>%</td><td>78.2</td></tr>
<tr><td>F5</td><td>Operating ratio (Operating cost coverage)</td><td>%</td><td>94.2</td></tr>
<tr><td>F9</td><td>Average revenue per m^3 sold</td><td>Kyat/m^3 water sold</td><td>170</td></tr>
<tr><td>F12</td><td>Unit operational cost for water sold</td><td>Kyat/m^3 water sold</td><td>181</td></tr>
<tr><td>H8</td><td>Training period*number of trainee/Total staff</td><td>Person*day</td><td>1.39</td></tr>
<tr><td>H11</td><td>Total staff number/1000 connections</td><td>person/ 000 conn.</td><td>5.4</td></tr>
<tr><td>PT1</td><td>Resource Capacity</td><td>MGD</td><td>245</td></tr>
<tr><td>C19-1</td><td>Water Volume Sold</td><td>Mil m^3/year</td><td>154</td></tr>
<tr><td>D2-7</td><td>New Pipeline Extension</td><td>Km</td><td>191</td></tr>
<tr><td></td><td>Pipe Rehabilitation/Replacement</td><td>Km</td><td>61</td></tr>
<tr><td>H2</td><td>Total Staff Number</td><td>Km</td><td>2,386</td></tr>
</table>
Note: Only target values of FY2020/21 are given.</td></tr>
<tr><td>2. NRW is decreased from OO % to OO % in the water supply area of YCDC.</td><td>The provisional target value of this indicator is set as follows.
"NRW is decreased from 64.4% to 43.1% in the water supply area of YCDC."
The setting of the target value was made based on the improvement of water meters, which is the main cause of non-physical loss. Regarding the reduction of leakage, which is the main cause of physical loss, it is planned to renew the pipeline of about 6km every year by constructing DMA in NRW Management Plan, but the effect of the reduced NRW amount is very small. Therefore, measures to reduce the amount of leakage are not considered in the reduction ratio. For details, refer to NRW Management Plan in Annex 5C.</td></tr>
<tr><td>3. The compliance ratio in terms of turbidity to meet the water quality standard is increased from OO% to OO%. The compliance ratio is increased from OO% to</td><td>The provisional target value of this indicator is set as follows as examined in "3-2-3 Water Quality Monitoring Plan".
1. Turbidity target for Nyaunghnapin WTP service area
  a) Outlet of WTP: 95 % of annual turbidity data is less than 2 NTU
  b) Water supply area: Not set
2. Turbidity target for Lagunbyin WTP service area
  a) Outlet of WTP: 75% of annual turbidity data is less than 1 NTU</td></tr>
</table>

Indicators	Contents of setting (provisional)
OO% in terms of residual chlorine (>0.2 mg/l).	b) Water supply area: Same as above Note 1: Since the project activities related to residual chlorine management are not sufficient, the target value of residual chlorine is not set in the Project. Note 2: The prerequisite for setting the target value for the Nyaunghnapin WTP service area is that the renovation of all sand filter basins at the Nyaunghnapin WTP is completed. Note 3: Regarding turbidity, there are areas where the raw water of the reservoirs is supplied as it is, and it is not possible to improve turbidity in such areas. In addition, it is difficult to predict the effect of improving turbidity at the tap due to the inflow of turbidity components inside the aged pipe into water. In the Project, therefore, it is appropriate to set a target value at the outlet of WTP and a target for the tap in the Lagunbyin WTP service area where new distribution and service pipes are laid.

5.2. Prospect of Achieving Overall Goal

The prospects for achieving the overall goal "Water supply services provided by YCDC are enhanced" are shown below.

Indicator No.	Achievement prospect
1	According to the monitoring results of MKPIs in the mid-term management plan (2018/19 year: 1st year), 9 of the 12 comparable indicators were improved from those of the 2016/17 values. Improvement of water supply services can be expected in the future in Yangon city as YCDC's own funded projects and donor funded projects including those funded by Japan are being implemented. Therefore, it is highly possible that this target will be achieved.
2	A flow monitoring system of water transmission and distribution mains has been installed, making it possible to monitor the NRW ratio in Yangon city. Systematic training programs at the newly constructed training center for NRW management, SOPs, training materials, NRW management plans, internal trainers, and all other assets including the C/P of the NRW Management Section developed in the Project are expected to contribute to fulfilling the requirements of this indicator. In NRW Management Plan, a plan was created at the beginning to focus on improvement activity related to water meters to reduce NRW ratio in a short period of time. In addition, efforts to improve the meter reading and tariff collection processes using the tariff collection manual will also contribute to the reduction of NRW ratio. The most important activity to achieve this target value is the improvement activity of water meter. If the improvement activity is implemented as planned, it is highly possible that this target value can be achieved. In addition to the improvement activities of water meters, it is indispensable to formulate rules for updating/replacement of meters. On the other hand, if the replaced water meters are damaged by untreated water supply of the reservoir raw water, it will be difficult to achieve the target value.
3	Planned renovation work of Nyaunghnapin WTP, start of full operation of Lagunbyin WTP, and proper turbidity management will contribute to the improvement of turbidity. In addition, all other assets developed in the Project, including SOPs, water quality management plans and internal instructors, are expected to contribute to fulfill the requirements of this indicator. On the other hand, unless the renovation work of the WTP is carried out, it is impossible to achieve the target value of Nyaunghnapin WTP.

5.3. Recommendations toward Achieving Overall Goal

The recommendations for achieving the overall goals are shown below.

(1) Recommendations for achieving each indicator

Indicator No.	Recommendation
1	a) WRAWSA needs to continuously monitor MKPIs in the mid-term management plan. b) In particular, it is necessary to accurately fill out the PIs data sheet of related sections, which is the basis of MKPIs monitoring, promote its regular submission to the Planning Section, and continue the confirmation and coordination work by Planning Section. c) The WRAWSA management needs to take the initiative to promote the activities of related organizations and Planning Section.
2	a) Relatively low-cost and immediate measure to reduce the NRW ratio is improvement activity related to water meters such as replacement of water meters, and it is necessary to focus on this activity. b) On the other hand, it is necessary to improve the water supply quality of the reservoir water because the untreated water supply of the raw water of the reservoir causes damage and functional deterioration of water meters. c) Accurate and regular meter reading is required through the improvement of work processes by tariff collection manual. d) It is necessary to continue NRW management by DMA and increase NRW management by constructing new DMA. e) It is necessary to improve the utilization of assets including systematic training program at the training center for NRW management, SOPs, training materials, NRW management plans, internal trainers, and the C/P of NRW Management Section.
3	a) It is necessary to carry out the renovation work of the Nyaunghnapin WTP as planned. b) It is necessary to properly operate and maintain Lagunbyin WTP, which will be in full operation, based on the technology acquired at Nyaunghnapin WTP. c) There are areas where the raw water of the reservoir is supplied as it is, and it is not possible to improve the turbidity in such areas. Therefore, it is necessary to improve the water quality of the reservoir water. d) There is a need to improve the utilization of all other assets developed, including SOPs, water quality management plans and internal trainers. e) In the future, it is desirable to focus on residual chlorine management activities and set target values for residual chlorine.

(2) Overall recommendations
The overall recommendations required to achieve the overall goal are given as follows.

1) Strengthening organizational governance for sustainable water utilities
With the aim of WRAWSA toward independent water supply utility in the future, lectures of basics of water supply utility and sustainable water supply utility, the third country training and governance seminars were implemented in the Project, and the activities for the C/P to learn and acquire the knowledge about organizational governance have been included in the activities of the Project. WRAWSA will need to continue to strengthen its overall management capacity for water supply utility to achieve a sustainable water supply utility as a major goal. In other words, WRAWSA has autonomy of business operation, is financially independent, is customer-oriented, follows rules, has clear work processes and duties, is operated by trained and highly motivated staff, and carries out efficient work. With these capacities, WRAWSA is required to aim for a utility that can provide good services.

2) Implementation of business improvement through the practice of PDCA cycle

A system to operate the PDCA cycle, including the creation of a mid-term management plan, was developed in the Project. It is necessary to run the PDCA cycle, utilize the capacities acquired though achievement of the outputs and project purpose, continuously improve operations, and aim to become a sustainable water supply utility. It is necessary to promptly approve action plans that have not yet been approved taking into account budget allocation to the activities in the plans.

3) Promotion of water rate revision

The water tariff is set so low that it cannot cover the operation and maintenance cost of the water supply system. In order to become a financially independent and sustainable water utility, it is necessary to revise the water tariff. WRAWSA has already submitted an application of tariff revision to the Yangon Regional Government in 2019 and needs to continue to follow up. When raising the tariff, it is necessary to provide sufficient explanation and public awareness activities to the citizens.

4) Improvement of customer service including toll collection work

Improving customer service and customer management is also important for aiming to be a customer-oriented organization. The Customer Service Management Division needs to instruct all T/Ss to carry out universal operations by utilizing customer service manuals and the like. In addition, it is necessary to apply the trial customer management system to all T/Ss, gradually upgrade the version, and continuously improve customer service.

5) Promotion of utilization of project outputs

WRAWSA needs to aim at execution of more efficient business and provision of improved services, by utilizing the capacities and outputs of institutional management of water supply utility, non-revenue water management, and water quality management acquired in the Project, as well as the rules such as the SOPs of all sections/offices created and the draft Water Supply Regulation.

6) Strengthening cooperation among the sections

After the organizational restructuring, the sections necessary for the water supply utility were established. WRAWSA shall aim to improve work efficiency and services by utilizing the achieved outputs in the Project and strengthen the cooperation among the sections and the guidance to T/S by the WRAWSA head office.

7) Continuous human resource development

Most of WRAWSA’s staff are part-time staff. Part-time young employees often resign. In addition, it is expected that the retirement age of skilled staff will increase in the near future. It is necessary to promote the understanding of decision makers, including the mayor and the regional government, regarding the placement of full-time staff and measures for resignation, and strive for continuous human resource development.

8) Initiatives for PPP

In order to carry out more efficient operation, the introduction of PPP is required for water supply utility as in the case of other countries. YCDC needs to clarify the role and organizational structure of WRAWSA in the water supply business operation before proceeding with the introduction of PPP.

Even with the introduction of PPP, WRAWSA still has many roles to play. As a public institution, WRAWSA is responsible for developing the entire water supply plan for the city of Yangon and monitoring the city’s water supply services to ensure high quality, safe, reliable and reasonably priced water supply services. WRAWSA will continue to need to acquire the ability to manage PPPs.

9) Leading role for water utility in the other cities

A new training center for non-revenue water management may accept trainees from other cities in Myanmar, and the central water quality laboratory may receive requests for water quality analysis and monitoring guidance from other laboratories in the country. It is recommended that WRAWSA take a leadership role as the best utility of water supply services in Myanmar.

5.4. Important Assumptions

In relation to the political instability in Myanmar that occurred in February 2021, the following are added to the important assumption of the overall goal.

1. Political instability will be settled early.
2. The necessary budget for implementing the prepared plans is secured.
3. The C/P will not leave their jobs in large numbers due to political instability.
4. The progress of the ongoing ODA loan project will not be significantly delayed.
5. The policy of water supply of the governments and YCDC remain unchanged.