Federal Capital Territory Administration
Federal Capital Territory Water Board
Federal Republic of Nigeria

THE FEDERAL CAPITAL TERRITORY REDUCTION OF NON-REVENUE WATER PROJECT IN FEDERAL REPUBLIC OF NIGERIA

PROJECT FINAL REPORT (MAIN REPORT)

January 2019

Japan International Cooperation Agency
Yachiyo Engineering Co., Ltd
Yokohama Water Co., Ltd

GE
JR
19 - 005

Federal Capital Territory Administration
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Exchange Rate applied in this Report

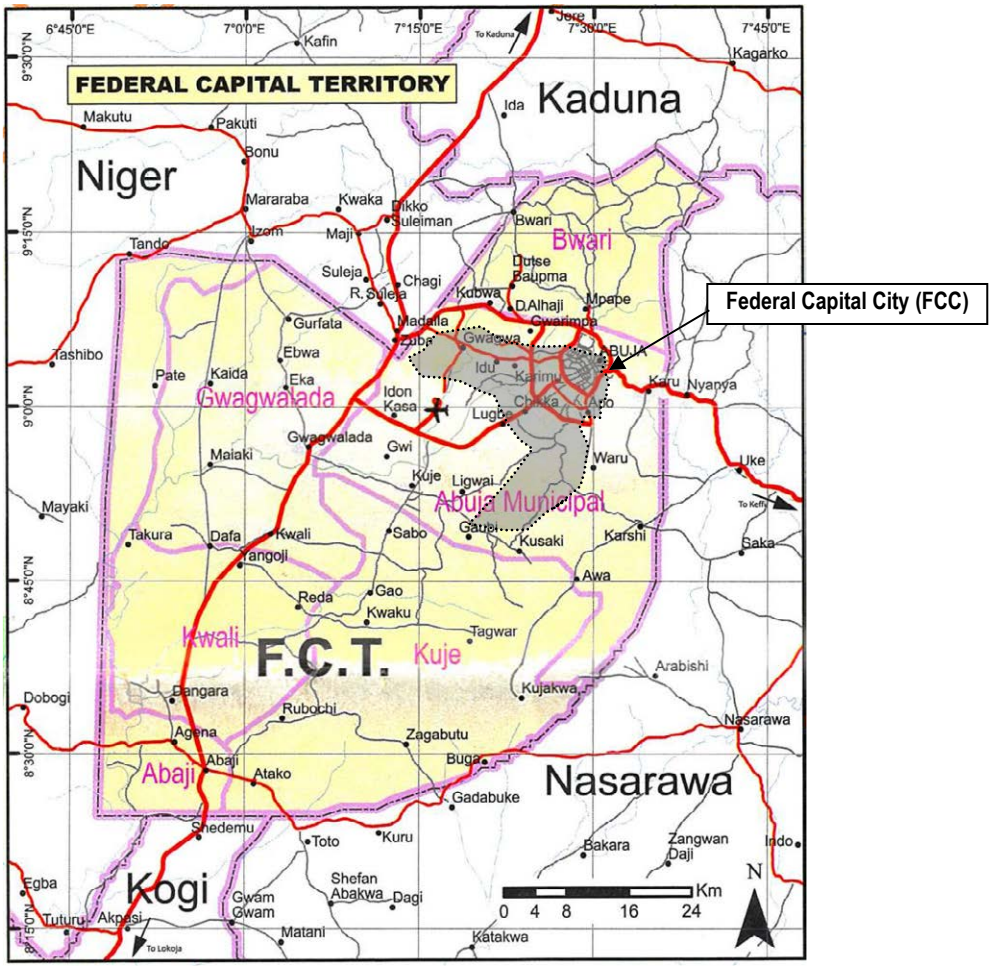
As of November 2018

USD 1.00 = JPY 112.201

NGN 1.00 = JPY0.31086

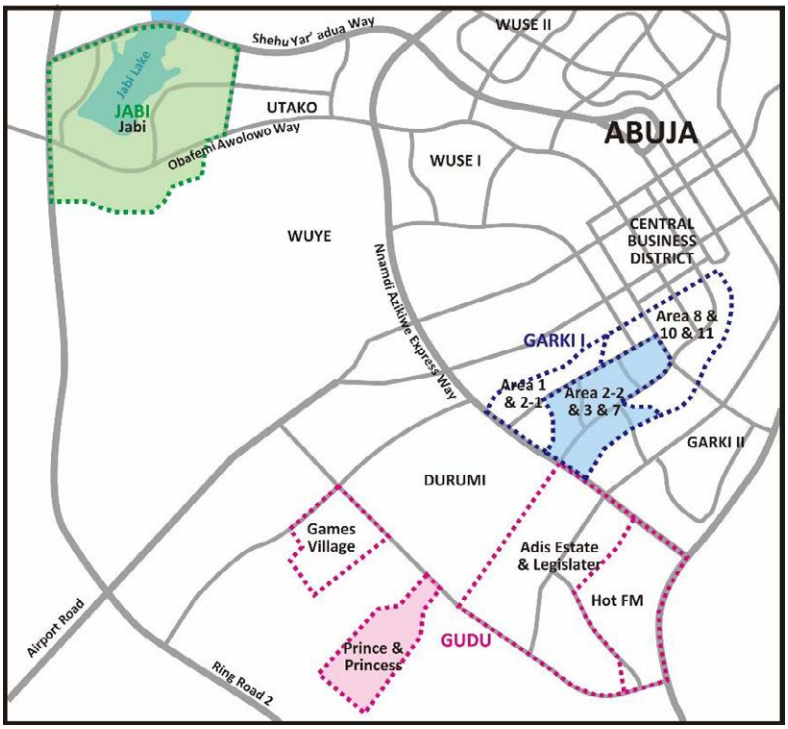
USD 1.00 = NGN 361

(Source: JICA Official Website)



Source: Brunel, Nigeria Road Map

Federal Capital Territory (FCT) and Federal Capital City (FCC)



Pilot Project Area (Gudu, Jabi and Garki I) and Pilot Metering Area

Project Monitoring Sheet I (Revision of Project Design Matrix)

PDM5

Project Title: The Federal Capital Territory Reduction of Non-Revenue Water Project
Version 5
Project Period: October 2014 to September 2018
Dated 28 Jun. 2018
Implementing Organization: Federal Capital Territory Administration (FCTA) / Federal Capital Territory Water Board (FCTWB)
Dicrect Beneficiaries: FCTWB, relevant staff of FCTWB Headquarters and pilot Area Offices
Monitoring: 27 Jun. 2018
Project Site: FCT
Pilot Area Offices: Jabi, Garki I and Gudu

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
<Overall Goal> Non-Revenue Water reduction activities are routinely implemented in the service area of FCTWB.	a. NRW reduction operations are carried out according to the medium-term strategic plan for NRW reduction (2019-2023) .	a. Report of NRW reduction activities and monitoring by NRW Unit (NRW ratio, records of leakage detection, repair, disconnection of illegal connections, etc.)			
<Project Purpose> Capacity of FCTWB for NRW reduction is strengthened	a. The medium-term strategic plan for NRW reduction (2019-2023) is approved by FCTA by the end of the Project. b. Relevant staff of FCTWB (i.e. members of NRW Management Team and Pilot NRW Action Teams) become equipped with skills and knowledge necessary for NRW reduction according to the criteria set by the Project for each level. c. NRW ratio of each PMA is monitored.	a. Date of approval of the plan b. Results of joint assessment based on the criteria set by the Project c. Record of NRW ratio kept by NRW Unit	A. Policy support for NRW reduction is not discontinued Policy support for NRW reduction is not discontinued B. Natural disaster/ political instability/ economic crisis that affect the service area of FCTWB do not occur C. Activities to implement the medium-tem strategic plan are not discontinued or delayed		
<Outputs>					
1. Level of NRW of both the service area of FCWTB and water distribution areas is monitored and estimated.	1a. Record of NRW ratio is kept by NRW Unit. 1b. NRW ratio of the service area of FCTWB is reported to its Joint Management Meeting. 1c. NRW ratio of the service area of FCTWB is reported to Management of FCTWB . 1d. Periodic records of data and estimation on water distribution management such as water flow of zonal meters and water pressure are kept by NRW Unit.	1a. Record of NRW ratio 1b&1c. Material for meetings submitted by NRW Unit 1d. Periodic records of data on water distribution management	A. Staff of FCTWB (i.e. members of NRW Management Team and Pilot NRW Action Teams) trained through the Project do not leave the office in large numbers		
2. Methods/operational procedures for effective NRW reduction are established through pilot projects at Pilot Metering Areas (PMAs) under pilot Area Offices (*1)	2a. Decrease rate of NRW ratio for each Sub Metering Area of a PMA reaches at least 80% of its target at the end of the respective NRW reduction operations. 2b. Technical manuals for Area Office managers and field operators (i.e. technical officers and meter readers), including audio visual materials, are approved by Head of Department (HoD) for Distribution and HoD for Commerce.	2a. Record of NRW ratio kept by NRW Unit 2b. Date of approval of the manuals			
3. A medium-term strategic plan of FCTWB for NRW reduction is developed, utilizing the results of Output 1-2 (*2)	3a. Draft medium-term strategic plan for NRW reduction (2019-2023) is submitted by FCTWB to FCTA for review and approval. 3b. An annual NRW reduction plan (2019) is committed by the governing Board of FCTWB, to be incorporated in FCWTB's annual recurrent and capital budget plan (2019) for submission to FCTA for review and approval. 3c. A planning manual for NRW reduction is approved by the General Manager of FCTWB. 3d. Framework of water distribution management is established.	3a. Date of official letter submitting draft strategic plan 3b. Date of commitment incorporating annual NRW reduction plan in annual recurrent and capital budget plan 3c. Date of approval of the manual 3d. Implementing structure and workflow of water distribution management			

Note (*1): NRW components targeted by Output 2 are (i) invisible leakage; (ii) customer meter malfunction; and (iii) illegal connection
Note (*2): A medium-term strategic plan is a five-year plan, which may include medium-term target, strategies and actions, timeframe, human resource requirement, on-the-job training mechanism, cost-benefit analysis of NRW reduction, etc. It is noted that NRW components addressed by the strategic plan are not limited to the ones mentioned in (*1) above: they shall be discussed and determined in developing the outline of the strategic plan (through Activity 3-4).

Activities	Inputs		Important Assumption	
	The Nigerian Side	**The Japanese Side**	A. Natural disaster / political / instability / economic crisis that affect the Project activities do not occur.	
1-1 Install bulk meters to water treatment plants 1 and 2 1-2 Measure/estimate water production of water treatment plants 1, 2, 3 and 4 1-3 Tally the above water production data/estimation 1-4 Calculate the water consumption based on the billing data 1-5 Calculate NRW ratio of the service area of FCTWB using the results obtained from Activity 1-3 and 1-4 1-6 Install zonal meters, water pressure sensor and pilot remote monitoring (telemetry) system 1-7 Measure/estimate and collect data for water distribution management such as water flow of zonal meters and water pressure	**Project Personnel** 1. Project Director: Director of Economic Planning, Research and Statistic Department, FCTA 2. Project Manager: General Manager of FCTWB 3. Deputy Project Manager: HoD for Administration and Supply/FCTWB 4. Technical Managers (Also Leaders of NRW Management Team): HoD for Distribution and HoD for Commerce /FCTWB 5. Members of NRW Management Team (FCTWB): - Head of Special Project Unit of Distribution Department (as Coordinator) - Relevant Head of Unit (HoU) and officers of the Distribution Department, Commerce Department, and Administration and Supply Department 6. Heads of other relevant Departments and Unit of FCTWB: HoD for Finance, HoD for Production, HoU for Planning Research and Statistics (PRS) 7. Members of NRW Action Team: Area Manager, Assistant Area Manager (Distribution), Assistant Area Manager (Commerce), technical officers (Distribution) and meter readers (Commerce) of each pilot Area Office 8. Other personnel mutually agreed upon as necessary	**Japanese Experts** 1. Chief Advisor / NRW Reduction Planning / Water Distribution Management 1 2. Deputy Chief Advisor / NRW Reduction Planning 3. NRW Reduction Operations Management 4. Leakage Detection Technology 5. Commercial Loss 6. Hydraulic Analysis / GIS 7. Procurement Manage't / Coordination 8. Facility Design / Construction Supervision 9. Equipment Design / Installation 10. Water Distribution Management 2 11. Remote Monitoring Design 12. Remote Monitoring Device Installation / Training 13. Financial Analysis / Organization 14. Other experts mutually agreed upon as necessary	**Pre-Conditions** A. Furnished offices for Japanese Experts are secured at the Headquarters and each Pilot Area Office of FCTWB. B. Project Personnel is assigned with the finalized list.	
2-1 Review existing NRW reduction operations at each pilot Area Office 2-2 Conduct capacity assessment of the relevant staff of each pilot Area Office 2-3 Identify and select a Pilot Metering Area (PMA) for each pilot Area Office based on the selection criteria of PMA(*3) 2-4 Prepare/update distribution network drawings for each PMA 2-5 Install water flow meters to each PMA and measure in/outflows monthly 2-6 Zone each PMA into Sub Metering Areas (SMA) 2-7 Isolate a SMA by installing valves 2-8 Update the distribution network drawings for each SMA 2-9 Measure an initial level of NRW of each SMA 2-10 Detect target NRW components (i.e. invisible leakage, customer meter malfunction, and illegal connection) of each SMA 2-11 Develop a NRW reduction operation plan of each SMA ,including reduction target, for review by Head of Distribution Department 2-12 Review and approve NRW reduction operation plan of each SMA 2-13 Implement the NRW reduction operations at each SMA 2-14 Monitor the progress of the NRW reduction operations of each SMA 2-15 Measure level of NRW of each SMA at the end of the respective operations 2-16 Prepare a report on pilot projects, covering Activity 2-1~2-15 2-17 Develop manuals for NRW reduction for Area Office managers and field operators (i.e. technical officers and meter readers), including audio visual materials	**Land, Building and Facilities (to be financed by Couterpart Fund)** 1. Office building and facilities necessary for the implementation of the Project 2. Office spaces and necessary facilities for the Japanese Experts at the FCTWB Headquarters and each pilot Area Office, including internet connection and air conditioners 3. Chambers for flow meters and valves for the selected PMAs/SMAs. 4. Electric wiring to bulk/zonal meters, loggers and pressure sensors. 5. Other facilities mutually agreed upon as necessary **Local Costs (to be financed by Couterpart Fund)** 1. Cost for installation, operation and maintenance of the provided equipment and cost for pipe repair at PMAs 2. Administration and operational costs, including cost for local travel for the Project Personnel, demurrage at local customs point, licensing cost of radio application and cost for communication of telemetric device for selected zonal meter(s) and water pressure sensor(s) 3. Other costs mutually agreed upon as necessary	**Equipment** 1. Bulk meters and loggers for water treatment plants 2. Water flow meters, valves, and customer meters for SMA 3. Leakage detection equipment for PMA 4. Pipe repair equipment for PMA 5. Vehicles (Pick-ups) 6. Generator for project office 7. Zonal meters, loggers and water pressure sensors 8. Telemetric monitoring system for selected zonal meters 9. Solar powering systems for zonal meters 10. Other equipment mutually agreed upon as necessary **Facilities** 1. Modification of existing billing system 2. Chambers for bulk meters for water treatment plants and zonal meters **Training of the Nigerian Project Personnel** 1. Eighteen persons mutually agreed upon will be trained in Japan. 2. GIS training in Nigeria		
3-1 Establish a Working Group for NRW planning (*4) 3-2 Review existing plans, implementation structure, on-the-job training mechanism, etc. related to NRW reduction at FCTWB 3-3 Conduct hydraulic and water pressure distribution analyses of the pipeline networks 3-4 Develop outlines of the medium-term strategic plan and its annual NRW reduction plan 3-5 Develop the first medium-term strategic plan (2019-2023) for approval by FCTA 3-6 Develop an annual NRW reduction plan based on the strategic plan as an integral part of an annual recurrent and capital plan of FCTWB for approval by FCTA 3-7 Develop a planning manual for NRW reduction 3-8 Review existing plans, activities and implementing structure, etc. related to water distribution management 3-9 Establish framework of water distribution management				**Issues & Countermeasures**

Note (*3) Selection criteria of PMA are as follows: (i) Safety for night works is secured in measuring minimum night flow. (ii) Distribution network is separated and it is easy to isolate it in measuring NRW ratio: and (iii) NRW ratio is supposedly high.
Note (*4) Working Group for NRW planning would consist of Project Manager (as chair), Deputy Project Manager, Technical Managers, Head of Finance Dept., Head of Production Dept., Head of PRS Unit, and members of NRW Management Team.

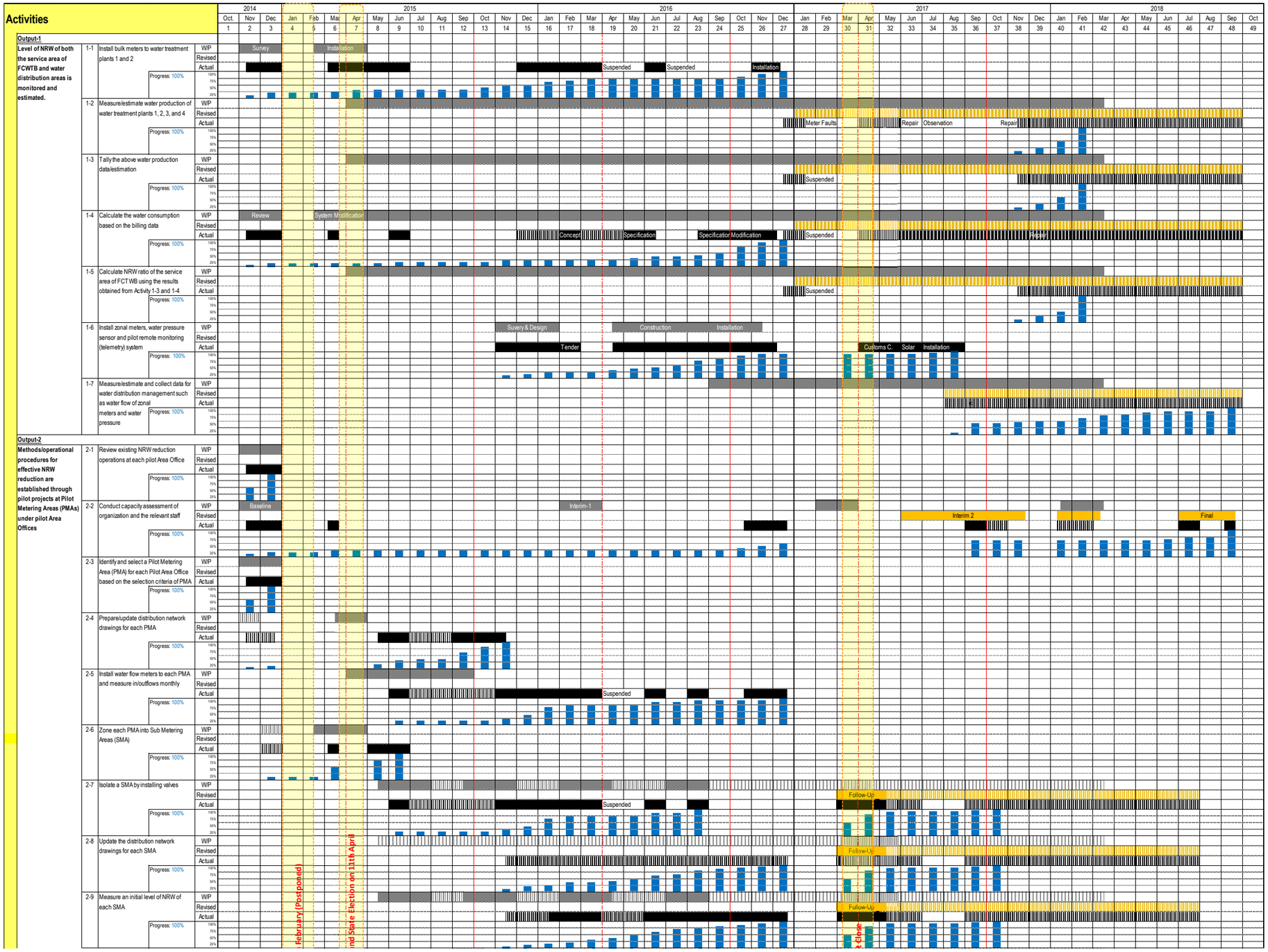
Project Monitoring Sheet II (Plan of Operations)

Plan of Schedule and Actual Work Period

PO$_5$

Version: 5
Dated: 28 Jun. 2018
Monitoring: 27 Jun. 2018

Project Title: The Federal Capital Territory Reduction of Non-Revenue Water Project



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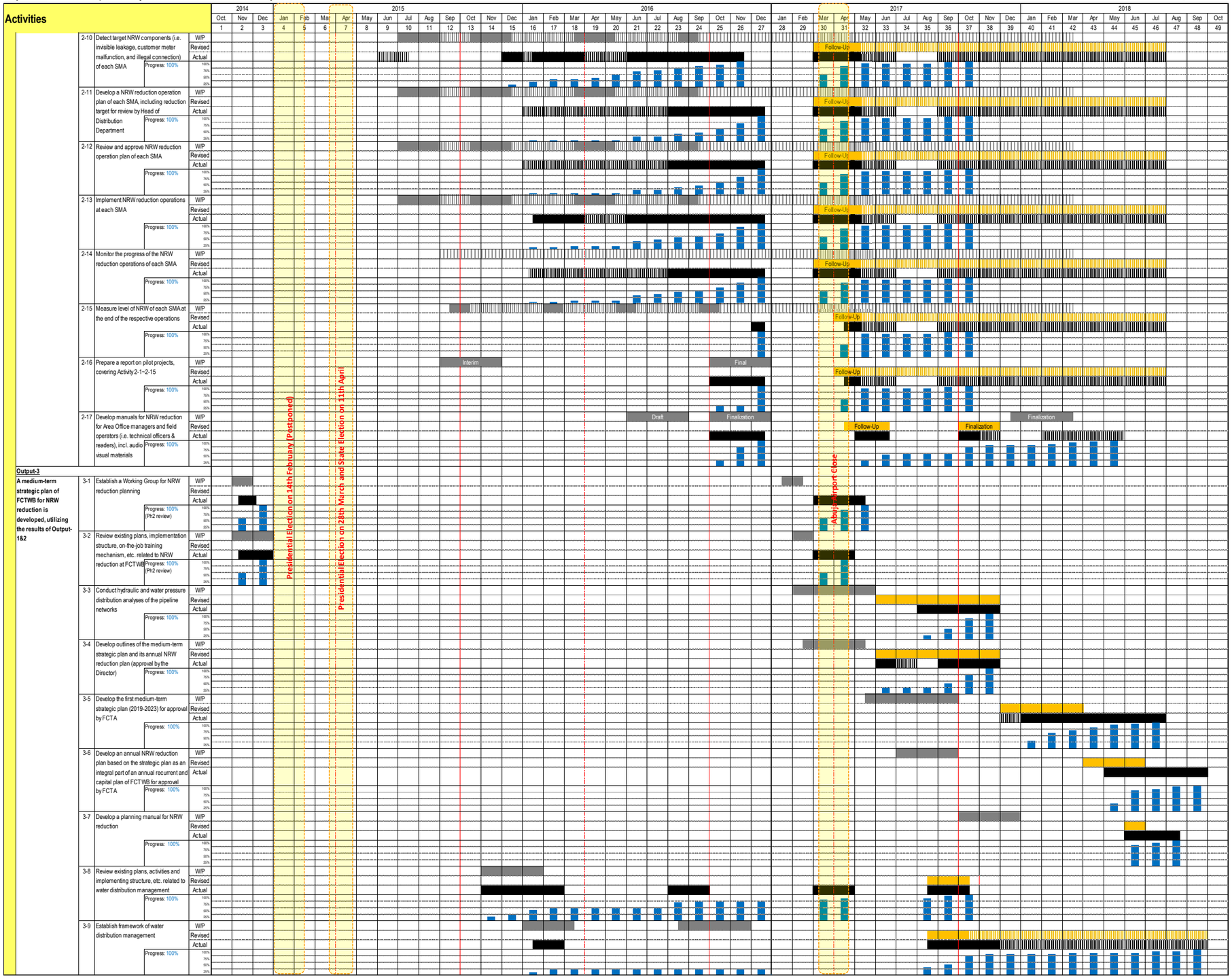

Project Monitoring Sheet II (Plan of Operations)

PO5

Version: 5

Dated: 28 Jun. 2018

Monitoring: 27 Jun. 2018

Plan of Schedule and Actual Work Period

Project Title: The Federal Capital Territory Reduction of Non-Revenue Water Project

Inputs (the Japanese side)		2014			2015													2016												2017									2018								
		Oct.	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
JICA Expert																																																
1 Akinori MIYOSHI	WIP																																															
Chief Advisor / NRW Reduction Planning / Water Distribution Management	Revised																																															
	Actual																																															
2 Taketoshi FUJIYAMA	WIP																																															
Deputy Chief Advisor / NRW Reduction Planning	Revised																																															
	Actual																																															
3 Toru TOYODA	WIP																																															
NRW Reduction Operations Management	Revised																																															
	Actual																																															
4 Kiyoshi KIYAMA	WIP																																															
Leakage Detection Technology	Revised																																															
	Actual																																															
5 Hiroyuki MORITA	WIP																																															
Commercial Loss	Revised																																															
	Actual																																															
6 Hiroyuki MORITA	WIP																																															
Hydraulic Analysis / GIS	Revised																																															
	Actual																																															
7 Toshinobu KASUYA	WIP																																															
Procurement Management / Coordinator	Revised																																															
	Actual																																															
8 Tomohiro SHIMIZU	WIP																																															
Facility Design / Construction Supervision	Revised																																															
	Actual																																															
9 Kiyoshi KIYAMA	WIP																																															
Equipment Design / Installation	Revised																																															
	Actual																																															
10 Takeshi YAJIMA	WIP																																															
Water Distribution Management 2	Revised																																															
	Actual																																															
11 Tomohiro SHIMIZU	WIP																																															
Remote Moniotoring / Remote Monitoring System Insllation & Training 1	Revised																																															
	Actual																																															
12 Takashi MORI	WIP																																															
Remote Monitoring System Insllation & Training 2	Revised																																															
	Actual																																															
13 Toshinobu KASUYA	WIP																																															
Remote Monitoring System Insllation & Training 3	Revised																																															
	Actual																																															
14 Takashi MORI	WIP																																															
Procurement Management / Coordinator 2	Revised																																															
	Actual																																															
15 Noboru OSAKABE	WIP																																															
Financial Analysis / Organization	Revised																																															
	Actual																																															
Equipment																																																
1 Leakage detection equipment	WIP																																															
*3PMAs in Japan (JICA)	Revised																																															
	Actual																																															
2 Bulk meters (ultrasonic flow meter)	WIP																																															
*WTP in Japan (JICA)	Revised																																															
	Actual																										Installation																						
3 Water meter, flow meter and valves	WIP																																															
*3PMAs in Nigeria (JICA Expert)	Revised																																															
	Actual																																															
4 Pipe repair equipment	WIP																																															
*3PMAs in Nigeria (JICA Expert)	Revised																																															
	Actual																																															
5 Vehicles (Pickup truck)	WIP																																															
*Leakage Detection in Nigeria (JICA)	Revised																																															
	Actual																																															
6 GIS software, office equipment	WIP																																															
*FCTWB HQs in Nigeria/Other (JICA Expert)	Revised																																															
	Actual																																															
7 Zonal meters, pressure sensors and remote monitoring system	WIP																																															
*Whole System in Japan (JICA)	Revised																																															
	Actual																																															
8 Standby power generation and storage battery (Solar)	WIP																																															
in Nigeria (JICA)	Revised																																															
	Actual																																															
Nigerian Consultant/Contractor																																																
1 Modification of billing and collection system	WIP																																															
	Revised																																															
	Actual																			Concept					Specification					Specification Modification																	
2 GIS and database training	WIP																																															
	Revised																																															
	Actual																																															
3 Construction of chambers for zonal meter and water pressure sensor	WIP																																															
	Revised																																															
	Actual																																															
4 Installation of standby power generation and storage battery (Solar)	WIP																																															
	Revised																																															
	Actual																																															
5 Construction of chambers for bulk meter (including cable installation)	WIP																																															
	Revised																																															
	Actual																										Construction																						
Training in Japan	WIP																																															
Plan: 4 trainees x 3 times = 12 trainees	Revised																																															
Actual: 4 trainees x 1 (Management) + 8 trainess x 1 (D&C Joint) = 12 trai	Actual																																															

Presidential Election on 14th February (Postponed)

Presidential Election on 28th March and State Election on 11th April

Abuja Airport Close

Project Monitoring Sheet II (Plan of Operations)

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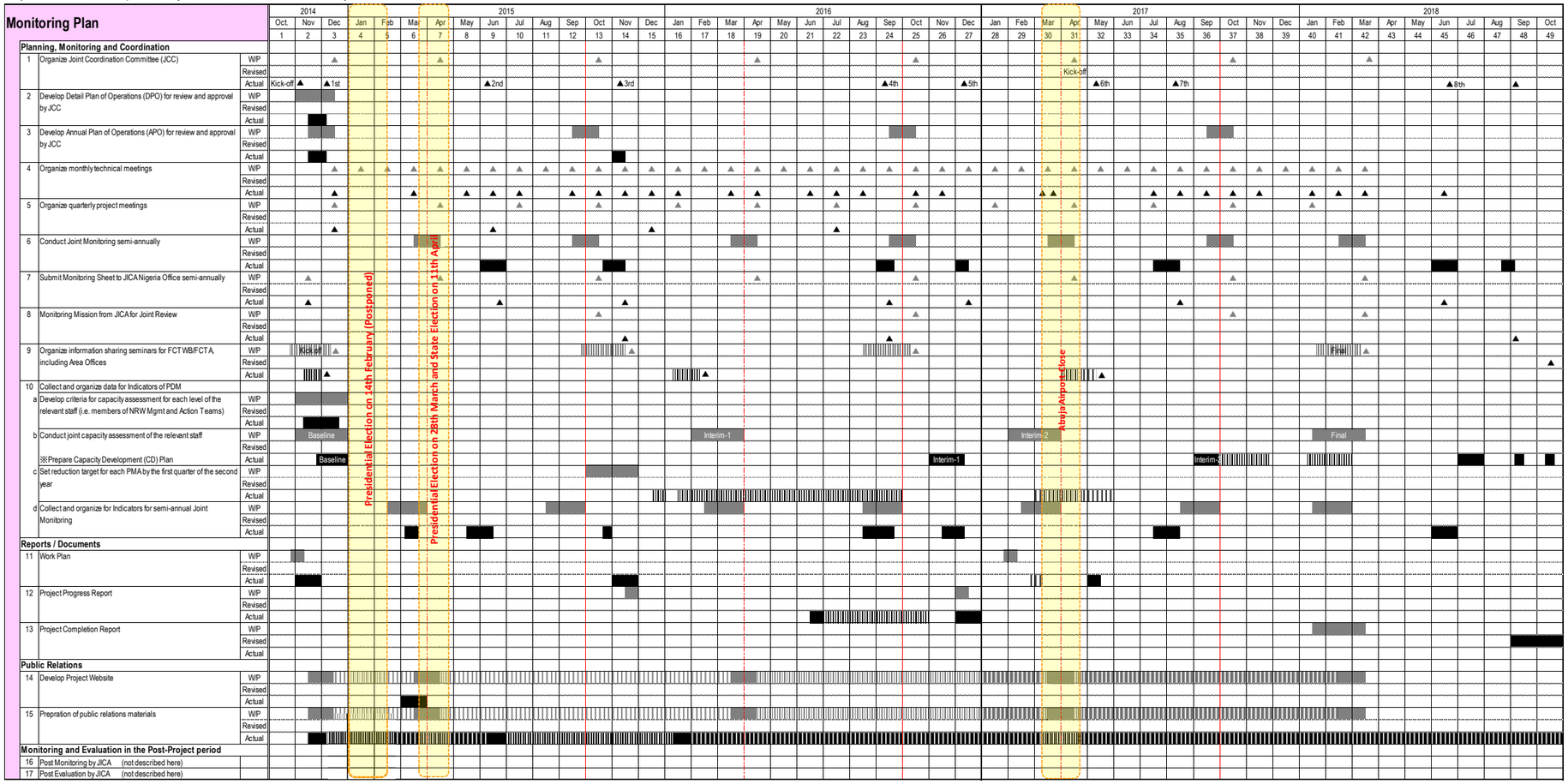


PHOTOS

Joint Coordinating Committee

Kick-Off Meeting

2nd JCC Meeting

5th JCC Meeting

7th JCC Meeting

Joint Project Monitoring

Preparation of Project Monitoring Sheets

Preparation of Project Monitoring Sheets

Joint Monitoring Meeting

Joint Monitoring (Site Visit)

Workshops and Seminar

1st Workshop

2nd Workshop (Presentation)

3rd Workshop

3rd Workshop (Demonstration)

Final Seminar

Final Seminar (Announcement)

Input: Procurement and Provision of Equipment

Handover Ceremony of Equipment

Inspection of OA Equipment

Handover of Equipment to Pilot Area Offices

Isolation Valves and Fittings for PMA/SMA

Leakage Repair Equipment

Conventional Water Meters

Input: Training in Japan

1st Training (GIS Mapping)

2nd Training (Field Meter Reading)

2nd Training (Field Leakage Detection)

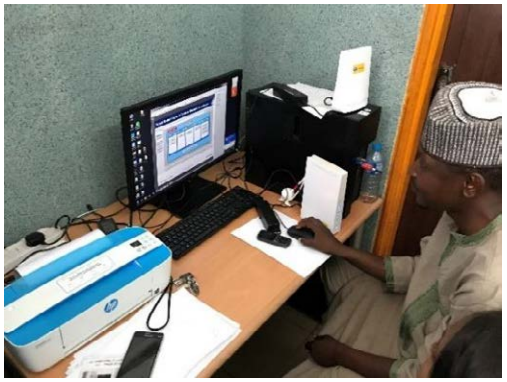
3rd Training (Water Meter Labo)

Input: Training in Nigeria

	
GIS Training	Certification of GIS Training
	
Lecture on GIS in a Pilot Area Office	Introduction of Pipeline Map Book
	
Training on 24hrs Flow Measurement	Training on Leakage Detection Equipment
	
Training on Leakage Detection Equipment	Training on Hydraulic Analysis

	
Training on Telemetry System	Billing System

Input: Chamber Construction of Zonal Meters with Solar System

	
Chamber Construction at Tank No.3.1	Chamber Construction at Tank Kubwa
	
Chamber Construction at Tank No.3.2	Zonal Meter and Logger at Tank Airport
	
Solar System at Tank 4	Pilot Telemetry System at Headquarters

CONTENT

CHAPTER 4. RESULT OF JOINT REVIEW

CHAPTER 5. FOR THE ACHIEVEMENT OF OVERALL GOALS AFTER THE PROJECT COMPLETION

ATTACHMENT

ABBREVIATION

AC	Asbestos Cement (pipe)
AGIS	Abuja Geographic Information System
AMR	Automatic Meter Reading
CA	Capacity Assessment
CD	Capacity Development
C/P	Counterpart
DI	Ductile Iron (Pipe)
DMA	District-Metered Area
E/N	Exchange of Notes
FCC	Federal Capital City (Abuja)
EPRS	Economic Planning, Research and Statistics (Department of FCTA)
FCDA	Federal Capital Development Authority
FCT	Federal Capital Territory
FCTA	Federal Capital Territory Administration
FCTWB	Federal Capital Territory Water Board
FMWR	Federal Ministry of Water Resources
F/R	Final Report
GI	Galvanized Steel (pipe)
GIS	Geographical Information System
GRP	Glass-fiber Reinforced Plastic (pipe)
HOD	Head of Department
HOU	Head of Unit
HQ	Headquarters
HRD	Human Resource Development
ISO	International Organization for Standardization
IT	Information Technology
IWA	International Water Association
JCC	Joint Coordinating Committee
JICA	Japan International Cooperation Agency
LCD	Liter per Capita per Day
M/P	Master Plan
M/M	Minutes of Meeting
MIS	Management Information System
MNF	Minimum Night Flow
NPC	National Population Commission
NRW	Non-Revenue Water
NWRI	National Water Resources Institute
Off-JT	Off the Job Training
OJT	On the Job Training
O&M	Operation and Maintenance
PDM	Project Design Matrix
PE	Polyethylene (pipe)
PI	Performance Index
PMA	Pilot Metering Area
PO	Plan of Operation
PPP	Public Private Partnership
PR/R	Progress Report
PRS	Planning, Research and Statistics (a Unit of FCTWB)
R/D	Record of Discussions
SCADA	Supervisory Control And Data Acquisition
SIV	System Input Volume
SMA	Sub Metering Area
SOP	Standard Operating Procedures
STDD	Satellite Towns Development Department (FCT)
uPVC	Unplasticized Polyvinyl Chloride (pipe)
WTP	Water Treatment Plant

CHAPTER 1. BASIC INFORMATION OF THE PROJECT

1.1 Country and Project Area

Abuja Federal Capital City (FCC) located in the north-east of the Federal Capital Territory (FCT), the Federal Republic of Nigeria

1.2 Title of the Project

The Federal Capital Territory Reduction of Non-Revenue Water Project

1.3 Duration of the Project

Duration of the Project by Phase is as follows:

Table 1.3-1: Duration of the Project

Phase	Planned originally	Actual
Phase 1	November 2014 to December 2016	October 2014 to January 2017
Phase 2	January 2017 to May 2018	February 2018 to November 2018

Source: Project Team

Remarks: Duration of the Project was extended for six (6) months in accordance with revision of PDM (Ver.3 to 4) in August 2017.
Duration mentioned in PDM had been "October 2014 to March 2018 (September 2018 after the extension) for reasons of expediency in implementation.

1.4 Background

1.4.1 Background of the Project

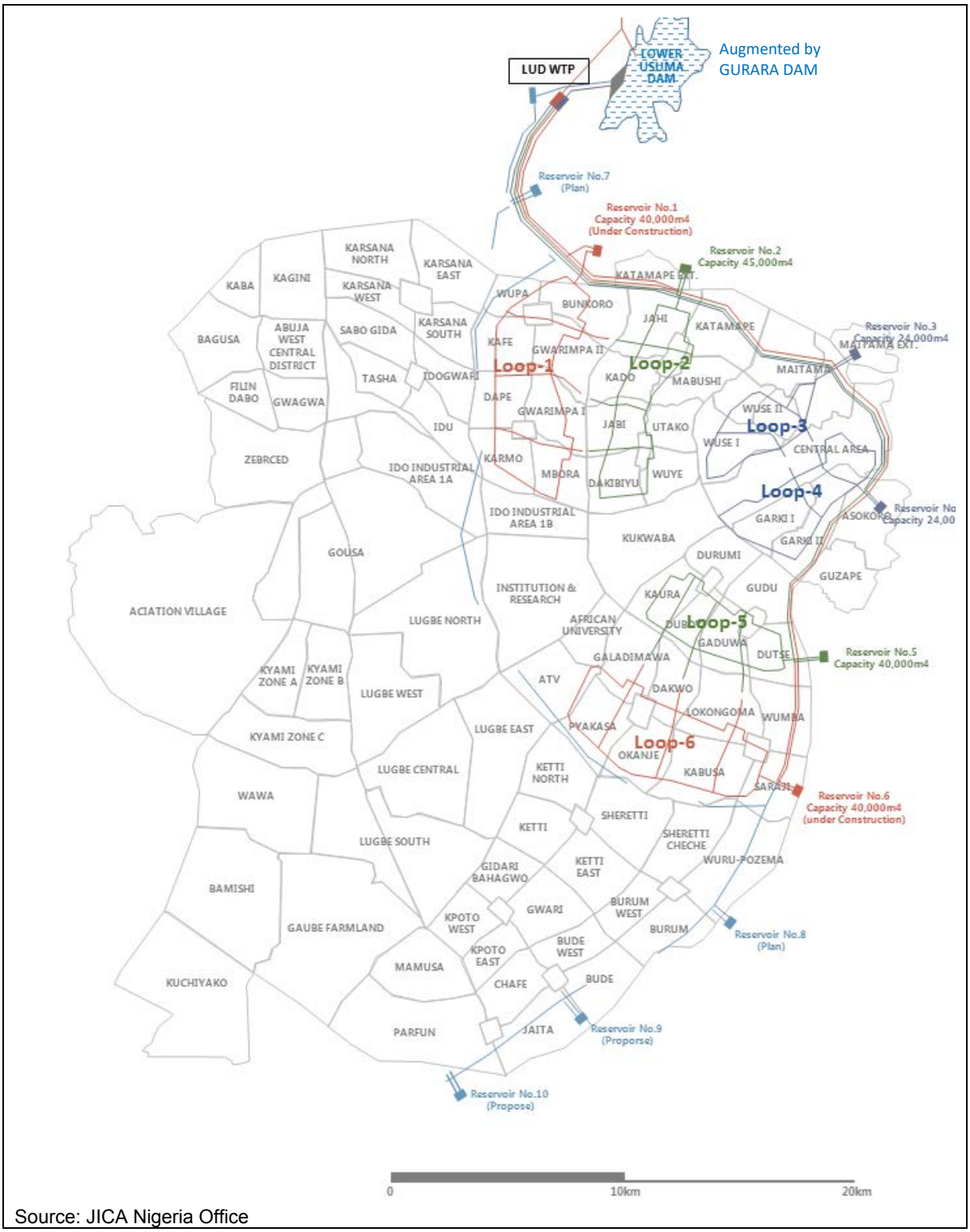
In the Abuja FCC, water supply facilities have been developed based on water supply master plan prepared in 1980. Although new water treatment plants were recently constructed to meet increasing water demand by mass-migration and urbanization, distribution facilities such as service reservoirs and networks have lagged behind in development. On the subject of Non-Revenue Water (NRW) in FCC, the Detail Planning Survey by Japan International Cooperation Agency (JICA) estimated it at about 38% in 2014, and the strategic plan for 2011-2015 of the Federal Capital Territory Administration (FCTA) sets its target level at 25%. However, the Federal Capital Territory Water Board (FCTWB) in charge of operation and maintenance has not taken effective actions against NRW because of its shortage of experience, knowledge and qualified personnel on planning and execution of NRW reduction. Improvement in NRW is a key issue in water supply services.

Under the circumstance, the Government of the Federal Republic of Nigeria requested technical cooperation to the Government of Japan in order to strengthen NRW reduction capacity of the FCTWB, then JICA conducted preliminary survey in August 2013 and the Detail Planning Survey in May 2014. Both Governments finally concluded the Record of Discussions (R/D) on 14th July 2014 (refer to Annex 1) to implement "The Federal Capital Territory Reduction of Non-Revenue Water Project" (the Project).

Based on the R/D, both Governments discussed to confirm the matters and officially launched the Project at the Kick-off meeting on 6th November 2014.

1.4.2 Existing Piped Water Supply System in FCC

The existing piped water supply system in FCC (currently, Phase 1 to Phase 4 development areas and outskirts) consists of water source from Lower Usuma Dam (LUD) augmented by Gurara Dam, LUD water treatment plants, pipelines, reservoirs (tanks) and booster pumps. Figure 1.4-1 shows the system.



Source: JICA Nigeria Office

Figure 1.4-1: Existing Piped Water Supply System in FCC

(1) Water Supply Areas by Existing Piped Water Supply System

The Project identified areas covered by development areas and existing piped water supply system as shown in Table 1.4-1.

FCTWB has supplied water by gravity and partially pumping-up in 24 hours in principle. However, the areas located outskirts particularly receive water four hours a day by rationing because these areas were originally not targeted in Abuja Water Supply Master Plan and lower priority than other phase development areas.

Table 1.4-1: Water Supply Areas by Existing Piped Water Supply System

Development Areas	Water Supply Areas by existing Piped System
Phase 1	Maitama, Wuse I, Wuse II, Central Area, Asokoro, Garki I, Garki II *Development was almost completed.
Phase 2	Jahi, Katampe, Katampe Ext., Kado, Mabushi, Jabi, Utako, Dakibiyu, Wuye, Durumi, Gudu, Duboyi, Gaduwa, Apo, Dutse, Kaura *Development was partially completed, currently distribution mains and networks have been constructed in the area.
Phase 3	Gwarinpa I, Gwarinpa II, Karmo *Development was a little completed, currently distribution mains and networks have been constructed in the area.
Phase 4	(none)
Outskirts	Bwari, Ushafa, Kubwa, Gwagwalada, Karu, Nyanya
Others	Airport, Abuja University, KCK School, Barracks

Source: Project Team

(2) Water Sources

Table 1.4-2 shows information of water sources for FCC.

Table 1.4-2: Water Sources for FCC

Water Source	Description
Lower Usuma Dam (LUD)	Capacity: 100 million m^3 Owned by: FCTA/FCTWB Location: Federal Capital Territory
Gurara Dam	Capacity: 880 million m^3 (Augmentation to LUD: 12m^3/sec) Owned by: Federal Ministry of Water Resources Location: Kaduna State

Source: FCTWB

(3) Water Treatment Plant

Table 1.4-3 shows information of Lower Usuma Dam (LUD) water treatment plants in existing piped water supply system.

Table 1.4-3: Water Treatment Plants in Existing Piped Water Supply System

LUD Water Treatment Plant	Description
WTP Phase-1	Capacity: 120,000 m^3/day, Year of Construction: 1987
WTP Phase-2	Capacity: 120,000 m^3/day, Year of Construction: 2000
WTP Phase-3	Capacity: 240,000 m^3/day, Year of Construction: 2014
WTP Phase-4	Capacity: 240,000 m^3/day, Year of Construction: 2014

Source: FCTWB

As shown in Table 1.4-4, the Project Team estimated water production of Lower Usuma Dam (LUD) water treatment plants.

Table 1.4-4: Estimated Water Production of Water Treatment Plants (m3/day)

LUD Water Treatment Plant	2014	2015	2016	2017
WTP Phase-1*1	88,252	89,087	68,159	90,805
WTP Phase-2*2	77,452	87,611	65,846	80,005
WTP Phase-3*3	82,849	82,849	82,849	82,849
WTP Phase-4*3	82,849	82,849	82,849	82,849
Total	**331,402**	**342,395**	**299,703**	**336,507**

Remarks
- *1: Estimated from data of the flow meter along raw water conveyance line from LUD.
- *2: Estimated from the past flow data and comparison with Phase 1 data because of no existing functional flow meter.
- *3: Measured from existing flow meter at the outlet from WTPs
- Loss in treatment was considered

Source: Project Team

(4) Pipelines

a. Transmission Mains (or Primary Pipelines)

FCTWB has supplied treated bulk water from LUD water treatment plants through four transmission mains to major tanks covering water supply areas (approx. 44km). Four bulk meters enabling FCTWB to measure inflow volume to the whole piped water supply system were installed along these transmission mains at the outlet from the WTP under the Project.

- No.1: Transmission Main (DN600mm) to Tank Bwari covering the areas outside of Phases
- No.2: Transmission Main (DN1500mm) to Tank 2 & 5 series covering the areas in the entire Phase-2 Development Area and a part of Phase-3 Development Area
- No.3: Transmission Main (DN1500mm) to Tank 3 & 4 series covering the areas in the entire Phase-1 and Karu/Nyanya, outside of Phases
- No.4: Transmission Main (DN1200mm) to Tank Kubwa, Airport and Gwako series covering the areas outside of Phases)

b. Distribution Mains (Secondary Pipelines)

Distribution mains are the pipelines from reservoirs (tanks) to water supply areas, sometimes as a part of distribution network in FCTWB (approx. 296km). (Pipeline Unit for D300mm or more. Area Offices for less than 300mm)

c. Distribution Network (Tertiary Pipelines)

Distribution network is the pipelines having connections to service pipes in water supply areas in FCTWB (approx. 339km). (Pipeline Unit for D300mm or more. Area Offices for less than 300mm)

(5) Reservoirs (Tanks)

There are major 16 concrete tanks in existing piped water supply system to which water is supplied by gravity and partially pumping up. Reservoir Unit is in charge.

Table 1.4-5 shows information of existing tanks. Not listed here, but Tank 1 and 6 for Phase-3 development area are under construction, meanwhile, Tank 7, 8 and 9 are still in planning stage.

Table 1.4-5: Reservoirs (Tanks) in Existing Piped Water Supply System

Reservoir/Tank	No. of Compartment	Capacity (m^3)	Water Level (m)	Construct. Year
Tank 1	-	(40,000)	-	Under Construction
Tank 2	2	45,000	520	2003
Tank 3 Main	2	12,000	534	1984
Tank 3 Ext.	2	12,000	534	1984
Tank 3.1	2	5,400	590	1987
Tank 3.2	2	5,400	575	1990
Tank 4 Main	2	12,000	534	1984
Tank 4 Ext.	2	12,000	534	1994
Tank 4.1 Main	2	2,700	575	1984
Tank 4.1 Ext.	2	10,000	575	1990
Tank 4.1.1	2	5,400	597	1990
Tank 4.2	2	10,000	483	1993
Tank 5	2	40,000	520	2003
Tank 6	-	(40,000)	-	Under Construction
Bwari	2	12,500	610	2006
Kubwa	2	12,000	470	1993
Airport	2	12,000	367	1994
Gwako	2	20,000	246	1994

Source: FCTWB

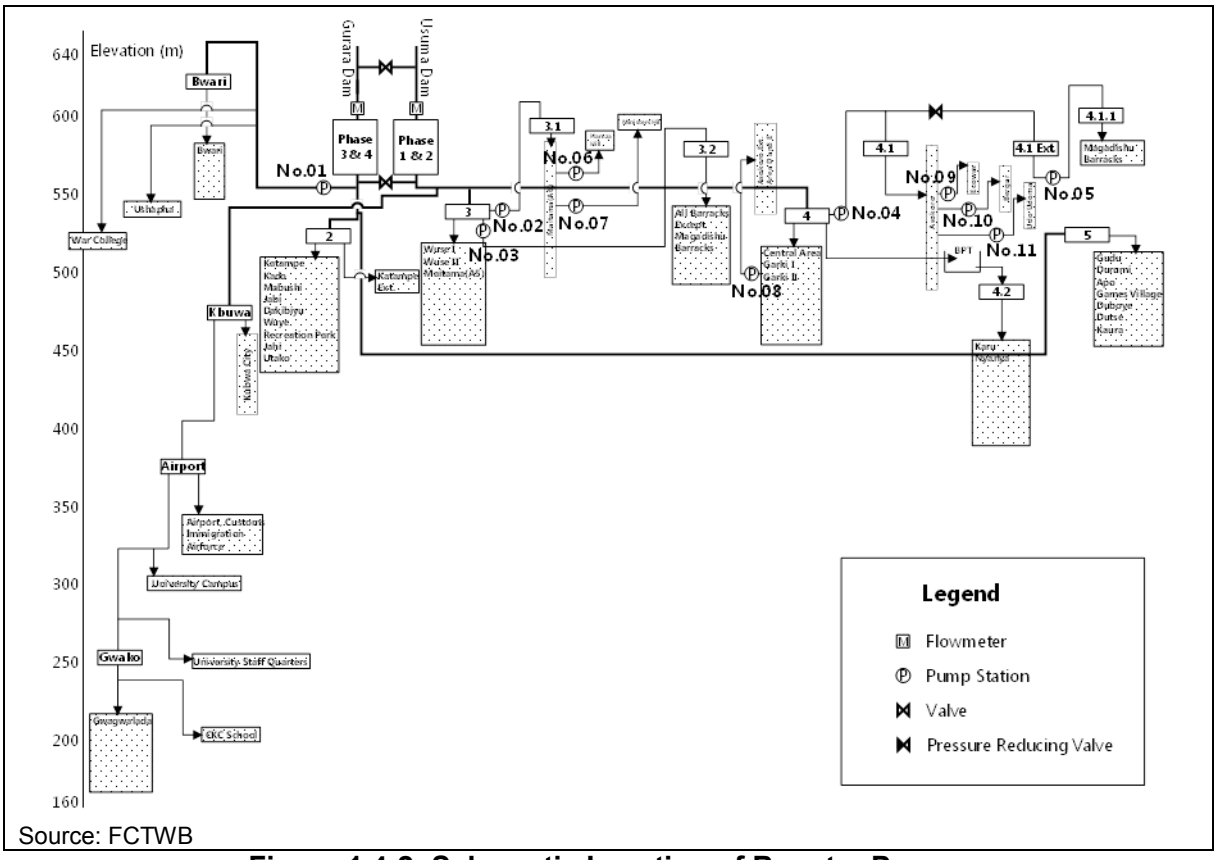
(6) Booster Pumps along Transmission Mains

Table 1.4-6 describes information of booster pumps along transmission mains and Figure 1.4-2 shows their schematic locations. Electro-mechanical Unit is in charge.

Table 1.4-6: Booster Pumps in Existing Piped Water Supply System

Pump	Capacity (m^3/h)	Head (m)	Power Consumption (kW)	No. of Pumps	Speed (rpm)
No.01 Bwari	TBC (operated by Lower Usuma WTP, Production Department)				
No.02 Tank 3 main	280	88	110	4	1,480
No.03 Tank 3 ext.	200	64	55	3	1,480
No.04 Tank 4	280	60	75	3	1,480
No.05 Tank 4.1	100	50	37	3	1,480
No.06 Hamza Hill	26	50	11	3	2,935
No.07 Minister Hill	26	50	11	3	2,935
No.08 ECOWAS	Under construction				
No.09 Dantata	80	68	37	3	2,945
No.10 Berger	26	50	11	3	2,935
No.11 Udo Udoma	Inactive				

Source: FCTWB



Source: FCTWB

Figure 1.4-2: Schematic Location of Booster Pumps

1.4.3 Commercial Aspects of FCTWB

(1) Customer Category

Customers are categorized as below:

- Domestic
- Commercial
  Commercial (un-coded)
  Major Consumers (Co-operate Body, Mini Hotel/Restaurant, Major Consumer, Petrol Station/Plaza, Private School/Clinic)
- Institutions (Embassy, High Commission, Ministry/ Parastatals, Liaison Office, Religion)
- Others (Public Tap/Convenience & Kiosk, Lifting Point for Bulk Selling)

(2) Customer Meters

Customer meters are three types and non-metered as below:

- Conventional (mechanical)
- Automatic Meter Reading (AMR) in Phase 1 development area
- Prepaid
- Non-metered (flat-rate)

(3) FCTWB's Divisions for Meter Reading

FCTWB's divisions for meter reading are as below:

- Domestic: Area Offices, AMR Unit and Prepaid Unit
- Commercial
  Commercial (un-coded): Area Offices and AMR Unit
  Major Consumers: 5 Units and AMR Unit
- Institutions: 3 Units
- Others (Public Tap/Convenience & Kiosk: 1 Unit, Lifting Point for Bulk Selling: Area Offices)

(4) Billing Measures

Billing measures by customer meter type are as below:

- Conventional (mechanical): Meter-reading or Estimate automated if unreadable
- Automatic Meter Reading (AMR) : Meter-reading or Estimate automated if unreadable
- Prepaid: Prepaid or ad hoc Flat-rate if malfunctioning
- Non-metered (flat-rate): Fixed charge

(5) Billing Systems

Billing systems by customer meter type are as below:

- Conventional (mechanical): Puma 1
- Automatic Meter Reading (AMR) : Puma 3
- Prepaid: Stand-alone system (directly linked to Finance and Accounting)
- Non-metered (flat-rate): Puma 1

*Remarks: Puma 1 and Puma 3 were merged and upgraded as Puma 4 under the Project.

(6) FCTWB's Divisions for Billing

FCTWB's divisions for billing are as below:

- Conventional (mechanical): Billing Unit
- Automatic Meter Reading (AMR) : AMR Unit
- Prepaid: Prepaid Unit if necessary
- Non-metered (flat-rate) : Billing Unit

(7) Water Tariffs

Water tariffs are as below:

- **Domestic**
  Meter Reading & Estimate: N80/m3, Flat-rate: N5,500/month
- **Commercial (un-coded)**
  Meter Reading & Estimate: N150/m3, Flat-rate: Subject to customer (e.g. N45,000/month)
- **Major Consumers**
  Meter Reading & Estimate: N150/m3, Flat-rate: Subject to customer (e.g. N45,000/month)
- **Institutions**
  Meter Reading & Estimate: N80-N100/m3, Flat-rate: Subject to customer (e.g. N45,000/month)
- **Public Tap/Convenience & Kiosk**
  Flat-rate: N15,000-30,000/month
- **Lifting Point (Bulk Selling)**
  Subject to size of Water Truck

1.5 Overall Goal, Project Purpose, Outputs and Activities

(1) Overall Goal

Non-Revenue Water reduction activities are routinely implemented in the service area of FCTWB.

(2) Project Purpose

Capacity of FCTWB for NRW reduction is strengthened.

(3) Outputs and Activities

Output-1: Level of NRW of both the service area of FCWTB and water distribution areas is monitored and estimated.

Activity 1-1: Install bulk meters to water treatment plants 1 and 2
Activity 1-2: Measure/estimate water production of water treatment plants 1, 2, 3 and 4
Activity 1-3: Tally the above water production data/estimation
Activity 1-4: Calculate the water consumption based on the billing data
Activity 1-5: Calculate NRW ratio of the service area of FCTWB using the results obtained from Activity 1-3 and 1-4
Activity 1-6: Install zonal meters, water pressure sensor and pilot remote monitoring (telemetry) system
Activity 1-7: Measure/estimate and collect data for water distribution management such as water flow of zonal meters and water pressure

Output-2: Methods/operational procedures for effective NRW reduction are established through pilot projects at Pilot Metering Areas (PMAs) under pilot Area Offices

Activity 2-1: Review existing NRW reduction operations at each pilot Area Office
Activity 2-2: Conduct capacity assessment of the relevant staff of each pilot Area Office
Activity 2-3: Identify and select a Pilot Metering Area (PMA) for each pilot Area Office based on the selection criteria of PMA
Activity 2-4: Prepare/update distribution network drawings for each PMA
Activity 2-5: Install water flow meters to each PMA and measure in/outflows monthly
Activity 2-6: Zone each PMA into Sub Metering Areas (SMA)
Activity 2-7: Isolate a SMA by installing valves
Activity 2-8: Update the distribution network drawings for each SMA
Activity 2-9: Measure an initial level of NRW of each SMA
Activity 2-10: Detect target NRW components (i.e. invisible leakage, customer meter malfunction, and illegal connection) of each SMA
Activity 2-11: Develop a NRW reduction operation plan of each SMA, including reduction target, for review by Head of Distribution Department
Activity 2-12: Review and approve NRW reduction operation plan of each SMA
Activity 2-13: Implement the NRW reduction operations at each SMA
Activity 2-14: Monitor the progress of the NRW reduction operations of each SMA
Activity 2-15: Measure level of NRW of each SMA at the end of the respective operations
Activity 2-16: Prepare a report on pilot projects, covering Activity 2-1~2-15

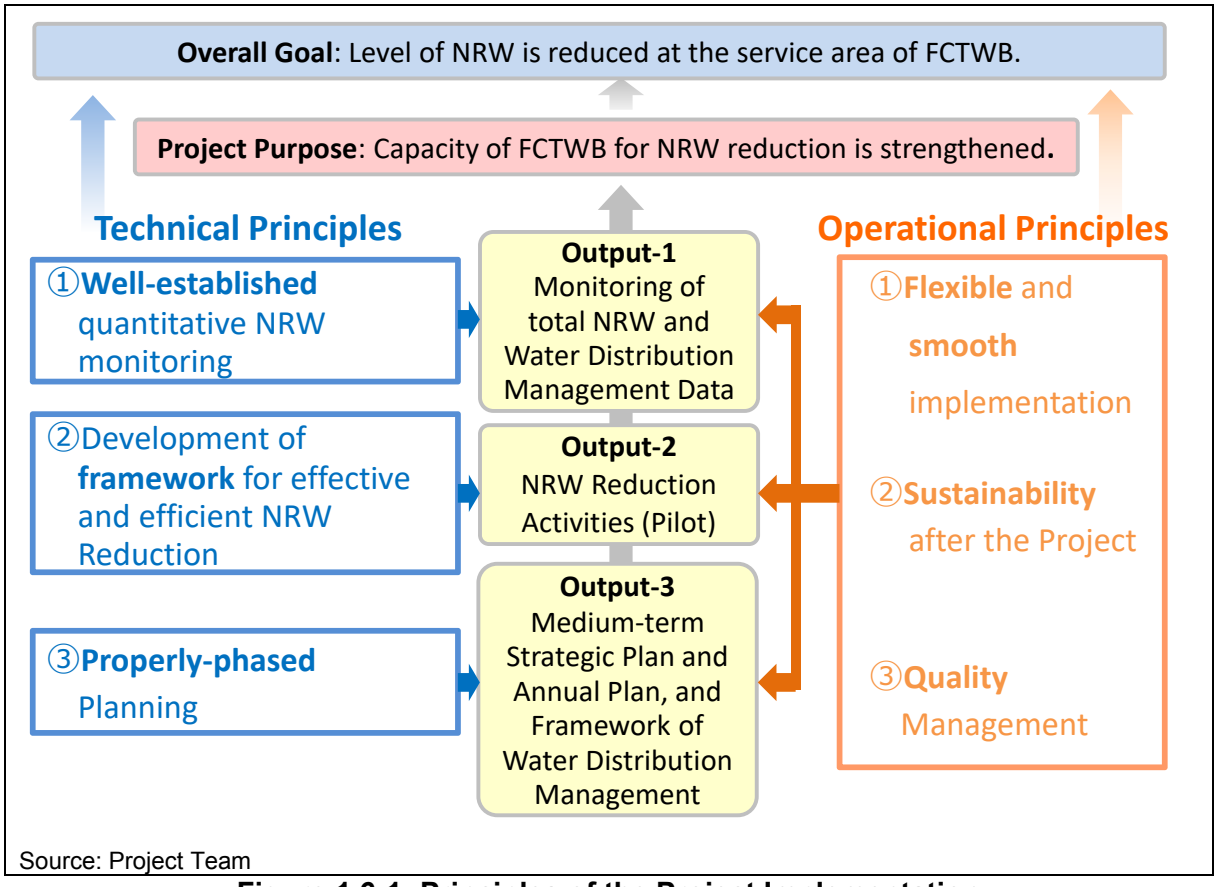
Activity 2-17: Develop manuals for NRW reduction for Area Office managers and field operators (i.e. technical officers and meter readers), including audio visual materials

Output-3: A medium-term strategic plan of FCTWB for NRW reduction is developed, utilizing the results of Output 1 and 2

Activity 3-1: Establish a Working Group for NRW planning
Activity 3-2: Review existing plans, implementation structure, on-the-job training mechanism, etc. related to NRW reduction at FCTWB
Activity 3-3: Conduct hydraulic and water pressure distribution analyses of the pipeline networks
Activity 3-4: Develop outlines of the medium-term strategic plan and its annual NRW reduction plan
Activity 3-5: Develop the first medium-term strategic plan (2019-2023) for approval by FCTA
Activity 3-6: Develop an annual NRW reduction plan based on the strategic plan as an integral part of an annual recurrent and capital plan of FCTWB for approval by FCTA
Activity 3-7: Develop a planning manual for NRW reduction
Activity 3-8: Review existing plans, activities and implementing structure, etc. related to water distribution management
Activity 3-9: Establish framework of water distribution management

1.6 Principle of the Project Implementation

Figure 1.6-1 shows principles of the Project implementation from the viewpoints of technical and operational aspects.



Source: Project Team

Figure 1.6-1: Principles of the Project Implementation

1.7 Implementing Agency

- Federal Capital Territory Administration (FCTA)
- Federal Capital Territory Water Board (FCTWB) *Established in 1989.

1.8 Project Implementing Structure

Table 1.8-1 shows the Project member list and Table 1.8-2 shows the JICA Expert Team member list. Figure 1.8-1 shows the Project implementing structure consisting of the following committee, group and teams.

- **Joint Coordinating Committee (JCC)** headed by Director of Economic Planning, Research and Statistics of FCTA as "Project Director"
- **Working Group for NRW Reduction Planning** headed by Director of FCTWB "Project Manager" and Head of Department (HOD) of Administration as "Deputy Project Manager"
- **NRW Management Team** headed by HOD of Distribution of FCTWB as "Technical Manager (Team Leader)" as well as HOD of Commerce as "Technical Manager (Co-Team Leader)", consisting of members from FCTWB Headquarters
- **NRW Action Team** headed by each pilot Area Office Manager as "Team Leader", consisting of members from three pilot Area Offices
- **JICA Headquarters and Nigeria Office**
- **JICA Expert Team** headed by Chief Advisor, consisting members for eleven roles

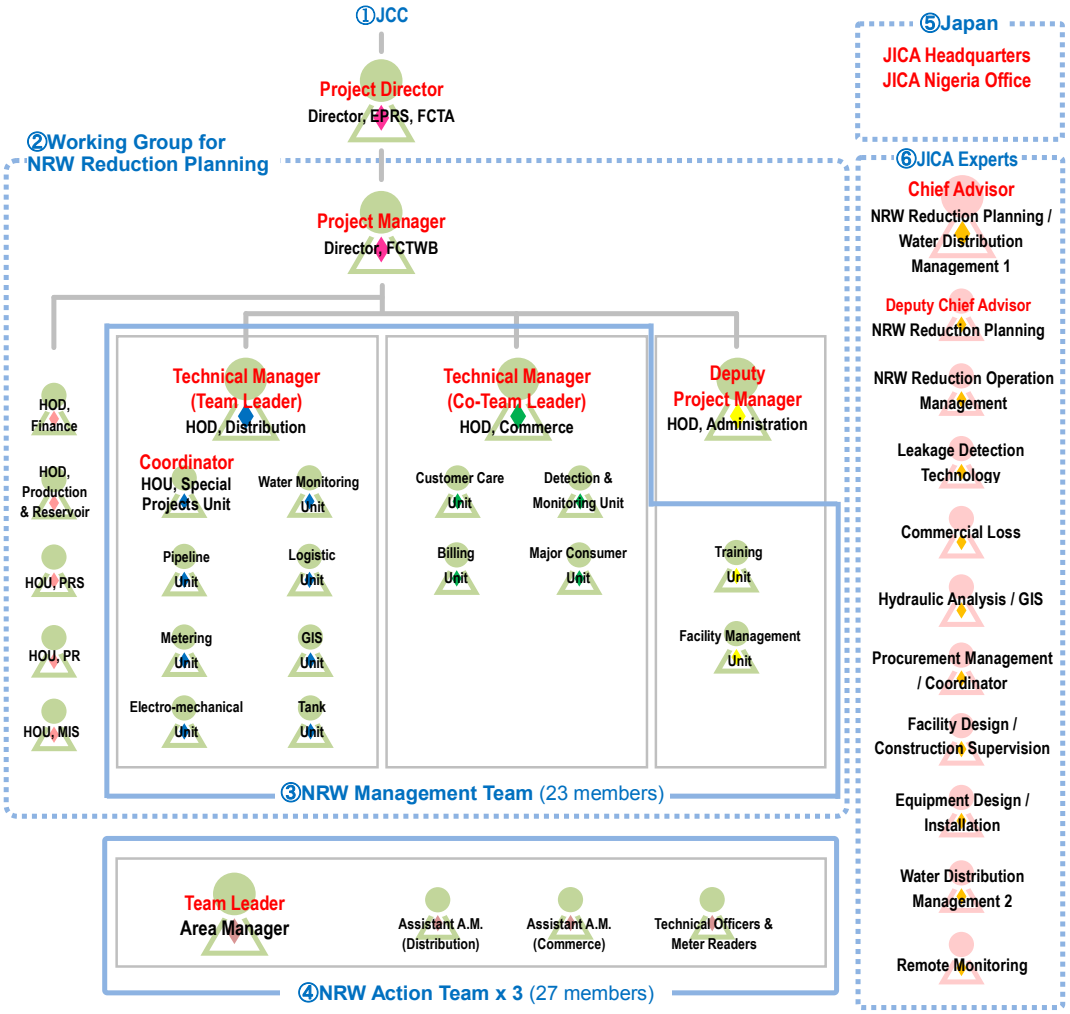
Table 1.8-1: Project Member List

Names	Positions and Organization
Project Leaders	
Mr. Abubakar Sani Pai	Project Director / Director of EPRS, FCTA
Mr. (Engr.) A. A. Nahuche	Project Manager / General Manager, FCTWB (Former Technical Manager / HoD Distribution)
Mr. (Engr.) Abolade R. Lawal	Technical Manager / HoD: Distribution (Former Coordinator, HoU: Special Projects)
Mr. Taiwo Adeyemi	Technical Manager / HoD: Commerce
Mr. Hudu Bello *Transferred	(Former Project Manager / Director of FCTWB)
Mr. S.T. Bello *Demise	(Former Deputy PM / HoD: Administration & Supply)
Mr. Adis S. Muhammad *Transferred	(Former Technical Manager / HoD: Commerce)
Head of other relevant Departments and Units	
Mr. (Engr.) Aliyu Usman	Deputy Director
Ms. Hafsat Ahmed Lawi	HoD: Finance and Account
Mr. Sunday Agbonthane	HoD: Reservoir and Production
Mr. Dele Olatunji	HoU: Multilateral Relations
Mr. Abbas A. Ahmed	HoU: Public Relations
Mr. Fabikun Kehinde	HoU: MIS
Ms. Bunmi Olowookere *Transferred	HoU: Planning, Research and Statistics
NRW Management Team **Distribution Department**	
Mr. (Engr.) Moh. Kabir Rabiu	Coordinator / HoU: NRW Reduction
Mr. Musa Dikko	HoU: Pipeline
Mr. (Engr.) Abdullahi Masaud	Area Manager: Gwarimpa (Former HoU: Metering General)
Mr. Abdulrahman Shehu Sani	HoU: Metering General
Mr. Abubakar Ubale Abuba	AMR Meter
Mr. Shehu Suleiman	HoU: GIS
Mr. Abdulrahman Muhammed	NRW Reduction Unit (O&M Unit / Sectional Head of Tank 1 & 6 Project)

Names	Positions and Organization
Mr. Mohammed Dauda	Technical Officer, Pipeline Unit
Mr. Igbinosa Courage	NRW Reduction Unit
Mr. Hillary Chimeuche Ezeh	Surveyor, GIS Unit
Commerce Department	
Mr. Danjuma Isah	HoU: Monitoring and Detection
Ms. Rose Akpan	HoU: Billing
Ms. Issac O. Owolabi *Retired	HoU: Customer Care
Mr. Aliyu Maradun * Transferred	HoU: Major Consumers
NRW Action Team	
Jabi Area Office	
Mr. Muhammed S. Ramat *Transferred	Team Leader / Area Manager (Distribution)
Mr. Sadiq Salihu	Assistant Area Manager (Distribution)
Mr. Sulaiman Aminat Muhammad	Assistant Area Manager (Commerce)
Ms. Jummai Ugbodaga	Senior Commercial Officer (Commerce)
Mr. Mohammed Moh'd	Planning Officer (Commerce)
Mr. Aliyu Ibrahim	Senior Works Superintendent (Distribution)
Mr. Abubakar Danladi	Foreman (Distribution)
Mr. Muhammad Husaini	Higher Trade Officer (Commerce)
Mr. Mahmud Muhammed	Foreman (Distribution)
Mr. Hassan Yelwa	STA (Commerce)
Gudu Area Office	
Mr. Habib Ahmed Kiru *Transferred	Team Leader / Area Manager (Distribution)
Mr. Umar Ibrahim	Assistant Area Manager (Commerce)
Mr. Abdul Ozumi	Assistant Area Manager (Distribution)
Mr. Adamu Ismaila	Unit Head (Commerce)
Mr. Abdul Yusuf	Supervisor of Prince & Princess Estate
Mr. Friday Daniel Maigida	Plumber (Distribution)
Mr. Salisu Mohammed	Plumber (Distribution)
Garki I Area Office	
Mr. Adesoji Adenuga *Transferred	Area Manager (Commerce)
Mr. Choji Pam	Assistant Area Manager (Commerce)
Mr. Mohammed Gana	Assistant Area Manager (Distribution)
Ms. Fatima A. Abdullahi	Commercial Officer I
Mr. Iliya Galadima	Higher Works Super Intendant (Distribution)
Mr. Raymond Olowookere	Forman (Distribution)
Mr. Ibrahim Yelwa	Forman (Distribution)
Mr. Vincent Zakwoi	Senior Works (Commerce)
Mr. Kenneth Mudu	Senior Craft man (Distribution)
Support Members	
Mr. Mumini Adekunle Raifu	Assistant Area Manager (Structure Engr.)
Mr. (Engr.) Tope Aluko	Head of Electro Mechanical Unit
Mr. Bulus Amos	Head of Booster Station Unit

Table 1.8-2: Project Member List

Position	Name
Chief Advisor / NRW Reduction Planning	Mr. Akinori MIYOSHI
Deputy Chief Advisor / NRW Reduction Planning	Mr. Taketoshi FUJIYAMA
NRW Reduction Operations Management	Mr. Toru TOYODA
Leakage Detection Technology	Mr. Kiyoshi KIYAMA
Commercial Loss	Mr. Hiroyuki MORITA / Mr. Takuji OKUBO
Hydraulic Analysis / GIS	Mr. Shinta SEGAWA / Mr. Hiroyuki MORITA
Water Distribution Management	Mr. Akinori MIYOSHI / Mr. Shinta SEGAWA / Mr. Takeshi YAJIMA
Equipment Design / Installation	Mr. Kiyoshi KIYAMA
Facility Design / Construction Supervision	Mr. Taketoshi FUJIYAMA / Mr. Shinichiro SATO / Mr. Tomohiro SHIMIZU
Remote Monitoring System Installation & Training	Mr. Tomohiro SHIMIZU / Mr. Takashi MORI / Mr. Toshinobu KASUYA
Financial Analysis / Organization	Mr. Noboru OSAKABE
Procurement Management / Coordinator	Mr. Kazuhiro ISHIURA / Mr. Hiroki NIIMURA / Mr. Kenji YOSHIDA / Mr. Takashi MORI

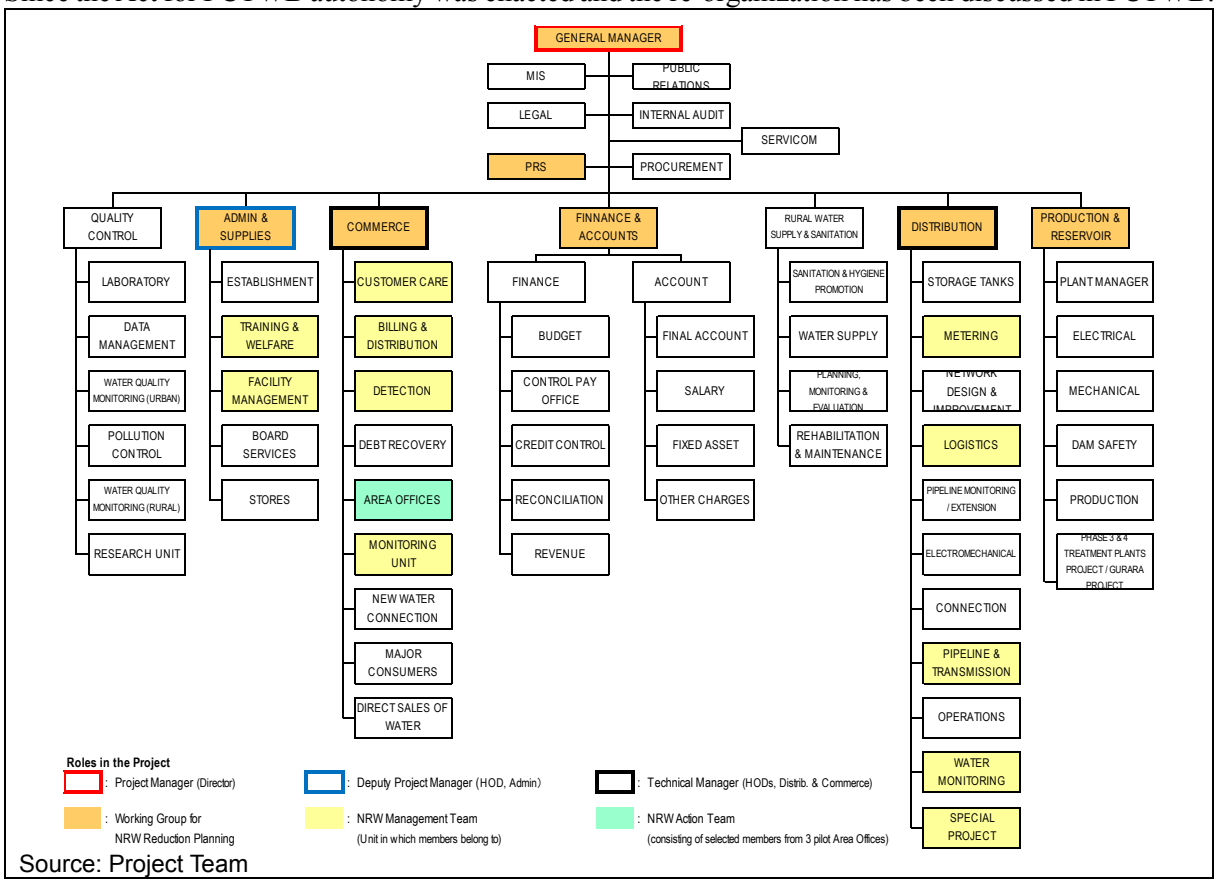


Remarks: Logistic Unit was replaced by newly-created “NRW Unit”.
Source: Project Team

Figure 1.8-1: Project Implementing Structure

Figure 1.8-2 shows the organogram of FCTWB. Currently, FCTWB consists of headquarters and 13 Area Offices located in water supply service area of FCC including the suburbs or satellite towns. As of September 2018, FCTWB has about 750 regular staff excluding casual staff.

Since the Act for FCTWB autonomy was enacted and the re-organization has been discussed in FCTWB.



Source: Project Team

Figure 1.8-2: Organogram of FCTWB

Figure 1.8-3 shows relationship between the Nigerian counterparts and the JICA Experts in terms of their major roles in the Project Implementation.

Nigerian Counterparts / JICA Experts	Working Group for NRW Reduction Planning								NRW Management Team															NRW Action Team (Pilot)					Other
	Project Director / Director, EPRS, FCTA	Project Manager Director, FCTWB	Deputy P.M. HOD, Administration	HOD, Finance	HOD, Production	HOU, PRS	HOU, PR	HOU, MIS	Technical Manager HOD, Distribution	Technical Manager HOD, Commerce	Coordinator / HOU, Special Project Unit	Logistics Unit	Pipeline Unit	GIS Unit	Metering Unit	Water Monitoring Unit	Tank Unit	Electro-Mechanical Unit	Customer Care Unit	Billing Unit	Monitor. & Detect. Unit	Major Consumer Unit	Training Unit	Facility Mngmt. Unit	Area Office Manager	Assistant A.O.M. (Dist.)	Assistant A.O.M. (Com.)	Technical Officers	Meter Readers	Area Office Manager
Chief Advisor / NRW Reduction Planning / Water Distribution Mngmt 1	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●					●
Deputy Chief Advisor / NRW Reduction Planning	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			●	●	●	●	●	●	●					
NRW Reduction Operation Management									●	●	●	●	●	●	●	●			●	●	●	●			●	●	●	●	●	
Leakage Detection Technology									●		●	●	●												●	●		●		
Commercial Loss										●	●				●	●			●	●	●	●			●	●	●		●	
Hydraulic Analysis / GIS									●		●	●	●	●						●		●			●	●				●
Facility Design / Construction Supervision									●		●		●			●	●	●												
Equipment Design / Installation									●		●		●			●	●	●												
Water Distribution Management 2									●	●	●	●	●	●		●	●			●		●								●
Remote Monitoring									●		●	●				●	●	●												
Procurement Mngmt. / Coordinator			●						●	●	●	●												●	●					

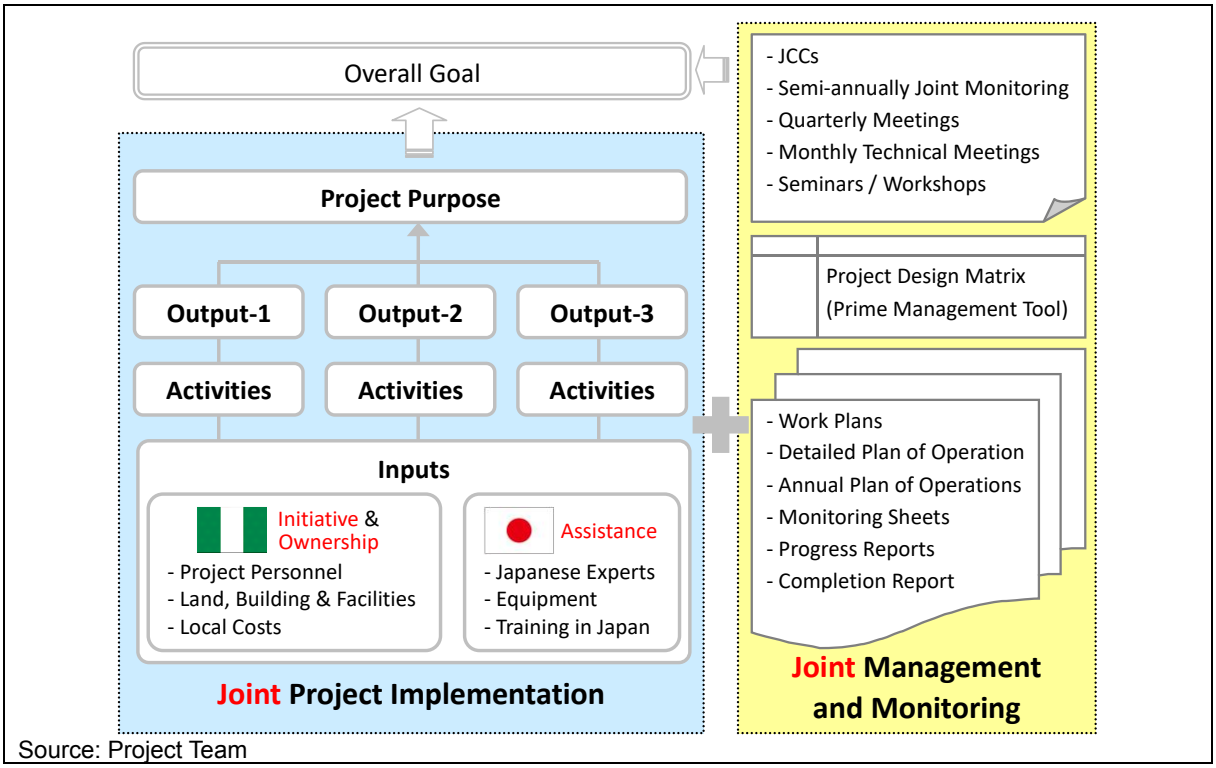
Source: Project Team

Figure 1.8-3: Relationship Matrix between Nigerian Counterparts and JICA Experts

1.9 Project Operation and Management

1.9.1 Concept of Project Management

Figure 1.9-1 shows concept of project operations and management.



Source: Project Team

Figure 1.9-1: Concept of Project Operations and Management

1.9.2 Joint Management and Monitoring

(1) Joint Coordinating Committee

Joint Coordinating Committee (JCC) was organized during the implementation of the Project.

1) Roles and Responsibilities of JCC

- Decision making and coordination between Nigeria and Japan
- Deliberation of major issues and provision of advice
- Monitoring and evaluation of the Project
- Approval of PDM and its revision, and Joint Monitoring Sheet, etc.

2) Schedule of JCC Meeting

In Phase 1 and Phase 2, JCC meetings have been held as follows, which were supposed to be held if the need arises during the Project.

- Kick-off Meeting held on 6 November, 2014
- 1st JCC Meeting held on 2 December, 2014
- 2nd JCC Meeting held on 23 June, 2015
- 3rd JCC Meeting held on 12 November 2015
- 4th JCC Meeting held on 22 September 2016
- 5th JCC Meeting held on 20 December 2016
- 6th JCC Meeting held on 16 May 2017
- 7th JCC Meeting held on 24 August 2017
- 8th JCC Meeting held on 28 June 2018
- Closing JCC Meeting held on 5 September 2018

3) Main Topics in JCC Meetings

Table 1.9-1 shows main topics in the meetings held until now (refer to Annex 2).

Table 1.9-1: Main Topics in JCC Meetings

Title	Date	Main Topics	Attendance
Kick-off	6 Nov. 2014	- Presentation of overview of draft Work Plan including Project Monitoring Sheet Ver. 0, PDM_1 and PO_1 - Project Team members - Project budget - Office Space and Facilities for the Project	28
1st JCC	2 Dec. 2014	- Presentation and approval of the Work Plan including Project Monitoring Sheet Ver. 0, PDM_1 and PO_1 - Establishment of Working Group for NRW Reduction Planning - Security issues in the field activities	19
2nd JCC	23 June. 2015	- Insufficient of counterpart fund - Existence of duplicated/return bills, which may affect unreliable financial analysis including NRW - Customs clearance and tax exemption for equipment from Japan - Presentation of Project Monitoring Sheet Ver. 1	21
3rd JCC	12 Nov. 2015	- Insufficient of counterpart fund - Existence of duplicated/return bills, which may affect unreliable financial analysis including NRW - Issues on as-built drawings - Presentation of Project Monitoring Sheet Ver. 2 - Presentation of revised PDM and PO, Work Plan on additional activities and inputs - Approval of Project Monitoring Sheet Ver. 2, revision of PDM (PDM_2), PO (PO_2) and concept of Work Plan on additional activities and inputs	25
4th JCC	22 Sep. 2016	- Extension of the Project period, requested by the Nigerian side - Taking over the chamber construction and procurement of small materials for Pilot activities, requested by the Nigerian side - SMA out of PMA monitoring area - Removal or relaxation of AGIS security - Challenge in as-built drawings - Technical advice on prepaid meter - Presentation of Project Monitoring Sheet Ver. 3 including revised PDM and PO - Approval of Project Monitoring Sheet Ver. 3, revision of PDM (PDM_3) and PO (PO_3) - Action Plan by participants in the 2nd training in Japan	23
5th JCC	20 Dec. 2016	- Progress and Extension of the Project Period - Counterpart Fund - AGIS Security - Active Cooperation between FCDA and FCTWB - Quality Management and Fundamentals - Legal instrument (enabling law) establishing FCTWB - Information sharing - Presentation of Project Monitoring Sheet Ver. 4 - Observation and carry-over of the Activities - Explanation of revision of PDM and PO - Approval of Project Monitoring Sheets Ver. 4 - Way forward for Phase 2 - Amendment of Record of Discussion (R/D)	19
6th JCC	16 May 2017	- Discipline and Training in FCTWB - Problem in Flow Measurement of Bulk Meter - Discrepancy between As-built Drawing and Actual Situation	26

Title	Date	Main Topics	Attendance
		- Results of Pilot Project - Workshop - Performance Management - Project Office's Environment - Project Vehicle - Approval of Work Plan (Phase-2) and Working Group for NRW Reduction Planning - Future Revision of Project Design Matrix	
7th JCC	24 Aug. 2017	- Revision of PDM and PO - Review and Streamlining of Meter Reading and Billing, and Clearly-stated Procedures - Prompt Summary of Pilot Projects - Facilitating Timely Execution of Counterpart Fund 2017 - Development and Effective Utilization of GIS - Strengthening Collaboration between Distribution Department and Commerce Department - Awareness Raising of Quality Management - Encouraging Individual's Effort on NRW Reduction - Knowledge Sharing System of Counterpart Personnel in FCTWB - Actions toward FCTWB Autonomy and Bill - Strengthening Partnership between FCTWB and FCDA - Project Vehicle - Approval of Project Monitoring Sheet (Draft) - Revision of PDM (PDM_4) and PO (PO_4)	27
8th JCC	28 Jun. 2018	- Personnel Reassignment of the FCTWB's Project Members - Preparation for FCTWB Autonomy - Project Vehicle - Data Acquisition by Bulk and Zonal Flow Meters - Customers' Zonal and PMA Coding - Irregular Billing Cycle - Monitoring of NRW Ratio and/or related Data in Zone and PMA - Results of Pilot Projects - The Draft Medium-Term Strategic Plan for NRW Reduction (2019-2023) - FCTA's Approval Process of the Draft Medium-Term Strategic Plan for NRW Reduction (2019-2023) - Incorporation of Annual NRW Reduction Plan (2019) to FCTWB's Annual Recurrent and Capital Budget Plan (2019) - Approval of Project Monitoring Sheet (Draft) - Approval of Revision of PDM (PDM_5) and PO (PO_5) - Approval of the Draft Medium-Term Strategic Plan for NRW Reduction (2019-2023)	21
Closing JCC	5 Sep. 2018	- Result of the Project, Achievement and Backlog - Approval of the Medium-Term Strategic Plan for NRW Reduction (2019-2023) and incorporation of Annual NRW Reduction Plan to FCTWB's Recurrent and Capital Budget Plan - Utilization and Information Sharing of the Result of Project - Budgeting of the Medium-Term Strategic Plan for NRW Reduction (2019-2023) - Outstanding Issues (Data Acquisition by Bulk and Zonal Flow Meters (Output-1), Customers' Zonal/PMA Coding (Output-1), Irregular Billing Cycle (Output-1), Monitoring of NRW Ratio and/or related Data (Output-2), The Final Capacity Assessment (Output-2), Project Vehicle, and Seminar)	31

Source: Project Team

(2) Semi-Annual Joint Monitoring

1) Objectives of Joint Monitoring

- Verification of project progress
- Verification of achievement of project purpose and outputs
- Revision of planning and strategy for development of impact
- Risk management of the Project

2) Schedule of Joint Monitoring

In Phase 1 and Phase 2, a series of joint monitoring have been conducted as follows:
- 1st Joint Monitoring in November 2014 (Monitoring Sheets Ver. 0)
- 2nd Joint Monitoring in June 2015 (Monitoring Sheets Ver. 1)
- 3rd Joint Monitoring in November 2015 (Monitoring Sheets Ver. 2)
- 4th Joint Monitoring in September 2016 (Monitoring Sheets Ver. 3)
- 5th Joint Monitoring in December 2016 (Monitoring Sheets Ver. 4)
- 6th Joint Monitoring in August 2017 (Monitoring Sheets Ver. 5)
- 7th Joint Monitoring in June 2018 (Monitoring Sheets Ver. 6)

3) Results of Joint Monitoring

Results of joint monitoring have been recorded in Project Monitoring Sheets (refer to Annex 3), and presented and approved in Joint Coordinating Committee meeting.

(3) Quarterly Project Meeting and Monthly Technical Meeting

Quarterly meeting charged by Project Manager as well as monthly technical meeting chaired by Technical Manager or Coordinator have been conducted at FCTWB to share updated information and discuss issues in activities among the Project Team members and the JICA Expert Team. Table 1.9-2 shows record of meetings (refer to Annex-4).

Table 1.9-2: Quarterly Project Meeting and Monthly Technical Meeting

Date	Main Topics	Attendance
16 Dec. 2014 (Quarterly & Monthly)	- Location and Construction of Chamber for Ultrasonic Flow-Meter at outlets of Water Treatment Plant (Phase 1&2) - System Modification of Billing System - Creation of PMAs and Selection Criteria for Pilot Project - Capacity Assessment and Capacity Development Plan - Equipment to be procured by JICA	35
10 Mar. 2015 (Monthly)	- Location of the Bulk Flow-Meters and Valves and their Chamber Structure Creation of PMAs and Selection Criteria for Pilot Project - Identification of Chamber Location - Bill of Quantity of Chamber Structure	9
19 Mar. 2015 (Monthly)	- Final Location of Chambers and Structure - Agreement on Equipment to be procured - Demarcation of the Works on Procurement - Identification of Chamber Location	14
8 May 2015 (Monthly)	- Project Schedule and Procurement in Japan - Bill of Quantity of Chambers for Flow-Meter and Valve - System Modification of Billing System - GIS Training - Capacity Assessment and Capacity Development Plan	24
25 Jun. 2015 (Quarterly & Monthly)	- Final Confirmation of Size and Material of Pipeline at where Valves and Flow-Meters will be installed - Temporary-Excavated Pit for Ultrasonic Flow-Meter and Security/ Safety Issues - Change from Chamber to Casing with Spindle for D300mm Valve - Appointment of Coordinator for Commercial Loss - Restriction of Meter Replacement in selected PMAs - AGIS Issues - Project Monitoring Sheet	32
23 Jul. 2015 (Monthly)	- Results of the 2nd JCC Meeting (Brief of Problems, Issues and Estimation of NRW Ratio) - Follow-up of the 2nd JCC Meeting, Removal of Restriction on GIS, Handover of Equipment - Change on Garki I PMA, Recommendation by JICA Experts	28
17 Sep. 2015 (Monthly)	- Creation of PMAs/SMAs and Verification of Pipe Size and Materials in PMAs - Duplicated/Return Bills - AGIS Issues - Counterpart Fund - Tax Exemption and NCC - The 3rd JCC Meeting and Annual Joint Monitoring - Schedule of the Project Activities - Weekly/Biweekly Meeting	24
21 Oct. 2015 (Monthly)	- Creation of PMAs - Progress of GIS Network Drawings - Duplicated/Return Bills - GIS Training - Counterpart Fund - Equipment from Japan - Weekly/Biweekly Meeting	28
17 Nov. 2015 (Monthly)	- Creation of PMAs - Implementation of Pilot Project - Duplicated/Return Bills - GIS Training	11

Date	Main Topics	Attendance
	- Counterpart Fund	
22 Dec. 2015 (Quarterly & Monthly)	- Follow-up of the 3rd JCC Meeting - Progress of Pilot Project in Prince & Princess - Overall Schedule of Pilot Project in 2016 - Design of Water Distribution Management and Zonal Meters - Progress of Action Plan (presented in Training in Japan) - Newsletter Volume 3 - Workshop and Stakeholder Forum scheduled in February 2016	38
20 Jan. 2016 (Monthly)	- Activities for Output-1 Chamber Construction at outlet of LUD-WTP Duplicated /Return Bills and Schedule of Deactivation, and Modification of Billing System Equipment for the Project (Additional Activities and Inputs) - Activities for Output-2 Chamber Construction in PMAs of Jabi and Garki I Pilot Project in PMA of Gudu Pilot Project in PMA of Jabi and Garki I - Any other Business Newsletter Volume 3 Workshop and Stakeholder Forum	15
23 Mar. 2016 (Monthly)	- Activities for Output-1 - Activities for Output-2	22
28 Apr. 2016 (Monthly)	- Activities for Output-1 - Activities for Output-2 - Counterpart Fund	32
15 Jun. 2016 (Monthly)	- Field visit to project sites by the JICA President on 16th June 2016 - Deactivation of return bills - Updating GIS maps in three PMAs and AGIS security - Activities for Output-1 - Activities for Output-2 - Presentation on installation of four cables for ultrasonic flow-meter - Presentation on how to prepare water balance analysis - Additional equipment to leakage repair equipment	36
27 Jul. 2016 (Quarterly & Monthly)	- Joint monitoring and JCC meeting - Action Plan by Participants in the 2nd Training in Japan - Presentation on AGIS challenges and possible solutions - Deactivation of return bills and modification of billing system - Update of counterpart fund and autonomy of FCTWB - Activities for Output-1 - Activities for Output-2 - Presentation on some results of 24 hours consumption measurement of the sampled customers	41
24 Aug. 2016 (Monthly)	- Joint monitoring and JCC meeting - Specification of modification of billing system - Updating GIS maps in three PMAs - Submission of letter to FCTA on relaxation of AGIS security - Update of counterpart fund and autonomy of FCTWB - Activities for Output-1 - Activities for Output-2 - Explanation on results of meter error test	31
6&12 Oct. 2016 (Monthly)	- Result of joint monitoring and JCC meeting - Implementation of modification of billing system - Response on relaxation of AGIS security - Activities for Output-1	23&20

Date	Main Topics	Attendance
	- Activities for Output-2 - Presentation on 3 water meter types, Q&As and comments - Presentation on action plan by Gudu Area Office (participant in training in Japan) for additional NRW reduction activities	
17 Nov. 2016 (Monthly)	- Activities for Output-1 - Activities for Output-2	16
9 Mar. 2017 (Monthly)	- Results in the Phase 1 - Necessity of follow-up of the pilot projects - Schedule of the Pilot projects	32
31 Mar. 2017 (Monthly)	- Progress and challenges of the pilot projects - Updated schedule of the pilot projects	28
31 Jul. 2017 (Monthly)	- Preparation of Monitoring Sheet II	24
29 Aug. 2017 (Monthly)	- Results of project monitoring which was ended in the 7th JCC meeting - Schedule of activities including follow-up of the pilot project in Garki I, distribution management, hydraulic analysis and GIS - Contents of medium-term strategic plan - Appoint staff in charge of medium –term strategic plan	30
28 Sep. 2017 (Monthly)	- Progress of follow-up of the pilot project in Garki I and achievement on NRW ratio - Progress on distribution management and zonal meter installation - Outlines of the medium-term strategic plan - Challenges on non-full flow of water transmission main lines at USUMA - Progress of developing database required for hydraulic analysis - Progress of hydraulic analysis	33
1 Feb. 2018 (Monthly)	- Challenges on flow measurement - Progress of zonal coding - Hydraulic analysis - Telemetry system - Challenges on non-full flow of water transmission main lines	29
15 Mar. 2018 (Monthly)	- Schedule of the Project - Progress of zonal coding and telemetry system - Progress of Medium-term strategic plan - Progress of switch-over construction - Update of FCTWB's autonomy	28
1 Jun. 2018 (Monthly)	- Medium-term Strategic Plan - Annual Plan for NRW Reduction 2019	20
17&18 Oct. 2018 (Seminar Preparation & Commerce)	- Discussion for contents of seminar - Staff in charge	14&12

Source: Project Team

(4) Workshop

The Project convened workshops as shown in Table 1.9-3 (refer to Annex 5 for the programme, attendances and presentation materials). The JICA Expert Team encouraged the Project Team to take initiative of workshops including presentation.

Table 1.9-3: Workshop

Title	Date	Main Topics	Attendance
1st Workshop	4 Dec. 2014	Main Session - Background of the Project, and NRW situation of FCT (FCTWB) - Brief explanation and principles of the Project implementation (JICA expert) - NRW video - Good practices of NRW reduction in Yokohama city (JICA expert) - Work plan, schedule and progress (JICA expert) Supplementary Session - Group discussion on zoning of pilot metering area by the Project members from distribution department and area offices	80
2nd Workshop	17 Feb. 2016	Session 1: Water Distribution Management - Project progress and introduction (FCTWB) - Concept and ideal of water distribution management (FCTWB) - Installation of bulk & zonal meters and pilot remote monitoring (FCTWB) - Drawing and GIS in FCTWB (FCTWB) - Hydraulic analysis for diagnosis of distribution network (FCTWB) - Current situation of billing (FCTWB) Session 2: NRW Reduction Pilot Project - NRW and procedures of pilot project (FCTWB) - Concept and Creation of PMA/SMA (FCTWB) - Findings in Gudu before NRW Reduction Operations (FCTWB) - Findings in Jabi before NRW Reduction Operations (FCTWB) - Meter Error Test (FCTWB) Session 3: Wrap-up - Practice of Water Balance Analysis (JICA Expert) - Action Plan by Trainees in Japan (FCTWB) - Suggestions (JICA Expert) - Clarification of Problems and Way Forward (FCTWB)	106 *External organizations were not invited.
3rd Workshop	9 May 2017	Session 1: Output-1: NRW Calculation and Monitoring - Bulk & Zonal Meters (FCTWB) - Billing System (FCTWB) - Works and Challenges (FCTWB) Session 2: Output-2: NRW Reduction Pilot Projects - Procedures of Pilot Project (FCTWB) - Gudu Case Study (FCTWB) - Jabi Case Study (FCTWB) - Garki I Case Study (FCTWB) - Findings in Case Studies, Issues and Challenges (FCTWB) * Equipment for NRW reduction are displayed or demonstrated. Session 3: Output-3: NRW Reduction Strategic Planning in Phase-2 - Work Plan (Phase-2) (FCTWB) - Working Group on Strategic Planning (FCTWB) - Way Forward	121

Source: Project Team

(5) Seminar

In order to introduce the Project's results to the stakeholders, state water agencies, international development partners, etc., the seminar took place on 22nd October 2018 with 117 attendances. Contents of the seminar is as follows, and refer to Annex 5 for details.

Session 1: The Medium-Term Strategic Plan for NRW Reduction (2019-2023)
- Current Status of Water Services and FCTWB (FCTWB)
- Project Outline (FCTWB)
- The Medium-Term Strategic Plan of NRW Reduction (FCTWB)
- Approval of the Medium-Term Strategic Plan of NRW Reduction and Driving Force of implementing NRW Reduction (FCTWB)

Session 2: Results and Impact of the Federal Capital Territory Reduction of Non-Revenue Water Project
- NRW Calculation/Estimation and Monitoring (FCTWB)
- Results of NRW Reduction Pilot Projects (FCTWB)
- Distribution Management (FCTWB)
- Findings and Lessons learnt (FCTWB)
- Case Sample of Voluntarily-initiated NRW Reduction (FCTWB)

Session 3: Questions & Answers, Discussion and Way Forward
- Questions & Answers, and Discussion
- Way Forward

(6) Public Relations

The Project prepared several newsletters and utilized media as a tool of public relations (refer to Annex 6).

CHAPTER 2. CAPACITY ASSESSMENT & CAPACITY DEVELOPMENT PLAN

2.1 Introduction

Methodology of assessment, more details of capacity assessment and capacity development plans are described in Annex 7.

In order to implement the Project steadily by FCTWB and project members to be empowered through capacity development by the JICA Expert Team, at the beginning of the Project, the Project made Capacity Assessments (CA) for setting up baseline and Capacity Development (CD) Plan at 1: Organizational Level, 2: Individual Level and 3: Institution, Policy and Society Level.

Concerning the CA as a baseline at organizational level, the Project analysed data as of 2013 and 2014 and had interviews with Director and Head of Distribution Department of FCTWB. Secondly, in the light of the CA as a baseline at individual level, the Project had interviews with Project Technical Managers, NRW Management Team members (excluding administrative members) and NRW Action Team members (three Area Office managers and groups). Thirdly, the Project analysed the CA of institution, policy and society level based on the existing information and interviews with some of NRW Management Team members.

The CD Plans for both organization and individuals are required primarily so as to achieve the project purpose. Secondarily, an approach to aspect of institution, policy and society and encouragement to Federal Capital Territory Administration (FCTA) and FCTWB are significant actions to enhance their capacity and facilitate their performance. Furthermore, the Project focuses on sustainability of NRW reduction so that FCTWB can improve water supply services and ultimately approach to overall goal in the future.

For the CD plan at organizational level, the Project considered;

- Establishment of routine work on NRW reduction
- Introduction of vehicle and equipment required for creation of Pilot Metering Area (PMA) and Sub-Metering Area (SMA), database and flow measurement
- Sustainability of the work for permanent or semi-permanent team
- Periodical trainings

On the other hand, at individual level, the Project considered;

- Preparation of action plans (if applicable)
- Motivation for proactive measures against NRW
- Full understanding of NRW reduction operations and development of database for the existing distribution networks
- Accumulation of practical experience of NRW reduction operations through the pilot project

The JICA Expert Team intensively directed the appointed Project Team members of the NRW Management Team and the NRW Action Team through individual CD plans.

In addition, the Project suggested an approach to aspects of institution, policy and society.

Capacity at both organizational and individual levels was scheduled to be monitored periodically by interim assessments and evaluated at the end of the Project.

Table 2.1-1: Schedule of Capacity Assessment and Capacity Development Plan

	2014	2015	2016	2017	2018
Output-1					
Output-2					
Output-3					
CA&CD		CA (Baseline)&CD Plan		CA (Interim)	Final

Remarks: Revised in September 2018

2.2 Capacity Assessment and Capacity Development at Organizational Level

2.2.1 Performance Indicators

Table 2.2-1 shows performance indicators of water supply services of FCTWB.

Table 2.2-1 Performance Indicators of Water Supply Services of FCTWB

Cate.	Sub-Cate.	Index	Historical Data		Remarks	Relevant Outputs
			As of 2014 (Baseline)	As of 2018 (Final CA)		
Technical aspects	Measurers of NRW	NRW ratio (%)*	60.7	48.3	Baseline: Water Balance of FCTWB Year 2013 Final: Medium-Term Strategic Plan	1, 2, 3
		Water production (m^3/day)	232,798	310,630	Baseline: JICA Preliminary Survey in August 2014 (Source: FCTWB) Final: Medium-Term Strategic Plan	1, 3
		Billed water (m^3/day)	91,506	160,630	Baseline: Water Balance of FCTWB Year 2013 Final: Medium-Term Strategic Plan	1, 2, 3
		Ratio of water meter installation	85.3	93.4	Baseline: Billing Method Summary Report (as of Sep. 2014) by Area Offices Final: FCTWB Total Connections: 51,215 Water Meters installed: 47,843 *A number of automated estimate bills has remained.	1, 2
		Number of the water pipe breaks responded to within 24 hours (%)	N.A.	N.A.	Baseline: - Final: No answers about response within 24 hours because of the limited budget, logistics and discretion of expenditures for O&M particularly in Area Offices.	2
		Quantity of NRW (m^3/km/day)	208.1	220.9	Baseline: JICA Expert Team, (232,798 – 91,506m^3/day) / (44+296+339km) Final: The Project, (310,630-160,630m^3/day) / (44+296+339km) * NRW volume increased according to increase in water production while NRW ratio improved.	1, 2, 3
		Quantity of NRW (m^3/connection/day)	3.0	3.1	Baseline: JICA Expert Team, (232,798-91,506m^3/day)/(47,610connections) Final: the Project, (310,630-160,630m^3/day) / (47,843connections) * NRW volume increased according to increase in water production while NRW ratio improved.	1, 2, 3
Non-technical aspects	Financial performance	Water tariff collection ratio (%)	47.0	31.3	Baseline: JICA Preliminary Survey in August 2013 (Source: Financial Statement 2012 of FCTWB) ●Revenue: N4,522.7million ●Collected: N2,125.7million Final: Financial Statement 2017 of FCTWB ●Revenue: N5,276.6million ●Collected: N1,651.3million * Not increased because of existence of return (duplicated) bills in the billing system which depresses collection ratio, and also frequent estimate bills and irregular billing cycle in the past years.	1
		Billing amount (N. x1000)	4,522,708	5,276,600	Baseline: Financial Statement 2013 of FCTWB Final: Financial Statement 2017 of FCTWB	1
		Unit operational cost for water (N./m^3)	84.6	44.0	Baseline: Operational Cost: Production Cost (chemical, fuel, etc.) + Personnel Cost + Administrative Cost + Pension = N. 1,074,456,115 + N. 875,243, 967 + N. 827, 200,475 + N. 48,698,767 = N. 2,825,599,324 N. 2,825,599,324 / (91,506m^3/day x 365 days) Final: Operational Cost: Production Cost (chemical, fuel, etc.) + Personnel Cost + Administrative Cost + Pension = N.1,083.5million + N.401.4million + N. 1,017.2million + N.	1, 2

Cate.	Sub-Cate.	Index	Historical Data		Remarks	Relevant Outputs
			As of 2014 (Baseline)	As of 2018 (Final CA)		
					75.2million = N. 2,577.3million N. 2,577.3million / (160,630m^3/day x 365 days)	
		Average revenue for water (N./m^3)	135.4	90.0	Baseline: N.4,522,708,000 / (91,506m^3/day x 365 days) Final: N. 5,276.6million / (160,630m^3/day x 365 days)	1, 2
		Average revenue for water (N./m^3) based on collected tariff	63.6	28.2	Baseline: N. 4,522,708,000 x 47% / (91,506m^3/day x 365 days) Final: N. 5,276.6million x 31.3% / (160,630m^3/day x 365 days)	1, 2
	Training	Total number of training days in the year on water supply sector (days/annual/staff)	0.009	0.011	Baseline: 4 times x 2 days = 8 days, 8 days / 880 staff members (proper) Final: 4 times x 2 days = 8 days, 8 days / 750 staff members (proper). * Considering OJT by the Project members on NRW, the indicator increases.	1, 2, 3

Source: Project Team by using data from FCTWB

2.2.2 Capacity Needs and Organizational Responsibilities in the Project

Table 2.2-2 shows capacity needs and organizational responsibilities in the Project.

Table 2.2-2: Capacity Needs and Organizational Responsibilities in the Project

No.	Small Category	Capacity Needs	Organizational Responsibilities in the Project
1	Condition of facilities	To improve condition of service connections	● Procurement of test-meter and customer meters, and installation or replacement (as a part of NRW reduction) ● Repair of leakages (as a part of NRW reduction)
2	Overall	To enhance O&M of the facilities	● Preparation of O&M manual on NRW reduction
3	Distribution network management	To make drawings of pipe facilities	● Procurement of GIS software, GPS handset, PCs and plotter ● Training of GIS operation ● Improvement and update of database
4		To zone distribution networks	● Creation of PMAs and SMAs ● Procurement and installation of valves for isolation and bulk flow meters for PMAs and SMAs
5		To ensure optimum pressure at customer meter points	● Procurement of hydraulic analysis software ● Training of hydraulic analysis software operation ● Identification of pipelines to be replaced by larger or smaller ones and also service areas to be targeted by pressure control ● Repair of leakages (as a part of NRW reduction)
6	NRW reduction	To measure NRW ratio accurately and reduce it	● Procurement and installation of ultrasonic flow meters at outlets of clear water tanks located in water treatment plants ● Modification of system for tallying water consumption (billed water) ● Procurement of vehicles, ultrasonic flow meter, data logger, leak detector, correlator, test-meter and customer meters, etc. ● Identification of NRW components such as detection of invisible leakages and illegal connections, meter functioning check, measurement of meter inaccuracy ● NRW reduction operations such as repair of leakages, disconnection or legalization of illegal connections, installation or replacement of customer meters. ● Preparation of NRW reduction strategic plan
7		To install customer meters	● Procurement and installation or replacement of customer meters (as a part of NRW reduction)
8		To install bulk meters	● Procurement and installation of bulk flow meters for PMAs and SMAs (as a part of distribution network management) ● Procurement and installation of ultrasonic flow meters at outlets of

No.	Small Category	Capacity Needs	Organizational Responsibilities in the Project
			clear water tanks located in water treatment plants (as a part of NRW reduction) ● The JICA Expert Team encourages FCTWB to facilitate installation of bulk flow meters proposed in existing study.
9	Organizational development	To ensure effective personnel management rules & regulations including incentives	● The JICA Expert Team encourages and supports FCTWB to adopt incentive schemes
10		To implement trainings periodically and systematically	● Systematized lectures, trainings and OJTs on NRW reduction with consideration for sustainability ● Trainings abroad (in Japan) ● Periodical workshops/seminars for information sharing

Source: Project Team

2.2.3 Capacity Development Plan at Organizational Level

Table 2.2-3 shows capacity development plan at organizational level. The second interim assessment was scheduled originally, but not conducted and combined to the final assessment in consideration of delay of pilot project.

Table 2.2-3: Capacity Development Plan at Organization Level

No.	Category	Capacity Needs	Baseline as of Dec-2014		Targets				Approaches to achieve the Targets		
			Current Status	Rating Max. 5	Interim-1 as of Feb-2016 (*original schedule)	Interim-2 as of Feb-2017 (*not conducted)	Final as of Feb-2018 (*original schedule)	Rating Max. 5	Interim-1 Jan-2015 to Feb-2016 (*original schedule)	Interim-2 Mar-2016 to Feb-2017 (*not conducted)	Final Mar-2017 to Feb-2018 (*original schedule)
1	Condition of facilities	To improve condition of service connections*1	80-94% of house connections are more than 25 years old.	2	80-94% of house connections are more than 25 years old.	80-94% of house connections are more than 25 years old.	60-79% of house connections are more than 25 years old.	3	To install new customer meters or replace existing meters by new ones and repair service pipelines for about 1,000 in the selected PMAs.	To install new customer meters or replace existing meters by new ones and repair service pipelines for about 1,500 in the selected PMAs.	To install new customer meters or replace existing meters by new ones and repair service pipelines for about 400 in the selected PMAs.
2	Overall	To enhance O&M of the facilities	Facilities do not have any O&M manuals.	1	Facilities do not have any O&M manuals.	Facilities have effective O&M manuals, which are followed reasonably well.	Facilities have effective O&M manuals, which are followed reasonably well.	4	To collect and organize data, and materials required for O&M manuals for NRW reduction.	To develop O&M manuals for NRW reduction based on the lessons learnt through Pilot Projects.	To update and modify O&M manuals for NRW reduction based on the lessons learnt through activities following Pilot Projects.
3	Distribution network management	To make drawings of pipe facilities	Available paper drawings of existing transmission and distribution trunk mains are quite limited.	1	Paper drawings are available for most of the existing transmission and distribution trunk mains, but drawings for branch distribution mains are limited.	Paper drawings are available for most of the existing distribution mains including branch distribution mains.	Updated CAD (or database) files are available for most of the existing transmission and distribution mains.	3	To develop GIS database of existing distribution networks in the selected PMAs.	To develop GIS database of existing distribution networks in the selected PMAs and also develop GIS database of existing distribution mains in water services area.	To develop GIS database of existing distribution networks in some other areas and also update GIS database of existing distribution mains in water services area.
4		To zone distribution networks*2	Proper zoning of distribution areas and proper sub-zoning of networks in each distribution area, based on considerations of topology and/or different water sources, rarely exist or do not exist at all.	1	Proper zoning of distribution areas exists to some extent, but proper sub-zoning of networks in each distribution area rarely exists or does not exist at all.	Proper zoning of distribution areas exists to some extent, but proper sub-zoning of networks in each distribution area rarely exists or does not exist at all.	Proper zoning of distribution areas exists to some extent, but proper sub-zoning of networks in each distribution area rarely exists or does not exist at all.	2	To create PMAs and SMAs in the selected PMAs.	To create PMAs and SMAs in the selected PMAs.	To create DMAs and Sub-DMAs in some other areas. To demarcate DMAs and Sub-DMAs in water services area.

No.	Category	Capacity Needs	Baseline as of Dec-2014		Targets				Approaches to achieve the Targets		
			Current Status	Rating Max. 5	Interim-1 as of Feb-2016 (*original schedule)	Interim-2 as of Feb-2017 (*not conducted)	Final as of Feb-2018 (*original schedule)	Rating Max. 5	Interim-1 Jan-2015 to Feb-2016 (*original schedule)	Interim-2 Mar-2016 to Feb-2017 (*not conducted)	Final Mar-2017 to Feb-2018 (*original schedule)
5	Distribution network management	To ensure optimum pressure at customer meter points *3	At most or all points, pressure is not between 5-45m.	1	At most or all points, pressure is not between 5-45m.	At most or all points, pressure is not between 5-45m.	At most or all points, pressure is not between 5-45m.	1	To repair leakages in the selected PMAs, this contributes to optimization of water pressure.	To repair leakages in the selected PMAs, this contributes to optimization of water pressure.	To repair leakages in some other areas, this contributes to optimization of water pressure. To conduct hydraulic analysis of existing distribution mains in water services area, this contributes to identify pipeline routes to be replaced and areas to be targeted for pressure control.
6	NRW reduction	To measure NRW ratio accurately and reduce it*4	More than 50%	1	36-50%	36-50%	36-50%	2	To calculate NRW ratio monthly through bulk flow installation and billing system modification, and conduct NRW reduction operations in the selected PMAs.	To calculate NRW ratio monthly, and conduct NRW reduction operations in the selected PMAs.	To calculate NRW ratio monthly, monitor NRW and conduct necessary measures in the selected PMAs, and expand NRW reduction operations into some other areas. To prepare NRW reduction strategic plan.
7		To install customer meters*5	Functioning customer meters are supposed to be installed for every household, but more than 30% of them are missing or not working well.	2	Functioning customer meters are supposed to be installed for every household and replaced with new ones periodically, but more than 10% of them are missing or not working well.	Functioning customer meters are supposed to be installed for every household and replaced with new ones periodically, but more than 10% of them are missing or not working well.	Functioning customer meters are supposed to be installed for every household and replaced with new ones periodically, but more than 10% of them are missing or not working well.	3	To install new customer meters or replace defective ones by new ones for about 400 in the selected PMAs.	To install new customer meters or replace defective ones by new ones for about 400 in the selected PMAs.	To install new customer meters or replace defective ones by new ones for about 200 in the selected PMAs.

No.	Category	Capacity Needs	Baseline as of Dec-2014		Targets				Approaches to achieve the Targets		
			Current Status	Rating Max. 5	Interim-1 as of Feb-2016 (*original schedule)	Interim-2 as of Feb-2017 (*not conducted)	Final as of Feb-2018 (*original schedule)	Rating Max. 5	Interim-1 Jan-2015 to Feb-2016 (*original schedule)	Interim-2 Mar-2016 to Feb-2017 (*not conducted)	Final Mar-2017 to Feb-2018 (*original schedule)
8	NRW reduction	To install bulk meters*6	Bulk meters for accurate measurement of water production and basic control of distribution are not installed at most of the places where they should be; or most of the existing bulk meters do not work well due to lack of maintenance.	1	There are enough functioning bulk meters for accurate measurement of water production and basic control of distribution, but not enough for calculating NRW ratio of each sub-zone (DMA) for effective NRW reduction. Majority of the existing bulk meters are well maintained.	There are enough functioning bulk meters for accurate measurement of water production and basic control of distribution, but not enough for calculating NRW ratio of each sub-zone (DMA) for effective NRW reduction. Majority of the existing bulk meters are well maintained.	There are enough functioning bulk meters for accurate measurement of water production and basic control of distribution, but not enough for calculating NRW ratio of each sub-zone (DMA) for effective NRW reduction. Majority of the existing bulk meters are well maintained.	3	To install bulk flow meters at both outlets from clear water tanks located in water treatment plants and inlets to the selected PMAs. JICA encourages FCTWB to install bulk flow meters proposed in existing study.	To install bulk flow meters at inlets to the selected PMAs. JICA encourages FCTWB to install bulk flow meters proposed in existing study.	To install bulk flow meters at inlets to some other areas. JICA encourages FCTWB to install bulk flow meters proposed in existing study.
9	Organizational development	To ensure effective personnel management rules and regulations including incentives*7	Working regulations and base salary systems are clear, but there is no incentive scheme in place.	2	Working regulations and base salary systems are clear, but there is no incentive scheme in place.	Working regulations and base salary systems are clear, but existing incentive schemes are ineffective.	Working regulations and base salary systems are clear; there are effective incentive schemes in place. Some critical rules on occupational health and safety are communicated to staff.	4	JICA encourages FCTWB to consider adoption of incentive schemes.	JICA supports FCTWB to adopt incentive schemes on a trial basis.	JICA supports FCTWB to establish effective incentive schemes.
10		To implement trainings periodically and systematically*8	Training is quite rare or not provided at all.	1	A limited number of training programs on some aspects is provided, however there are no incentives for staff to undertake training programs.	There are minimum levels of training required for important aspects, but incentives for staff to undertake training programs are limited.	An adequate number of training programs are provided on important aspects, including management and technical matters. There are enough incentives for staff to undertake training programs.	4	JICA conducts lectures, trainings and OJTs, and also provides training in Japan on mainly NRW reduction operations with emphasis on development of human resources (i.e.: trainers-to-be), so that FCTWB can implement in-house trainings in a periodical and systematical manner.	JICA conducts lectures, trainings and OJTs, and also provides training in Japan on mainly NRW reduction operations with emphasis on development of human resources (i.e. trainers-to-be), so that FCTWB can implement in-house trainings in a periodical and systematical manner.	JICA conducts lectures, trainings and OJTs, and also provides training in Japan on mainly NRW reduction strategic planning with emphasis on development of human resources (i.e. trainers-to-be), so that FCTWB can update and renew the strategic plan.

2.2.4 Result of Capacity Development at Organizational Level

Table 2.2-4 and Table 2.2-5 including criteria show the results of capacity development at organizational level, by comparison among baseline level, the target level by CD; and actual achieved level at the final.

Table 2.2-4 Rate Comparison among Baseline, Target and Actual Achieved Levels

Question Item	Baseline Level	Target Level by CD	Actual Achieved Level (Final)
Service connections	2	3	2
O&M of the facilities	1	4	2.5
Drawings of pipe facilities	1	3	2
Zoning of distribution networks	1	2	3
Water pressure at customer meter points	1	1	1.5
NRW ratio	1	2	2
Customer meters	2	3	2
Bulk meters	1	3	3
Effective personnel management rules and regulations including incentives	2	4	2.5
Implementation of training	1	4	2.5

Source: Project Team

Table 2.2-5: Capacity Assessment at Organization Level (Baseline, Interim-1 and Final)

Category			Project Type	Priority	Question (Reference No. of the same indicator if it is included in BT ①: LPI)	Level					Achieved Level (1-5)		
						1: Very Serious	2: Serious	3: Not Good Enough	4: Good	5: Very Good			
Large	Medium	Small				This level reflects the conditions of water utilities which need all-round assistance in all fields.	This level reflects the conditions of water utilities which need broad assistance in many fields.	This level is reflects the conditions of water utilities which need partial assistance in some fields.	This level reflects the conditions which water utilities in developing countries should aim for in the foreseeable future.	This level reflects the conditions of water utilities in developed countries.	Baseline.	Interim-1	Final
Aspects to be improved mainly by **Facility Investment (FI)**	Rehabilitation/ Replacement	Conditions of facilities	FI	1st	Q1: Service connections*1	95 - 100% of house connections are more than 25 years old.	80 - 94% of house connections are more than 25 years old.	60 - 79% of house connections are more than 25 years old.	40 - 59% of house connections are more than 25 years old.	0 - 39% of house connections are more than 25 years old.	2	2	2
		Average (Rehabilitation/Replacement)									2.0	2.0	2.0
	AVERAGE (FI)										**2.0**	**2.0**	**2.0**
Aspects to be improved mainly by **Capacity Development (CD)**	Technical aspects	Overall	CD	1st	Q2: O&M of the facilities	Facilities do not have any O&M manuals.	Facilities have O&M manuals which are not effective, leading to O&M deficiencies.	Facilities have O&M manuals which are not effective; however the current O&M is adequate.	Facilities have effective O&M manuals, which are followed reasonably well.	Facilities have effective and comprehensive O&M manuals, which are followed strictly.	1	2	2.5
		Distribution network management	CD/ FI	1st	Q3: Drawings of pipe facilities	Available paper drawings of existing transmission and distribution trunk mains are quite limited.	Paper drawings are available for most of the existing transmission and distribution trunk mains, but drawings for branch distribution mains are limited.	Small/Medium utilities: Paper drawings are available for most of the existing distribution mains including branch distribution mains. Large utilities: As above, and a primitive GIS has been established for transmission mains, trunk distribution mains, etc.	Small/Medium utilities: Updated CAD files are available for most of the existing transmission and distribution mains. Large utilities: A GIS has been well-established and updated for management of transmission mains and distribution mains, with reasonable accuracy.	Small/Medium utilities: A map book of existing mains has been prepared for referencing and is periodically updated using CAD. Large utilities: A GIS has been well-established and updated for management of transmission, distribution mains, customer information, etc. with good accuracy.	1	1	2

Category			Project Type	Priority	Question (Reference No. of the same indicator if it is included in BT ①: LPI)	Level					Achieved Level (1-5)		
						1: Very Serious	2: Serious	3: Not Good Enough	4: Good	5: Very Good			
Large	Medium	Small				This level reflects the conditions of water utilities which need all-round assistance in all fields.	This level reflects the conditions of water utilities which need broad assistance in many fields.	This level is reflects the conditions of water utilities which need partial assistance in some fields.	This level reflects the conditions which water utilities in developing countries should aim for in the foreseeable future.	This level reflects the conditions of water utilities in developed countries.	Baseline.	Interim-1	Final
			CD/ FI	1st	Q4: Zoning of distribution networks*2	Proper zoning of distribution areas and proper sub-zoning of networks in each distribution area, based on considerations of topology and/or different water sources, rarely exist or do not exist at all.	Proper zoning of distribution areas exists to some extent, but proper sub-zoning of networks in each distribution area rarely exists or does not exist at all.	Most distribution areas are properly zoned, but proper sub-zoning of networks in each distribution area is still limited.	All the distribution areas are properly zoned, and most distribution areas have proper sub-zoning in their distribution networks.	All the distribution areas are properly zoned, and most distribution areas have proper sub-zoning in their distribution networks. Multiple water sources, multiple lines of distribution trunk mains and mutual connections between distribution areas and sub-zones are also considered for improving the stability of water supply.	1	1	3
			CD/ FI	1st	Q5: Water pressure at customer meter points *3	At most or all points, pressure is not between 5-45m.	At approximately half of the points, pressure is not between 5-45m.	At approximately a quarter of the points, pressure is not between 10-45m.	At most points, usual pressure is between 10-45m but pressure drops significantly in the season of maximum water demand.	At most points, pressure is between 15-45m without significant pressure drop in the season of maximum water demand; or continuous and direct water supply with higher pressure to high buildings without using customers' receiving and elevated tanks has been introduced for water quality control.	1	1	1.5
Aspects to be improved mainly by **Capacity Development (CD)**	Technical aspects	NRW reduction	CD/ FI	1st	Q6: NRW ratio *4	More than 50%	36 - 50%	21 - 35%	10 - 20%	Less than 10%	1	1	2

Category			Project Type	Priority	Question (Reference No. of the same indicator if it is included in BT ①: LPI)	Level					Achieved Level (1-5)		
						1: Very Serious	2: Serious	3: Not Good Enough	4: Good	5: Very Good			
Large	Medium	Small				This level reflects the conditions of water utilities which need all-round assistance in all fields.	This level reflects the conditions of water utilities which need broad assistance in many fields.	This level is reflects the conditions of water utilities which need partial assistance in some fields.	This level reflects the conditions which water utilities in developing countries should aim for in the foreseeable future.	This level reflects the conditions of water utilities in developed countries.	Baseline.	Interim-1	Final
			CD/ FI	1st	Q7: Customer meters*5	There are no customer meters due to a flat-rate system, or the majority of existing customer meters are not functioning.	Functioning customer meters are supposed to be installed for every household, but more than 30% of them are missing or not working well.	Functioning customer meters are supposed to be installed for every household and replaced with new ones periodically, but more than 10% of them are missing or not working well.	Most households have well-functioning customer meters due to rigorous periodical meter exchange.	Almost all households have well-functioning customer meters with good accuracy.	2	2	2
			CD/ FI	1st	Q8: Bulk meters*6	Bulk meters for accurate measurement of water production and basic control of distribution are not installed at most of the places where they should be; or most of the existing bulk meters do not work well due to lack of maintenance.	There are not enough functioning bulk meters installed at the places requiring them for accurate measurement of water production and basic control of distribution; and existing bulk meters are not well maintained.	There are enough functioning bulk meters for accurate measurement of water production and basic control of distribution, but not enough for calculating NRW ratio of each sub-zone (DMA) for effective NRW reduction. Majority of the existing bulk meters are well maintained.	There are enough functioning bulk meters installed for calculating NRW ratio of each sub-zone (DMA) for effective NRW reduction. Most of the existing bulk meters are well maintained, and important meter readings are recorded periodically.	There are enough functioning bulk meters installed (with good accuracy) for calculating NRW ratio of each sub-zone (DMA) for effective NRW reduction. All of the existing bulk meters are well maintained, and important meter readings are recorded periodically and analyzed effectively.	1	3	3
		Average (Technical)									1.1	1.6	2.3
	Non-technical aspects	Organizational development	CD	1st	Q9: Effective personnel management rules and regulations including incentives*7	Working regulations and base salary systems are not clear.	Working regulations and base salary systems are clear, but there is no incentive scheme in place.	Working regulations and base salary systems are clear, but existing incentive schemes are ineffective.	Working regulations and base salary systems are clear; there are effective incentive schemes in place. Some critical rules on occupational health and safety are communicated to staff.	Working regulations and base salary systems are clear, and there are effective incentive schemes in place. Full set of regulations on occupational health and safety are communicated to staff.	2	2	2.5

Category			Project Type	Priority	Question (Reference No. of the same indicator if it is included in BT ①: LPI)	Level					Achieved Level (1-5)		
						1: Very Serious	2: Serious	3: Not Good Enough	4: Good	5: Very Good			
Large	Medium	Small				This level reflects the conditions of water utilities which need all-round assistance in all fields.	This level reflects the conditions of water utilities which need broad assistance in many fields.	This level is reflects the conditions of water utilities which need partial assistance in some fields.	This level reflects the conditions which water utilities in developing countries should aim for in the foreseeable future.	This level reflects the conditions of water utilities in developed countries.	Baseline.	Interim-1	Final
			CD	1st	Q10: Implementation of training*8	Training is quite rare or not provided at all.	A limited number of training programs on some aspects is provided, however there are no incentives for staff to undertake training programs.	There are minimum levels of training required for important aspects, but incentives for staff to undertake training programs are limited.	An adequate number of training programs are provided on important aspects, including management and technical matters. There are enough incentives for staff to undertake training programs.	A wide range of training programs are available. The completion of these training programs is generally a condition of promotion.	1	2	2.5
		Average (Non-technical)									1.5	2.0	2.5
	AVERAGE (CD)										**1.3**	**1.8**	**2.4**
OVERALL AVERAGE (FI & CD)											**1.7**	**1.9**	**2.2**

Note:
*1: Expected lifetime of house connections can be 25 years or more if using corrosion-resistant materials.
*2: Proper zoning and sub-zoning of distribution networks is a basic requirement for good pressure control, effective reduction of NRW, etc. The concept of zoning and sub-zoning is explained in *(2) Supporting Figures and Table*.
*3: Conversion table for different units of pressure is shown in *(2) Supporting Figures and Table*.
*4: Non-Revenue Water (NRW) ratio = (1-(annual water charged)/ (annual water produced)) x 100
If all the bulk meters necessary for this calculation are not installed, estimation of this average NRW ratio can be carried out based on some data of NRW in some areas.
The difference between NRW and UFW (Unaccounted for Water) is explained in *(2) Supporting Figures and Table*.
*5: Expected lifetime of customer meters is usually between 8 and 10 years, depending on their type and quality.
*6: Recommended calibration intervals for bulk flow meters are 5 years for wheel/mechanical type and 1 year for electromagnetic and ultrasonic types.
The size of District-Metered Area (DMA) is recommended to be about 1,000 - 3,000 households.
*7: Personnel management rules and regulations include: 1) working regulations, 2) base salary system, 3) incentive schemes, and 4) occupational health and safety regulations.
*8: Training programs are required for engineers, technicians, administration staff, managers, etc.

2.3 Capacity Assessment and Capacity Development at Individual Level

2.3.1 Capacity Assessment Areas

The CA at individual level mainly on NRW reduction varies depending on the area of expertise in which he/she engages or the Department/Unit/Area Office to which he/she belongs. Expertise is grouped into the following five (5) areas:

- NRW Management on Distribution (MD)
- NRW Management on Commerce (MC)
- GIS & Hydraulic Analysis (GIS&HA)
- NRW Action on Distribution (AD)
- NRW Action on Commerce (AC)

Each CA area consists of some assessment axes, which are rated between less than 0.5 as minimum/inexperience and 3.0 as maximum/target. Description of the rating is shown in Table 2.3-1.

Table 2.3-1: Description of Rating

Description	Rating
Excellent (outstanding understanding and initiative for in-house training)	3.0
Very good (considerable/significant understanding)	2.5 or more
Good (sufficient understanding)	2.0 or more
Average (satisfactory level)	1.5 or more
Fair (unsatisfactory level, but promise in the future improvement)	1.0 or more
Poor (unsatisfactory level)	0.5 or more
None (inexperience)	Less than 0.5

2.3.2 Approaches to achieve Target Capacity

Approaches to achieve target capacity consist mainly of lectures, discussion, presentation, workshops /seminar, OJT and Off-JT including training in Japan for some members. Table 2.3-2 shows basic strategy of these approaches by CA area. Moreover, to induce self-enlightenment, the Project introduces individual action plan to be prepared by each member and based on CA and CD plans at individual level.

Table 2.3-2: Basic Strategy of Approaches to achieve Target Capacity

CA Area		Approach	Frequency/When	By whom
1)	MD	Lectures	Periodically / as necessary	All Experts excluding GIS&HA Expert
		OJT	Routinely	Ditto
		Discussion	Technical meetings /as necessary	Members and Experts
		Presentation	At workshop/seminar, technical meetings	Members
2)	MC	Lectures	Periodically / as necessary	All Experts excluding GIS&HA Expert
		OJT	Routinely	Ditto
		Discussion	Technical meetings /as necessary	Members and Experts
		Presentation	At workshop/seminar, technical meetings	Members
3)	GIS& HA	Lectures	Periodically / as necessary	GIS&HA Expert
		OJT	Routinely	Ditto
		Off-JT (GIS)	TBD	Local company/professional
		Discussion	Technical meetings /as necessary	Members and Experts
		Presentation	At workshop/seminar, technical meetings	Members
4)	AD	Lectures	Periodically / as necessary	Leakage Detection Technology Expert

CA Area		Approach	Frequency/When	By whom
		OJT	Routinely	Ditto
		Discussion	Technical meetings /as necessary	Members and Experts
		Presentation	At workshop/seminar, technical meetings	Members
5)	AC	Lectures	Periodically / as necessary	Commercial Loss Expert
		OJT	Routinely	Ditto
		Discussion	Technical meetings /as necessary	Members and Experts
		Presentation	At workshop/seminar, technical meetings	Members
All Areas		Workshop/ Seminar	Annually	All members and Experts
		Technical Meeting	Monthly	Ditto
		Off-JT (Japan)	3 times for some members	JICA (for Management Team, Action Team and Working Group, respectively)

2.3.3 Result of Capacity Development at Individual Level

Figure 2.3-1 shows the results of capacity development at individual level by charts in the baseline assessment, the interim assessment and the final assessment. The second interim assessment was scheduled originally, but not conducted and combined to the final assessment in consideration of delay of pilot project.

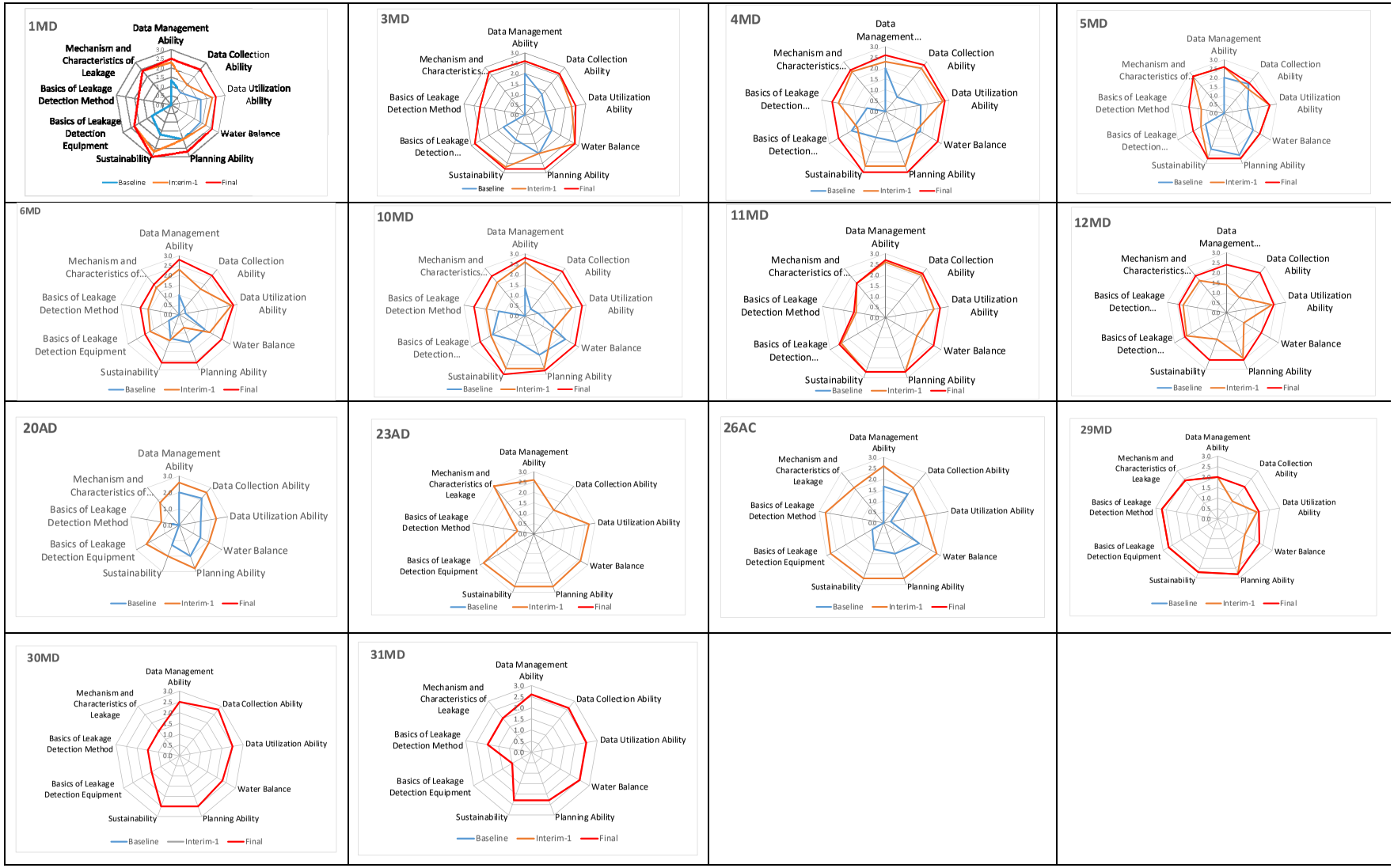
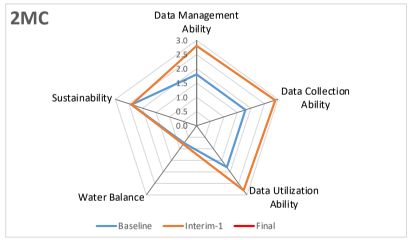
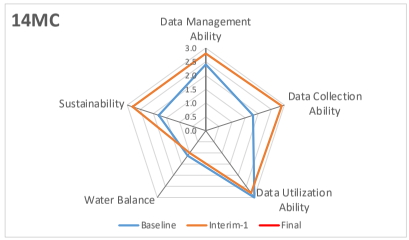
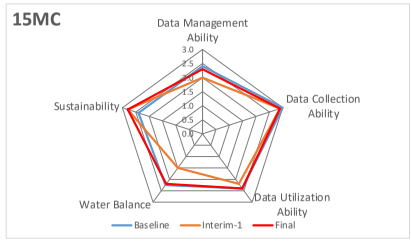


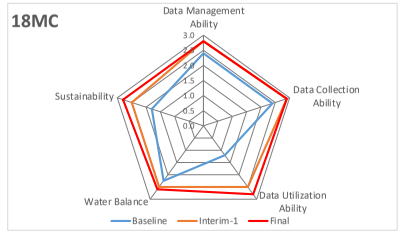
Figure 2.3-1: Charts of Capacity Development Results at Individual Level (1/3)

NRW Management on Commerce

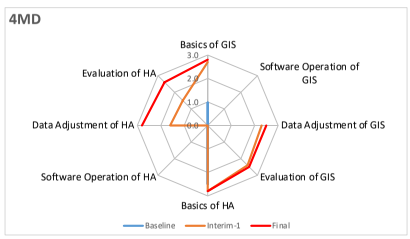


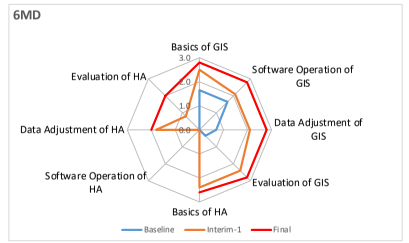


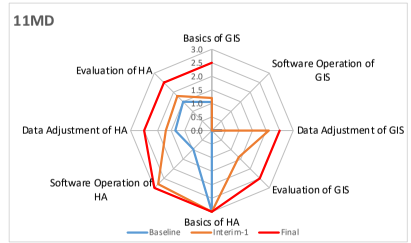


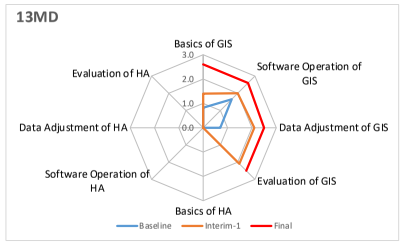


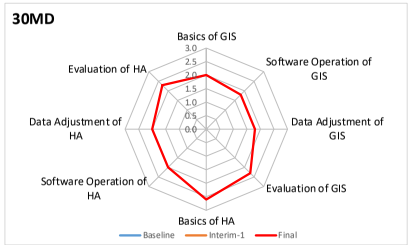
GIS & Hydraulic Analysis



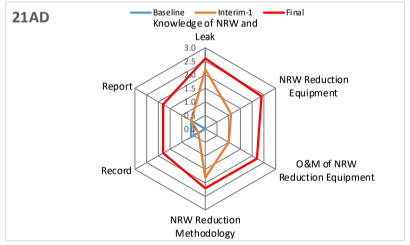


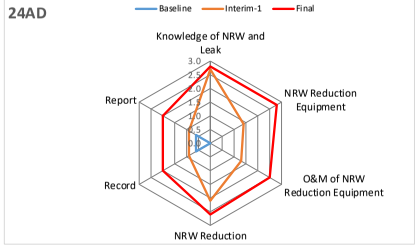






NRW Action on Distribution





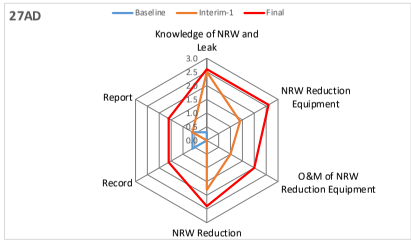


Figure 2.3-1: Charts of Capacity Development Results at Individual Level (2/3)

NRW Action on Commerce

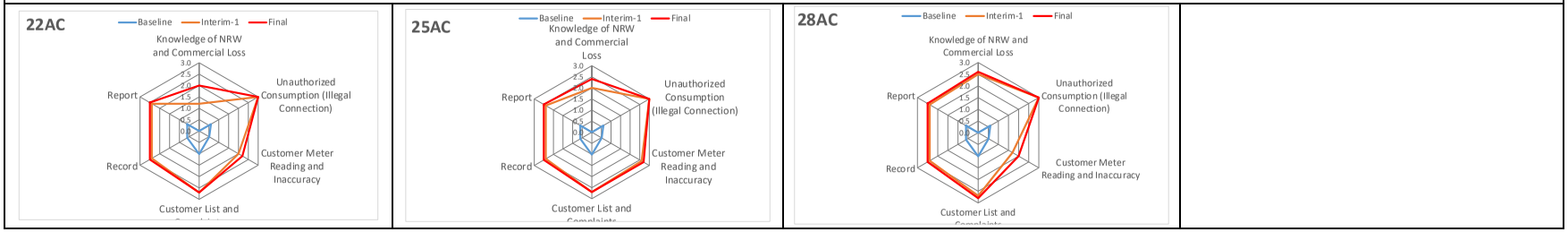


Figure 2.3-1: Charts of Capacity Development Results at Individual Level (3/3)

CHAPTER 3. RESULT OF THE PROJECT

3.1 Input of the Project

3.1.1 Input by the Japanese side

(1) JICA Expert Team

The JICA Experts for 11 areas of expertise were dispatched for approximately 113.39 person-months in total to implement the Project and develop capacity of the Project Team members between October 2014 and November 2018 (refer to Table 3.1-1).

Table 3.1-1: Person-Month of the JICA Experts by Phase

Phase	Period	Person-months
Phase 1	November 2014 to January 2017	67.50
Phase 2	February 2018 to November 2018	42.00
Total		109.50

Source: Project Team

(2) Provision of Vehicle and Equipment

For the implementation of the activities, vehicles and equipment were procured and handed over to FCTWB by JICA and the JICA Expert Team (refer to Table 3.1-2).

(3) Upgrading (Modification) of Billing System

Billing system was upgraded by local system engineering consultant outsourced by the JICA Expert Team. Refer to details in Section 3.2.1 (4).

- Commencement of works: September 2016
- Completion of works: December 2016
- Operation: Started in December 2016

(4) Chamber Construction for Zonal Meters

Chambers for zonal meters have been constructed by local contractors outsourced by the JICA Expert Team. Refer to details in Section 3.2.1 (6).

- Commencement of works: April 2016
- Completion of works: December 2016
- Operation: Started in October 2017

(5) Chamber Construction for Bulk Meters

Chambers for bulk meters were partially constructed by local contractors outsourced by FCTWB, however, the construction was suspended due to non-release of counterpart fund. In response to request by the Nigerian side in the 4th JCC meeting, JICA took over the construction. Refer to details in Section 3.2.1 (1).

- Commencement of works: October 2016 (The Japanese side took over the works from FCTWB)
- Completion of works: December 2016
- Operation: Started in December 2016

Table 3.1-2: List of Equipment procured by the Japanese Side (1/2)

No.	Equipment	Specification	Procurement in		Quantity		Hand-over	Remarks
			Japan	Nigeria	Plan	Actual		
For Activity 1-2								
1	Ultrasonic flow meter (stationary, 220m)	Ultrasonic pulse transmit time difference method, sensor for 600-1,500mm, 220m cable	✓		2	2	Done	including installation, commissioning and training
2	Ultrasonic flow meter (stationary, 300m)	Ultrasonic pulse transmit time difference method, sensor for 600-1,500mm, 300m cable	✓		2	2	Done	including installation, commissioning and training
3	Data logger (stationary)	Paperless, 6 points, 1s-1h record cycle, 4-20mA, trend, bar graph and histrical trend displays	✓		1	1	Done	for the above No.1&2 ultrasonic flow meters
For Activity 1-6								
1	Ultrasonic flow meter (stationary)	Ultrasonic pulse transmit time difference method, sensor for 300-1,500mm, 10m cable	✓		6	6	Done	including installation, commissioning and training
2	Ultrasonic flow meter (stationary)	Ultrasonic pulse transmit time difference method, sensor for 300-1,500mm, 20m cable	✓		3	3	Done	including installation, commissioning and training
3	Ultrasonic flow meter (stationary)	Ultrasonic pulse transmit time difference method, sensor for 300-1,500mm, 30m cable	✓		2	2	Done	including installation, commissioning and training
4	Ultrasonic flow meter (stationary)	Ultrasonic pulse transmit time difference method, sensor for 300-1,500mm, 40m cable	✓		2	2	Done	including installation, commissioning and training
5	Ultrasonic flow meter (stationary)	Ultrasonic pulse transmit time difference method, sensor for 25-250mm, 10m cable	✓		1	1	Done	including installation, commissioning and training
6	Data logger (stationary)	Paperless, 6pts, 1s-1h record cycle, 4-20mA, trend, bar graph and histrical trend displays	✓		13	13	Done	for the above No.1-5 ultrasonic flow meters
7	Data logger (portable)	2ch (flow and pressure), 1s - 24h record cycle, 4-20mA, 5 years battery life	✓		2	2	Done	
8	Remote Monitoring System	Telemetry with transmission, modem/router, container, interface, PC, printer, UPS, server, etc	✓		2	2	Done	Pilot system
9	Solar System	Type-1, 1100W		✓	8	8	Done	for the above ultrasonic flow meter
10	Solar System	Type-2, 1600W		✓	2	2	Done	for the above ultrasonic flow meter
11	Solar System	Type-3-1, 1300W		✓	2	2	Done	for the above ultrasonic flow meter and telemetry system
12	Solar System	Type-3-2, 1300W		✓	1	1	Done	for the above ultrasonic flow meter
For Activity 2-4 and 2-8								
1	GIS software	Intergraph Geomedia Essential		✓	1	1	Done	Software has been adopted by AGIS. V13.1
2	GIS software	ESRI ArcGIS Basic Version 10.3		✓	1	1	Done	Mainly for data input
3	Plotter (A0)	A0		✓	1	1	Done	
4	GPS terminal	High sensitivity, 2,000pts, 200routes, IPX7, built-in camera (5mega-pixel), USB, nickel hydride battery pack	✓		2	2	Done	Garmin
5	Personal computer	500HD, 4 GB Ram, Windows 7or8, Microsoft Office installed, Mouse		✓	2	2	Done	
6	Anti-virus software			✓	2	2	Done	for the above PCs (No.5)
7	UPS	1.2kVA		✓	2	2	Done	
For Activity 2-5								
1	Ultrasonic flow meter (stationary)	Ultrasonic pulse transmit time difference method, sensor for 450mm, 20m cable	✓		1	1	Done	
2	Data logger (portable)	2ch (flow and pressure), 1s - 24h record cycle, 4-20mA, 5 years battery life	✓		1	1	Done	for the above No.1 ultrasonic flow meter
3	Flow meter	Dia. 50mm with fittings			0	0	-	
4	Flow meter	Dia. 80mm with fittings			0	0	-	
5	Flow meter	Dia. 100mm with fittings			0	0	-	
6	Flow meter	Dia. 150mm with fittings		✓	0	1	Done	
7	Flow meter	Dia. 200mm with fittings		✓	1	2	Done	
8	Flow meter	Dia. 250mm with fittings			0	0	-	
9	Flow meter	Dia. 300mm with fittings		✓	3	3	Done	
For Activity 2-7								
1	Sluice valve	Dia. 50mm with fittings			2	0	-	
2	Sluice valve	Dia. 80mm with fittings			0	0	-	
3	Sluice valve	Dia. 100mm with fittings		✓	9	1	Done	
4	Sluice valve	Dia. 150mm with fittings		✓	12	7	Done	
5	Sluice valve	Dia. 200mm with fittings		✓	6	8	Done	
6	Sluice valve	Dia. 250mm with fittings			2	0	-	
7	Sluice valve	Dia. 300mm with fittings		✓	10	6	Done	

Table 3.1-2: List of Equipment procured by the Japanese Side (2/2)

No.	Equipment	Specification	Procurement in		Quantity		Hand-over	Remarks
			Japan	Nigeria	Plan	Actual		
For Activity 2-10								
1	Ultrasonic flow meter (portable)	Ultrasonic pulse transmit time difference method, sensors (small x3, medium x6, large x3)	✓		6	6	Done	
2	Data logger (portable)	2ch (flow and pressure), 1s - 24h record cycle, 4-20mA, 5 years battery life	✓		6	6	Done	
3	Leak noise correlator	Main unit, preamplifier and piezoelectric sensor	✓		2	2	Done	
4	Water leak detector	Acoustic type, piezoelectric sensor	✓		6	6	Done	
5	Non-metal pipe locator	Electromagnetic induction type for plastic pipe (PVC, PE)	✓		3	3	Done	
6	Metal locator	Optical and acoustical output signal, 50cm depth	✓		3	3	Done	
7	Time integral water leak detector	Automatic leak noise determination method	✓		3	3	Done	
8	Acoustic rod	1.5m length	✓		9	9	Done	
9	Distance meter	Max. 10km, 10cm scale	✓		3	3	Done	
10	Hammer drill	Dia. 38mm, 270rpm, 3,000 stroke/min	✓		3	3	Done	
11	Boring bar	Dia. 16mm, 1.0m length	✓		3	3	Done	
12	Drill bit	Dia.19×800mm	✓		9	9	Done	
13	Portable residual chlorine analyzer	DPD, absorptiometry, 0.02-2.00mg/L	✓		3	3	Done	
14	Metal pipe and cable locator	5m depth	✓		3	3	Done	
15	Reference meter	Portable built-in case type, 13-25mm	✓		3	3	Done	
16	Leakage quantity measurement device	13-25mm	✓		3	3	Done	
17	Personal computer	500HD, 2GB Ram, Windows 7or8, Microsoft Office installed, Mouse		✓	3	3	Done	
18	Anti-virus software			✓	3	3	Done	for the above PCs (No.17)
19	UPS	1.2kVA		✓	3	3	Done	
20	Inkjet printer	A4, Color, All-in-one		✓	3	3	Done	
21	Digital camera	Compact type, Optical zoom, 10 mega-pixel (min), LCD		✓	3	3	Done	
For Activity 2-13								
1	Generator	200V, 6.5kVA		✓	3	3	Done	
2	Asphalt cutter	3600RPM, 13kW		✓	3	3	Done	
3	Concrete breaker			✓	3	3	Done	
4	Small-sized dewatering pump	2"		✓	3	3	Done	
5	Small-sized tamper			✓	3	3	Done	
6	Electric drum	50m		✓	3	3	Done	
7	Customer meter	Dia. 2/3" with fittings, conventional type			388	0	-	
8	Customer meter	Dia. 1" with fittings, conventional type		✓	259	600	Done	
9	Customer meter	Dia. 50mm with fittings, conventional type			89	0	-	
10	Customer meter	Dia. 80mm with fittings, conventional type			23	0	-	
11	Customer meter	Dia. 100mm with fittings, conventional type			7	0	-	
12	Compact Reciprocating Saw	Pipe cutting		✓	3	3	Done	
For Output 2								
1	Pickup truck for pilot sites			✓	2	2	Done	
For Operation of the Project								
1	Laser printer	A4, B/W		✓	1	1	Done	
2	Inkjet printer	A3, Color		✓	1	1	Done	
3	Multifunction copier	A3, B/W		✓	1	1	Done	
4	Graphic/movie editing software	Windows Movie Maker, Microsoft Powerpoint		✓	1	1	Done	Free or preinstalled softwares to be utilized.
5	Projector	3,000 Lummen, HDMI, VGA, USB port		✓	1	1	Done	

(6) Lectures and Training Sessions

Separately from workshops, regular meetings and daily teaching/communication, the JICA Expert Team conducted lectures and training sessions as shown in Table 3.1-3 for the Project Team members (refer to Annex 8).

Table 3.1-3: Lectures and Training Sessions

Date	Theme	Attendance
8 Jun. 2015	Leak Sound and Mechanism, Leakage Survey Methodology (HQs)	16
9 Jun. 2015	Leak Sound and Mechanism (Garki I)	7
10 Jun. 2015	Leak Sound and Mechanism (Jabi)	6
11 Jun. 2015	Leak Sound and Mechanism (Gudu)	6
15 Jun. 2015	Leakage Survey Methodology (Garki I)	9
18 Jun. 2015	Basic Concept and How to Utilize GIS (Gudu)	4
18 Jun. 2015	Leakage Survey Methodology (Gudu)	4
19 Jun. 2015	Basic Concept and How to Utilize GIS (Jabi)	6
19 Jun. 2015	Leakage Survey Methodology (Jabi)	6
23 Jun. 2015	Basic Concept and How to Utilize GIS (Garki I)	5
25 Jun. 2015	Estimation of NRW	32
25 Jun. 2015	Basic Concept and How to Utilize GIS (HQs)	13
23 Jul. 2015	PMA and SMA	28
30 Nov. 2015	Pilot Kick-off Explanatory Meeting / Procedures (Gudu)	30
30 Nov. 2015	Leakage Detection Procedures and Equipment (Gudu)	10
30 Nov. 2015	Customer Meter Reading and Commercial Loss Survey (Gudu)	15
30 Nov. 2015	Test Meter (Gudu)	15
1 Feb. 2016	Pilot Kick-off Explanatory Meeting / Procedures (Jabi)	15
1 Feb. 2016	Leakage Detection Procedures and Equipment (Jabi)	6
1 Feb. 2016	Customer Meter Reading and Commercial Loss Survey (Jabi)	6
4 Feb. 2016	Water Distribution Management (HQs)	15
9 Feb. 2016	Test Meter (Jabi)	13
17 Feb. 2016	Practice of Water Balance Analysis (a part of the 2nd Workshop)	106
8 Mar. 2016	Test Meter (Garki I)	11
26 May 2016	Pilot Kick-off Explanatory Meeting / Procedures (Garki I)	16
26 May 2016	Leakage Detection Procedures and Equipment (Garki I)	10
15 Jun. 2016	Water Balance Analysis	33
7 Aug. 2017	NRW Reduction Operations Manual (Visual Material), HQs & Gudu	15
8 Aug. 2017	NRW Reduction Operations Manual (Visual Material), HQs & Jabi	16
9 Aug. 2017	NRW Reduction Operations Manual (Visual Material), HQs & Garki I	12
22 Sep. 2017	Function of the Pilot Remote Monitoring (Telemetry) System	26
28 Sep. 2017	Guideline of Formulating Medium-term Strategic Plan	30
10 Oct. 2017	Hydraulic Analysis	8
10 Nov. 2017	Procedure of Visualization by Graph from Digital Record of UFM	3
13 Nov. 2017	Procedure of NRW Ratio Calculation	2
10 Oct. 2017	Management of Network Drawings and Data by GIS	2
12 Jan. 2018	Costing and Rating of Water	15
5 Feb. 2018	Study on Costing and Pricing	14
17 Oct. 2018	Analysis of FCTWB's Commerce	13

(7) GIS Training for Project Team Members in Nigeria

To enhance practical ability of GIS-related staff of FCTWB, the Project conducted GIS training covering

introduction to GIS, basics of software "GeoMedia Essentials" and "ArcGIS" by local company outsourced by the JICA Expert Team in Abuja for seven working days from 23rd November to 1st December 2015. Refer to Annex 9 for details.

(8) Training for Project Team Members in Japan

The 1st Training

The Project conducted the 1st training on management for four (4) participants in Yokohama City, Japan for two weeks in August 2015. Table 3.1-4 shows participants in the training, and Annex 10 shows the Action Plan prepared by the participants.

Table 3.1-4: Participants in the 1st Training in Japan (Management)

No.	Name	Position in the Project	Position in FCTWB
1	Engr. A. A. Nahuche	Technical Manager	HoD: Distribution
2	Mr. Adis S. Muhammad	Technical Manager	HoD: Commerce
3	Engr. Aliyu A. Usman	Member	HoD: Reservoir & Production
4	Mr. Musa Dikko	Member	HoU Pipeline Unit, Distribution

The 2nd Training

The Project conducted the 2nd training on distribution (technical) and commerce for eight (8) participants in Yokohama City, Japan for two weeks from the middle of June to the beginning of July 2016. In consideration of issues and challenges on NRW in FCTWB, the participants are composed of the Project Team members jointly from Distribution and Commerce Departments. Table 3.1-5 shows participants in the training, and Annex 10 shows the Action Plan prepared by the participants.

Table 3.1-5: Participants in the 2nd Training in Japan (Distribution and Commerce)

No.	Name	Position in the Project	Position in FCTWB
1	Engr. Lawal R. Abolade	Coordinator	Head of Special Projects Unit, Distribution
2	Mr. K. Habib Ahmed	Member	Gudu Area Office Manager
3	Mr. D. Mohammed Dauda	Member	Technical Officer, Pipeline Unit, Distribution
4	Mr. S. Abdulrahman Sani	Member	Senior Technical Officer, Pre-paid Meter Unit, Distribution
5	Mr. Danjuma Isah	Member	Head of Monitoring and Detection Unit, Commerce
6	Mr. Sulaiman Shehu	Member	Head of AMR Meter Unit, Head of GIS Unit, Distribution
7	Mr. Aliyu M. Maradun	Member	Head of Major Consumers Unit, Commerce
8	Mrs. Akpan Rose A.	Member	Head of Billing Unit, Commerce

The 3rd Training

The Project conducted the 3rd training on strategy for six (6) participants in Yokohama City, Japan for one week in the middle of July 2017. In consideration of issues and challenges on development and O&M of water services in FCT, the participants are composed of the Project Team members jointly from FCDA and FCTA. Table 3.1-6 shows participants in the training (refer to Annex 10).

Table 3.1-6: Participants in the 3rd Training in Japan (Strategy)

No.	Name	Position in the Project	Position in FCDA/FCTWB
1	Engr. Ahmad S. Hadi	Stakeholder	Director, Engineering Services, FCDA
2	Engr. Ezeoha F. Obiora	Stakeholder	Deputy Director, Water & Sewage, Engineering Services, FCDA
3	Engr. Osayande J. Uyi	Stakeholder	Deputy Director, Engineering Design and Evaluation, FCDA
4	Engr. Oluwadamisi E. Abiodun	Stakeholder	Deputy Director, Engineering PPP, Mass Housing / PPP, FCDA
5	Engr. Aliyu A. Usman	Member	Head of Department, Reservoir & Production
6	Engr. Lawal R. Abolade	Coordinator	Assistant Director, Distribution, FCTWB

3.1.2 Input by the Nigerian side

(1) Project Team Member

The Nigerian side appointed its personnel as Project Director from FCTA, Project Manager, NRW Management Team members and NRW Action Team members from FCTWB, as mentioned above.

(2) Provision of the Project Offices and Facilities

FCTWB provided project office equipped with air conditioner, water dispenser, refrigerator and etc. for the JICA Expert Team in the Headquarters, and also bore expenses including utility costs necessary for the implementation of the Project. However, the JICA Expert Team suffered from frequent power outages and FCTWB faced a difficulty in procurement of fuel due to scarcity of counterpart fund, so JICA procured a generator for the Project office in the Headquarters.

(3) Chamber Construction for Bulk Meters

Chambers for bulk meters were partially constructed by local contractors outsourced by FCTWB, however, the construction was suspended due to non-release of counterpart fund. Therefore, the Nigerian side requested the Japanese side to take over the construction in the 4th JCC meeting, refer to details in Section 3.2.1 (1).

- Commencement of works: January 2016 (The Japanese side took over works in October 2016)
- Completion of works: December 2016
- Operation: Started in December 2016

(4) Chamber Construction for PMA

Chambers for PMA were constructed by local contractors outsourced by FCTWB. Refer to details in Section 3.2.2 (6).

- Commencement of works: November 2015
- Progress: 90% (including electrical works, installation of flow-meter and valves)
- Operation: Started except for a chamber in PMA of Garki I

(5) Other Expenses

FCTWB dealt with customs clearance of equipment from Japan and assisted the JICA Expert Team to obtain temporary stay permission, but had faced difficulty due to non-release of counterpart fund.

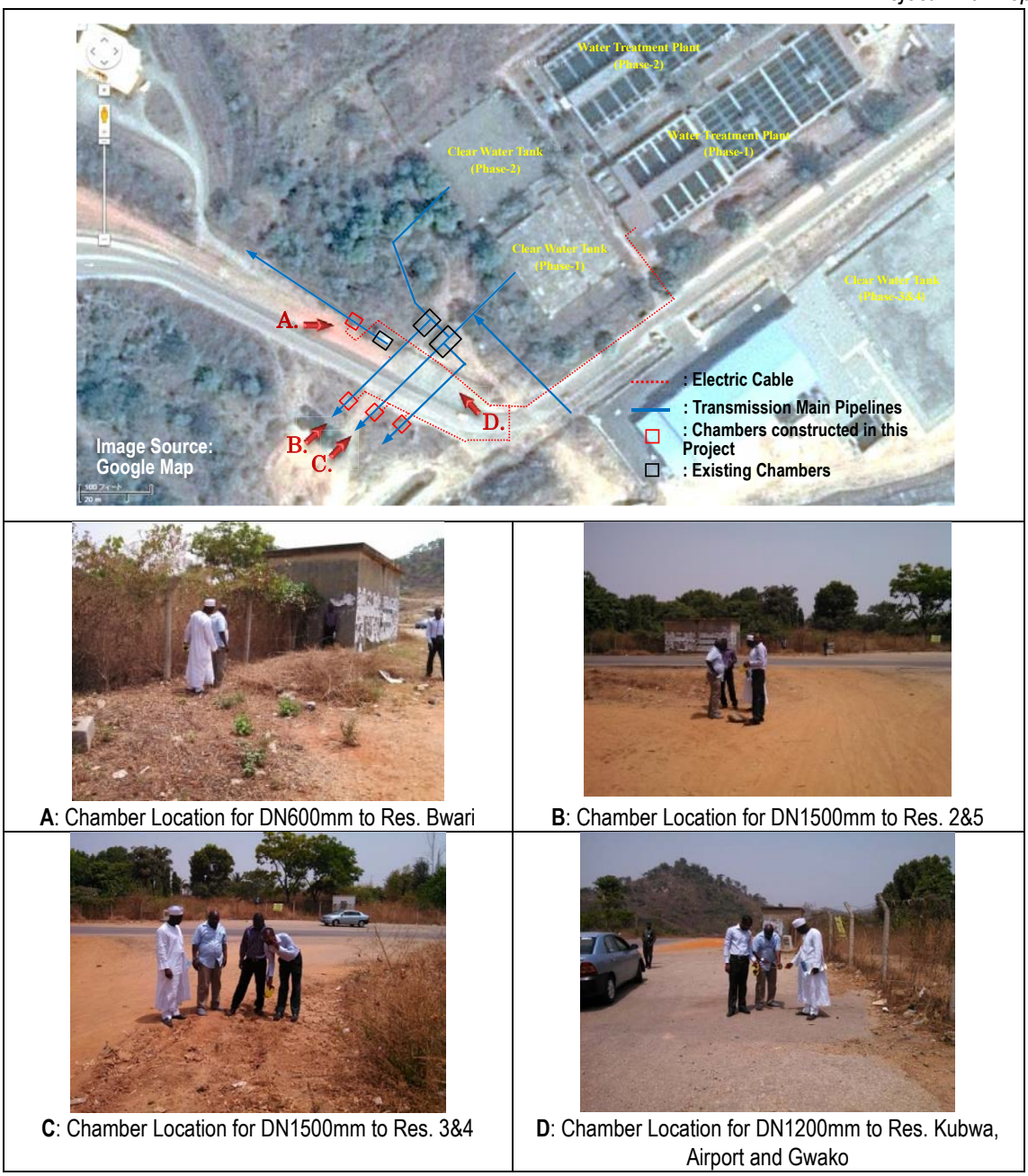
3.2 Activities of the Project

3.2.1 Activities for Output-1

(1) Install bulk meters to water treatment plants 1 and 2 (Activity 1-1)

Bulk meters aim to measuring total inflow (system input volume) and then analysing water balance in the entire FCTWB's water supply system.

The Project Team and the JICA Expert Team examined the position on the existing transmission pipelines for bulk meters (ultrasonic flow-meters) which were installed at the outlets of Lower Usuma water treatment plant. Figure 3.2-1 shows approximate locations of the chambers for housing bulk meters.



A: Chamber Location for DN600mm to Res. Bwari

B: Chamber Location for DN1500mm to Res. 2&5

C: Chamber Location for DN1500mm to Res. 3&4

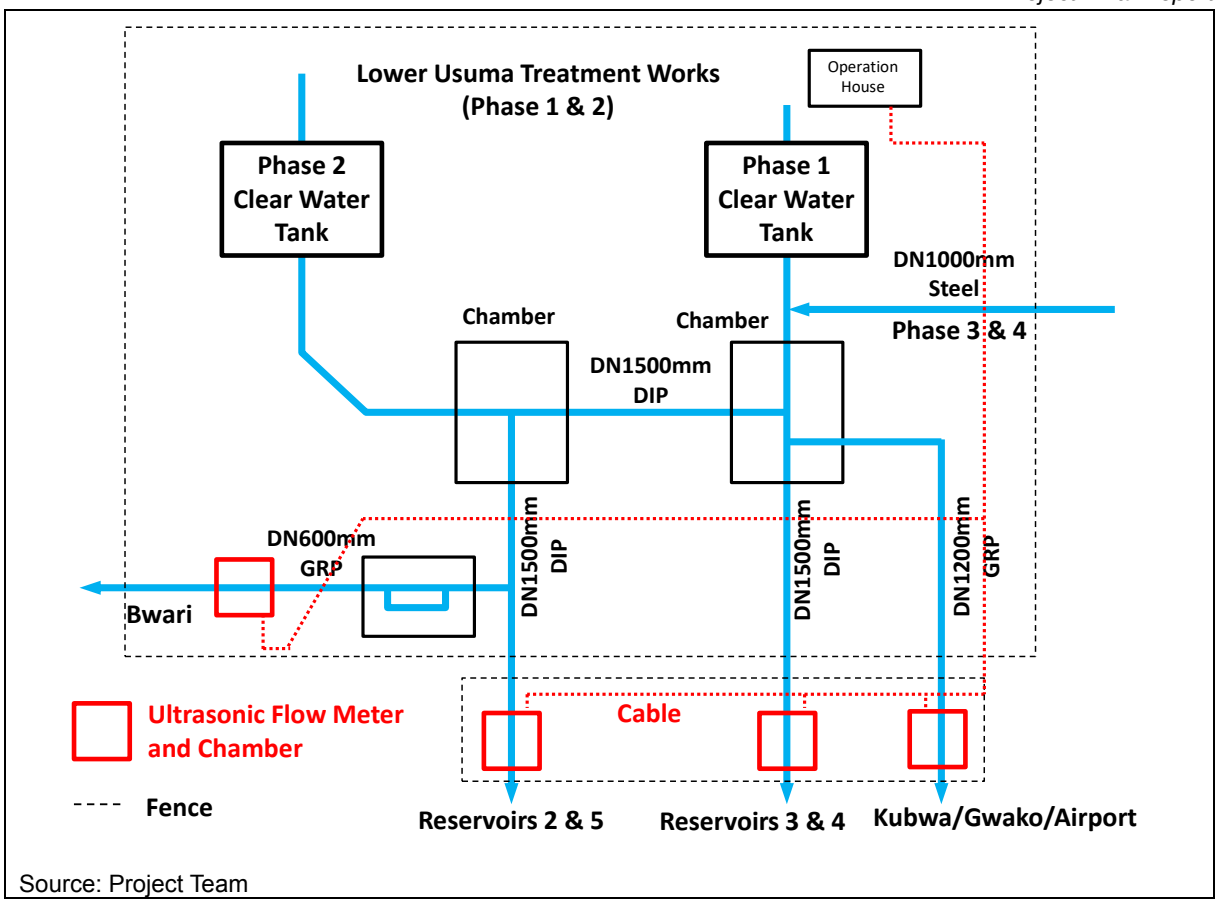
D: Chamber Location for DN1200mm to Res. Kubwa, Airport and Gwako

Figure 3.2-1: Location of Bulk Meters

There are four transmission mains at the outlets of Lower Usuma water treatment plant. Each transmission main from No.1 to No.4 is to convey water to the following tanks:

- No.1: Transmission Main (DN600mm) to Tank Bwari
- No.2: Transmission Main (DN1500mm) to Tank 2 & 5 series
- No.3: Transmission Main (DN1500mm) to Tank 3 & 4 series
- No.4: Transmission Main (DN1200mm) to Tank Kubwa, Airport and Gwako series

Figure 3.2-2 shows schematic of chambers for bulk meters and electric cable layout. Electric signal is transferred to a data logger installed in the existing operation house.



Source: Project Team

Figure 3.2-2: Schematic of Chambers for Bulk Meters and Electric Cable Layout

Structure designing of chambers as well as specifying equipment such as ultra-sonic flow meters and data logger were completed (refer to Table 3.2-1). Drawings of chambers and conceptual diagram of installation of ultrasonic flow-meter, cable, and cabinet box are shown in Annex 11.

Table 3.2-1: List of Procurement for Activity 1-1

No	Item	Qty.	Procured by	Procured in	Status
1	Ultrasonic Flow-meter (stationary)	4	JICA	Japan	Procured and handed over
2	Data logger (stationary)	1	JICA	Japan	Ditto
3	Chamber Construction	4	FCTWB	Nigeria	Under construction

Four (4) bulk meters with a data logger were procured by JICA and handed over to FCTWB.

Chambers for bulk meters were partially constructed by local contractors outsourced by FCTWB, but the construction was suspended due to non-release of counterpart fund. In response to request by the Nigerian side in the 4th JCC meeting, JICA took over the construction in October 2016. The construction of the chambers were completed in December 2016. Afterward, four bulk flow meters with a logger were installed by the Project.

Ultra-sonic flow-meter (Line Bwari, Dia. 600mm)

Main Units, Logger and Breaker Box

Chamber (Line 1&2 and Kubwa)

Chamber (Line Bwari)

Figure 3.2-3: Bulk Flow-meters, Chambers and Cables

(2) Measure/estimate water production of water treatment plants 1, 2, 3 and 4 (Activity 1-2)

After the completion of Activity 1-1, the Project Team were supposed to measure water production (inflow to the whole water supply system) by reading of bulk meters. However, the Project identified that interference of water flow at the connection point from water treatment plants No.3&4 at the upstream of bulk flow-meters had caused inadequate water flow into the water supply system. Also, this had led to the situation that water demand surpasses supply, then this had caused non full flow of water in pipelines, data deficiency and overflow from clear water tanks of water treatment plant No.3&4.

Through series of discussion with FCDA, FCTWB and the Project Team with advisory support from the JICA Expert Team, the Nigerian Side relocated the connection point in May 2018 (refer to Annex 12). The Project Team confirmed improvement in situation by the fact that overflow had decreased drastically from 150,000m^3/day to 7,000m^3/day approximately (refer to Figure 3.2-4). This corresponds to NRW reduction of 143,000m^3/day and can bring increase in revenue of 4.6 billion Naira per year to FCTWB (143,000 m^3/day x N90/m3 for both domestic and commercial customers x 30days x 12months).

FCTWB will be able to gain NGN380million monthly (NGN4.6billion yearly).

Accordingly, the Project Team measured/estimated inflow to the whole water supply system by using the recorded data. Refer to Section 3.2.1 (5) for details.

As of the end of the Project, FCTWB has tried to solve non-recording of the bulk meter along Line 1 (Tanks 2 and 5), which seems to be due to malfunction of sensor.

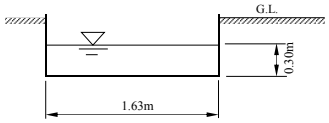
Field Discussion with FCDA

Relocation of Connection Point

Changes of Overflow by Relocation of Connection Point (Overflow as NRW)

Before: 25th September 2017

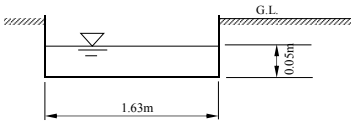
a.	Drain Distance:			16.8	m
b.	Time (average for twice):		= (4.74s+4.82s)/2	4.78	s
c.	Flow Velocity:	a. / b.	= 16.8m/4.78s	3.51	m/s
e.	Flow Area:	See the below	= 1.63m x 0.30m	0.49	m^2
f.	Flow Rate:	c. x e.	= 3.51m x 0.49m^2	1.72	m^3/s
g.	Ditto (hourly)	f. x 60 x 60	= 1.72m^3/s x 60 x 60	6,192	m^3/hour
h.	Ditto (Daily)	g. x 24hrs	= 6192m^3/hrs x 24hrs	148,608	m^3/day



i.	Current Water Production at Phase 3&4:	40% of Design Capacity of Phase 3&4	= ((240,000m^3/day + 240,000m^3/day)) x 40%	192,000	m^3/day
j.	Percentage of Wasted Water Flow Rate:	h. / i.	= 148,608m^3/day / 192,000m^3/day	**77.4**	%

After: 30th August 2018

a.	Drain Distance:			12.8	m
b.	Time (average for twice):		= (15.63s+11.93s+12.17s)/3	13.24	s
c.	Flow Velocity:	a. / b.	= 12.8m/13.24s	0.97	m/s
e.	Flow Area:	See the below	= 1.63m x 0.05m	0.08	m^2
f.	Flow Rate:	c. x e.	= 0.97m/s x 0.08m^2	0.08	m^3/s
g.	Ditto (hourly)	f. x 60 x 60	= 0.08m^3/s x 60 x 60	288	m^3/hour
h.	Ditto (Daily)	g. x 24hrs	= 288m^3/hrs x 24hrs	6,912	m^3/day



i.	Current Water Production at Phase 3&4:			150,000	m^3/day
j.	Percentage of Wasted Water Flow Rate:	h. / i.	=6,912m^3/day / 150,000m^3/day	**4.6**	%

Figure 3.2-4: Interference of Water Flow at Connection Point

(3) Tally the above water production data/estimation (Activity 1-3)

After the completion of Activity 1-2, the Project Team tallied inflow to the whole water supply system by using the measured/estimated inflow data. Refer to Section 3.2.1 (5) for details.

(4) Calculate the water consumption based on the billing data (Activity 1-4)

It was revealed that a considerable number of return bills exist in billing system of FCTWB, which definitely make analysis inaccurate. Commerce Department has not figured out the actual figure of quantity of existing return bills, but estimated them about 6,600 according to relevant staff. FCTWB has been aware of them for years, nonetheless, has never dealt with and then has kept on issuing the bills to be returned eventually.

Return bills mean the bills which are supposed to be eliminated or deactivated but have not been done, then have resulted in being returned or not delivered. A main cause is negligence of duty in FCTWB,

but the reasons why return bills have remained are:

Return Bills

- In spite of conversion of meter types including flat-rate, duplicated customer accounts have remained. One of them is billed properly, while another becomes a return bill.
- In spite of address modification or re-subscription, old customer accounts have remained.
- In spite of move of customers or their displacement/demolition by the Government, uninhabited customer accounts have remained.
- As long as these bills have remained, the existing billing system keeps on issuing the bills by automated estimating programme, regardless of meter reading

Consequently, the Project made a decision to suspend discussion about upgrading of the billing system to calculate the monthly water consumption until FCTWB takes actions.

FCTWB identified about 4,800 return bills in the existing billing system and eliminated or deactivated some of them. In response to this, specification of upgrading of billing system was finalized (refer to Table 3.2-2 and 3.2-3) and then the JICA Expert Team outsourced implementation of the upgrading to a system engineering consultant between September and December 2016 (refer to Annex 13).

However, after the completion, the Project Team had faced a number of system's bug, which were solved by the consultant eventually, and also spent a large amount of time for both zonal coding for water distribution management and PMA coding for PMA monitoring.

Table 3.2-2: Technical Specifications for Upgrading of Billing System

Item	Description
General Requirements	• Implement system-wide web-browser based modern and user-friendly interface. • Implement functions to allow flexible retrieval, sorting and extraction of data by any attributes. • Create input boxes to allow comments in the application lifecycle. • Implement flexible and fast search routine using any attribute of choice. • Optimize system to allow fast retrieval of large amounts of data.
Billing	• Implement automated validation function to prompt alerts whenever irregular, questionable and abnormal values are detected compared to past consumptions or a pre-set range of consumption and also large outstanding balances as well. • Implement function to allow optional estimated billing. • Implement function to allow exclusion of customer from billing. • Migrate billing history to the new database. • Optimize billing module to accurately use meter readings for bill computation. • Optimize metering module to allow automated removal of estimated bills when meter readings are captured for past months.
Metering	• Create tunnels for integrating handheld metering for future implementation. • Optimize meter reading capture module to accurately integrate meter readings with billing functions. • Optimize meter editing module to become more user friendly. • Migrate meter reading history to the new database
Revenue	• Create interface to allow automated and accurate distribution of payments from suspense account to individual customer accounts. • Automate transfer of e-payments from payment provider into the billing database. • Migrate payment history to the new database.
Audit	• Implement interface to allow validation of payments (e-Payments included) before posting into individual customer accounts.
Customer Management	• Optimize account number assignment during customer creation to eliminate arbitrary values and duplicates. • Optimize customer editing module to become more user friendly. • Add new data entry attributes such as zones (may not be included in the bill print out)
Reports	• Implement functions to allow flexible retrieval, sorting and extraction of data by any attributes.

Item	Description
	• Data reporting and exports should include both Naira value and water volume (cubic meter). • Create new report templates.
Security	• Implement global standards security system with emphasis on validation, encryption, "bug" tracking and potential threats ensuring a secure and hack-free system. • Implement role based authorization. • Create admin module for easy management of users and their associated system roles.
Hardware	• Refer to the following table
Platform Software	• Refer to the following table
Services	• Setup the new servers within an enterprise architecture. • Install and configure new software and necessary components on the FCTWB billing servers. • Set up of six (6) sets of computer workstation with interconnectivity to the FCTWB domain.
Training	• Conduct a five day training of system administrators and operators on use of new software. • Create user manuals (one (1) soft copy and two (2) hard copies)
Maintenance	• Maintain system for two (2) years after deployment.

Source: Project Team

Table 3.2-3: Equipment for Upgrading of Billing System

Category	Cost Items	Description	Qty.	Unit
Server Infrastructure	Computer Server and Accessories	HP ProLiant DL560 Gen8 E5-4603v2 2P 32GB-R Hot Plug SFF 1200W RPS Server Enterprise Server	3	unit
Computers	High-end Computer Workstations	HP HPE h8qe series, 8GB HDD, 1TB RAM	6	unit
Platform Software	Operating System	Microsoft Windows Server 2012 R2	3	license
Platform Software	Microsoft SQL Server	Microsoft SQL Server 2014 Standard Edition (1 processor license)	1	license
Custom Enterprise Software	Automated Billing Application	Custom Automated Billing Application (Active-PUMA 1.0 Upgrade)	1	license
Custom Enterprise Software	Automated Billing Application	Custom Automated Billing Application (Merging of upgraded Active-PUMA 1.0 and Active-PUMA 3.0 into one common platform)	1	license
Implementation, Integration and Deployment	Data Integration	Existing and new data integration (millions of payment, bill, meter reading and customer records)	1	lot
Training	Training, Capacity Building and Refreshment	Five day training of system administrators and operators on use of new software	5	day

Source: Project Team

(5) Calculate NRW ratio of the service area of FCTWB using the results obtained from Activity 1-3 and 1-4 (Activity 1-5)

By using the results, particularly system input volume and billed water consumption obtained from Activity 1-3 and 1-4, the Project calculated NRW and ratio of the whole service area of FCTWB, distribution zones and Pilot Metering Areas (PMA). Table 3.2-4 shows results.

1) How to Calculate/Estimate NRW Ratio

Firstly, the Project measured/estimated "A. System Input Volume"

Secondary, the Project Team calculated/estimated "Water Consumed: Revenue Water" by three ways:

- "B. Straightforward/As-it-is Estimation" of water consumed: revenue water

Metered Billed Water Consumed + (Flat-Rate/Estimate Billed Amount / Unit Price)
*By applying unit price for domestic: N80/m^3 or commercial: N150/m^3

- "C. Metered Average-based Estimation" of water consumed: revenue water
  Metered Billed Water Consumed + (Number of Flat-Rate/Estimate Customer x Average Metered Billed Water Consumed per customer)
  *Domestic and commercial respectively
- The lower one between B and C, "D. Lower water consumed: revenue water"

Thirdly, the Project Team calculated/estimated NRW and ratio from the above ways, "E, F and G", among which the Project Team suggests adopting "G".

2) Review of Figures

These figures could be calculated/estimated at the end of the Project because of non-full flow of water and malfunctioning of bulk, zonal and PMA meters, as well as delay in zonal/PMA coding of customers in billing system. Therefore, for example, the NRW ratio of the bulk total (the whole system) as monthly data "52.8%" were not used in the medium-term strategic plan on NRW reduction, which applied "48.3%" as an baseline and annual data.

The difference between the estimate water production "0.34 million m^3/day" in 2017 (refer to Table 1.4-4) and system input volume of the total bulk "0.28 million m^3/day (6.84 million m^3/month)" is "0.16 million m^3/day", which is nearly equal to "0.14 million m^3/day", the reduced overflow from clear water tanks of water treatment plant No.3&4 (refer to Section 3.2.1(2)). This can be a proof of a big impact by the Project.

It is necessary for FCTWB to continue monitoring NRW periodically, to accumulate and study them, also utilized them for the implementation of the medium-term strategic plan on NRW reduction.

Regarding some minus figures or ratios, the Project Team concluded these may have happened because of the automated estimate bills for "B. Straightforward/As-it-is Estimation" which often create a large billed amount, and also because of the large metered average consumption particularly from major consumers for "C. Metered Average-based Estimation".

Difference of the system input volumes between the bulk total (6.84 million m^3/month) and the zonal total (6.73 million m^3/month) is 0.11 million m^3/month (1.6%), which corresponds to NRW along transmission mains and at reservoirs (tanks), however this looks a quite small. As FCTWB has observed actually leaks and burst unauthorized unmetered consumption or illegal connections along transmission mains, FCTWB should make complete survey and study NRW along transmission mains and reservoirs as an activity included in the medium-term strategic plan on NRW reduction.

The Project Team concluded the reason why NRW ratios in PMAs are higher than pilot project results (Gudu 20.4% to E:27.0% or F:28.0%, Jabi 30.9% to E:66.0% or F:85.8%, Garki I 34.7% to E:52.9% or F:64.0%) are differences in timeframe, and revenue water from meter reading directly or from billing system. Specifically, in the pilot projects (Activities for Output 2), PMA meter reading and customer meter reading were based on field data and conducted in the short interval (e.g. 7 days in principle). On the other hand, in Activity 1-5, those in calculation/estimation were based on billing system data including estimate bills and conducted in the long interval (currently several months). In the billing system, the Project Team actually observed both Jabi and Garki I PMAs have a lot of estimate bills in August 2018 billing cycle (Jabi: approx. 200 estimate bills in 600 total bills, and Garki I: approx. 180 estimate bills in 450 total bills).

It is necessary for FCTWB to update customer data and ensure meter reading to calculate NRW ratio for PMA accurately as an urgent issue.

Table 3.2-4: Calculation/Estimation of Monthly NRW and Ratio of Bulk, Zonal and PMA Level (Latest Billing Cycle: August 2018)

BULK	Bulk-SIV (m3/month)			Water Consumed : Revenue Water (m3/month)						NRW					
	A: Volume (m3/month)	Month	Valid Days	No. of Cusutomer	Meter Type	Month of Billing Cycle	B. Straightforward/As-it-is Estimation (by Naira/m3)	C. Metered-Average-based Estimation	D: Lower Water Consumed (B or C)	A-B=E: m3/month	E / A: %	A-C=F: m3/month	F / A: %	A-D=G: m3/month	G / A: %
Kubwa Line	1,950,379	October-18	1	18,029	Conventiona & PrepaidI	August-18	1,094,335	616,445	616,445	856,044	43.9%	1,333,934	68.4%	1,333,934	68.4%
Tank 3&4 Line	3,729,601	April-18	16	21,973	Conventional & AMR	August-18	1,929,878	2,556,051	1,757,842	1,799,723	48.3%	1,173,549	31.5%	1,971,758	52.9%
Tank 2&5 Line	1,028,334	April-18	16	7,593	Conventional & Prepaid	August-18	1,307,573	815,754	815,754	-279,239	-27.2%	212,580	20.7%	212,580	20.7%
Bwari Line	131,012	April-18	16	1,310	Conventional	August-18	65,887	37,064	37,064	65,125	49.7%	93,949	71.7%	93,949	71.7%
Total	**6,839,326**			**48,905**			**4,397,672**	**4,025,313**	**3,227,104**	**2,441,654**	**35.7%**	**2,814,013**	**41.1%**	**3,612,222**	**52.8%**

ZONAL	Zonal-SIV (m3/month)			Water Consumed : Revenue Water (m3/month)						NRW					
	A: Volume (m3/month)	Month	Valid Days	No. of Cusutomer	Meter Type	Month of Billing Cycle	B. Straightforward/As-it-is Estimation (by Naira/m3)	C. Metered-Average-based Estimation	D: Lower Water Consumed (B or C)	A-B=E: m3/month	E / A: %	A-C=F: m3/month	F / A: %	A-D=G: m3/month	G / A: %
Tank 2	1,852,950	August-18	26	5,809	Coventional & Prepaid	August-18	1,102,472	668,853	668,853	750,477	40.5%	1,184,097	63.9%	1,184,097	63.9%
Tank 3	769,130	August-17	31	8,633	Conventional & AMR	August-18	736,736	1,147,620	736,736	32,395	4.2%	-378,490	-49.2%	32,395	4.2%
Tank 3.1	286,011	May-18	31	1,906	Conventional & AMR	August-18	244,443	125,379	125,379	41,568	14.5%	160,632	56.2%	160,632	56.2%
Tank 3.2	9,359	August-18	31	-	Mambilla Barrack	August-18	0	0	0	9,359	100.0%	9,359	100.0%	9,359	100.0%
Tank 4	1,554,574	August-18	31	7,220	Conventional & AMR	August-18	736,851	1,110,177	736,851	817,724	52.6%	444,398	28.6%	817,724	52.6%
Tank 4.1	Non record			1,179	Conventional & AMR	August-18	104,305	118,304	104,305	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Tank 4.1.1	7,299	August-18	31	-	Mogadishu Barrack	August-18	0	0	0	7,299	100.0%	7,299	100.0%	7,299	100.0%
Tank 4.2	103,058	July-18	17	3,035	Conventional & Prepaid	August-18	107,543	54,572	54,572	-4,485	-4.4%	48,486	47.0%	48,486	47.0%
Tank 5	619,806	July-18	16	1,784	Conventional & Prepaid	August-18	205,100	146,901	146,901	414,706	66.9%	472,905	76.3%	472,905	76.3%
Tank Airport	26,285	August-18	27	96	Conventional	August-18	20,871	10,169	10,169	5,414	20.6%	16,115	61.3%	16,115	61.3%
Tank Bwari	131,012	April-18	16	1,310	Conventional	August-18	65,887	37,064	37,064	65,125	49.7%	93,949	71.7%	93,949	71.7%
Tank Gwako	531,889	August-18	31	3,577	Conventional & Prepaid	August-18	229,674	101,774	101,774	302,215	56.8%	430,115	80.9%	430,115	80.9%
Tank Kubwa	837,660	July-18	17	14,356	Conventional	August-18	843,790	504,501	504,501	-6,130	-0.7%	333,159	39.8%	333,159	39.8%
Total	**6,729,033**			**48,905**			**4,397,672**	**4,025,313**	**3,227,104**	**2,331,360**	**34.6%**	**2,703,720**	**40.2%**	**3,501,929**	**52.0%**

PMA	PMA-SIV (m3/month)			Water Consumed : Revenue Water (m3/month)						NRW					
	A: Volume (m3/month)	Month	Valid Days	No. of Cusutomer	Meter Type	Month of Billing Cycle	B. Straightforward/As-it-is Estimation (by Naira/m3)	C. Metered-Average-based Estimation	D: Lower Water Consumed (B or C)	A-B=E: m3/month	E / A: %	A-C=F: m3/month	F / A: %	A-D=G: m3/month	G / A: %
Gudu	89,558	October-18			Conventional & Prepaid	August-18	65,338	64,496	64,496	24,220	27.0%	25,062	28.0%	25,062	28.0%
Jabi	390,892	October-18			Conventional	August-18	132,809	55,370	55,370	258,083	66.0%	335,522	85.8%	335,522	85.8%
Garki I	92,884	October-18			Conventional & AMR	August-18	43,759	33,399	33,399	49,125	52.9%	59,485	64.0%	59,485	64.0%

Source: Project Team

(6) Install zonal meters, water pressure sensor and pilot remote monitoring (telemetry) system (Activity 1-6)

Through site visit and observation, the Project Team and the JICA Expert Team confirmed the locations along outlet pipelines from tanks, at which the zonal meters (ultrasonic type) are installed.

As shown in Figure 3.2-5 and Table 3.2-5, the Project Team and the JICA Expert Team designed 14 zonal meters with data loggers at the outlet from 13 tanks, two (2) pilot telemetry systems, 13 solar power systems and eight (8) chambers to be newly constructed for housing zonal meters.

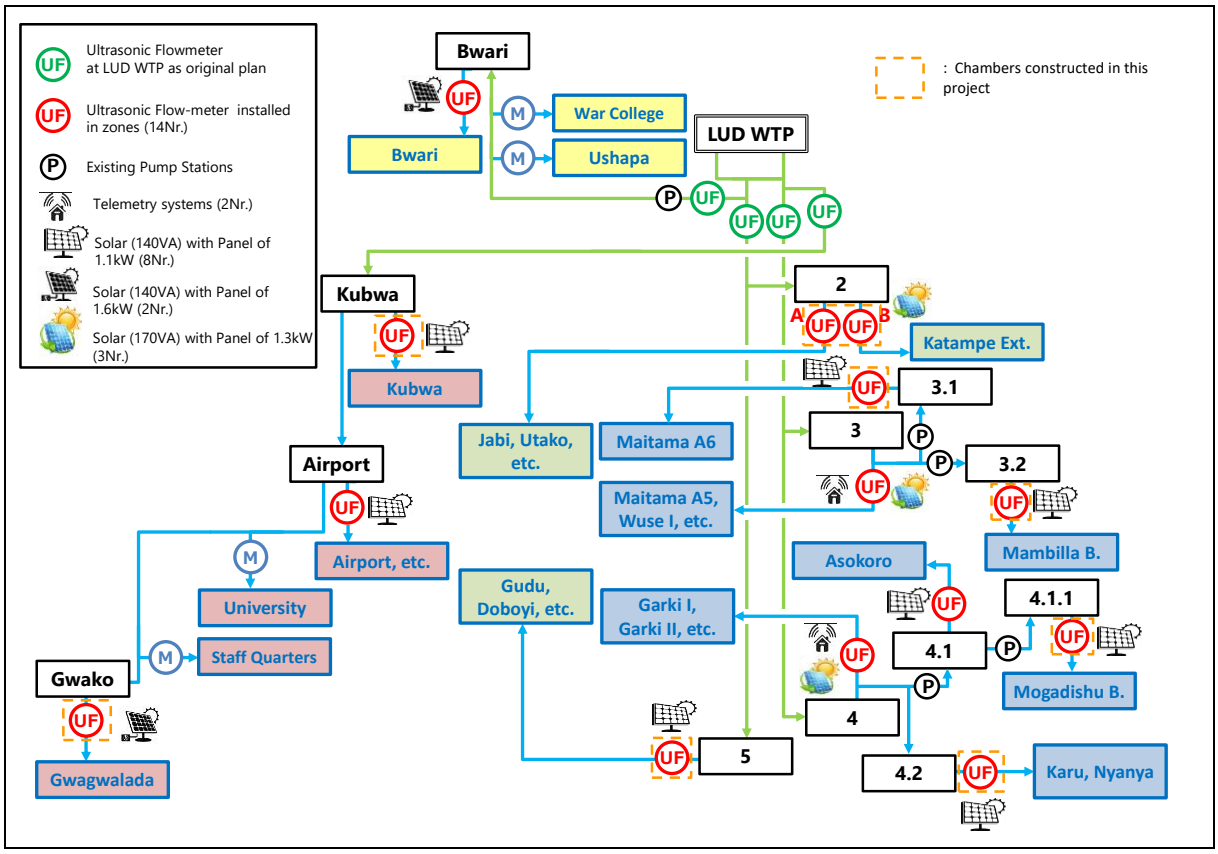


Figure 3.2-5: Schematic of Location of Zonal Meters, Telemetry, Solar System and Chambers

Table 3.2-5: List of Procurement for Activity 1-6

No	Item	Qty.	Procured by	Procured in
1	Ultrasonic Flow-meter (stationary)	14	JICA	Japan
2	Data Logger (stationary)	13	JICA	Japan
3	Data Logger (portable)	2	JICA	Japan
4	Telemetry System	2	JICA	Japan
5	Solar Power System	13	JICA	Nigeria
6	Chamber Construction	8	JICA	Nigeria

Source: Project Team

Aims, design criteria and basic specifications of equipment to be procured for this activity are as follow:

1) Zonal Meter (Ultrasonic type)

Zonal meters aim to measure the distributed flow from the specific reservoirs to each water distribution zone. The measured flow data is recorded in data logger and utilized to analyze water balance by zone and to examine or prioritize whether FCTWB has to take an urgent action including NRW reduction activities in particular zone.

The following conditions were applied for designing locations of zonal meter:

- Ultrasonic type in principle to avoid cutting pipe then disrupting water supply

- To focus on only distribution pipelines from service reservoir supplying water to users
- To exclude distribution pipelines between two service reservoirs, and also service pipes connected directly to transmission mains (e.g. War College by D150mm)
- Zonal meters are installed inside the existing operation houses in principle, but if not appropriate situation or enough space, construction of new chambers is proposed.

As a design standard of ultrasonic flow-meter as zonal meter, manufacturer stipulates in principle that the flow-meter is supposed to be installed at 10D (10 x pipe diameter) or more away from bend, junction and reducer on the upstream side of the flow-meter and also at 5D (5 x pipe diameter) or more on the downstream side. If the above requirements are met, zonal meter can be installed inside the existing operation house. But if not like inadequate space, the Project constructs new chamber.

The Project Team and the JICA Expert Team visited 21 candidate locations to check conditions for zonal meter installation. Table 3.2-6 shows 14 proposed locations of zonal meter installation and different cases of actual situation.

Table 3.2-6: Location of Zonal Meter Installation

Proposed Location of Zonal Meter		Case of Actual Situation	Meter Housing
Tank 3, 4 and 4.1	3	A. 10D or more from zonal meter to bend, etc. on the upstream side	Existing operation house
Tank Bwari and Airport	2	B. 5D or more but less than 10D from zonal meter to bend, etc. on the upstream side	Existing operation house
Tank 2, 3.1, 3.2, 4.1.1, 4.2, 5, Kubwa and Gwako (*Two meters in Tank2)	9	C. Less than 5D from zonal meter to bend, etc. on the upstream side	Chamber to be newly constructed

Remarks
- Zonal meters should be installed preferably inside the existing operation house to avoid construction of new chamber associated with additional cost. However, position of zonal meter is subject to space and conditions along outlet pipe in the existing operation house. Actually, not all situations of 14 proposed locations can meet the requirements of installation of ultrasonic flow-meter.
- In order to reduce the cost of chamber construction, the Project mitigates a design standard technically. Case “B” is a one considering mitigation (from 10D to 5D) of distance from zonal meter to bend, junction and reducer on the upstream side of the meter.
- If distance on the upstream side of zonal meter is shortened from 10D to 5D, error of flow measurement is about 3.5%. The Project regards this mitigation as acceptable. Just for reference, this is lower than error of data input of pipe thickness (3.9% in 1.0mm).

Source: Project Team

2) Pilot Telemetry System

Telemetry system enables FCTWB to take prompt actions for the unexpected accident and to make more efficient in NRW reduction through real-time transmission of flow data of the selected zonal meter to central monitoring room to be located in headquarters of FCTWB and monitoring of the flow data.

In addition, the lessons learned from the pilot telemetry system will be utilized for expansion of the system to the other zones in the future.

Pilot telemetry system has two main components:

a) Central Monitoring System

Central monitoring system consists of six items, which are (a) monitoring software for data acquisition (Water flow), (b) personal computer, (c) monitor, (d) printer, I uninterruptible power system and (f) external antenna. The above system was installed in a particular room of FCTWB Headquarters. Specification of monitoring system is summarized in Table 3-2-7.

Table 3.2-7: Specification of Monitoring System

No.	Item	Specification
1	Hardware	Power Source: AC230V, 1-Phase, 50Hz
1-1	Personal Computer for Central Monitoring	OS : Windows 7 or equivalent operating system CPU : Intel Core i3-6100 or equivalent RAM : More than 4 G HDD : More than 500 GB
1-2	Monitor	20 inch or more
1-3	Printer	A4 Printer
1-4	External Antenna	Large type
2	Software	
2-1	Monitoring Software	Software Functions; Program for Collection Monitoring Spreadsheet for Data Collection Alarm System

Source: Project Team

b) Telemetry System

Telemetry system mainly consists of telemeter main unit, housing board and antenna. The telemetry systems were installed at service reservoirs "Tank No.3" and "Tank No.4" selected by the Project Team considering the site location in the central area "Phase-1" of FCC. Specification of the system is summarized in Table 3.2-8.

Table 3.2-8: Specification of Telemetry System

No.	Item	Specification
1	Box (Equipment Storage Panel)	Power Source : AC230V, 1-Phase, 50Hz Dimension : Approx.400Wx 1050H x 250mmD
2	Main Unit	Circuit Breaker : 2P2E 30AF/5AT Arrester : AC230V, DC24V (Power and Signal Line) Comm. Device : SMS (Short Messaging Service)
3	Antenna	Small type

Source: Project Team

There are two methods of data transmission from telemetry system to the central monitoring system: "wired method" and "wireless method". Each of them has two aspects: "private line or encryption system" and "general telecommunication line". Table 3.2-9 shows their features.

The Project regards the data to be obtained, water flow rate as not highly-confidential information. Therefore, in consideration of the features and security issues such as vandalism or theft of wired line, the Project adopted "wireless method".

Table 3.2-9: Features of Methods of Data Transmission

System / Method	Items	Wired Method		Wireless Method	
		Private Line	Gen. Telecom. Line	Encryption System	Gen. Telecom. Line
Features	Security	High	Low	Relatively High	Low
	Cost	High	Low	High	Low
	Line Construct.	Required	Required (Electric Pole – Site)	Not Required	Not Required
	Facility	Required (Line Terminal)	Required (Line Terminal)	Complicated	Simple
	Comm. Speed	Selectable	Fixing	Selectable	Fixing
Evaluation		Not good	Not good	Good	Very Good

Source: Project Team

Also, through examination of features of two transmission systems: "analog digital conversion" and

"short messaging service (SMS)" as shown Table 3.2-10, the Project adopted using "SMS" because of lower cost of telecommunication and easy establishment and maintenance of the system.

Table 3.2-10: Features of Transmission System

System	Items	Analogue Digital Conversion	SMS
Method		Transmitting by using conversion from analogue signal containing DC 4-20mA to digital 8, 16 and 32bits	Allocating the analogue signal containing DC 4 -20mA to particular flow rate in advance
Features	Corresponding Signal	Compatible for all type analogue signal	Only for predetermined data
	Use Bandwidth	Wide	Narrow
	Cost	High	Low
	Facility	Many	Few
	Maintenance	Not Easy	Easy
	Comm. Speed	Selectable	Constant
Evaluation		Not good	Good

Source: Project Team

Finally, main components of the pilot telemetry system by location are as shown in Table 3.2-11.

Table 3.2-11: Installation Location of the System

Location	System to be installed
FCTWB HQs	(1) Central Monitoring System (2) SMS Antenna (3) SMS Transmitter/ Receiver
Service Reservoirs (Tank No.3 and No.4)	(1) Telemetry System (2) SMS Antenna (3) SMS Transmitter/ Receiver

Source: Project Team

3) Solar Power System

a) General Summary of Solar Power System

FCT (Abuja) is often not in good electrical power supply condition, and such power circumstance causes voltage fluctuation. Furthermore, power failure often occurs. Power supply by solar power system is therefore recommended aiming at stable data logging despite a presence of power network adjacent to the installation points. As a main power source, solar power system can secure stable power supply to zonal meters (ultrasonic type) for continuous measurement of flow data.

Regarding a battery, 12V battery is generally distributed in Abuja, and it is easy to procure it in comparison with 24V battery. In addition, load capacity used is 140 to 170VA. Nominal voltage of battery was therefore determined, taking into consideration the convenience of battery replacement. Table 3.2-12 shows the characteristic of battery type and the evaluation result selecting 12V battery.

Table 3.2-12: Comparison Chart for the Battery Characteristic

Battery Type	12V Battery	24V Battery	Serial Connection of 12V Battery (24V)
Advantage	It is easy to obtain since 12V battery is generally distributed in Abuja.	It is possible to reduce cable size.	It is possible to reduce cable size.
Disadvantage	Cable size gets thick.	It is difficult to obtain in comparison with 12V battery, due to distribution circumstances in Abuja.	- There is concern about improper connection. - In order to avoid quick degradation of battery capacity, it is required to connect several batteries having same charge and discharge characteristic.
Evaluation	Good Use of 12V battery is appropriate from the view point of marketability and O&M condition, although cable size gets thick.	Fair Considering the convenience O&M activity, use of 24V battery is not recommended.	Fair Considering the O&M condition, it is not recommended to apply serial connections being concerned about capacity degradation.

Source: Project Team

Considering the above conditions and specifications of equipment such as zonal meter (ultrasonic type) with separate data logger and telemetry system, the Project Team members from Electro-mechanical Unit of FCTWB and the JICA Expert Team finally specified solar power system as shown in Table 3.2-13.

Table 3.2-13: Specification of Solar Power System

System	Type-1	Type-2	Type-3	
Specification	140VA, 1.1kW *1), DC12V **[Battery]** Deep Cycle, DC12V Four Units **[Charge Controller]** DC12V, Three Units Control: Charge & Discharge Charging Current: DC60A Charge and Discharge System: PWM (Pulse With Modulation control) **[DC/AC Inverter]** 500W Continuous Power, One Unit Input Voltage: DC12V Output Voltage: AC230V **[Switcher]** Changeover between Commercial and Solar Power, One Unit	140VA, 1.6kW *1), DC12V **[Battery]** Deep Cycle, DC12V Six Units **[Charge Controller]** DC12V, Four Units Control: Charge & Discharge Charging Current: DC60A Charge and Discharge System: PWM (Pulse With Modulation control) **[DC/AC Inverter]** 500W Continuous Power, One Unit Input Voltage: DC12V Output Voltage: AC230V	170VA, 1.3kW *1), DC12V **[Battery]** Deep Cycle, DC12V Five Units **[Charge Controller]** DC12V, Three Units Control: Charge & Discharge Charging Current: DC60A Charge and Discharge System: PWM (Pulse With Modulation control) **[DC/AC Inverter]** 500W Continuous Power, One Unit Input Voltage: DC12V Output Voltage: AC230V **[Switcher]** Changeover between Commercial and Solar Power, One Unit	
Service Reservoir	Tank 3.1, 3.2, 4.1, 4.1.1, 4.2, 5, Kubwa and Airport	Tank Bwari and Gwako	Tank 2	Tank 3 and 4
Power for	One Ultrasonic Flow-meter and Data Logger	One Ultrasonic Flow-meter and data Logger	Two Ultrasonic Flow-meters and data Logger	One Ultrasonic Flow-meter, Data Logger and One Telemetry System
Qty.	8	2	1	2
Remarks	Commercial power supply is available, but not stable.	Commercial power supply is not available.	Commercial power supply is available, but not stable.	Commercial power supply is available, but not stable.

Source: Project Team

b) Required Power Capacity and Output of Solar Power System and Output of Solar System

Calculation statement of required power capacity and output of solar power system is indicated in Annex 14.

4) Chamber Construction and Zonal Meter Installation

Designing of eight chambers for housing zonal meter was completed. Refer to the drawings of chambers consisting of seven (7) types in Annex 14. Through discussions and site surveys considering workability with ultrasonic flow-meter inside chamber, locations and design were confirmed and finalized by the Project Team members of Pipeline Unit and Tank Unit and the JICA Expert Team.

Although some difficulties such as stagnant rain water were found, construction works of eight chambers for housing zonal meter were implemented by a local contractor outsourced by the JICA Expert Team from the middle of April 2016.

The Project Team members and the JICA Expert Team including local assistants supervised construction works through visual inspection, measuring, photo recording of each work item, and evaluation of concrete strength test results, etc. To ensure safety, they instructed the contractor to pay attention to collapse of sidewall, to set up caution tape and wear helmet and boots.

Chamber construction and zonal meter installation were completed in October 2017.

(7) Measure/estimate and collect data for water distribution management such as water flow of zonal meters and water pressure (Activity 1-7)

The Project measured/estimated and collected data for water distribution management. Refer to Table 3.2-4 in Section 3.2.1 (5).

3.2.2 Activities for Output-2

(1) Prepare/revise procedures of pilot project

The following Figure 3.2-6 shows procedures of the pilot project in a PMA in terms of Distribution aspects for physical loss (leakage) and Commerce aspects for commercial loss.

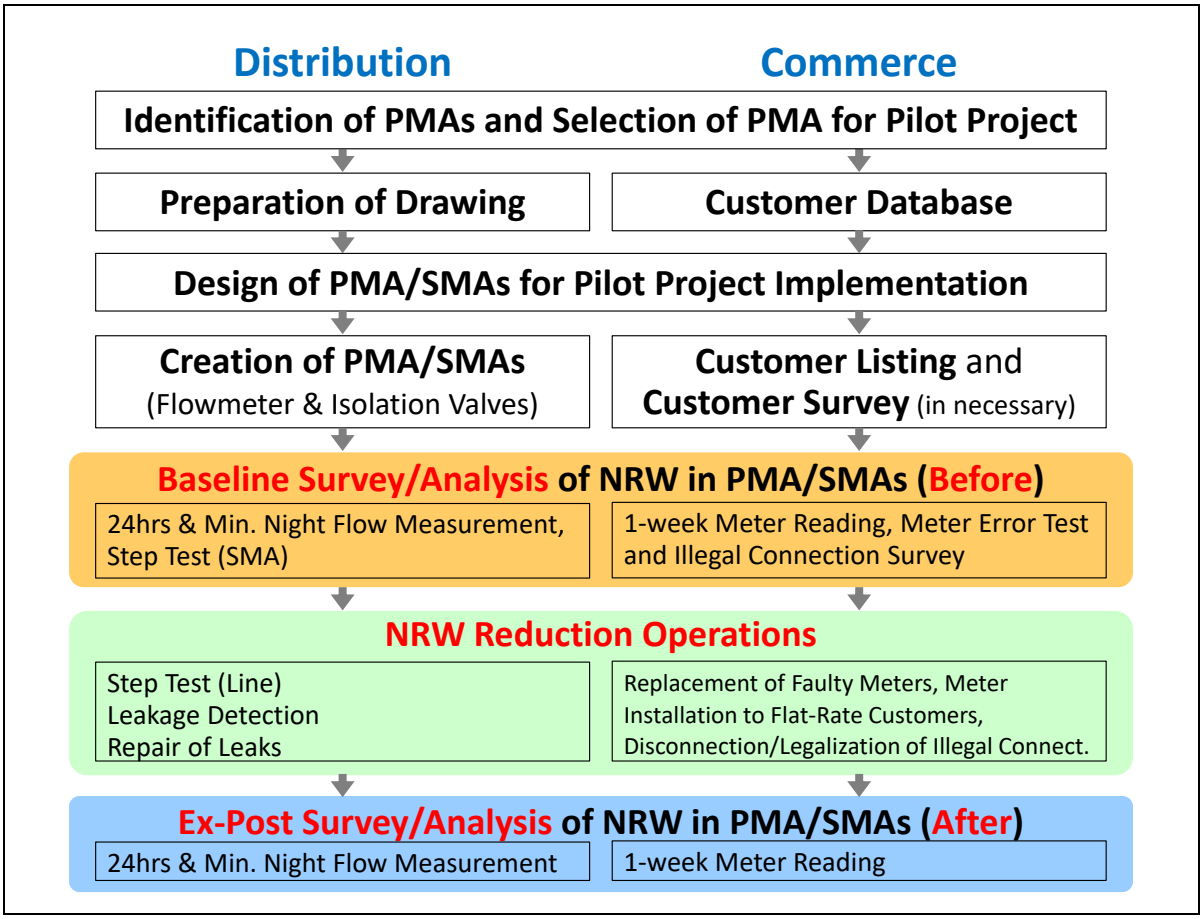


Figure 3.2-6: Procedures of Pilot Project

(2) Review existing NRW reduction operations at each pilot Area Office (Activity 2-1)

NRW can be defined as: "the water which is produced at the costs but lost before reaching customers, or but not used effectively".

International Water Association (IWA) clarifies NRW by using water balance sheet as shown in Table 3.2-14, but FCTWB modifies it by adding "b. Billed Unmetered Consumption (Nominal Excess Use)" as a component of NRW as shown in Table 3.2-15 in consideration of actual situation.

Table 3.2-14: IWA's Water Balance Sheet

System Input Volume (SIV)	Authorized Consumption	Billed Authorized Consumption	a. Billed Metered Consumption	1) Revenue Water
			b. Billed Unmetered Consumption	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	2) **Non-Revenue Water (NRW)**
			d. Unbilled Unmetered Consumption	
	Water Losses	Commercial (Apparent) Losses	e. Unauthorized Consumption	
			f. Customer Metering Inaccuracies and Data Handling Errors	
		Physical (Real) Losses	g. Leakage on Transmission and/or Distribution Mains	
			h. Leakage and Overflows at Utility's Storage Tanks	
			i. Leakage on Service Connections up to Point of Customer Use	

Source: International Water Association

Table 3.2-15: FCTWB's Water Balance Sheet

System Input Volume (SIV)	Authorized Consumption	Billed Authorized Consumption	a. Billed Metered Consumption	1) Revenue Water
			b. Billed Unmetered Consumption	
			b. Billed Unmetered Consumption (Nominal Excess Use)	2) **Non-Revenue Water (NRW)**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	
			d. Unbilled Unmetered Consumption	
	Water Losses	Commercial (Apparent) Losses	e. Unauthorized Consumption	
			f. Customer Metering Inaccuracies and Data Handling Errors	
		Physical (Real) Losses	g. Leakage on Transmission and/or Distribution Mains	
			h. Leakage and Overflows at Utility's Storage Tanks	
			i. Leakage on Service Connections up to Point of Customer Use	

Source: Project Team

Various issues related to NRW to be addressed reside in FCTWB, and factors causing NRW exist extensively in terms of both commercial and physical aspects.

Results of review of situation and existing NRW reduction operations in FCTWB by component in water balance sheet are as follows. The numbering correspond to the above water balance sheet.

1) Revenue Water

a. Billed Metered Consumption

FCTWB has billed based on metered consumption as revenue water, however, it is not necessarily properly-read consumption because of the following three factors: return bills, estimate bills and prepaid

meters.

Return bills: A certain number of "return bills" in the billing system hampers accurate calculation of revenue water, which have been generated automatically by estimating billing as a result of duplication and lack of deactivation. FCTWB has not dealt with them properly in spite of moving, change in address indication, conversion of meter type of customers. Hence, the return bills should be eliminated.

Estimate bills: Consumption includes one by "estimate bills" automatically-generated by billing system namely "Puma" in case of unreadable or inaccessible meters and also zero consumption. A certain number of estimate bills have been issued continuously in both conventional meter and Automatic Meter Reading (AMR) meter. If the estimate billing repeats over a long period of time, a large amount of gap between actual meter-read bill and estimate bill might happen then cause trouble with customers.

Prepaid meters: Prepaid meters in some estates are categorized in this component. While the prepaid meter system has an advantage of revenue increase financially, figuring out water consumption physically is difficult because of system design and its independent feature from the billing system.

Consumption by the estimate billing and prepaid meters causes inaccurate calculation of revenue water in specific interval for periodical monitoring. Therefore, the estimate billings should be reduced by accurate meter reading, and the prepaid meters should be read and monitored separately from the system.

b. Billed Unmetered Consumption

Regardless of category such as domestic or commercial customers and major consumers such as hotel, plaza, school, public tap, bulk selling and etc., FCTWB has a certain number of flat-rate customers and consumers. As long as they consume water within the amount converted by dividing flat rate by unit price (N80 for domestic customers and N150 for commercial customers or major consumers), this category has no particular problem.

2) Non-Revenue Water (NRW)

b. Billed Unmetered Consumption (Nominal Excess Use)

If flat-rate domestic or commercial customers and major consumers consume water more than the amount converted by dividing flat rate by unit price, it is categorized as nominal excess use, a component of NRW in FCTWB.

c. Unbilled Metered Consumption

In principle, no cases exist in FCTWB.

d. Unbilled Unmetered Consumption

Water for maintenance of pipelines such as pipe cleaning by FCTWB as well as water extraction for emergent fire-fighting are categorized here, but they are not recurring consumption. These water consumption should be treated as Unbilled Metered Consumption by installing meter and reading.

Water discharging from washout or air valves along transmission or distribution mains for breaking water pressure is considerable consumption by FCTWB. Also, water supply to FCTWB staff quarters is exempt from billing as welfare. These should be metered and recorded.

Other than these cases, as mentioned in the above b) Billed Unmetered Consumption (Nominal Excess use), the excess use by flat-rate customers or major consumers is categorized here and should be captured then prevented by installing water meters. About 7,000 customers or major consumers remain in flat-rate ones.

e. Unauthorized Consumption

Illegal connections to air valves and drain/washout valves along transmission mains have been sometimes found out when the FCTWB does maintenance.

In distribution network, illegal connection or tampering, for example, bypass connection by customer to avoid meter-read consumption or direct connection by non-customer, is identified as unauthorized

consumption in FCTWB. Nevertheless, efficient countermeasures have not been taken systematically and actively. Track record of billed consumption and numbers of customers are useful to identify irregularity.

Moreover, customers of flat-rate, AMR meter and prepaid meter are not monitored physically due to their conditions or product features, which may lead to illegal connection or tampering.

f. Customer Metering Inaccuracies and Data Handling Errors

FCTWB does not have only equipment or laboratory to test customer meters but also meter standardization. Particularly, the deteriorated meters which gets worse in accuracy, are supposed to be replaced with new ones by Metering Unit, but replacement has not been regulated in FCTWB. It is generally said that customer metering accuracy differs from meter type and product quality.

Data handling errors may arise in the manual process such as meter reading and writing in memo paper in the field, transcription to reading form in the office and then data entry to billing system.

g. Leakage on Transmission and/or Distribution Mains

FCTWB and Area Offices do not have equipment and skilled staff for leakage detection, and especially Area Offices are not equipped for prompt and smooth repair of leaks due to lack of logistics and material stock.

Pipeline Unit of the Headquarters is in charge of transmission and distribution mains or network of diameter 300mm or more. Whenever obviously-visible considerable leaks and pipe bursts occur along the mains or someone reports, Pipeline Unit repairs them.

Area Offices take care of distribution network of less than diameter 300mm. Same as the above, whenever obviously-visible considerable leaks and pipe bursts occur along the pipelines or someone reports, Area Offices repairs them.

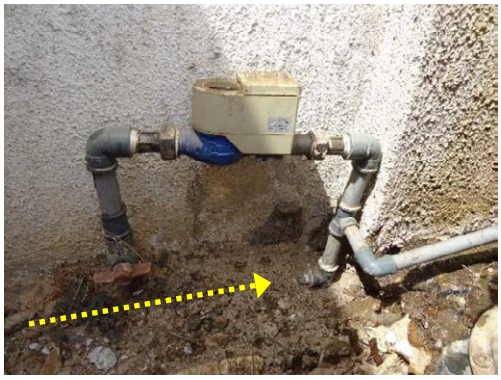
h. Leakage and Overflows at Utility's Storage Tanks

Overflow from clear water tanks of water treatment plants III&IV had been observed frequently, with which FCDA coped by interconnection relocation of outlet pipelines. Some distribution tanks have constant leak which is inconsiderable unless amount of leak is severe.

i. Leakage on Service Connections up to Point of Customer Use

Area Offices in charge of service connections (service pipes from branches along distribution network to water meters) do not have equipment and skilled staff for leakage detection, and they are not equipped for prompt and smooth repair of leaks due to lack of logistics and material stock.

Whenever obviously-visible considerable leaks and pipe bursts occur along the pipelines or someone reports, Area Offices repairs them. However, repair is not always appropriate in quality.



Illegal Bypassing

Leak from Distribution Pipe

Leak from Service Pipe Fittings

Overflow from WaterTreatment Platn III&IV

Figure 3.2-7: Non-Revenue Water of FCTWB

(3) Conduct capacity assessment of the relevant staff of each pilot Area Office (Activity 2-2)

As described below in "Chapter 2 Capacity Assessment and Capacity Development Plan", the Project conducted capacity assessment of the relevant staff of each pilot Area Office. Refer to Chapter 2 and Annex 7.

(4) Identify and select a Pilot Metering Area (PMA) for each pilot Area Office based on the selection criteria of PMA(*3) (Activity 2-3)

Three PMAs were selected for conducting NRW reduction operations in the areas of which three pilot Area Offices of FCTWB are in charge, namely Gudu, Jabi and Garki I.

1) Definition of Pilot Metering Area

Pilot Metering Area (PMA) is defined as District Metered Area (DMA) in the Project, which is a discrete area of distribution networks.

2) Selection of Pilot Metering Areas

The Project created some to-be PMAs prior to selection of a PMA in each pilot Area Offices, then selected three PMAs based on the following criteria shown in Table 3.2-16:

Table 3.2-16: Selection Criteria of PMA

No.	Criteria	Reasons that Criterion were selected	Weighting Factor (%)
1	Safety conditions	To secure safety of the Project Team members and experts in field activities	35
2	Leakage frequency	To secure impact of NRW reduction operations	30
3	Availability of network drawings and data	To secure work efficiency and accuracy of data analysis	15
4	No. of customers	To secure impact of NRW reduction operations	10
5	Ease in flow measurement	To prioritize easy flow measurement	5
6	Customer meter type	To learn the differences among customer meter types	5
Total			100

Source: Project Team

As shown in Table 3.2-17, eight to-be PMAs were scored by the above criteria, and then the one with the highest point in each pilot Area Office was selected as a PMA.

Table 3.2-17: Results of Scoring and Selection of PMAs

To-be-PMAs		Safety Conditions			Leakage Frequency			Availability of Network Drawing and Data			No. of Customers			Ease in Flow Measurement			Customer Meter Type			Total Score
		A	-		B	-		C	-		-	D		-	E		-	F		
		Difficulty in NRW Reduction Operations	Score	Weighting Factor (x 35%)	Leakage	Score	Weighting Factor (x 30%)	Existing Drawings and Data	Score	Weighting Factor (x 15%)	Total No. of Customers	Score	Weighting Factor (x 10%)	No. of Inlets and Outlets	Score	Weighting Factor (x 5%)	No. of Customer Meters Pre-paid for Gudu Mechanical for Jabi AMR for Garki I	Score	Weighting Factor (x 5%)	
Gudu																				
1	Hot FM	3	3	1.05	1	1	0.30	1	1	0.15	593	1	0.10	1	3	0.15	450	1	0.05	**1.80**
2	Adis Estate & Legislator	2	2	0.70	1	1	0.30	2	2	0.30	1,092	3	0.30	2	2	0.10	450	1	0.05	**1.75**
3	Prince & Princess	3	3	1.05	3	3	0.90	2	2	0.30	1,102	3	0.30	1	3	0.15	750	3	0.15	**2.85**
4	Games Village	3	3	1.05	1	1	0.30	2	2	0.30	665	1	0.10	2	2	0.10	665	2	0.10	**1.95**
Jabi																				
1	Jabi (the whole area)	3	3	1.05	2	2	0.60	2	2	0.30	862	1	0.10	2	2	0.10	-	3	0.15	**2.30**
2	-																			
3	-																			
Garki I																				
1	Area 1 & 2-1	2	2	0.70	1	1	0.30	3	3	0.45	2,061	2	0.20	1	3	0.15	1,457	3	0.15	**1.95**
2	Area 2-2 & 3 & 7	3	3	1.05	2	2	0.60	3	3	0.45	1,376	3	0.30	2	2	0.10	741	2	0.10	**2.60**
3	Area 8 & 10 & 11	2	2	0.70	2	2	0.60	3	3	0.45	1,215	3	0.30	2	2	0.10	651	1	0.05	**2.20**

Note:
A: Not Serious: 3, Serious: 2, Very Serious: 1
B: Very Serious: 3, Serious: 2, Good: 1
C: Well-existing: 3, Partially Existing: 2, Non-existing: 1
D: 1,000 to 1,500 customers (Based on indexmentioned in RD): 3, More than 1,500 customers: 2, Less than 1,000 customers: 1
E: One Place: 3, Two Places: 2, At Least Three Places: 1
F: Many: 3, Medium: 2, A Few: 1

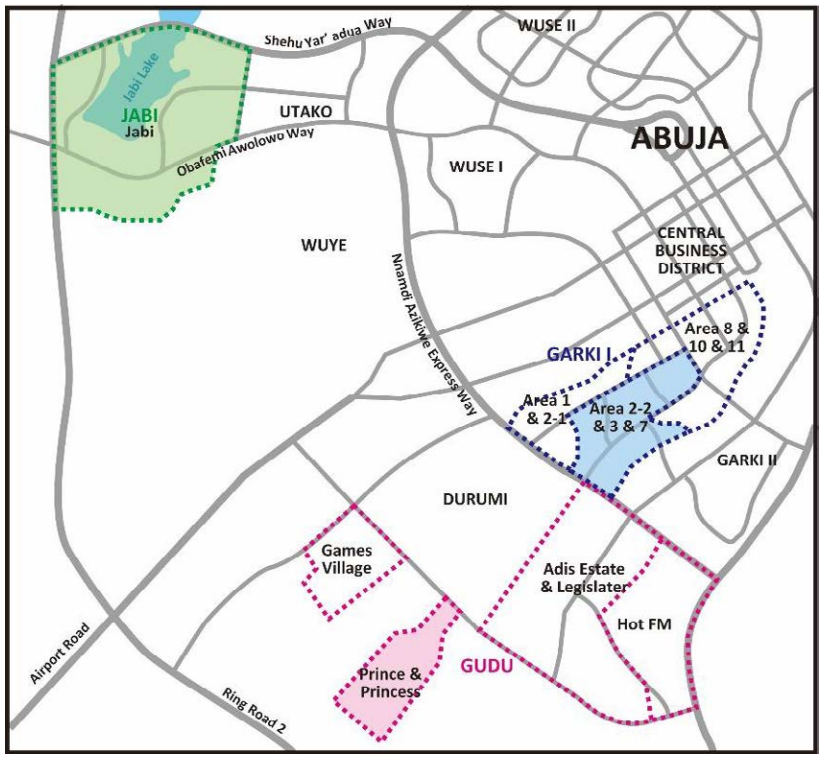
* Major consumers in Area 8 & 11 in Gark -I are not included in the total number of customers.
* A part of Area 8 located in Garki II was included in the light of distribution network configuration.
* Colored areas, which scored the highest point in each pilot Area Office, were selected as PMAs.

Source: Project Team

The selected PMAs are as follows and their locations are shown in Figure 3.2-8.

Selected Three PMAs for Pilot Project

- Gudu Area Office : Prince & Princess
- Jabi Area Office : Jabi (the whole area)
- Garki I Area Office : Area 2-2 & 3 & 7



Source: Project Team

Figure 3.2-8: Location of Pilot Metering Areas

3) Modification of Isolation and Design of PMA

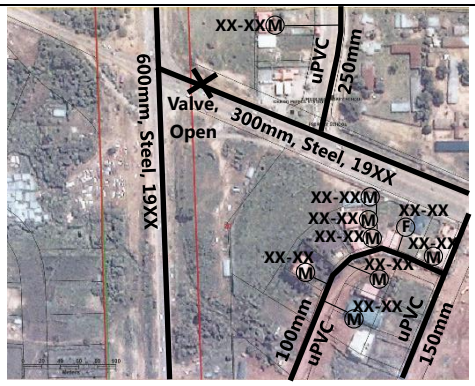
Through field confirmation of actual pipeline route and conditions of distribution networks, location and functionality of isolation valves, the Project was forced to modify isolation and design of PMAs such as installation points of flow-meter.

(5) Prepare/update distribution network drawings for each PMA (Activity 2-4)

For pilot projects in three PMAs, due to defective drawing management, limited GIS development and organizational weakness in GIS, FCTWB does not have any as-built-drawings and GIS base maps of Gudu PMA and Jabi PMA located in the Phase-2 development area. Meanwhile, FCTWB has the existing GIS base map of Garki I PMA located in the Phase-1 development area, but less-accurate data was found out through the activity. Therefore, the Project took the following procedures to prepare and update distribution network drawings:

a. GIS Unit prints out the satellite images of three PMAs from the existing GIS database.
b. Each pilot Area Office makes a sketch of existing distribution network pipelines, valves, fire hydrants etc. and then describes data such as pipe size, material on the satellite images.
c. GIS Unit inputs the obtained sketch and data to the existing GIS database.
d. GIS Unit prints out GIS maps and confirms them with Pipeline Unit and pilot Area Offices.
e. GIS Unit modifies and updates the GIS data.
f. GIS Unit collects the actual positions of valves and fire hydrants, etc. by using GPS terminal in the field.
g. GIS Unit modifies and updates the GIS data.
h. GIS Unit prints out the GIS maps and feeds back them to Pipeline Unit and pilot Area Offices.
i. If any wrong information, changes or additional information, Pipeline Unit and pilot Area Offices share them with GIS Unit.
j. GIS Unit collects the actual positions of them in the field.
k. GIS Unit modifies and updates the GIS data.
l. GIS Unit prints out the GIS maps and feeds back them to Pipeline Unit and pilot Area Offices.
m. GIS Unit, Pipeline Unit and pilot Area Offices repeat 9) to 12).

Satellite Image

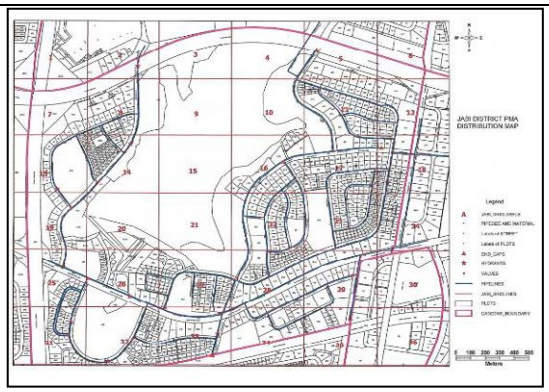


Sketch of Pipeline Information

Sketch from Area Office

Confirmation in Area Office

Field Survey by using GPS Terminal



Completion of GIS Map

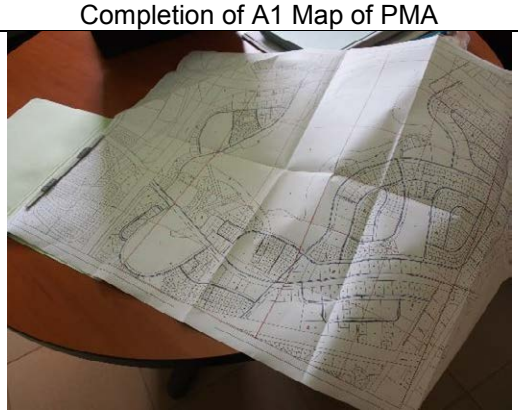
Figure 3.2-9: Activities for GIS Map

Prior to the activity, the JICA Expert Team carried out a series of lectures on GIS to relevant Project Team members of the headquarters and three pilot Area Offices. The lectures include basic concept and convenience of GIS, how to utilize GIS and introduction of the case of Yokohama Waterworks Bureau such as map book and mapping system by using video data as an effective training tool to promote much more practical understating of GIS.

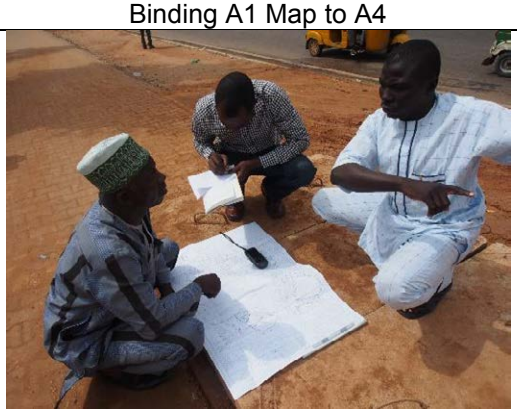
Through discussions among the Project Team members, the grid system of 1,000m x 1,000m covering the whole water supply system of FCTWB was newly created (Minna Geodetic Datum, Printing Scale: 1/2,000 in A1 paper) and preparation of "Pipeline Map Book" was proposed (2,000m x 3,000m, Printing Scale: 1/10,000 in A3 paper) in consideration for practicality. The created A1 maps were bound to A4, carried to the sites and will have been utilized for site survey, etc.

Completion of A1 Map of PMA

Binding A1 Map to A4



A1 Index Map



On-site Utilization of A1 Map

Figure 3.2-10: A1 Maps

In addition, in order to enhance practical ability of GIS-related staff of FCTWB, the Project conducted GIS training covering introduction to GIS, basics of software "GeoMedia Essentials" and "ArcGIS" by local company outsourced by the JICA Expert Team in Abuja for seven working days from 23rd November to 1st December 2015 (refer to Section 3.1.1 (7)).

Drawings of three (3) PMAs were prepared and have been updated as a trial case of Pipeline Map Book of FCTWB. Issue of AGIS security, which has hindered data import/export, sharing and analysis, was taken to Permanent Secretary of FCTA and then both AGIS and FCTWB started communication at the working level to solve the issue.

For the extension of activities in PMAs to the whole area of FCTWB, GIS Unit started the process of 'a.' to 'm.' above for all Area Offices. Satellite images of the whole areas of FCTWB were prepared for each Area Office and making a sketch of pipeline information were requested to them, successively submitted from some Area Offices and the input work to GIS is progressing.

(6) Design and create PMA/SMAs. (Activity 2-5, 2-6, 2-7 and 2-8)

1) Common Concept and Methodology among Three PMAs and SMAs

This section covers the following activities:

- Design PMA and SMAs for pilot project implementation.
- Install water flow-meters to each PMA and measure in/outflows monthly. (Activity 2-5)
- Zone each PMA into Sub Metering Areas (SMA). (Activity 2-6)
- Isolate a SMA by installing valves. (Activity 2-7)
- Update the distribution network drawings for each SMA. (Activity 2-8)

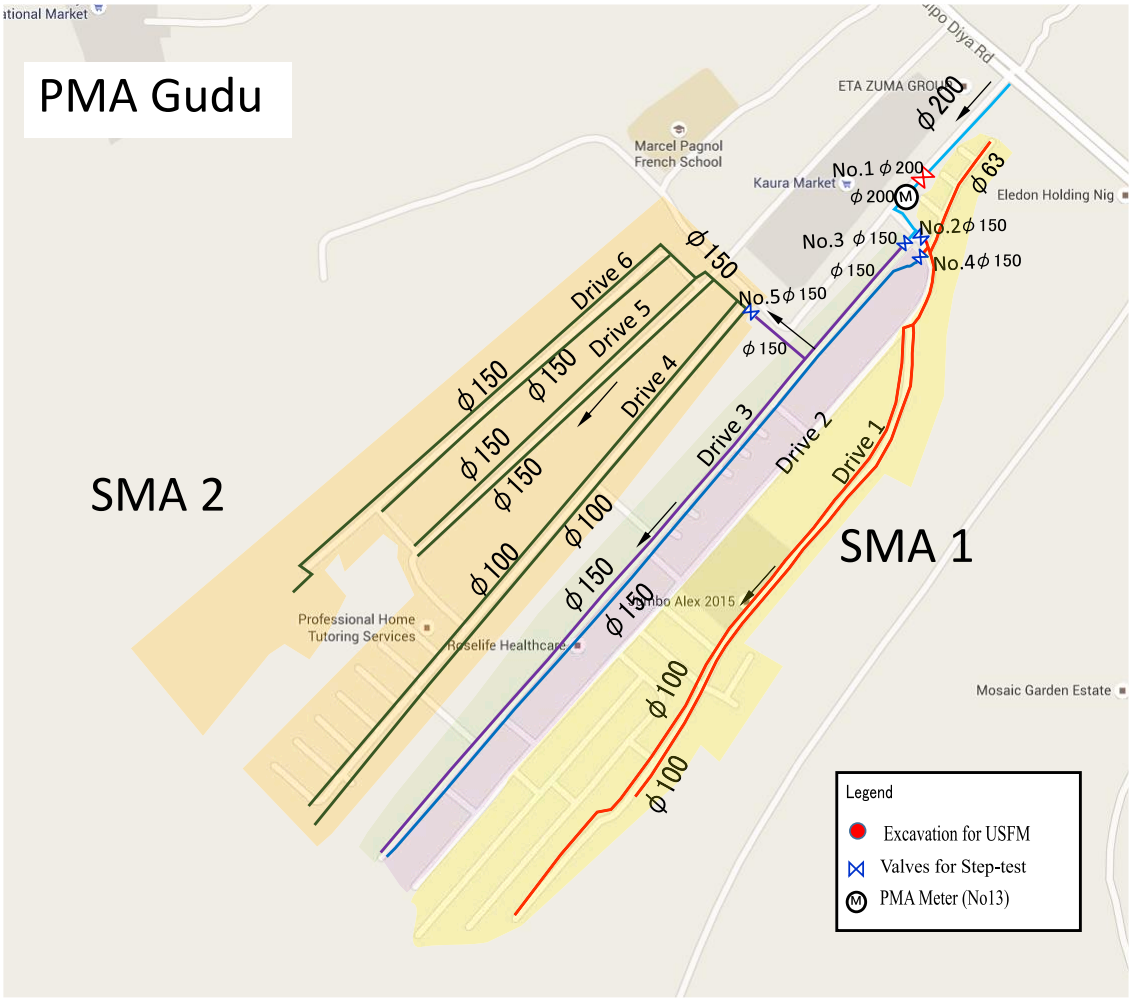
PMA/SMAs in three pilot Area Offices were designed and created as follows:

- Preferably, each PMA has one water inlet point and no outlet points. If any multiple inlet points exist, those points except for one are expected to be closed permanently. If any outlet points exist and they cannot be closed, outlet flow-meter is installed in addition to inlet flow-meter as PMA meters.
- PMA is divided into several, for example two to four SMAs according to scale of the PMA, distribution network configuration and location of valves.
- Chamber for PMA meter should have enough space to set a portable ultrasonic flow-meter.
- A valve is supposed to exist or be installed with chamber having enough space to set a portable ultrasonic flow-meter at an inlet point of each SMA. If any difficulties, pipeline at the point should be exposed for temporary measurement.
- If it is impossible to close the outlet point of SMA as an inlet point to outside of PMA, a flow-meter should be installed and read. And chamber having enough space to set a portable ultrasonic flow-meter should be constructed. If any difficulties, pipeline at the point should be exposed for temporary measurement.

2) Design and Creation of Gudu PMA/SMAs

- There are six main streets called Drive in Gudu PMA “Prince & Princess” and two pipelines are laid in parallel along the both sides of Drives 1, 3, 4, 5 and 6. No pipelines are laid in Drive 2. Therefore, houses along Drive 2 get water from pipelines laid in Drives 1 and 3, but it is not clear which houses get water from either pipeline of Drive 1 or one of Drive 3.
- Therefore, Drives 1, 2 and 3 were allocated as SMA 1, meanwhile Drives 4, 5 and 6 were allocated as SMA 2.
- There were an existing flow-meter and a valve at the inlet point of PMA, but the flow-meter was malfunctioning. Hence, the Project procured mechanical flow-meter (200mm) and its fittings, then replaced the malfunctioning one (No.1) by the newly-procured one.
- Also, the Project procured and replaced No.2, No.3 and No.5 valves and their fittings (150mm) to create (isolate) SMAs.

Figure 3.2-11 shows Gudu PMA (Prince & Princess) and SMAs.



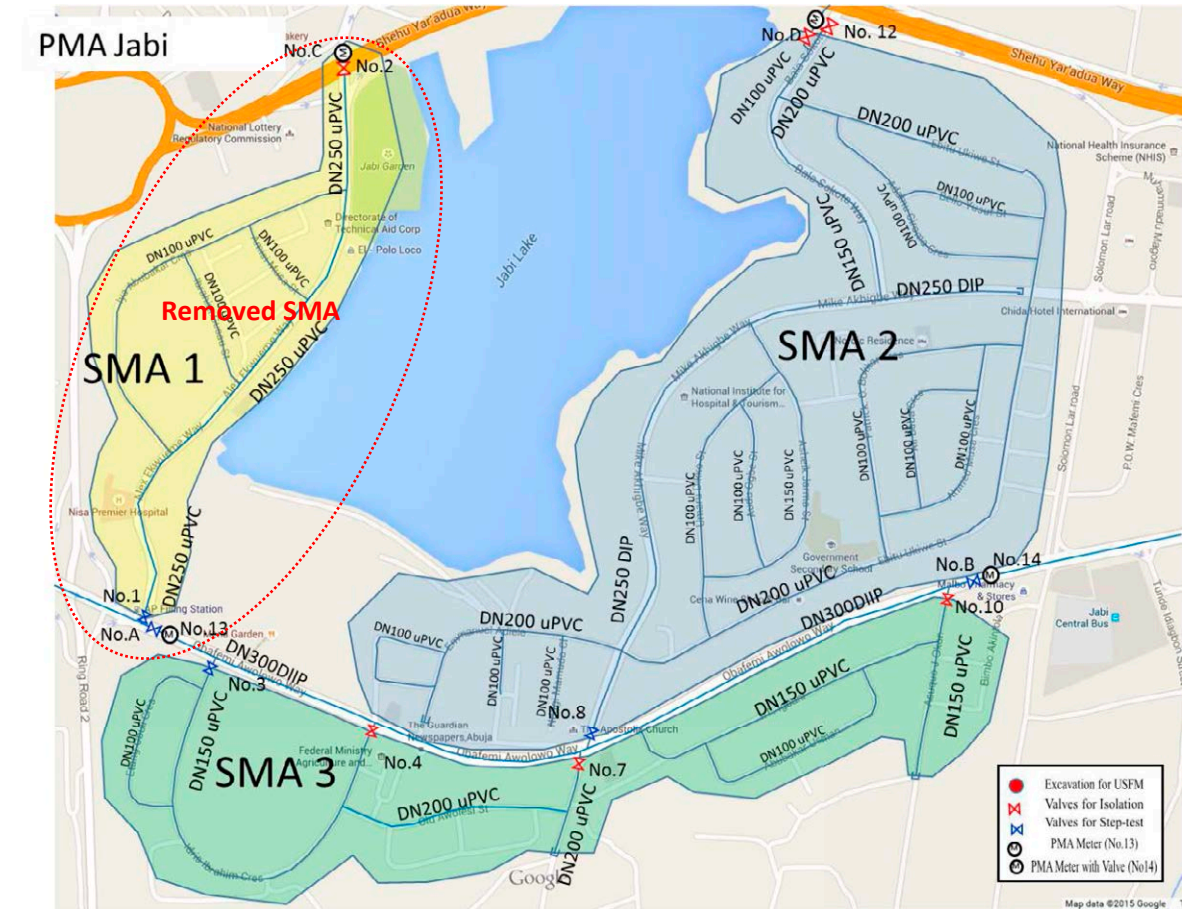
Source: Project Team

Figure 3.2-11: Gudu PMA (Prince & Princess) and SMAs

3) Design and Creation of Jabi PMA/SMAs

- There are three SMAs surrounding Jabi Lake. North-west area is SMA 1, north-east area is SMA 2 and south area along Ohafemi Awolowo Way is SMA 3.
- A PMA meter at the inlet point was supposed to be installed in the upstream side of the branch to SMA 1 by the original design based on information of FCTWB, but actually it was installed in the downstream side. The Project was forced to change the location because depth of existing pipe at the original inlet point was deeper than one recognized by FCTWB and there are no alternative locations because of underground obstacles to retain concept of the original design. Then, SMA 1 became the area outside of monitoring of water flow into PMA in terms of network configuration.
- As a result of the 4th JCC meeting, SMA 1 was officially removed in order to avoid further delay of the Project activities (Activity 2-8 to 2-16).
- The Project procured two mechanical flow-meters as PMA meters at No.13 for inflow and No. 14 for outflow.
- In addition, the Project procured valves for isolation at No. B, No. C, No. 1 and No. 2.

Figure 3.1-12 shows Jabi PMA and SMAs.



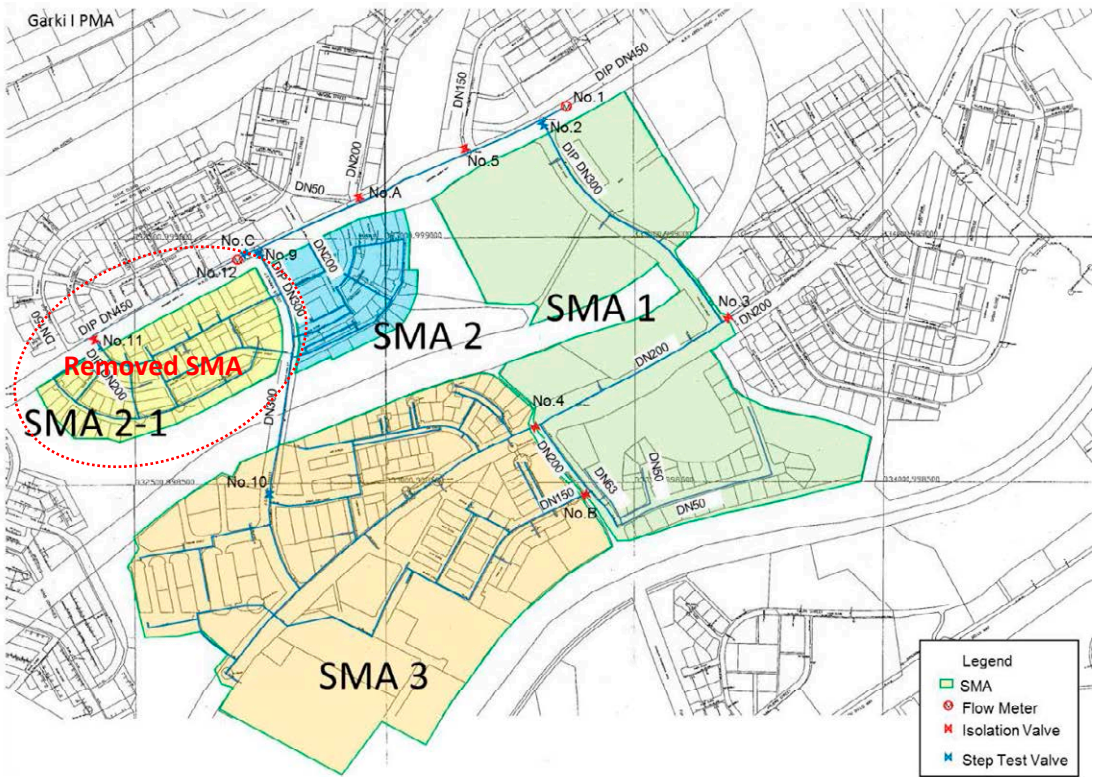
Source: Project Team

Figure 3.2-12: Jabi PMA and SMAs

4) Design and Creation of Garki I PMA/SMAs

- The area along both J. S. Tarkar Street and Tafa Balewa Way across creek is SMA 1. The area along J. S. Tarkar Street and located in the north side of creek is SMA 2. The area along Tafa Balewa Way and located in the south side of creek is SMA 3.
- SMA 2 was originally designed based on information from FCTWB that water flows into SMA 2 from J. S. Tarkar Street by closing isolation vale at No.11. However, the Project found out it impossible because of discrepancy in actual water flow between one recognized by FCTWB at design stage and another confirmed during installation of flow-meter and valves, and there are no alternative ways to retain concept of the original design. Therefore, the western part of SMA 2 "SMA 2-1" separated from PMA, that is, SMA 2-1 supplied from the branch at No.11 became out of monitoring of water flow into PMA.
- As a result of the 4th JCC meeting, SMA 2-1 was officially removed in order to avoid further delay of the Project activities (Activity 2-8 to 2-16).
- The Project procured an ultrasonic flow-meter and a mechanical flow-meter as PMA meters for No.1 for inflow and No.12 for outflow. As of October 2016, the ultrasonic flow-meter at No.1 has not been installed yet, because delay in electrical works to be done soon.
- Also, the Project procured valves for isolation at No.2, No.3, No.4, No.5, No.9, No.10, No.11 and No.E.

Figure 3.2-13 shows Garki I PMA (Area 2-2 & 3 & 7) and SMAs.



Source: Project Team

Figure 3.2-13: Garki I PMA (Area 2-2 & 3 & 7) and SMAs

(7) Prepare customer list in PMA/SMAs.

The Project collected customer information from relevant Units of the FCTWB Headquarters and each pilot Area Office and prepared customer list prior to implementation of NRW reduction operations. Complication or over-segmentation in customer categories, meter types, Units and Area offices in charge, billing systems, limited capability of the systems and discrepancy of customer information have made it difficult for the Project to organize customer data. Also, unbilled authorized customer including FCTWB, staff quarters and other Government authorities exist in PMA/SMAs, of which consumption should be measured.

1) Customer List of Gudu PMA/SMAs

Table 3.2-18 shows customer list of Gudu PMA/SMAs. This list excluded expecting no water supply from FCTWB, such as users of borehole, vacant houses, disconnected houses, meter removed hoses etc. Most of customers have prepaid meter and some conventional meter exist.

Table 3.2-18: Customer List of Gudu PMA/SMAs

Category	Meter Type	SMA 1	SMA 2	Total	Remarks
Domestic Customer	Conventional	29	35	**64**	
	Flat-Rate	17	40	**57**	
	AMR	0	0	**0**	
	Prepaid	408	235	**643**	
	Unknown	1	5	**6**	
	Sub-Total	**455**	**315**	**770**	
Commercial Customer	Conventional	4	0	**4**	
	Flat-Rate	0	0	**0**	
	AMR	0	0	**0**	
	Prepaid	7	1	**8**	
	Unknown	0	1	**1**	
	Sub-Total	**11**	**2**	**13**	
Major Consumers	Conventional	0	0	**0**	
	Flat-Rate	0	1	**1**	
	AMR	0	0	**0**	
	Prepaid	0	0	**0**	
	Unknown	0	0	**0**	
	Sub-Total	**0**	**1**	**1**	
Total		**466**	**318**	**784**	

Source: Project Team

2) Customer List of Jabi PMA/SMAs

Table 3.2-19 shows customer list of Jabi PMA/SMAs. Most of customers have conventional meter and some major consumers exist.

Table 3.2-19: Customer List of Jabi PMA/SMAs

Category	Meter Type	SMA 1	SMA 2	SMA 3	Total	Remarks
Domestic Customer	Conventional	-	357	178	**535**	
	Flat-Rate	-	5	0	**5**	
	AMR	-	0	0	**0**	
	Prepaid	-	0	0	**0**	
	Unknown	-	0	0	**0**	
	Sub-Total	**-**	**362**	**178**	**540**	
Commercial Customer	Conventional	-	14	18	**32**	
	Flat-Rate	-	1	0	**1**	
	AMR	-	0	0	**0**	
	Prepaid	-	0	0	**0**	
	Unknown	-	0	0	**0**	
	Sub-Total	**-**	**15**	**18**	**33**	
Major Consumers	Conventional	-	8	8	**16**	Except Borehole customer
	Flat-Rate	-	9	6	**15**	
	AMR	-	0	0	**0**	
	Prepaid	-	0	0	**0**	
	Sub-Total	**-**	**17**	**14**	**31**	
Total		**-**	**394**	**210**	**604**	

Source: Project Team

Note: SMA 1 was removed from PMA due to reposition of a PMA inflow meter, so the figures of SMA 1 are not included in the total of PMA.

3) Customer List of Garki I PMA/SMAs

Table 3.2-20 shows customer list of Garki I PMA/SMAs. Most of customers have AMR meter and some major consumers exist. Due to existing of faulty meters, there are many flat rate customers.

Table 3.2-20: Customer List of Garki I PMA/SMAs

Category	Meter Type	SMA 1	SMA 2	SMA 3	Total	Remarks
Domestic Customer	Conventional	0	30	17	**47**	
	Flat-Rate	14	24	65	**103**	
	AMR	12	88	139	**239**	
	Prepaid	0	0	0	**0**	
	Unknown	0	0	0	**0**	
	Sub-Total	**26**	**142**	**221**	**389**	
Commercial Customer	Conventional	0	0	4	**4**	
	Flat-Rate	2	0	7	**11**	
	AMR	3	0	10	**14**	
	Prepaid	0	0	0	**0**	
	Unknown	0	0	0	**0**	
	Sub-Total	**5**	**3**	**21**	**29**	
Major Consumers	Conventional	1	0	7	**8**	Except Borehole customer
	Flat-Rate	2	0	16	**18**	
	AMR	1	0	7	**8**	
	Prepaid	0	0	0	**0**	
	Unknown	0	0	0	**0**	
	Sub-Total	**4**	**0**	**30**	**33**	
Total		**35**	**145**	**272**	**452**	

Source: Project Team
Note: SMA 2 was lessened due to reposition of a PMA flow-meter.

(8) Conduct baseline survey/analysis of NRW in PMA/SMAs (Activity 2-9 and 2-10)

This section covers the following activities:

- Measure an initial level of NRW of each SMA. (Activity 2-9)

  * From the beginning of the pilot project, schedule had been delayed as a result of survey on water consumption of customer because of complexity of category on customer, meter types, billing system, water tariff, meter reading system and flat rate as well as automated estimate billing, moreover inaccessible meters.
  After taking unexpected time, step test, meter error test, 24hrs flow measurement, MNF survey and meter reading were completed. However, unexpected results of MNF survey, particularly certain volume of flow in the midnight, still brought confusion during conducting countermeasures and ex-post NRW ratio calculation. The Project also implemented 24hrs customer consumption survey and unbilled authorized customer listing.

- Detect target NRW components (i.e. invisible leakage, customer meter malfunction, and illegal connection) of each SMA. (Activity 2-10)

1) Baseline Items and Survey Methods

The Project surveys the following items for NRW reduction in PMA/SMAs. Table 3.2-21 shows the items and survey methods.

Table 3.2-21: Baseline Items and Survey Methods

Baseline Item	Category in Water Balance Sheet	Survey Methods	Team
Water inflow	System Input Volume	a. 24hrs measurement of water inflow to PMA and SMA	- Distribution
Revenue water	Billed Authorized Consumption	b. 1-week customer meter reading	- Commerce
Excess use by flat-rate customers or major consumers	Unbilled authorized consumption	c. Temporary installation of customer meter and reading (sampling). * Major customer's consumption was estimated from consumption of same category and scale of facility customer which could get actual water consumption by 24hrs flow volume measurement.	- Distribution & Commerce - Distribution
Illegal connection or tampering	Commercial loss	d. Survey on customers having irregular consumption identified by track record of monthly consumption, e. Acoustic check with opening/closing stop cocks or valves	- Commerce - Distribution
Customer metering inaccuracies	Commercial loss	f. Customer meter error test (sampling)	- Distribution
Leakage on distribution networks and service connections	Physical loss	g. Minimum night flow measurement, h. Step test (area)	- Distribution - Distribution
Consumption pattern of customers or major consumers (both billed or unbilled)	-	i. 24hrs consumption measurement (sampling)	- Distribution

Source: Project Team

a. 24hours Measurement of Water Inflow to PMA and SMAs

After confirmation of isolation, the Project installs some ultrasonic flow-meter(s) at inlet/outlet point and measures water flow for 24 hours to calculate one-day water inflow to a PMA.

Ultrasonic Flow-meter

Installation on Pipeline

Figure 3.2-14: Ultrasonic Flow Meter

b. 1-week or longer, Customer Meter Reading

The Project reads all existing customer meters which is inside PMA/SMAs in one-week period to

calculate presumptively-billed one-day consumption in PMA/SMAs.

c. Temporary Installation of Customer Meter and Reading (Sampling)

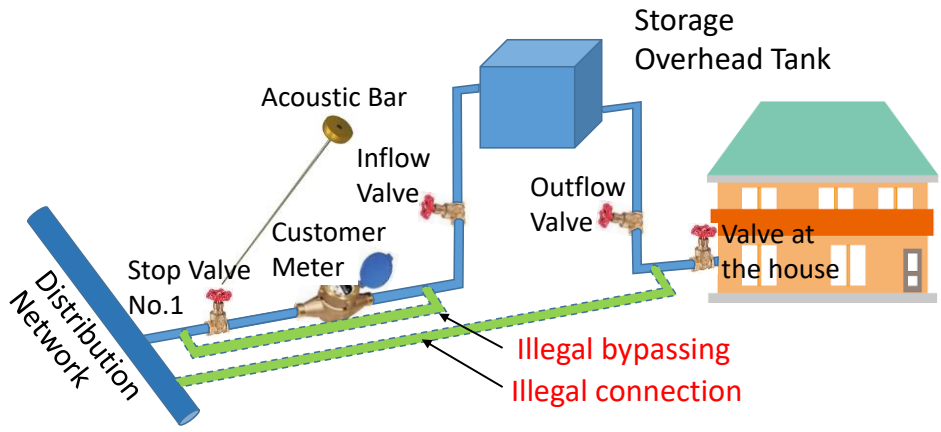
The Project samples 10 to 15 from existing flat-rate/unmetered customers or major consumers in each PMA/SMAs and installs temporary customer meters, then reads the meters in one-week period to calculate one-day excess use by them in each PMA/SMAs by comparison to their water consumption based on the formula dividing flat-rate by N80/m^3 for domestic or N150/m^3 commercial.

d. Survey on Customers having Irregular Consumption

The Project collects track record of monthly consumption of all metered customers or major consumers in each PMA/SMAs and identifies irregular consumption such as relatively-low and unstable cases, then makes the following survey to detect illegal connections.

e. Acoustic Check with Opening/Closing Stop Cocks or Valves

In principle, according to a result of the above survey, the Project conducts acoustic check by using acoustic stick with opening or closing existing stop cocks or valves to detect illegal connections or tampering. This acoustic check can be done together with leak detection on service connections. Figure 3.2-15 shows method of detection of illegal connections by acoustic check.



i. Look around customer meter to find unusual pipelines
ii. Shut stop valve No. 1
iii. Confirm the pilot on customer meter doesn't move
iv. Shut outflow valve
v. Listen sound at stop valve No. 1 by using acoustic bar
vi. If any water flow sound, shut inflow valve
vii. Listen sound at stop valve No. 1
viii. If no water flow sound, there may be an bypass
ix. Shut valve at the house
x. Listen sound at stop valve No. 1
xi. If no water flow sound, there may be an illegal connection

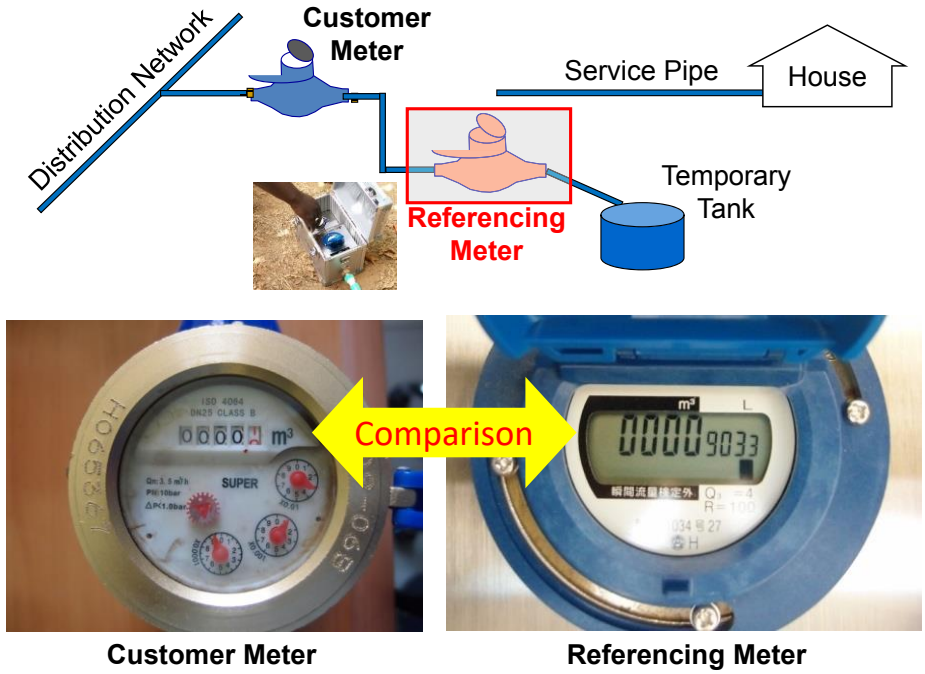
Source: Project Team

Figure 3.2-15: Method of Detection of Illegal Connections by Acoustic Check

f. Customer Meter Error Test (Sampling)

The Project randomly samples totally about 300 meters from existing metered customers or major consumers in PMAs and installs referencing meter next to each customer meter, then tests and calculates inaccuracy of the customer meter. Figure 3.2-16 shows method of customer meter error test.

However, information to be recorded at the same time of meter error test, such as meter diameter, type, product year, installation year and manufacturer were not enough to do statistical analysis.



Source: Project Team

Figure 3.2-16: Method of Customer Meter Error Test

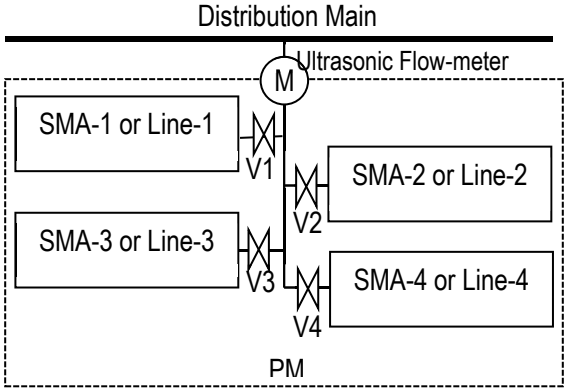
g. Minimum Night Flow Measurement

According to the result of 24 hours measurement of water inflow to PMA, the Project can find out the minimum night flow and its time. NRW components are usually analyzed on the assumption that the minimum night flow is regarded as total volume of leakage. However, this assumption does not apply to the Project because customers may consume water including water storage at private overhead tank during nighttime hours and also someone may consume water illegally. Therefore, the Project cannot regard the minimum night flow as leakage unless consumption pattern of customers or major consumers as well as detection of illegal connections is conducted.

h. Step Test (Area)

Although the minimum night flow may not be regarded as leakage, to narrow down "from area to smaller-area or line" or prioritize SMAs and pipelines in necessary to be targeted for leak detection, the Project conducts step test using ultrasonic flow-meter by closing/opening valves stepwise at the minimum night flow time. Figure 3.2-17 shows procedures of step test.

- Open the valve V1, close the valves V-2, 3 and 4. The flow measured by flow-meter becomes water flow into SMA-1 or Line-1.
- Open the valve V2. The balance subtracting water flow into SMA-1 or Line-1 from the flow measured by flow-meter becomes water flow into SMA-2 or Line-2.
- Open the valve V3. The balance subtracting water flow into SMA-1&2 or Line-1&2 from the flow measured by flow-meter becomes water flow into SMA-3 or Line-3.
- Open the valve V4. The balance subtracting water flow into SMA-1&2&3 or Line-1&2&3 from the flow measured by flow-meter becomes water flow into SMA-4 or Line-4.



Source: Project Team

Figure 3.2-17: Procedures of Step Test

i. 24hrs Consumption Measurement (Sampling)

The Project sampled 20 from existing domestic customers or major consumers (billed and unbilled) in each PMA/SMAs and installs ultrasonic flowmeter, then measured water flow volume for 24hrs to understand their consumption pattern. Results are shown on chapters of each PMA.

j. Estimation of Major Customer Water Consumption by Customer Category

The Project faced difficulty to calculate water consumption of Major customers due to lack of actual meter reading data, also had no data for Unbilled Authorized customers. Therefore, the Project estimated water consumption by a few existing meter reading data and customer's 24hrs flow measurement data that the Project had done. To do estimate water consumption, the Project classified existing meter reading data and customer's 24hrs flow measurement result as scale of a facility, such as number of staffs, students, rooms and beds etc.

Table 3.2-22 shows result of estimated water consumption volume of customers. This estimated volume was reflected in calculations of NRW for each PMA & SMAs on item of "Billed Authorized Consumption" and "Unbilled Authorized Consumption"

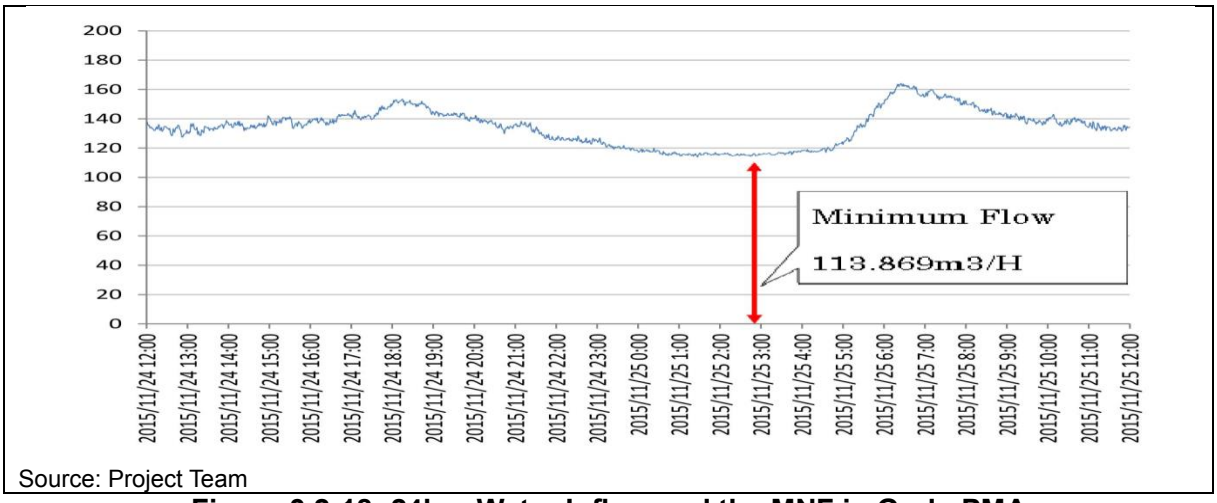
Table 3.2-22: Estimation of Major Customer Consumption

Category I	Category II	Scale unit	Scale	Volume m3/d
1. Ministries, Parastatals, Liaison Offices		Staff	<100	20
			>=100	30
2. Mini-hotels, Restaurants	Restaurant	Table	<20	10
			>=20	30
	Mini-hotel	Room	<30	30
			>=30	50
3. Private school, Hospitals, Clinics	Clinic			5
	Hospital	Bed	<50	10
			>=50	60
	School	Student	<500	30
			>=500	80
4. Cooperate bodies, Financial Institute		Staff	<20	10
			>=20	25
5. Plazas, Petrol Stations	Plaza			15
	Petrol St			10
6. Public Taps, Kiosks	Public tap			5
7. Religious institute		Faithful	<100	5
			>=100	15

2) Baseline Analysis in Gudu PMA/SMAs

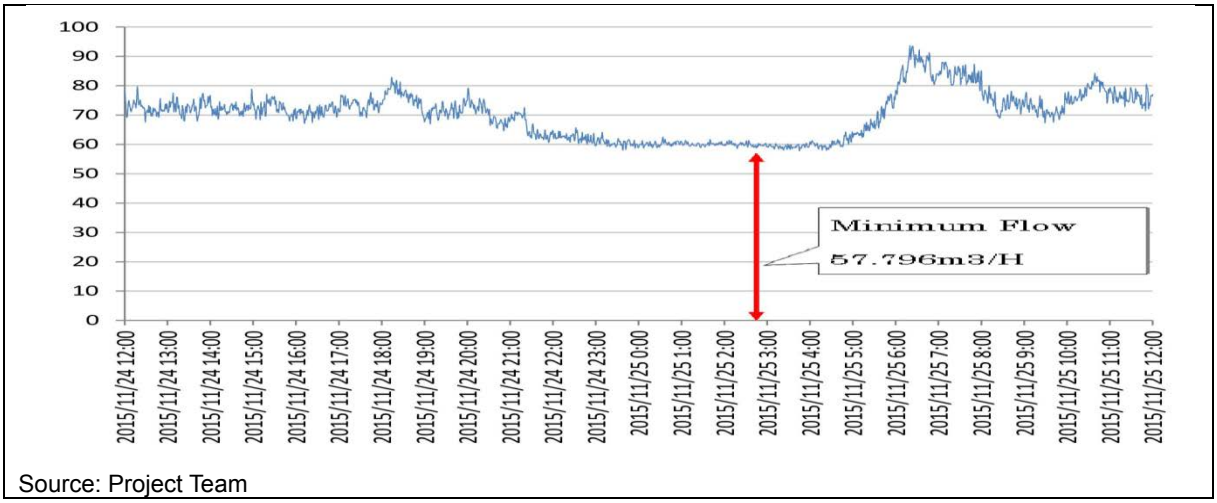
a. 24hrs water flow measurement and MNF

The results of measurement of 24hrs water inflow to PMA/SMAs and the minimum night flow are shown in Figure 3.2-18 to Figure 3.2-20 and Table 3.2-23. The minimum night flow is remarkably high and accounts for 85% of average flow. This means, the Project cannot regard the minimum night flow as leakage and presumes that it includes consumption such as water storage and also illegal use during nighttime hours.



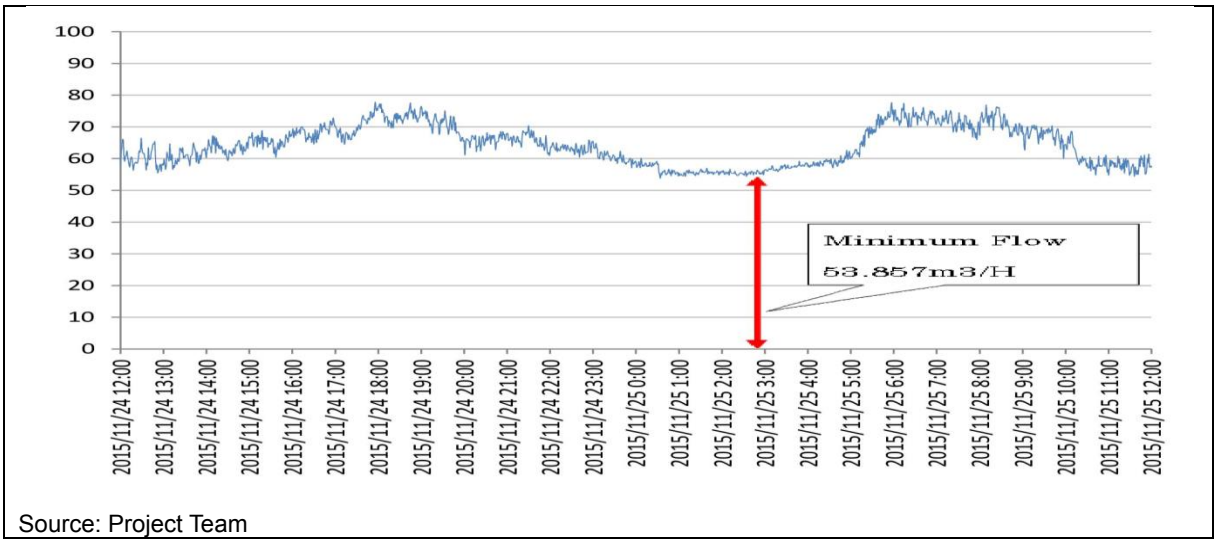
Source: Project Team

Figure 3.2-18: 24hrs Water Inflow and the MNF in Gudu PMA



Source: Project Team

Figure 3.2-19: 24hrs Water Inflow and the MNF in Gudu SMA 1



Source: Project Team

Figure 3.2-20: 24hrs Water Inflow and the MNF in Gudu SMA 2

Table 3.2-23: 24hrs Water Inflow and the MNF in Gudu PMA/SMAs

	Total Inflow (m^3/day)	Average Inflow (m^3/hr)	Minimum Night Flow (m3/hr)	MNF / Average Inflow (%)
PMA	3,216	134	114	85.1%
SMA 1	1,680	70	58	82.9%
SMA 2	1,536	64	54	84.4%

Source: Project Team

b. Customer's 24hrs Consumption Measurement (Sampling)

To find the cause of high percentage of the MNF, the Project conducted a survey regarding filling time for the private storage tank by the 24hrs flow measurement for 20 customers in each PMA. Table 3.2-24 shows a result in Gudu PMA. Against the Project expectation that water flow might be filled in customer storage tanks in midnight, result showed no domestic and commercial customer which obviously filling their tank and average midnight(11PM – 5AM) flow was only 0.0526m3/h and 0.047 m3/h respectively, too little to assume as tank inflow cause the high MNF (0.0526 x 780 households ≒ 40m3/h < 114 m3/h of MNF). However, it is fact that some customers and major customers use water through the night.

It was obvious that most of MNF volume is not considered to be leakage, also it was difficult to assume leakage volume other than the volume that became clear by a result of leakage investigation. Such quantity of water is categorized as an item of water balance analysis in Japan; "Unidentified consumption", however the water balance analysis of has not this kind of category. Consequently the Project classified it to the merged category of "e: Unauthorized Consumption", "g: Leakage on Distribution Network" and "i: Leakage on Service Connections to Point of Customer Use" which exist on the water balance analysis sheet. This classification method was applied to all water balance analysis of baseline stage and ex-post stage.

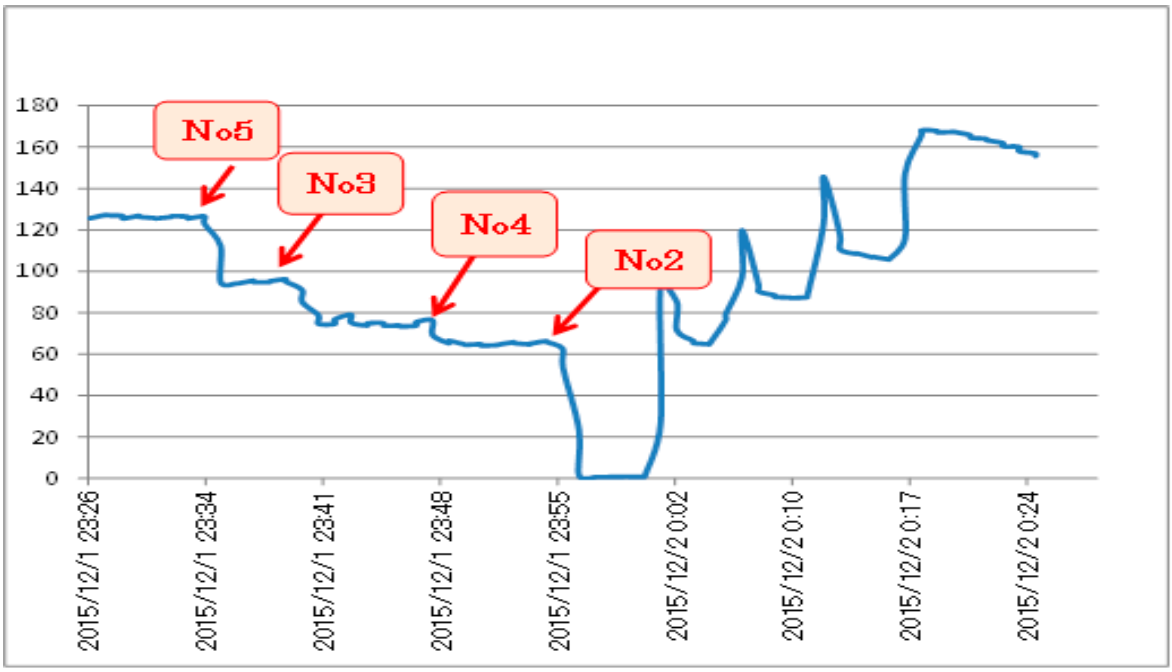
Table 3.2-24: Customer's 24hrs Water Consumption Measurement in Gudu

S/N	Categories		Device No	Name	Plot NO/Drive NO	Meter size (mm)	number of staff, rooms or beds	Midnight average volume m3/h 23:00-5:00	1day Volume m3/d
1	Domestic Pre-paid & Conventional	Domestic Pre-paid	2065	House 18A	Drive 4	25mm		0.038	1.32
2		Domestic Pre-paid	2068	House ID	Drive 4	25mm		0.11	2.92
3		Domestic Pre-paid	2068	74	Driver 6	25mm		0.07	1.78
4		Domestic Pre-paid	2064	River Rima Loadge	Plot 21, Drive 5	25mm		0.08	3.74
5		Domestic Pre-paid	2065	House 40	Drive 5	25mm		0.055	1.48
6		Domestic Pre-paid	2065	House 35, 1st Crest.	Drive 2	25mm		0.03	1.66
7		Domestic Pre-paid	2064	Osays25 DRV6	Drive 6			0.059	2.51
8		Domestic Conventional	2062	House2	Drive2			0.073	1.39
9		Domestic Conventional	2067	'HSE21.3AV	Drive3			0.021	1.18
10		Domestic Pre-paid	2065	13B.DRIVE3	Drive3			0.04	2.22
	Commercia Pre-paid/Conventiona and other institutions				Domestic Midnaight Average			0.0576	
11		Commercial Pre-paid	2066	De-Estate S/Market	Drive 2 C/Shop	25mm		0.04	0.84
12		Commercial Pre-paid	2065	Amnesty Boutique	Drive 1 C/Shop	25mm		0.02	1.24
13		Commercial Conventional	2064	Alnur Laundry	Drive 2 C/Shop	20mm		0.038	0.95
14		Commercial Pre-paid	2064	Ojays Hotel	Plot 23/25, Drive	25mm		0.058	2.64
15		Commercial Conventional	2067	Madam Dish Rest.	Drive 2 C/Shop	20mm		No data	2.5
16		Commercial Conventional	2062	Remmys Laundry	Laundry			0.02	0.72
17		Commercial Pre-paid	2064	Rotex Saloon	Saloon			0.009	0.26
18		School Conventional	2065	Nini Gift Academy	Drive2			0.096	2.3
19		Commercial Pre-paid	2067	Tuti Water	Bottle company			0.1	2.47
					Commercial Midnaight Average			0.047625	
20	Major C3	Private school	2064	British Academy	Drive6	100mm	100 staff	4.7	105.3

Source: Project Team

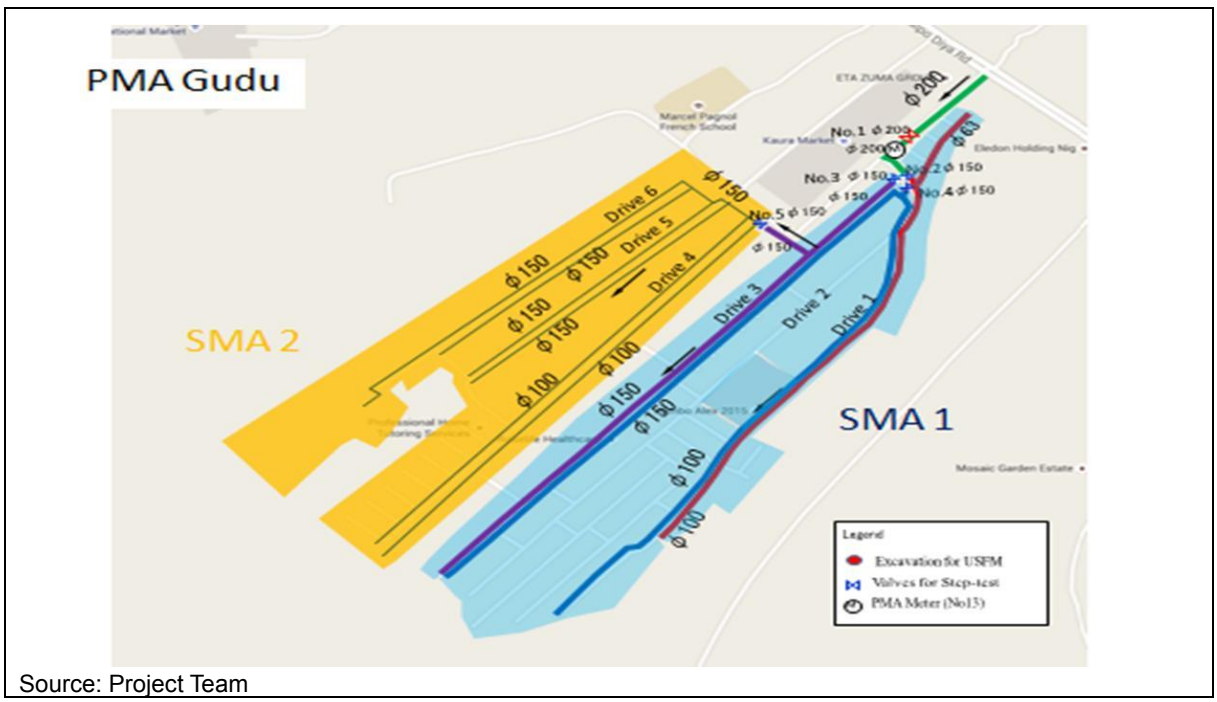
c. Step Test

The Project conducted step test of PMA to prioritize areas and pipelines for leak detection. The results are shown in Figure 3.2-21, Figure 3.2-22 and Table 3.2-25. The Project prioritized SMA 1 over SMA 2, because flow volume of SMA 1 was recorded more than 3 times of SMA2, this implied that possibility of leakage in SMA1 seemed more than SMA2.



Source: Project Team

Figure 3.2-21: Step Test in Gudu SMA 1



Source: Project Team

Figure 3.2-22: Gudu PMA

Table 3.2-25: Step Test in Gudu PMA

Valve Closing	Flow before Closing (m^3/hr)	Flow after Closing (m^3/hr)	Flow into Area and/or Line (m^3/hr)	Measured Area or Drive
-	126.3		-	PMA
No.5	126.3	94.9	31.4	SMA2(Drive4-6)
No.3	94.9	75.1	19.8	SMA1 Drive 3 (west side)
No.4		65.1	10.0	SMA1 Drive 3 (east side)
No.2		0.7	64.4	SMA1 Drive 1 (both sides)

Source: Project Team

d. Customer Meter Error Test

The project carried out customer meter error test and result is shown in Table 3.2-26. In Gudu there are two types of meter, Prepaid and Conventional, total tested meter was 133. Meter accuracy judged error ratio between + (plus) 10% and – (minus) 10% to be available of flow volume compared to test meter figure. Percentage of allowable range of prepaid meter ratio was 77.3%, Conventional type was 63.9% and total tested meter ratio was 74.4%. The error ratio which to be adopted amendment of water volume of metered consumption in water balance analysis sheet was - (minus) 1.5%. This means that the total metered volume should be increased by 1.5% of its volume.

Table 3.2-26: Meter Error Test result of Gudu PMA

GUDU	Prepaid, Conventional			
All	133			
10=>~>=−10%		total	99	74.4%
Number of meters: Out of standard				
>10	17			
<−10	17	total	34	25.6%
Average of total error percentage				
		−1.5%		
Prepaid	88			
10=>~>=−10%		total	68	77.3%
Number of meters: Out of standard				
>10	10			
<−10	10	total	20	22.7%
Convent	36			
10=>~>=−10%		total	23	63.9%
Number of meters: Out of standard				
>10	6			
<−10	7	total	13	36.1%

Source: Project Team

e. Water Balance Analysis

Table 3.2-27 to Table 3.2-29 show result of water balance as baseline. Gudu PMA showed 53.3% of NRW and SMA1, SMA2 showed 52.0%, 53.9% respectively. Water volume of items e, g, I were merged, because it was difficult to identify a leakage volume and illegal connection consumption clearly.

Table 3.2-27: Water Balance of Gudu PMA

Item				m^3/day	%	%
System Input Volume (SIV) 3,216	Authorized Consumption 1,830	Billed Authorized Consumption	a. Billed Metered Consumption	1,414	44.0	**46.7**
			b. Billed Unmetered Consumption	87.4	2.7	
			b. Billed Unmetered Consumption (Excess Use)	224.2	7.0	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-		
			d. Unbilled Unmetered Consumption	104.0	3.2	
	Water Losses 1,386	Commercial Losses	f. Customer Metering Inaccuracies	25.7	0.8	**53.3**
			e. Unauthorized Consumption	1,360.3	42.3	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-28: Water Balance of Gudu SMA 1

Item				m^3/day	%	%
System Input Volume (SIV) 1,680	Authorized Consumption 914	Billed Authorized Consumption	a. Billed Metered Consumption	785.2	46.7	**48.0**
			b. Billed Unmetered Consumption	20.9	1.2	
			b. Billed Unmetered Consumption (Excess Use)	48.2	2.9	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-		
			d. Unbilled Unmetered Consumption	59.4	3.5	
	Water Losses 766	Commercial Losses	f. Customer Metering Inaccuracies	13.2	0.8	**52.0**
			e. Unauthorized Consumption	8.1*	0.5	
		Physical Losses	g. Leakage on Distribution Network	484.0	28.8	
			i. Leakage on Service Connections up to Point of Customer Use			

* Illegal connections were founded in SMA1
Source: Project Team

Table 3.2-29: Water Balance of Gudu SMA 2

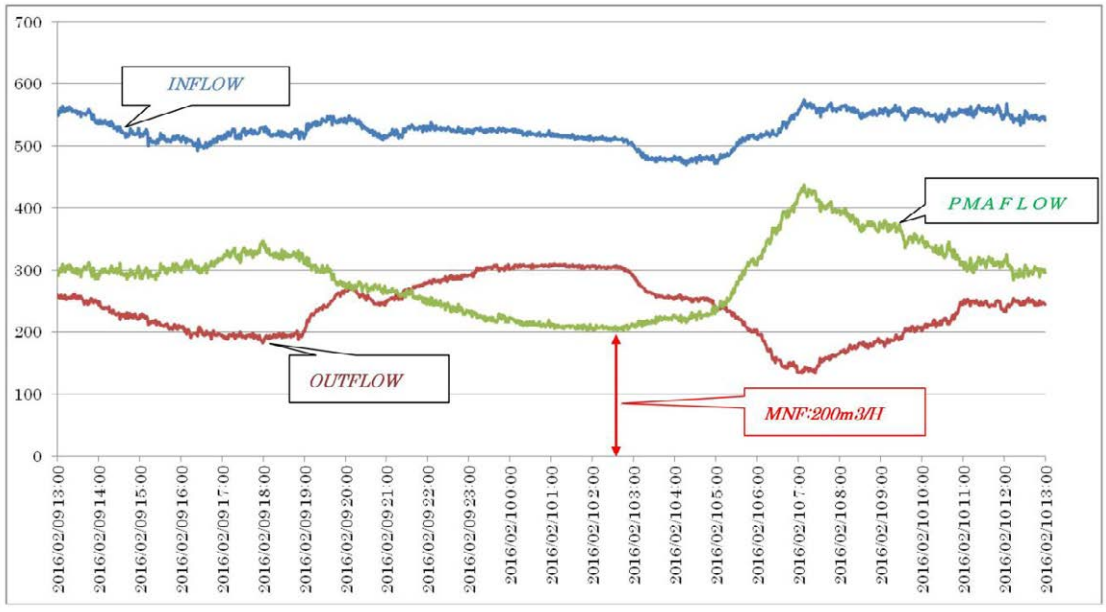
Item				m³/day	%	%
System Input Volume (SIV) 1,536	Authorized Consumption 928	Billed Authorized Consumption	a. Billed Metered Consumption	641.2	41.7	**46.1**
			b. Billed Unmetered Consumption	66.5	4.3	
			b. Billed Unmetered Consumption (Excess Use)	176.0	11.5	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	44.7	2.9	
	Water Losses 608	Commercial Losses	f. Customer Metering Inaccuracies	12.7	0.8	**53.9**
			e. Unauthorized Consumption	594.8	38.7	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

3) Baseline Analysis in Jabi PMA/SMAs

a. 24 hours Water Flow Measurement and MNF

The results of measurement of 24hrs water inflow to PMA and the minimum night flow are shown in Figure 3.2-23 and Table 3.2-30. The minimum night flow is remarkably high and accounts for 69% of average flow. This means, the Project cannot regard the minimum night flow as leakage and presumes that it includes consumption such as water storage and also illegal use during nighttime hours.



Source: Project Team

Figure 3.2-23: 24hrs Water Inflow and the MNF in Jabi PMA (SMA 2&3)

Table 3.2-30: 1st 24hrs Water Inflow and the MNF in Jabi PMA (SMA 2&3)

	Total Inflow (m³/day)	Average Inflow (m³/hr)	Minimum Night Flow (m³/hr)	MNF / Average Inflow (%)
PMA (SMA 2&3)	6,960	290	200	69.0%

Source: Project Team

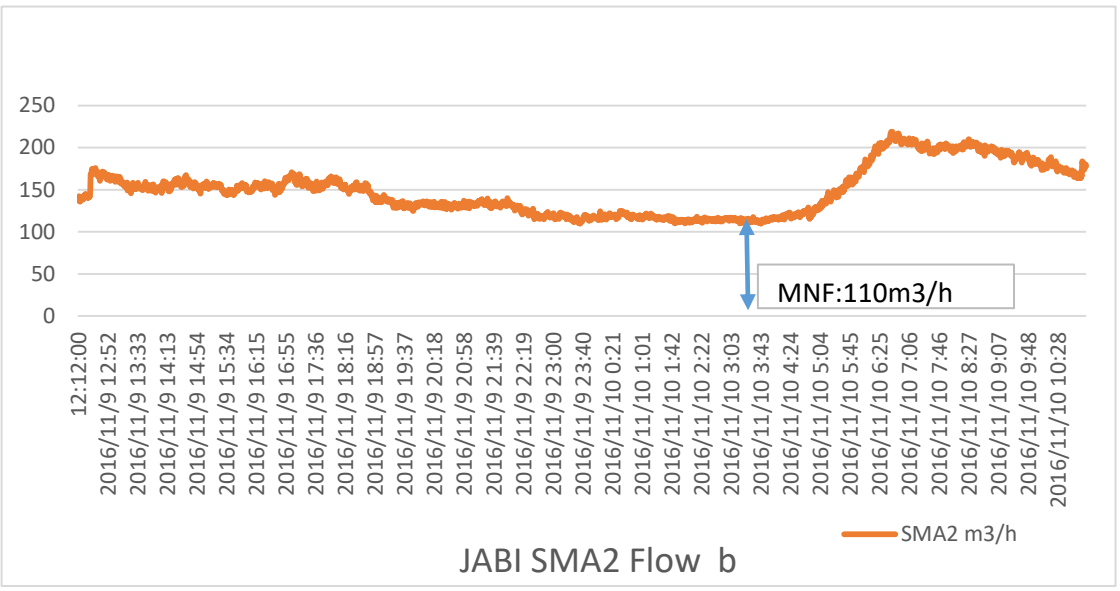
The project conducted second measurement of PMA and SMAs and result are shown Table 3.2-31and SMA2 flow graph is shown in Figure 3.2-24. The MNF was also remarkably high and accounted for 73.8% of average flow.

Consecutive data of 24hrs inflow measurement of PMA and SMA3 were not available, because measurement of outflow volume of PMA was carried out using an existing conventional flow meter.

Table 3.2-31: 2nd 24hrs Water Inflow and the MNF in Jabi PMA (SMA 2&3)

	Total Inflow (m^3/day)	Average Inflow (m^3/hr)	MNF (m^3/hr)	MNF / Average Inflow (%)
PMA (SMA 2&3)	8,445	227	-	73.8%
SMA2	3,572	149	110	-
SMA3	4,873	203	-	-

Source: Project Team



Source: Project Team

Figure 3.2-24: 2nd 24hrs Water Inflow and the MNF in Jabi (SMA 2)

b. Customer's 24hrs Consumption Measurement (Sampling)

Same as Gudu, result of flow measurement of Jabi also showed high percentage of the MNF/AF (Average Flow), the Project conducted a survey regarding flow pattern by the 24hrs flow measurement to find the cause of high ratio of MNW/AF for 25 customers in Jabi and Table 3.2-32 shows a result. The result showed domestic and uncorded commercial (one of the category of domestic user) customer which recorded much use water in midnight, average midnight flow was 0.62m3/h and 0.23 m3/h respectively. Other than Gudu, many customers in Jabi used water even midnight. And major customer recorded high flow volume, average was 1.05m3/h. This result gave a sense to the Project that most of the MNF was consumption of the customers throw their meter, not leakage all.

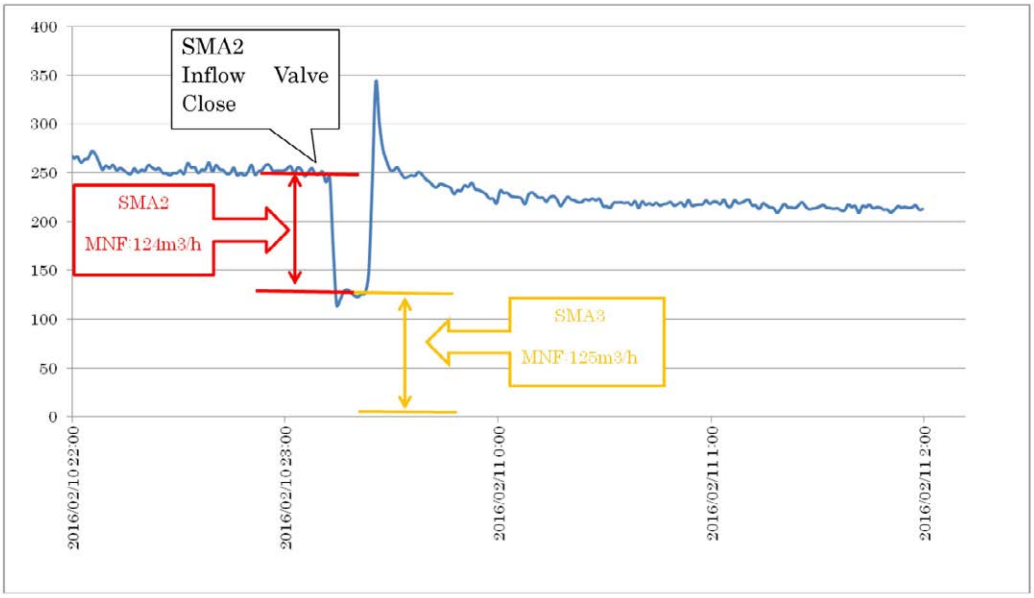
Table 3.2-32: Customer's 24hrs Water Flow Measurement in Jabi

S/N of the List	Categories		Name	Plot No.	Midnight flow (11PM-5AM) m3/h
1	Domestic & Uncorded Commercial customer	Domestic	Mrs. Patricia Fuster	280 Yusuf Bello	3.34
2		Domestic	Harmonic Plaza Residence	B254 A Sheik Jarma	0.18
3		Domestic	MacBas and sons ltd (N0 14)	Plot 187 Ahamed Musa	0.31
4		Domestic	Alh. Ishaku Ibrahim (N0 29)	Plot 180 Ahamed Musa	0.14
5		Domestic	Mr Partel (N0 8, Flat 1)	Plot 170 Ali Baba	
6		Domestic	7 Ethan obulu		0.01
7		Domestic		Plot 405 Ethan Obulu	0.20
8		Domestic		Plot 403, Ethan Obulu	2.87
				Average Domestic	**0.62**
9		Uncorded Commercial (Office)	Faruk Bello Bunza	Plot 466, Alex Ekweme	0.09
10		Uncorded Commercial (Plaza)	Harmonic Plaza	Plot 254, Alex Ekweme	0.23
11		Uncorded Commercial (Hospital)	Nera Hotel		0.01
12		Uncorded Commercial (Restaurant)	Throw Plaza	Piot 520	0.31
13		Uncorded Commercial (Hospital)	Nisa Clinic	Plot 619 Alex Ekweme	0.5
				Average Commercial	**0.23**
14	1	Ministries, Parastatals, Liaison Office	N C D C	Plot 803	0.24
15	2	Mini-hotels	Sandria Hotel	Plot 295	2.57
16		Mini-hotels	Heart Feed Hotel	Plot 383, Ethan Obulu	0.45
17		Mini-hotels	Sub-Hotel	Plot 621 Alex Ekweme	0.96
18		Restaurant	Jovidat Suites	Plot 518,	0.23
				Average hotel & Rest	**1.05**
19	3	Private or Government School	G S S Jabi		2.18
20		Private or Government School	lakeside Academy		0.74
21		Hospitals	Arewa Clinic	Plot 645,	0.06
22		Hospital	Nisa Clinic (2)	618	1.21
				Average P-School & Hosp,	**1.05**
23	4	Cooperate bodies, financial Institute	Toyota Bricoe	Plot 410,	0.09
24	5	Plaza	Jabi Plaza	Plot 92	0.55
25	5	Commercial	Jabi Shoprite		36.3
				Average of Plaza	**18.43**
			Average of much user	Domestic	**0.74**
			Except Shoprite	major	**1.01**

Source: Project Team

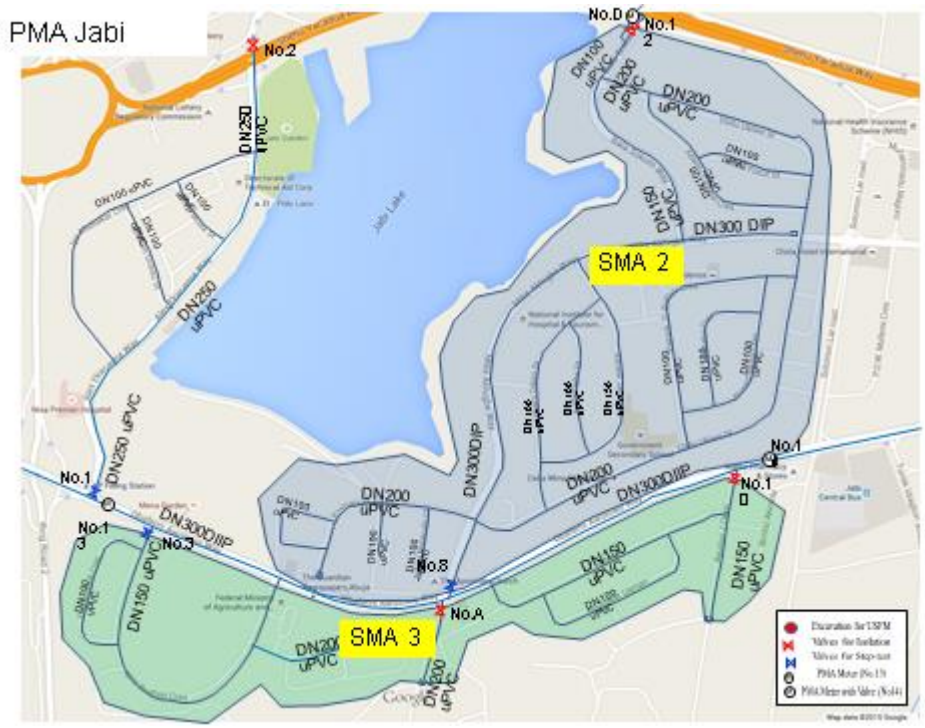
c. Step Test

The project conducted step test of PMA (SMA 2&3) to prioritize areas for leak detection. The results are shown in Figure 3.2-25. Water inflows for each SMA seem to be almost same, but the Project prioritized SMA 2 over SMA 3, because SMA 2 had more number of customer than SMA3 and possibility of leakage also seemed more.



Source: Project Team

Figure 3.2-25: Step Test in Jabi PMA (SMA 2&3)



Source: Project Team

Figure 3.2-26: Jabi PMA

Table 3.2-33: Step Test in Jabi PMA (SMA 2&3)

Valve Closing	Flow before Closing (m^3/hr)	Flow after Closing (m^3/hr)	Flow into Area and/or Line (m^3/hr)	Area	Street (Line)
-	249.0	249.0	-	SMA 2&3	All
No.8	249.0	125.0	124.0	SMA 2	All in SMA 2
-	125.0	125.0	125.0	SMA 3	All in SMA 3

Source: Project Team

d. Customer Meter Error Test

Result of customer meter error test is shown in Table 3.2-34. It appeared that many meters were inaccurate, 91 meters out of 125 (72.8%) meters were out of accurate level of error ratio less than equal plus or minus 10%. Therefore, the Project decided all meters should be replaced in Jabi PMA. Total numbers of replacing meters were about 600. The error ratio which to be adopted amendment of water volume of metered consumption was 11.9%. This means that the total metered volume should be decreased by 11.9% of its volume.

Table 3.2-34: Meter Error Test result of Jabi PMA

JABI	Conventional			
All	125			
10=>~>=-10%		total	34	27.2%
Number of meters: Out of standard				
>10	36			
<-10	55	total	91	72.8%
Average of total error percentage				
		11.9%		

Source: Project Team

Table 3.2-35 to Table 3.2-37 show result of water balance as baseline. Jabi PMA showed 70.0% of NRW and SMA2, SMA3 showed 45.6%, 87.6% respectively. NRW ratio of SMA3 was very high, however reasons of this was not clear. Items of e, g, I were not clear because of no data and lack of record. Data of measurement for water balance analysis was logged on the day different from the day of step test.

Table 3.2-35: Water Balance of Jabi PMA

Item				m^3/day	%	%
System Input Volume (SIV) 8,445	Authorized Consumption 2,808	Billed Authorized Consumption	a. Billed Metered Consumption	2,327.8	27.6	**30.0**
			b. Billed Unmetered Consumption	204.0	2.4	
			b. Billed Unmetered Consumption (Excess Use)	104.4	1.2	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	172.1	2.0	
	Water Losses 5,637	Commercial Losses	f. Customer Metering Inaccuracies	-306.5	-3.6	**70.0**
			e. Unauthorized Consumption	5,943.2	70.4	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-36: Water Balance of Jabi SMA2

Item				m³/day	%	%
System Input Volume (SIV) 3,572	Authorized Consumption 2,210	Billed Authorized Consumption	a. Billed Metered Consumption	1,796.5	50.3	**54.4**
			b. Billed Unmetered Consumption	146.8	4.1	
			b. Billed Unmetered Consumption (Excess Use)	94.3	2.6	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	172.1	4.8	
	Water Losses 1,362	Commercial Losses	f. Customer Metering Inaccuracies	-248.9	-7.0	**45.6**
			e. Unauthorized Consumption	1,611.2	45.1	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-37: Water Balance of Jabi SMA3

Item				m³/day	%	%
System Input Volume (SIV) 4,873	Authorized Consumption 613	Billed Authorized Consumption	a. Billed Metered Consumption	547.9	11.2	**12.4**
			b. Billed Unmetered Consumption	57.3	1.2	
			b. Billed Unmetered Consumption (Excess Use)	7.6	0.2	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	0	0	
	Water Losses 4,260	Commercial Losses	f. Customer Metering Inaccuracies	-59.5	-1.2	**87.6**
			e. Unauthorized Consumption	4,319.7	88.6	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

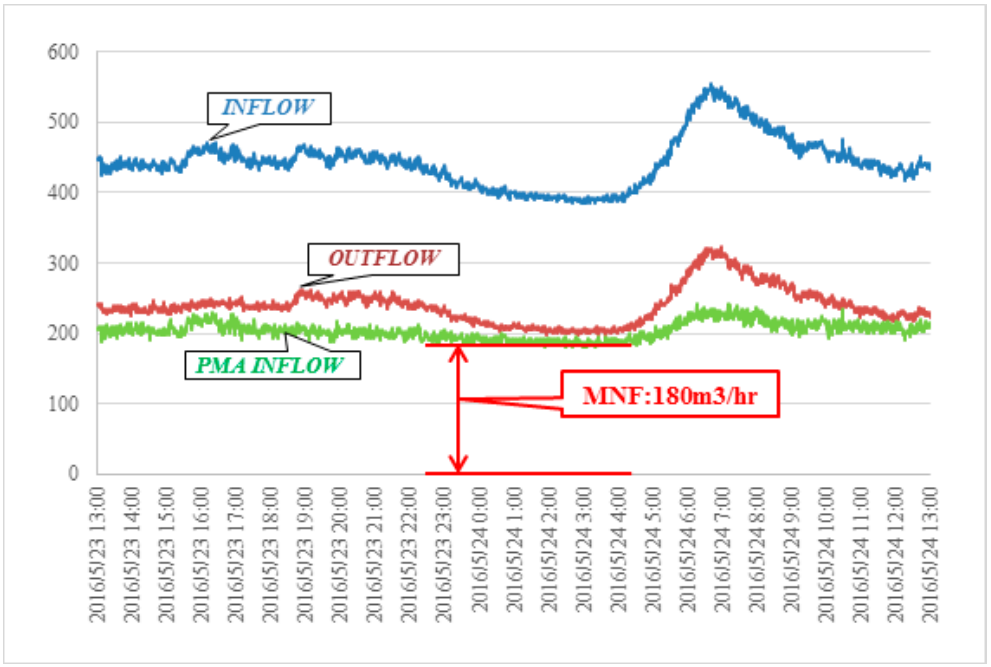
Source: Project Team

4) Baseline Analysis in Garki I PMA/SMAs

In Garki I PMA, it appeared that area of SMA3 included consumption of out of target area after the measurement of previous inflow measurement into PMA. Furthermore, distribution pipe network drawings were not correct, due to these reasons SMA2 and SMA3 could not isolate to measure consumption for each SMAs. Therefore, estimated volume is included in a calculation of distribution water analysis. Because of this reason, step test and 24hrs flow measurement did not reflect actual data of PMA and SMA2 and 3.

a. 24hrs Water Flow Measurement and MNF

The results of measurement of 24hrs water inflow to PMA/SMAs and the MNF are shown in Figure 3.2-27 and Table 3.2-38. The MNF is remarkably high and accounts for 88% of average flow. This means, the Project cannot regard most of MNF was not to be leakage. Water seems to be used by customer or used illegally during night.



Source: Project Team

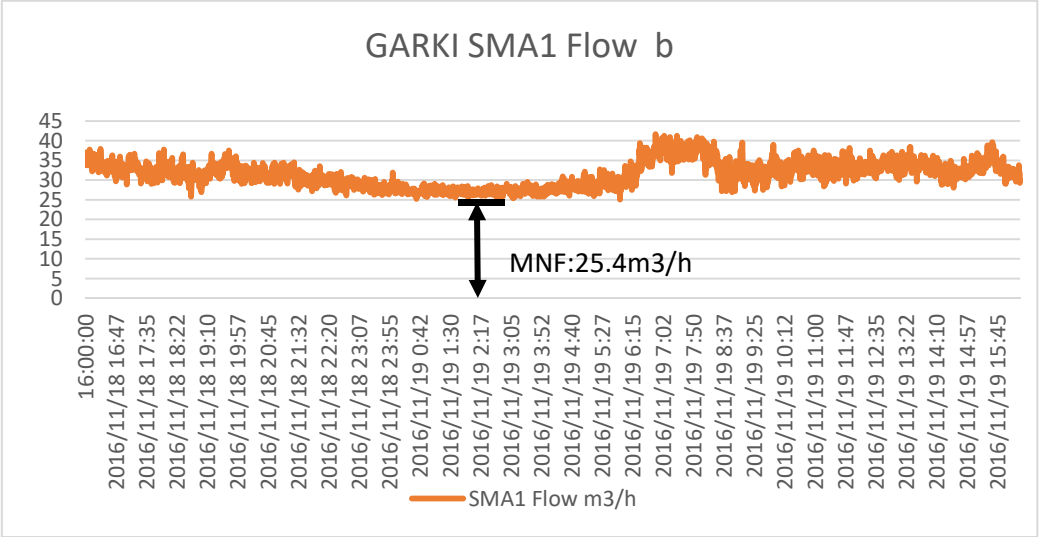
Figure 3.2-27: 24hrs Water Inflow and the MNF in Garki I PMA

Table 3.2-38: 24hrs Water Inflow and the MNF in Garki I PMA

	Total Inflow (m^3/day)	Average Inflow (m^3/hr)	Minimum Night Flow (m^3/hr)	MNF / Average Inflow (%)
PMA	4,896	204	180	88.2%

Source: Project

Regarding inflow measurement of PMA and SMAs, the Project conducted re-measurement for baseline measurement after confirmed the connection of distribution pipe lines and valves on it, so as to eliminate extra consumption of out of target area and make unclear isolated area. However, due to difficulty to solved incorrect pipeline network in SMA2 and SMA3, result of the flow measurement ever includes unclear consumption of SMA2 and SMA3. Re-measured 24hrs flow volume of SMA 1 is shown in Figure 3.2-28. Because of above mentioned reason, consecutive flow volume graphs and MNFs of PMA and SMAs are not available. However, flow volume of PMA and SMAs were calculated using existing and supplement data.



Source: Project Team

Figure 3.2-28: 24hrs Water Inflow and the MNF in Garki I PMA (SMA1)

b. Customer's 24hrs Consumption Measurement (Sampling)

Same as Gudu and Jabi, Garki I also showed high percentage of the MNF, the Project conducted a survey regarding flow pattern by the 24hrs flow measurement for 20 customers in Garki I and Table 3.2-39 shows a result. The result showed domestic and uncorded commercial customer (one of the category of domestic user) recorded a few volume in midnight, average midnight flow was 0.09m3/h and 0.12m3/h respectively. Customer did not use water in midnight. However it appeared that some major customers recorded high flow volume, average was 1.05m3/h. This result gave a sense to the Project that most of volume of the MNF was consumption of customer throw their meter or illegal connections, not leakage all.

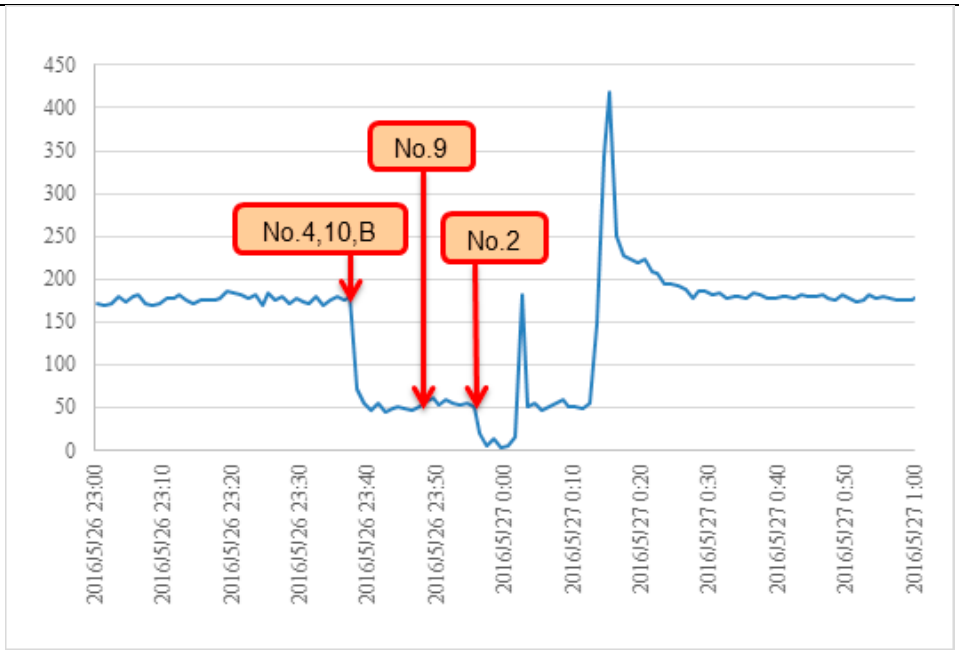
Table 3.2-39: Customer's 24hrs Water Flow Measurement in Jabi

S/N	Categories Number is Category of Major customer		SMA	Device N0	Name	Plot No / Street	Midnight Fow (11PM-5AM) m3/h	1 Day Consumption (M3/day)	Meter Types
1	Domestic & Commecial	Domestic	1	2066	Obinna Ajukwo	N0 4, Flat 2, Umudka	0.028	1.06	AMR
2		Domestic	2	2064	Engr. Saka Ikuje (Shared Meter – 4 Fat 5)	Fat 4, Block 6, 2 Cross River Area 3	0.037	1.51	AMR
3		Domestic	3	2066		N0 2, Langtang Close, Area 3	0.494	13.54	AMR
4		Domestic	1	2066	Dr. J. A. Abaaka	N0 4, Ngwa Close, Area 8 (A01) Garki	0.008	0.44	AMR
5		Domestic		2062		Flat 1, Close 1, Ede Close	0.017	2.29	AMR
6		Domestic	2	2062		N0 1, Jebba Close, Off Okene Close, Area 2	0.0338	2.84	AMR
7		Domestic	1	2066	Plot 612, Heritage House	Plot 612, Heritage House	0.033	2.55	AMR
					Average Domestic		0.09	**3.46**	
8		Uncorded Commercial Restaurant	3	2065	A-A Vision	Plot 456, Kontagora Close, Area 3	0.296	7.45	AMR
9		Uncorded Commercial (Hospita)	3	2066	Abuja Clinic	Plot N0 1014, Jos Street, Area 3	0.0552	2.3	AMR
10		Uncorded Commercial (Paza) Bank	3	2066	Eko Bank Plc	Plot 454, Kontagora Close, Area 3	0.1193	2.65	MECHANICAl
11		Uncorded Commercial (Mini-Hote)	3	2065	Eyte Guest Inn	No 4 Zungeru Cose, Area 3	0.005	10.44	AMR
					Average Commercial		0.12	**5.71**	
12	1	Ministries, Parastatals,l iason Office	3	2066	Immigration Office	N0 8 langtang Cose, Area 3	0.781	17.46	AMR
	1	Ministries, Parastatals,l iason Office	3		FCTWB	Area 3	1.06	24.2	No meter
					Average Ministries, Parastala		0.92	**20.83**	
13	2	Mini-Hotel	3	2065	Savanah Suites Group	Plot 1091, 8 Faskari Crescent, Area 3	0.196	10.57	AMR
14		Restaurant	3	2065	Flaming Restaurant	Tafawa Balewa Way, Area 3	0.071	1.71	MECHANICA
15		Mini-Hotel	3	2064	Sharon Ultimate Hotel	N0 9, Jos Street, Area 3	1.673	51.36	MECHANICA
					Average Minihotel, Restrant		0.65	**21.21**	Withou
16	3	Hospital	3	2066	Bepos Clinic and Maternity	N0 10 Faskari Crescent, Area 3 (A01) Garki	0.059	2.564	AMR
17	3	Hospital	1	2064	Garki Hospital	Tafawa Balewa Way, Area 3	3.149	99.47	MECHANICAl
18	3	Privete school	3	2064	Saint Aloys School	Plot No497, New Bussa Close, Area 3	0.256	6.64	AMR
19	3	Privete school	1	2066	Sister of Jesus	Plot 2136 Umudioka Close, Garki	0.149	3.78	AMR
					Average Praivate school, Hospital		0.90	**28.11**	Withou
20	4	Bank	3	2066	Guarantee Trust Bank	Plot 1073, Faskari Crescent	0.113	8.48	AMR
					Average Cooperate bodies, Financial Institute			**8.48**	

Source: Project Team

c. Step Test

The Project conducted step test of PMA at the same time MNF measurement to prioritize areas for leak detection. The results are shown in Figure 3.2-29 and Table 3.2-40. In this test, described before, the flow volume included indefinite volume because of uncertain pipe network. The graph shows sign of indefinite volume after No9 valve closed, water volume increase unexpectedly. The Project consider this situation, further pipe connection survey was needed until finding an actual pipe network.



Source: Project Team

Figure 3.2-29: Step Test in Garki I PMA

Table 3.2-40: Step Test in Garki I PMA

Valve Closing	Flow before Closing (m^3/hr)	Flow after Closing (m^3/hr)	Flow into Area and/or Line (m^3/hr)	Area	Street (Line)
-	168.9	168.9	-	All	-
No.4,10,B	168.9	43.8	125.1	SMA 3	-
No.9	43.8	51.0	-7.2	SMA 2	-
No.2	51.0	3.7	47.3	SMA 1	-

Source: Project Team

d. Customer Meter Error Test

In Garki I, there are two types of meter, AMR and Conventional. Table 3.2-41 shows both type of customer meters error test result. Allowable meter ratio was 61.9%. From the meter reading, 39-AMR "Faulty meter" were found and these meters were replaced. The error ratio which to be adopted amendment of water consumption volume of metered consumption was - (minus) 23.1%. This means that the total metered volume should be increased by 23.1 % of its volume.

Table 3.2-41: Meter Error Test in Garki I PMA

GARKI	AMR, Conventional			
All	84			
10=>~>=-10%		total	52	61.9%
Number of meters: Out of standard				
>10	9			
<-10	23	total	32	38.1%
Average of total error percentage				
		-23.1%		

Source: Project Team

e. Water Balance Analysis

Table 3.2-42 to Table 3.2-45 show the result of water balance as baseline. Garki I PMA showed 74.8%

of NRW and SMA1, SMA2 and SMA3 showed 85.1%, 74.8% and 70.0% respectively. NRW ratio of SMA1 was very high, however reasons of this fact were not clear. Items of e, g, I ware not clear because lack of data.

Table 3.2-42: Water Balance of Garki I PMA

Item				m^3/day	%	%
System Input Volume (SIV) 3,197	Authorized Consumption 1,220	Billed Authorized Consumption	a. Billed Metered Consumption	409.3	12.8	**25.2**
			b. Billed Unmetered Consumption	369.6	12.4	
			b. Billed Unmetered Consumption (Excess Use)	387.9	11.9	**74.8**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	41.0	1.3	
	Water Losses 1,977	Commercial Losses	f. Customer Metering Inaccuracies	167.2	5.2	
			e. Unauthorized Consumption	1794.8	56.1	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-43: Water Balance of Garki I SMA1

Item				m^3/day	%	%
System Input Volume (SIV) 754	Authorized Consumption 277	Billed Authorized Consumption	a. Billed Metered Consumption	66.3	8.8	**14.9**
			b. Billed Unmetered Consumption	46.2	6.1	
			b. Billed Unmetered Consumption (Excess Use)	161.5	21.4	**85.1**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	0	0	
	Water Losses 477	Commercial Losses	f. Customer Metering Inaccuracies	23.7	3.1	
			e. Unauthorized Consumption	456.3	60.5	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-44: Water Balance of Garki I SMA 2

Item				m³/day	%	%
System Input Volume (SIV) 682	Authorized Consumption 207	Billed Authorized Consumption	a. Billed Metered Consumption	130.9	19.2	**25.2**
			b. Billed Unmetered Consumption	32.8	6.0	
			b. Billed Unmetered Consumption (Excess Use)	26.9	3.9	**74.8**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	3.0	0.4	
	Water Losses 475	Commercial Losses	f. Customer Metering Inaccuracies	7.4	1.1	
			e. Unauthorized Consumption	501.7	73.6	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-45: Water Balance of Garki I SMA 3

Item				m³/day	%	%
System Input Volume (SIV) 682	Authorized Consumption 207	Billed Authorized Consumption	a. Billed Metered Consumption	130.9	12.4	**30.0**
			b. Billed Unmetered Consumption	32.8	17.6	
			b. Billed Unmetered Consumption (Excess Use)	331.4	18.8	**70.0**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	38.0	2.2	
	Water Losses 475	Commercial Losses	f. Customer Metering Inaccuracies	89.7	5.1	
			e. Unauthorized Consumption	774.1	44.0	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

(9) Develop a NRW reduction operation plan (Activity 2-11 and 2-12)

This section covers the following project activities:

- Develop a NRW reduction operation plan of each SMA, including reduction target, for review by Head of Distribution Department. (Activity 2-11)
- Review and approve NRW reduction operation plan of each SMA. (Activity 2-12)

Prior to developing NRW reduction operation plan of each SMA, the Project has provisionally implemented NRW reduction operations, particularly detection and repair of leaks after the NRW Action Team conducts MNF measurement and Step test with support of the JICA Expert Team on

leakage detection technology. All the activities had been done with or without the JICA Expert Team. However, methods of some of the countermeasure have not been transferred to FCTWB staff appropriate quality, so the JICA Expert Team will transfer their skill to FCTWB staff through the OJT.

In principle, the Project suggests to prepare SMA-based NRW Reduction Operation Plan covering the following contents:

Draft Contents of SMA-based NRW Reduction Operation Plan

1) **Outline of PMA and SMA**
   Basic Information and Features, Location, Boundary, Network Drawing, Position of PMA Flowmeter(s) and Isolation Valve(s) etc.
2) **Baseline Survey (before NRW Reduction Operations)**
   Workflow, Procedures, Customer Listing, Results of 1-week Customer Meter Reading, Customer Meter Error Test and Illegal Connection Survey, Results of Measurement of 24-hours Flow, MNF and Step Test (Area), Detection of Leaks, Water Balance Analysis, etc.
3) **NRW Reduction Operations Plan**
   Workflow, Procedures, Prioritization, Operations against Commercial Loss (Replacement or Newly-installation of Customer Meters, Disconnection or Legalization of Illegal Connections), Operations against Physical Loss (Step Test (Line), Detection of Leaks and Repair of Leaks), Scheduling, Cost Estimation and Logistics, etc.

(10) Implement and monitor NRW Reduction Operations (Activity 2-13 and 2-14)

This section covers the following project activities:

- Implement the NRW reduction operations at each SMA. (Activity 2-13)
- Monitor the progress of the NRW reduction operations of each SMA. (Activity 2-14)

In principle, the Project is supposed to implement NRW reduction operations efficiently according to NRW reduction operation plan, and all procedures that expected to implement in the plan were completed. Repair of leakages was completed in three PMAs. Meter replacement also completed in all PMAs.

1) NRW Reduction Operations

Table 3.2-46 shows NRW reduction operations in the Project.

Table 3.2-46: NRW Reduction Operations

Baseline Item	Category in Water Balance Sheet	NRW Reduction Operations	Team
Excess use by flat-rate customers or major consumers	Unbilled authorized consumption	a. Installation of customer meters	● Distribution
Illegal connection or tampering	Commercial loss	b. Disconnection or legalization of illegal connections, a. Installation of customer meters (after legalization)	● Commerce & Distribution ● Distribution
Customer metering inaccuracies	Commercial loss	c. Replacement of customer meters	● Distribution
Leakage on distribution networks and service connections	Physical loss	d. Step test (line), e. Leak detection, f. Repair of leaks	● Distribution ● Distribution ● Distribution

Source: Project Team

a. Installation of Customer Meters

The Project identifies some households which have no customer meter by customer listing and field works, and then installs customer meters to the households. If illegal connections are legalized, the Project also installs customer meters

b. Installation and Replacement of Customer Meters

The Project identifies the households which have no meter customer and Flat Rate customer by customer listing and malfunctioned meter by field works, and then installs customer meters.

Moreover, the Project replaced high error rate meters which were identified by meter error test.

Standard of range of appropriate use of existing customer meter error rate is less than +, - (plus, minus) 10% according to ISO. The Project conducted customer meter inaccuracy test, total sample meters were 342 in three PMAs, and observed the meters which error rate exceed +,- 10%. Numbers of installed new meters are about 950.

c. Disconnection or Legalization of Illegal Connections

Illegal connections are a serious problem in NRW reduction. There are two aspects of solution to eliminate illegal connections. One is technical and other is social aspect. Solution as a technical aspect is to strictly disconnect illegal users, this is still not fundamental solution, because water users have various backgrounds and reasons why they connect illegally. Meanwhile, solution as a social aspect is to legalize the households. It is important for FCTWB to convince water users to be legalized through the PR. In addition, if willingness/ability to pay is low, it is also significant for FCTWB to take some measure against payment. The numbers of the illegal connection are described in a section of each PMC with numbers of leakage.

The Project conducted illegal connection survey during leakage detection survey and meter error test in the customer's plot. Table 3.2-47 shows result of illegal connection survey. Water volume of each PMA was estimated that producing of the average of temporally meter consumption of each PMA and number of illegal connection.

Number of illegal connection in Gudu were more than other PMAs. The Project assumed that the reason of this is that Gudu have adopted prepaid meter system which does not need maintenance, its means no one had observed the meter and also condition of pipe installation around the meter, so remodelling of the plumbing and connection by the customer are enabled.

Estimated water volume of each PMA were reflected on the water balance analysis, as "Solved" to [Before stage (baseline)] and "Not yet solved" for [Ex post stage] respectively.

Table 3.2-47: Number of Illegal Connections

Item	Status	Gudu	Jabi	Garki I	Total
Number of illegal connection	Solved	23	6	4	33
	Undetermined by 1st,may,2017	10	4	19	33
	Total	33	10	23	66
Assumption of water volume	Solved	93.4	23.6	11.9	-
	Undetermined by 1st,May,2017	40.6	15.8	56.6	-

Source: Project Team

d. Repair of Leaks

After leak detection survey, the Project measures leaks and repairs them. If the pipes are deteriorated seriously, replacement by new ones may be more economical than repair from a long-term viewpoint. Pipe deterioration depends on not only pipe durability but also conditions of pipe laying. Conditions of pipe laying is influenced by various factors such as soil quality, groundwater, covering depth, loading and etc. It is very difficult to make criteria based on various factors to identify deteriorated pipe with exception of its appearance. Therefore, pipe durability is one of the criteria to examine repair or

replacement to be taken. The project detected many leakages mostly on service pipes and repair works were conducted by staff of area offices.

The numbers of the leakage are described in a section of each PMA with numbers of illegal connection.

2) Preparation of Customer List

Gudu PMA

Table 3.2-48 shows ex post stage customer list of Gudu PMA/SMAs. Number of customer is reduced about 50 houses because some customers were regarded no supply from FCTWB, such as vacant, borehole, disconnect etc. Faulty prepaid meters and flat have been replaced.

Table 3.2-48: Customer List of Gudu PMA/SMAs

Category	Meter Type	SMA 1	SMA 2	Total	Remarks
Domestic Customer	Conventional	24	35	**59**	
	Flat-Rate	36	35	**71**	
	AMR	0	0	**0**	
	Prepaid	422	213	**635**	
	Unknown	39	49	**88**	
	Sub-Total	**521**	**332**	**853**	
Commercial Customer	Conventional	4	0	**4**	
	Flat-Rate	2	0	**2**	
	AMR	0	0	**0**	
	Prepaid	11	2	**13**	
	Unknown	3	1	**4**	
	Sub-Total	**20**	**3**	**23**	
Major Consumers	Conventional	0	1	**1**	
	Flat-Rate	0	0	**0**	
	AMR	0	0	**0**	
	Prepaid	0	0	**0**	
	Unknown	0	0	**0**	
	Sub-Total	**0**	**1**	**1**	
Total		**541**	**336**	**877**	

Source: Project Team

Jabi PMA

Table 3.2-49 shows ex post stage customer list of Jabi PMA/SMAs. Total number of customer increased 16. According to the meter error test, many meters were not accurate; the Project decided replacing all meters in Jabi. Most of customers have conventional meter and some major consumers exist.

Table 3.2-49: Customer List of Jabi PMA/SMAs

Category	Meter Type	SMA 2	SMA 3	Total	Remarks
Domestic Customer	Conventional	356	180	**536**	
	Flat-Rate	2	0	**2**	
	AMR	0	0	**0**	
	Prepaid	0	1	**1**	
	Unknown	0	0	**0**	
	Sub-Total	**358**	**181**	**539**	
Commercial Customer	Conventional	14	20	**34**	
	Flat-Rate	0	0	**0**	
	AMR	0	0	**0**	
	Prepaid	0	0	**0**	
	Unknown	0	0	**0**	
	Sub-Total	**14**	**20**	**34**	
Major Consumers	Conventional	17	21	**38**	Unknown = borehole
	Flat-Rate	2	0	**2**	
	AMR	0	0	**0**	
	Prepaid	0	0	**0**	
	Unknown	0	0	**0**	
	Sub-Total	**19**	**21**	**40**	
Total		**391**	**222**	**613**	

Source: Project Team

Garki I PMA

Table 3.2-50 shows ex post stage customer list of Garki I PMA/SMAs. Number of customers reduced about 10 from previous stage. Faulty meters and flat rate customers' meter were replaced to new AMR meter, totally about 120 meters were replaced.

Table 3.2-50: Customer List of Garki I PMA/SMAs

Category	Meter Type	SMA 1	SMA 2	SMA 3	Total	Remarks
Domestic Customer	Conventional	0	31	15	**46**	
	Flat-Rate	0	2	6	**8**	
	AMR	22	109	204	**335**	
	Prepaid	0	0	0	**0**	
	Unknown	0	0	0	**0**	
	Sub-Total	**22**	**140**	**219**	**389**	
Commercial Customer	Conventional	0	0	1	**1**	
	Flat-Rate	0	0	1	**1**	
	AMR	5	3	12	**20**	
	Prepaid	0	0	0	**0**	
	Unknown	0	0	0	**0**	
	Sub-Total	**5**	**3**	**14**	**22**	
Major Consumers	Conventional	1	0	10	**11**	
	Flat-Rate	0	0	4	**4**	
	AMR	1	0	13	**14**	
	Prepaid	0	0	0	**0**	
	Unknown	3	0	6	**6**	
	Sub-Total	**5**	**0**	**30**	**35**	
Total		**32**	**143**	**263**	**446**	

Source: Project Team Note: SMA 2 was lessened due to change in boundary.

3) NRW Reduction Operations in Gudu PMA

a. Step Test

The Project conducted the step test at the baseline stage since it didn't carried out in this stage.

b. Installation and Replacement of Meter

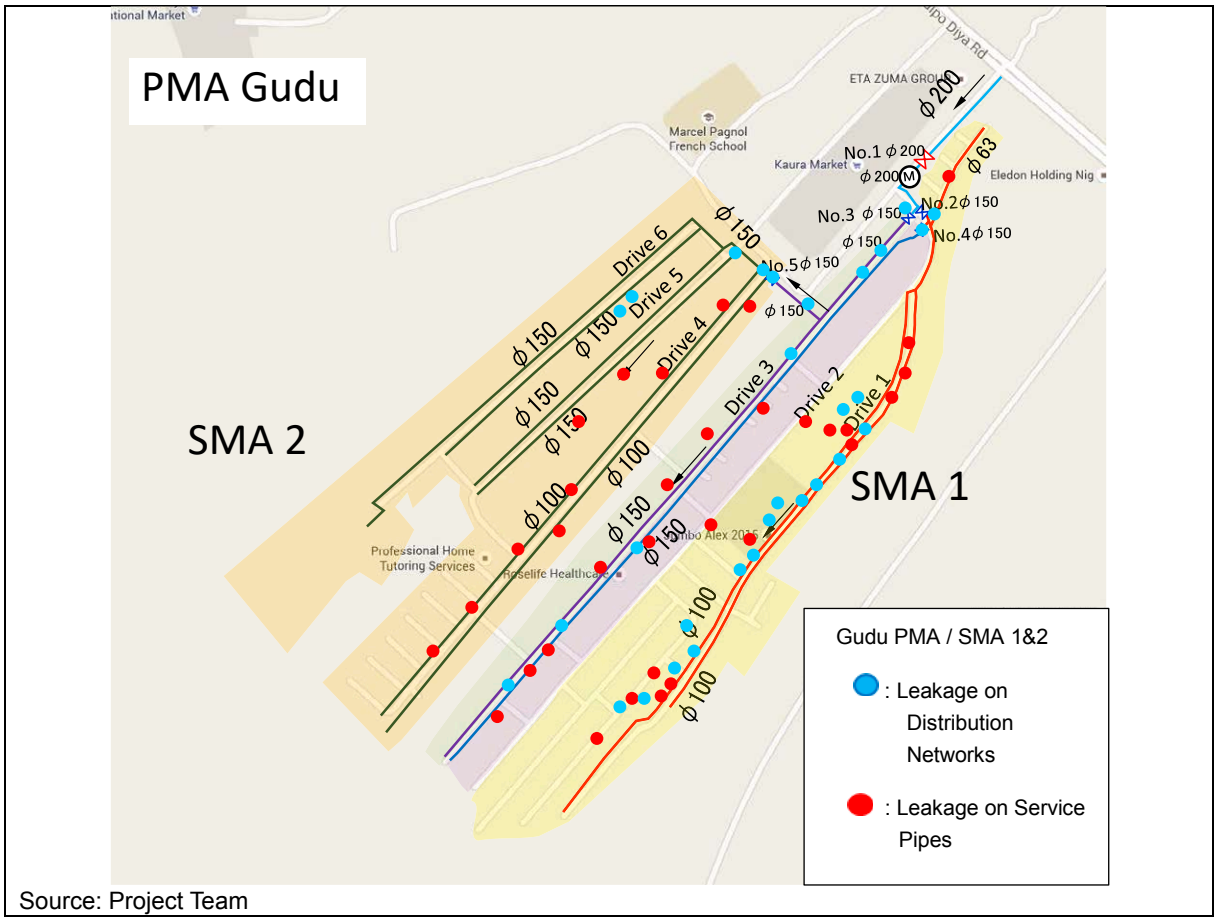
Total numbers of 196 new meters were installed to the customers who had no meter, flat rate and high error rate meters which were identified by the meter accuracy test.

c. Leakage and Illegal Connection Detection

Most of customer meters exist on customer's property, and these properties have robust gate, wall and sometimes with security guard. Also, updated customer information and service connection inventory does not exist. These conditions made it difficult for the Project to conduct door-to-door acoustic survey, so it took longer time than expected to do it.

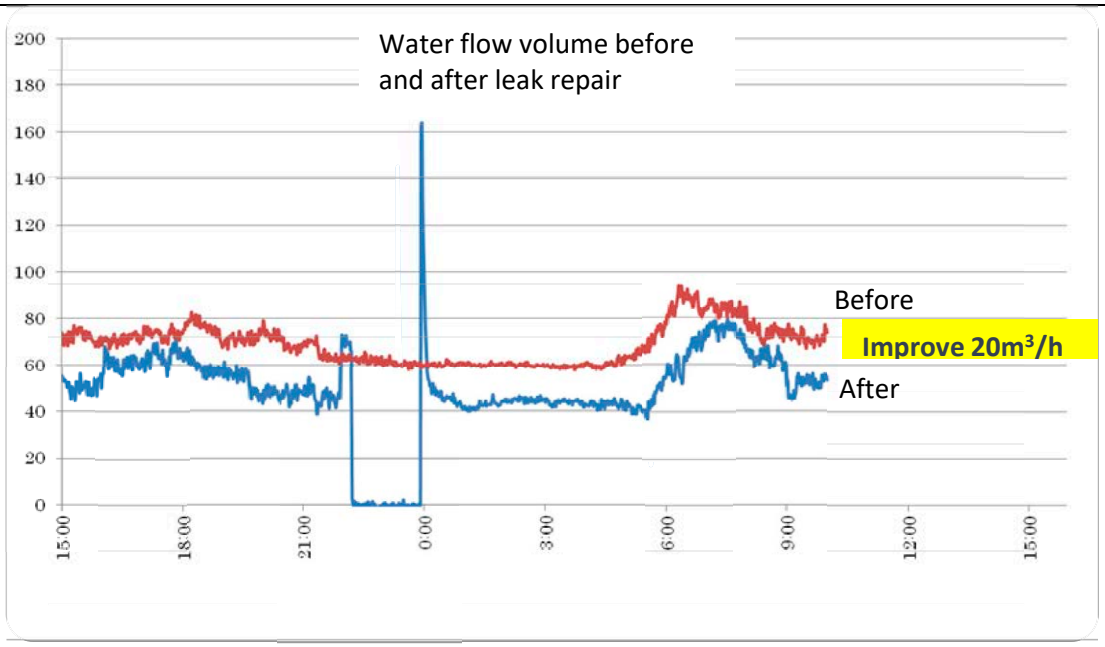
Although pipeline route acoustic survey is supposed to be conducted during nighttime hours when traffic noise is low and water supply conditions such as pressure are relatively stable, the Project conducted the survey during daytime hours considering security and little traffic in residential area. However, inaccurate location of distribution networks as well as pipeline routes on resident's properties or roadside green zones made it difficult for the Project to conduct the survey, so it took longer time than expected to do it.

In spite of these difficulties, the Project carried out leakage survey 2 times and could find many leakages on service pipes, valves and distribution pipes. Figure 3.2-30 describes all points of leakage and Figure 3.2-31 and Table 3.2-51 shows improved water volume after the 1st investigation and repair work of leakages. The difference of water flow volume was 480m^3/d.



Source: Project Team

Figure 3.2-30: Location of Leaks detected in Gudu PMA



Source: Project Team

Figure 3.2-31: Improvement of Flow Volume at Gudu PMA

Table 3.2-51: List of Leaks detected in Gudu PMA

PMA	SMA	Distribution Networks	Valves	Service Pipes	Total	Estimated Volume	Illegal Connection	Estimated Volume
Gudu	SMA 1	20	2	17	39	484m³	2	4 m³
	SMA 2	0	1	6	7	42 m³	2	4 m³
	Total	**20**	**3**	**23**	**46**	**526** m³	**4**	**8** m³

Source: Project Team

Table 3.2-52: Detail of Leaks and Illegal Connection Detected in Gudu (Before)

1. Leakage Volume

Pipe category		SMA	Number of leakages	Unit volume m3/d	Total m3/d
Service pipe	Pipe size				
	25	1	17	6	102
	25	2	6	6	36
	25Valve	1	2	6	12
	25Valve	2	1	6	6
	30	2	2	6	12
	30	2	1	2.4	2.4
	25	2	2	6	12
	25	1	4	2.4	9.6
	25	2	1	2.4	2.4
	Sub total		36		194.40
Distribution pipe	>=300				0
	250-150	1	8	20	160
	100	1	10	15	150
	50-100	1	2	30	60
	100	1	2	72	144
	100	1	1	24	24
	100	2	2	24	48
	100	2	2	12	24
	100	1	4	6	24
	100	1	3	2.4	7.2
	<=50				0
	Sub total		34		641.20
		SMA	1	53	692.80
		SMA	2	17	142.80
Grand total				⑪	**835.60**

2. Illegal Connection Volume

Pipe size	SMA	Number of connections	Unit volume m3/d	Total m3/d
25	1	13	4.06	52.78
25	2	4	4.06	16.24
25	1	2	4.06	8.12
20	2	4	4.06	16.24
Sub total		23		93.38
	SMA	1	15	60.9
	SMA	2	8	32.48
Grand Total			⑨	**93.38**

Source: Project Team

The Project conducted illegal connection survey by staff of area office and observed circumstances of

meter surrounding during meter error test. By this survey 33 illegal connections were detected. Table 3.2-53 shows number of detected illegal connections. Estimated illegal connection water volume of each PMA and SMAs were reflected on the water balance analysis, as "Determined" which disconnected or legalizes to [Before stage (baseline)] and "Undetermined" for [Ex post stage] respectively.

Table 3.2-53: List of Illegal Connections detected in Gudu PMA

PMA	SMA	Number of Illegal Connection	Estimated Volume
Determined	SMA 1	15	61m³/d
	SMA 2	8	32m³/d
	Total	23	93m³/d
Undetermined by 1st May 2017	SMA 1	7	28m³/d
	SMA 2	3	12m³/d
	Total	10	40m³/d*
Grand Total		33	133m³/d

Source: Project Team Note: Undetermined volume was reflected on Ex-post stage analysis.

4) NRW Reduction Operations in Jabi PMA

a. Step test

Step test was conducted at the baseline stage since it didn't carry out this stage.

b. Installation and Replacement of Meter

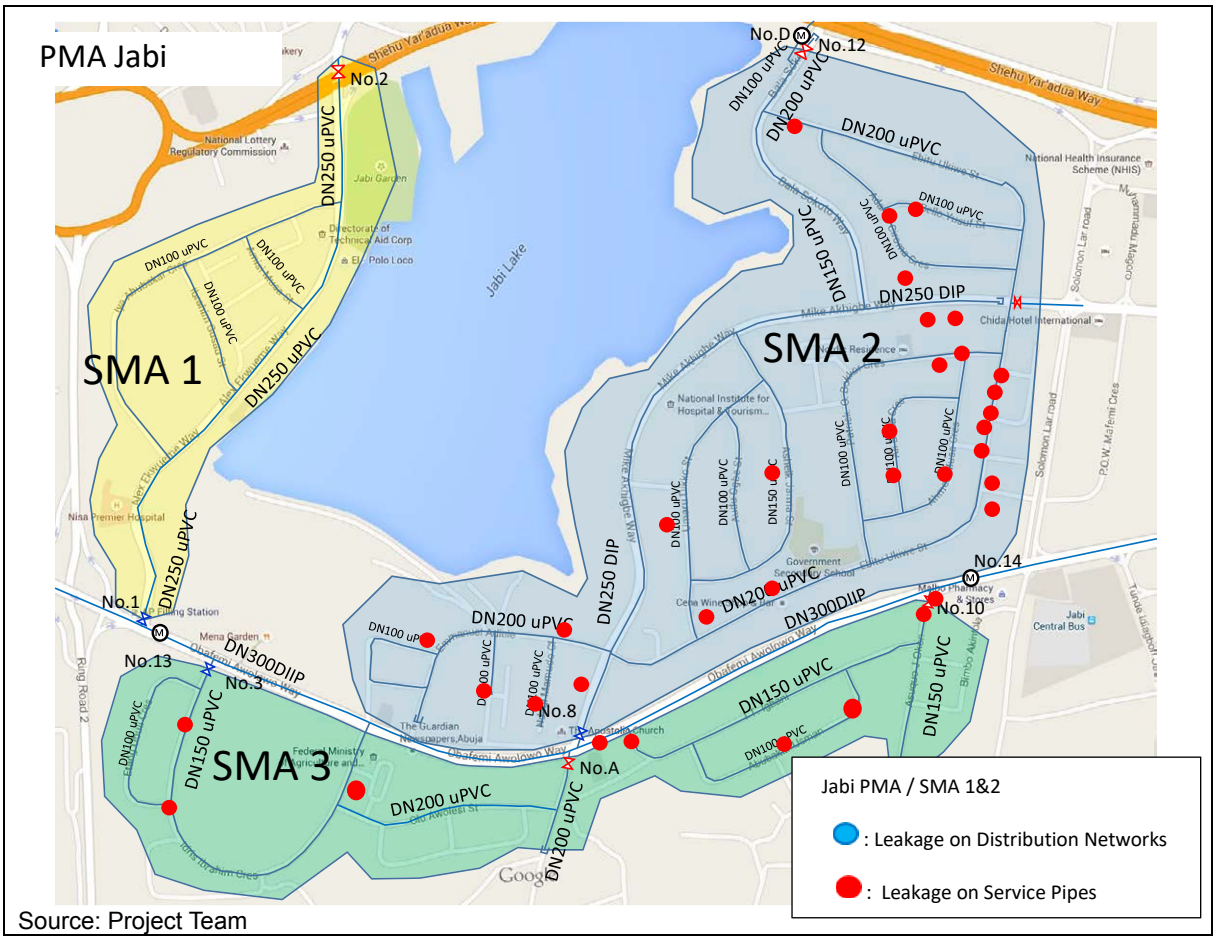
The Project decided that all customer meters should be replaced, based on the result of extremely high ratio (73%) of out of appropriate error ratio. About 600 meters in total were replaced in this PMA.

c. Leakage and Illegal Connection Detection

Most of customer meters exist in customer's property, and these properties have robust gate, wall and sometimes with security guard. Also, updated customer information and service connection inventory does not exist. These conditions made it difficult for the Project to conduct door-to-door acoustic survey, so it took longer time than expected period to do it.

The Project conducted the survey during daytime same reason of Gudu and it took time more than expected also same reason of Gudu.

The Project carried out 2 times leakage detection survey and illegal connection survey. Figure 3.2-32 shows location of detected leakage points. Result of detected number and estimated leak volume are described in Figure 3.2-54 and Table 3.2-55.



Source: Project Team

Figure 3.2-32: Location of Leaks detected in Jabi PMA

Table 3.2-54: List of Leaks detected in Jabi PMA

PMA	SMA	Distribution Networks	Valves	Service Pipes	Total	Estimated Volume
Jabi	(SMA 1)	0	0	(3)	(3)	-
	SMA 2	0	17	11	28	697m³/d
	SMA 3	0	3	6	9	144m³/d
	Total	**0**	**20**	**17**	**37**	**841m³/d**

Source: Project Team

Table 3.2-55: Detail of Leaks and Illegal Connection Detected in Jabi (Before)

1.Leakage Volume

Pipe category		SMA	Number of leakage	Unit volume m3/d	Total m3/d
Service pipe	Pipe size				
	25	2	6	2	12
	25	3	1	1	1
	32			1	0
	63	3	1	36	36
	63	2	1	24	24
	50	3	1	2.4	2.4
	30	2	3	72	216
	30	3	1	72	72
	30	2	8	48	384
	30	2	3	12	36
	30	3	2	12	24
	30	2	4	6	24
	30	3	1	2.4	2.4
	25	3	2	3	6
	20	2	3	0.24	0.72
	Sub total		37		840.52
Distribution pipe	>=300			600	0
	250-150			480	0
	100			100	0
	50-100			75	0
	<=50			50	0
	Sub total		0		0
		SMA	2	28	697
		SMA	3	9	144
Grand total				⑪	**840.52**

2. Illegal connection Volume

Pipe size	SMA	Number of connection	Unit volume m3/d	Total m3/d
50				0
32				0
25	2	6	3.94	23.64
20				0
Sub total		6		23.64
	SMA	2	6	23.64
	SMA	3	0	
Grand Total			⑨	**23.64**

Source: Project Team

Illegal connection survey carried out during meter error test. By this survey 10 illegal connections were detected.

Table 3.2-56 shows number of detected illegal connections. Estimated water volume of each PMA and SMAs were reflected on the water balance analysis, as “Determined” which disconnected or legalizes to [Before stage (baseline)] and “Undetermined” for [Ex post stage] respectively.

Table 3.2-56: List of Illegal Connections detected in Jabi PMA

PMA	SMA	Number of Illegal Connection	Estimated Volume
Determined	SMA 2	0	0
	SMA 3	6	24m³/d
	Total	6	24m³/d
Undetermined by 1st May 2017	SMA 2	4	16m³/d
	SMA 3	0	0
	Total	4	16m³/d*
Grand Total		10	40 m³/d

Source: Project Team *Undetermined volume was reflected on Ex-post stage analysis.

5) NRW Reduction Operations in Garki I PMA

a. Step Test

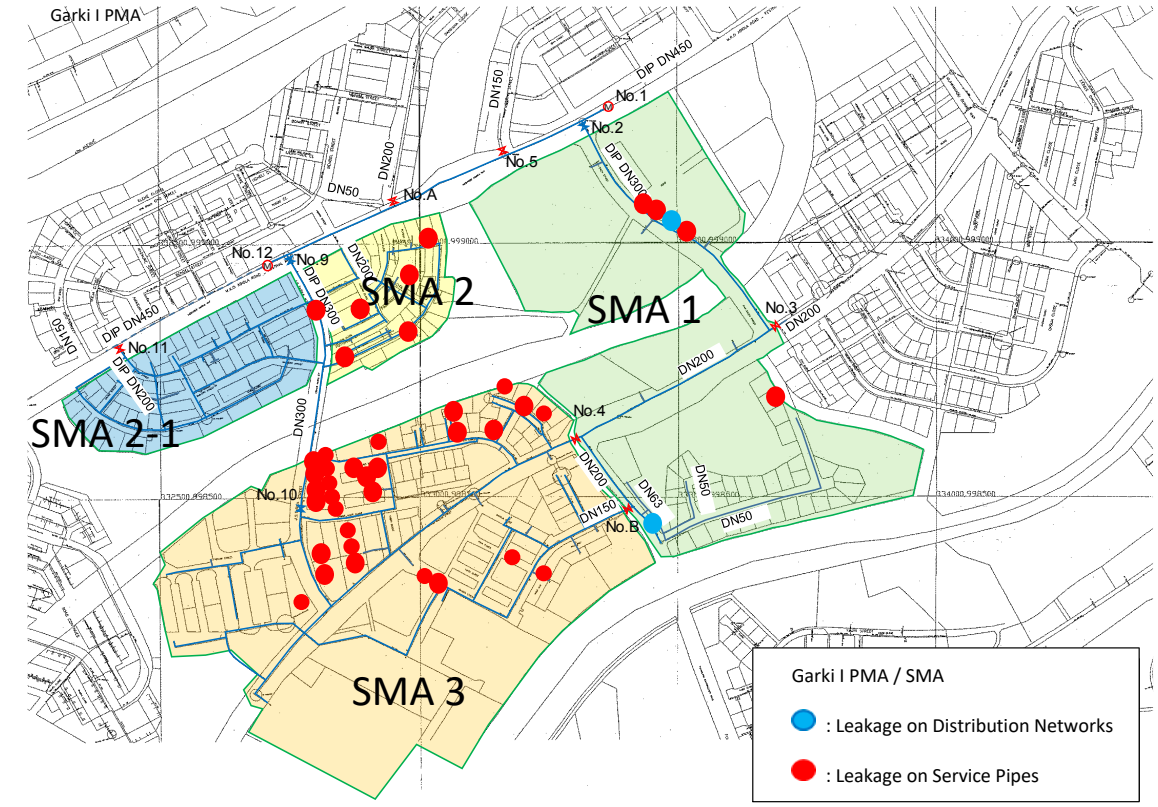
Because step test already done at the baseline stage it didn’t carry out this stage.

b. Installation and Replacement of Meter

Total numbers of 150 new meters were installed to the customers who had faulty meter, no meter, flat rate and high error ratio meters which were identified by the meter accuracy test and meter reading.

c. Leakage and Illegal Connection Detection

The project carried out leakage detection survey and illegal connection survey. As a result, project detected many leakages and some illegal connections. Figure 3.2-33 and Table 3.2-57 show location of leakage and number of leakage and estimated water volume.



Source: Project Team

Figure 3.2-33: Location of Leaks detected in Garki I PMA

Table 3.2-57: List of Leaks detected in Garki I PMA

PMA	SMA	Distribution Networks	Valves	Service Pipes	Total	Estimated Volume
Garki I	SMA 1	2	0	4	6	240m³/d
	SMA 2	0	3	2	5	21m³/d
	SMA 3	2	8	22	32	493m³/d
	Total	**4**	**11**	**28**	**43**	**754**m³/d

Source: Project Team

The Project conducted illegal connection survey, and 23 illegal connections were detected.

Table 3.2-58 shows number of detected illegal connections. Estimated illegal connection water volume of each PMA and SMAs were reflected on the water balance analysis, as “Determined” which disconnected or legalized to [Before stage (baseline)] and “Undetermined” for [Ex post stage] respectively.

Table 3.2-58: List of Illegal Connections detected in Garki I PMA

PMA	SMA	Number of Illegal Connection	Estimated Volume m³/d
Determined	SMA 1	0	0m³/d
	SMA 2	0	0m³/d
	SMA 3	4	12 m³/d
	Total	4	12m³/d
Undetermined by 1st May 2017	SMA 1	6	18m³/d
	SMA 2	2	16m³/d
	SMA 3	11	33m³/d
	Total	19	57m³/d*
Grand Total		23	69 m³/d

Source: Project Team *Undetermined volume was reflected on Ex-post stage analysis.

Detail of detected leaks and illegal connection on before stage (baseline) was described in Table 3.2-59.

Table 3.2-59: Detail of Leaks and Illegal Connection Detected in Garki I (Before)

Garki

1. Leakage Volume

Pipe category	Pipe size	SMA	Number of leakage	Unit volume m3/d	Total m3/d
Service pipe	20	3	14	2	28
	20	1	2	2	4
	50	3	2	30	60
	>50	3	1	24	24
	50	3	1	24	24
	50	3	1	12	12
	30	3	1	24	24
	30	3	2	12	24
	25	3	1	48	48
	25	1	1	12	12
	25	3	3	12	36
	25	2	3	6	18
	25	3	2	6	12
	25	1	1	2.4	2.4
	25	2	1	2.4	2.4
	25	3	1	2.4	2.4
	26	2	1	0.24	0.24
	27	3	1	0.24	0.24
	Sub total		39		333.68
Distribution pipe	>=300				0
	250-150	3	1	150	150
	250-150	1	1	72	72
	100	1	1	72	72
	<=50	3	1	48	48
	Sub total		4		342
		SMA	1	6	240.4
		SMA	2	5	20.64
		SMA	3	32	492.64
Grand total				⑪	**753.68**

2. Illegal connection Volume

Pipe size	SMA	Number of connection	Unit volume m3/d	Total m3/d
25	1	0		0
25	2	0	2.98	0
25	3	4	2.98	11.92
Sub total		4		11.92
	SMA	1	0	0
	SMA	2	0	0
	SMA	3	4	11.92
Grand Total			⑨	**11.92**

Source: Project Team

The amount of leakage and illegal connection water volume were reflected on items e, g, I, in the water balance sheet.

(11) Conduct Ex Post Stage Survey/Analysis of NRW in PMA/SMAs (Activity 2-9 and 2-10)

This section covers the following project activities:

- Measure ex post stage level of NRW of each SMA. (Activity 2-9)

  Schedule of the Project faced delay of progress due to delay of meter replacement mostly as a result of delay of procurement of accurate meters in Nigeria, procedures of precaution to the police office to do a 24hrs measurement with UFM at the field and also remaining unclear location and connection of distribution pipe lines etc..
  24hrs flow measurement, MNF survey and meter reading were completed. Measurement of MNF at Garki I SMA2 suffered confusion in collecting data, because of incorrect distribution pipe network information, however, the Project discovered new connecting pipe and could measure flow lastly.

a. 24hrs Measurement of Water flow of PMA & SMAs

The Project installed some ultrasonic flow-meters at inlet/outlet point and measured water flow for 24 hours to calculate one-day water consumption of PMA & SMAs. At the same time, MNF measurement was carried out.

Source: Project Team

Figure 3.2-34: Installation on Pipeline, Ultrasonic Flowmeter

b. Customer Meter Reading

The Project read all existing, replaced and newly installed customer meters located inside PMA/SMAs, kept duration of reading period more than one-week to calculate presumptively-billed one-day consumption in PMA/SMAs.

c. MNF Measurement

At the same time of 24 hours measurement of water inflow to PMA and SMAs, the Project found out the MNF and minimum flow. NRW components are usually analyzed on the assumption that the MNF is regarded as total volume of leakage. However, this assumption does not apply to the Project because some customers consume water during nighttime hours. Therefore, the Project cannot regard the MNF as leakage unless consumption pattern of customers or major consumers as well as detection of illegal connections is conducted.

d. Remaining Illegal Connections

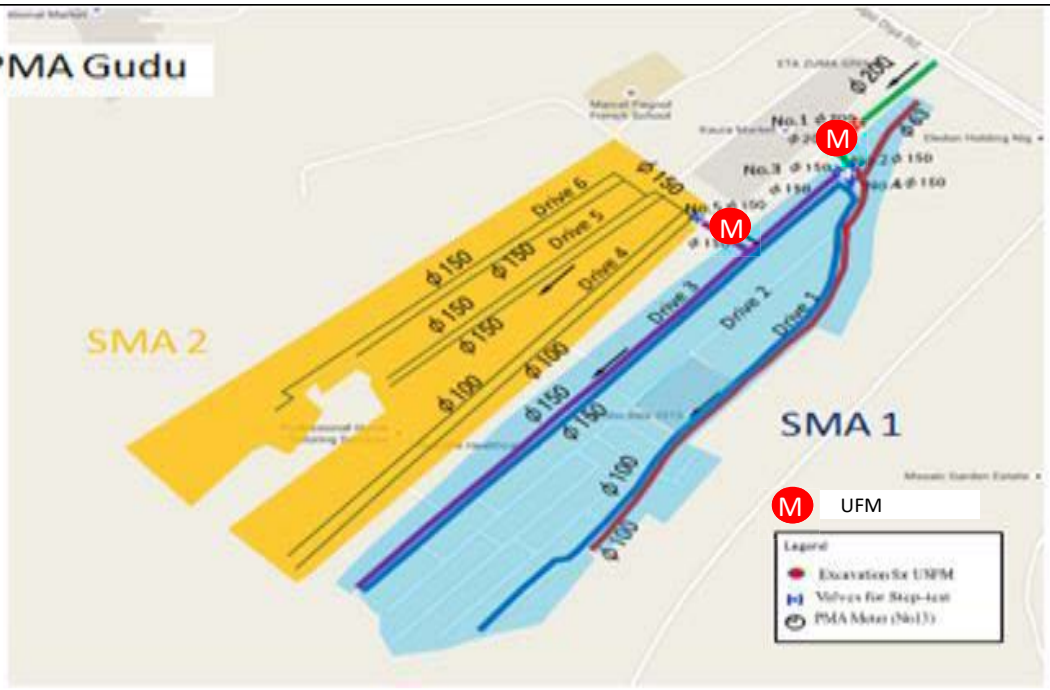
The Project detected 66 illegal connections in all PMAs and solved 33 connections by way of disconnection or legalization and installed a meter. However, unfortunately during the Project, 33 connections were remaining as illegal status. Table 3.2-60 shows remaining number of connections and assumed water volume. Estimated water volume is reflected on the Ex Post stage analysis.

Table 3.2-60: List of Remaining Illegal Connection for Ex Post Stage

PMA	Number of Connections	Estimated Water Volume
Gudu	10 (SMA1:7, SMA2:3)	41m³/d (SMA1:28, SMA2:12)
Jabi	4 (SMA2:4, SMA3:0)	16m³/d (SMA2:16, SMA3:0)
Garki I	19 (SMA1:6, SMA2:2, SMA3:11)	57m³/d (SMA1:18, SMA2:6, SMA3:33)

1) Ex Post Stage Water Balance Analysis in Gudu PMA

The Project conducted 24hrs measurement of water flow into PMA and SMAs using ultrasonic flow meter (UFM) installation location is shown as Figure 3.2-35.

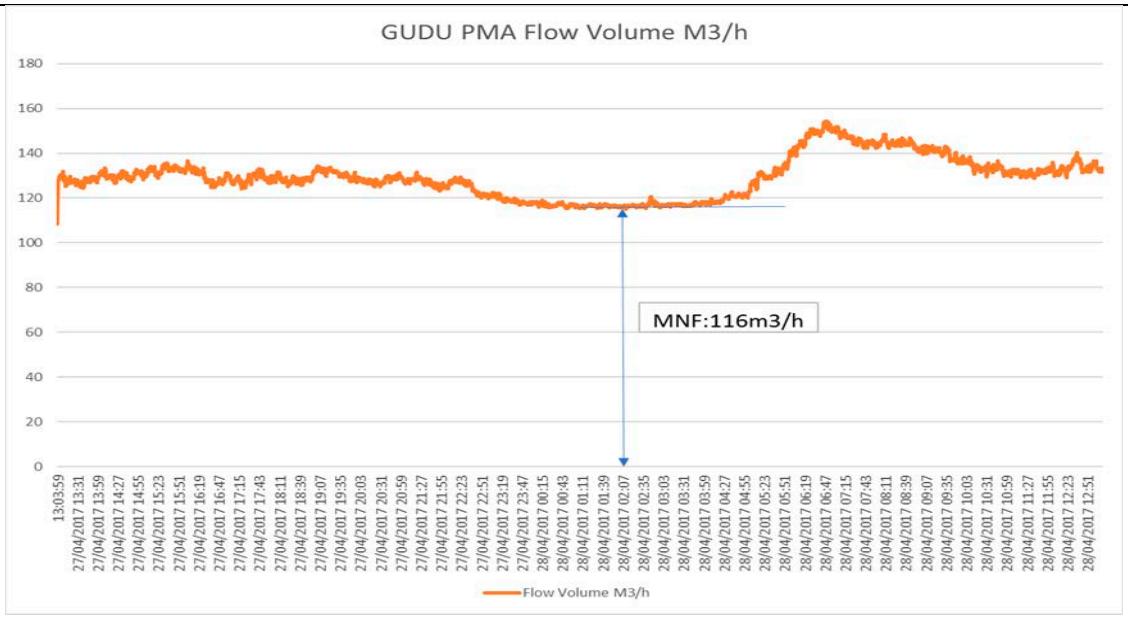


Source: Project Team

Figure 3.2-35: Location of UFMs in Gudu PMA

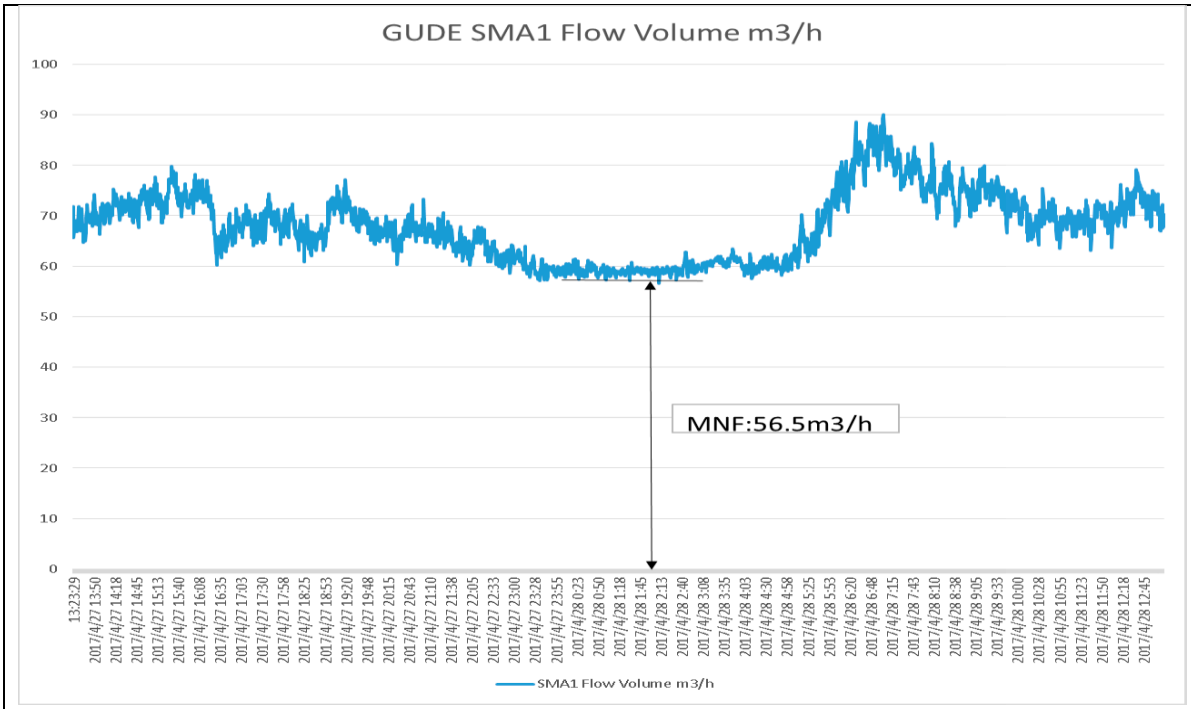
The measurement results and the MNF are shown in Figure 3.2-36 to Figure 3.2-38 and Table 3.2-61. The MNF of PMA is remarkably high same as previous stage and accounts for 90% of average flow. Each SMA showed same high ratio.

Because of high MNF in the baseline stage measurement, the Project assumed that there were water flow in to the customer tanks in night and thus performed 24hrs customer's flow measurement, however could not be confirmed such a fact in Gudu. In addition, the sign which suggested existence of the leaks that balanced with high MNF by the leakage detection activities has not been found.



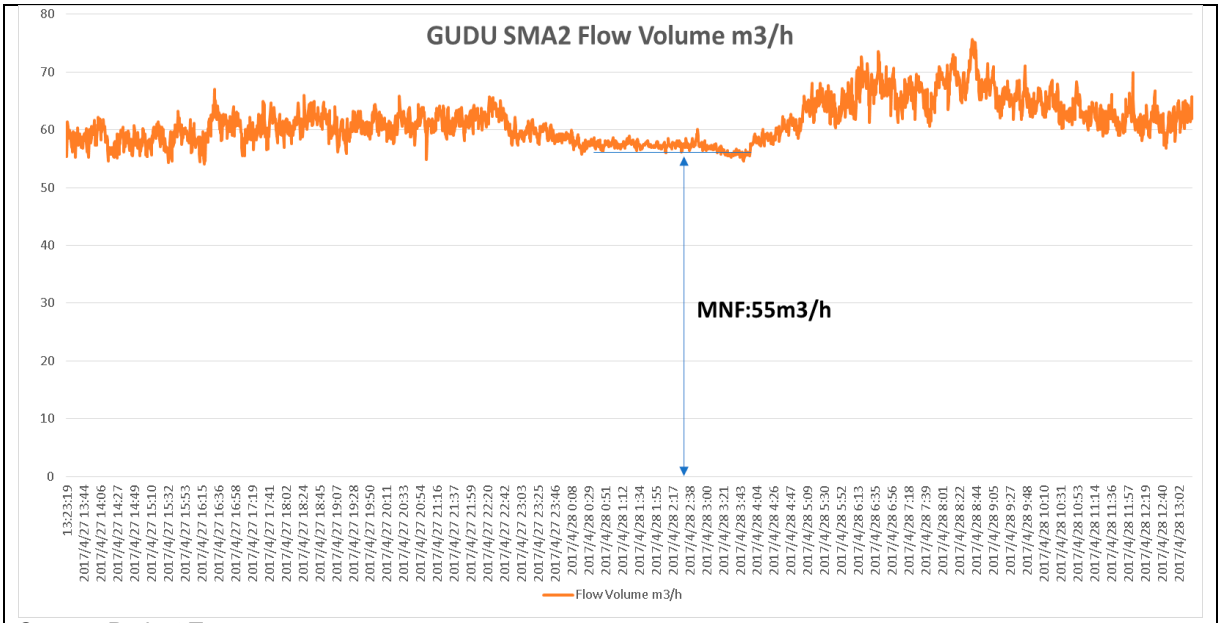
Source: Project Team

Figure 3.2-36: Location of UFMs in Gudu PMA



Source: Project Team

Figure 3.2-37: 24hrs Water Inflow and the MNF in Gudu PMA (SMA 1)



Source: Project Team

Figure 3.2-38: 24hrs Water Inflow and the MNF in Gudu PMA (SMA 2)

Table 3.2-61: 24hrs Water Inflow and the MNF in Gudu PMA

	Total Inflow (m^3/day)	Average Inflow (m^3/hr)	MNF (m3/hr)	MNF / Average Inflow (%)
PMA	3,102	128	116	90%
SMA 1	1,631	68	57	83%
SMA 2	1,471	61	55	90%

Source: Project Team

Table 3.2-62 to Table 3.2-64 show result of water balance as ex post stage. Result of NRW ratio of PMA is 20.4%, reduced 32.9 points from the baseline stage. At SMA1, NRW ratio remarkably improved become only 12.1%, reduced 39.9 points from the baseline stage. NRW of SMA2 become 29.9% reduced 24.0 point.

Table 3.2-62: Water Balance of Gudu PMA

Item				m^3/day	%	%
System Input Volume (SIV) 3,102	Authorized Consumption 2,774	Billed Authorized Consumption	a. Billed Metered Consumption	2,373	76.5	**79.6**
			b. Billed Unmetered Consumption	97.0	3.1	
			b. Billed Unmetered Consumption (Excess Use)	199.6	6.4	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	104.0	3.4	
	Water Losses 328	Commercial Losses	f. Customer Metering Inaccuracies	0	0	**20.4**
			e. Unauthorized Consumption	327.7	10.6	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-63: Water Balance of Gudu PMA (SMA1)

Item				m^3/day	%	%
System Input Volume (SIV) 1,631	Authorized Consumption 1,596	Billed Authorized Consumption	a. Billed Metered Consumption	1,382.5	84.8	**87.9**
			b. Billed Unmetered Consumption	50.9	3.1	
			b. Billed Unmetered Consumption (Excess Use)	103.5	1.4	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	59.4	3.6	
	Water Losses 35	Commercial Losses	f. Customer Metering Inaccuracies	0	0	**12.1**
			e. Unauthorized Consumption	34.7	2.1	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

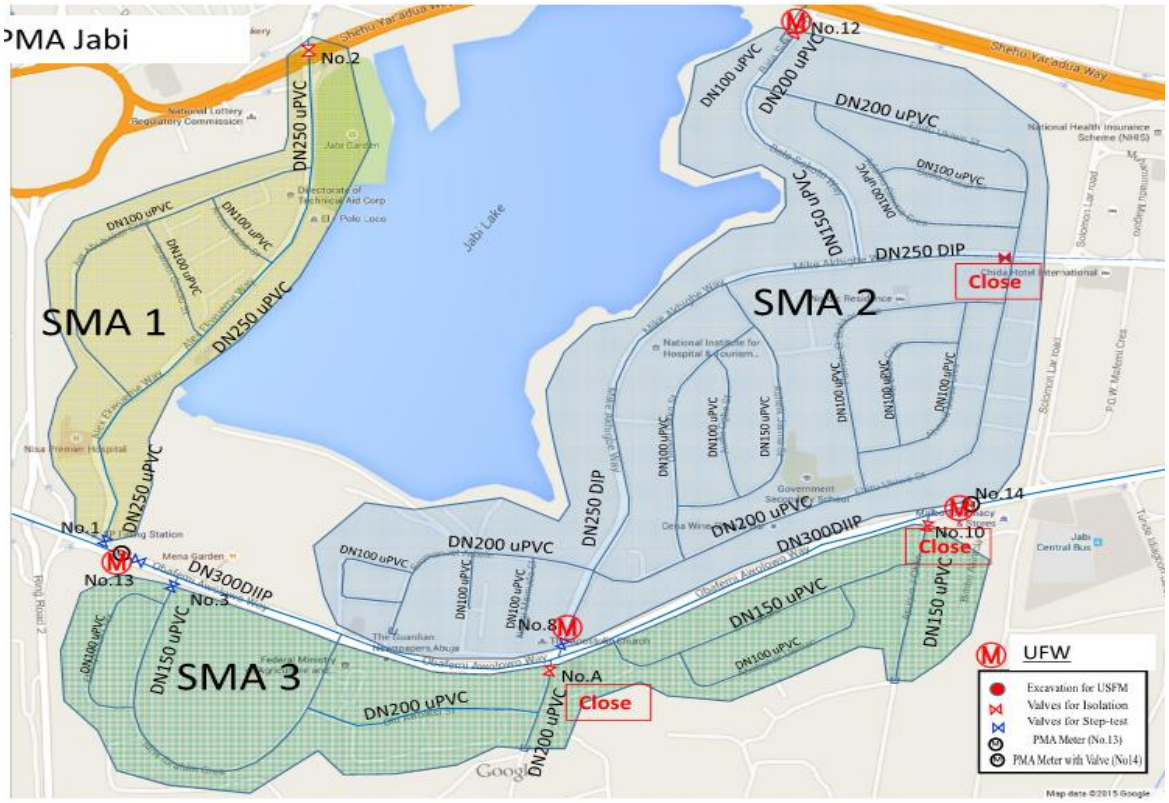
Table 3.2-64: Water Balance of Gudu SMA2

Item				m^3/day	%	%
System Input Volume (SIV) 1,405	Authorized Consumption 912	Billed Authorized Consumption	a. Billed Metered Consumption	985.1	67.0	**70.1**
			b. Billed Unmetered Consumption	46.1	3.1	
			b. Billed Unmetered Consumption (Excess Use)	96.1	6.5	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	44.7	3.0	
	Water Losses 493	Commercial Losses	f. Customer Metering Inaccuracies	0	0	**29.9**
			e. Unauthorized Consumption	299.1	20.3	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

2) Ex post stage analysis in Jabi PMA

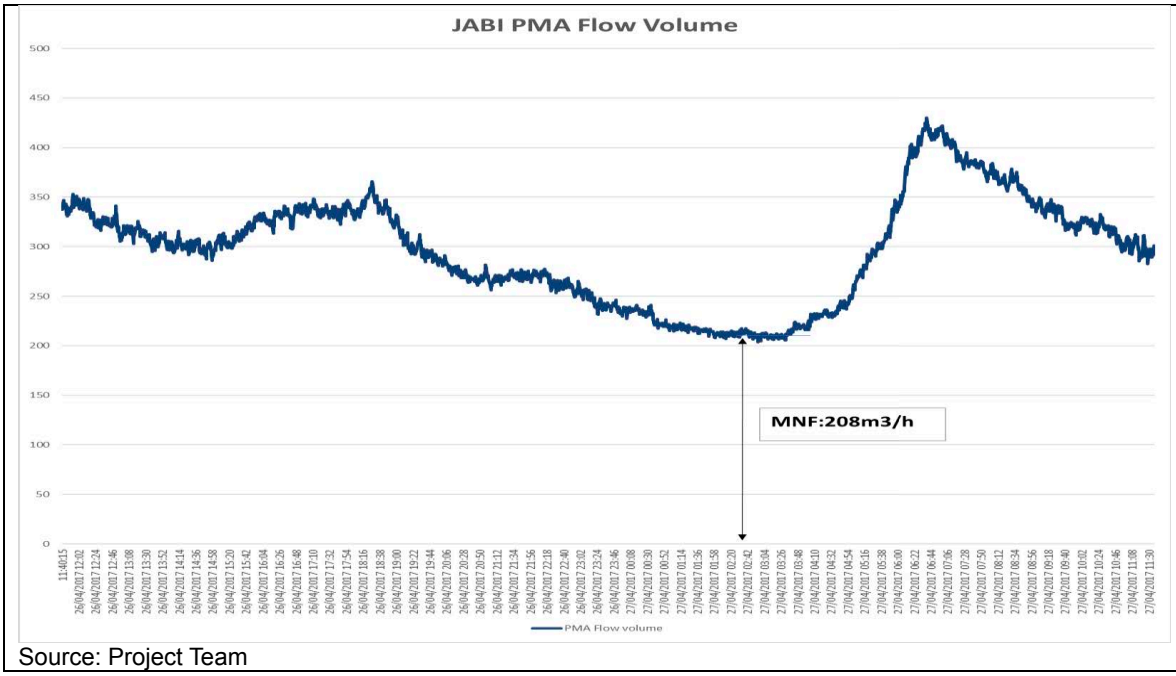
The project conducted 24hrs measurement of flow volume of PMA and SMAs using ultrasonic flow meter (UFM), location of installation is shown as Figure 3.2-39.



Source: Project Team

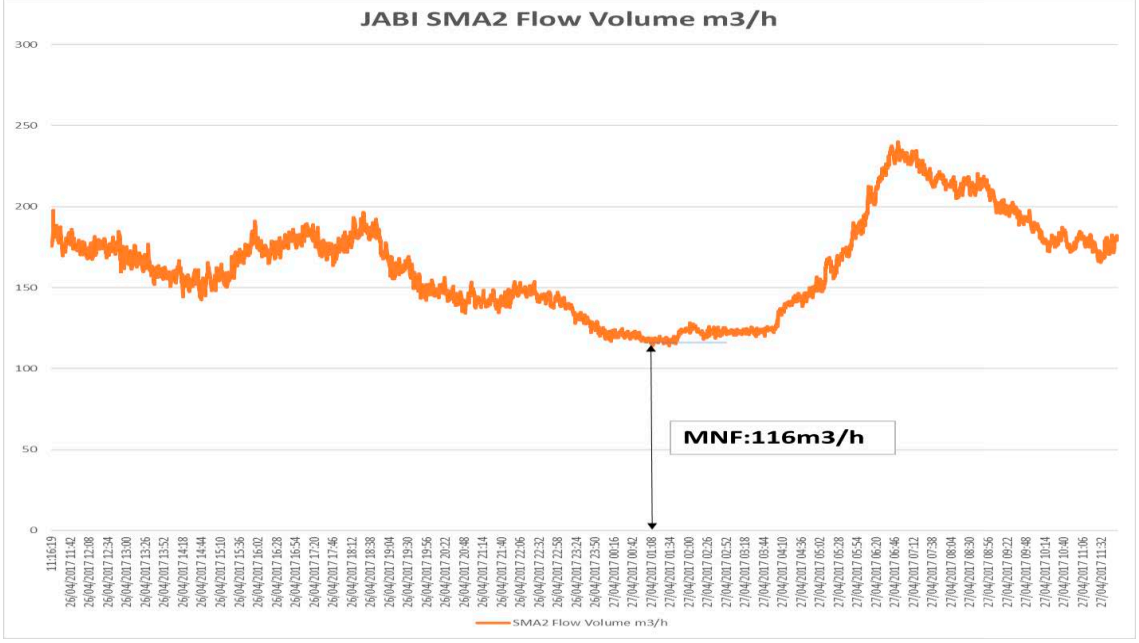
Figure 3.2-39: Location of UFMs in Jabi PMA

The results of measurement of 24hrs water inflow to PMA and the MNF night flow are shown in Figure 3.2-40 to 3.2-42 and Table 3.2-65.



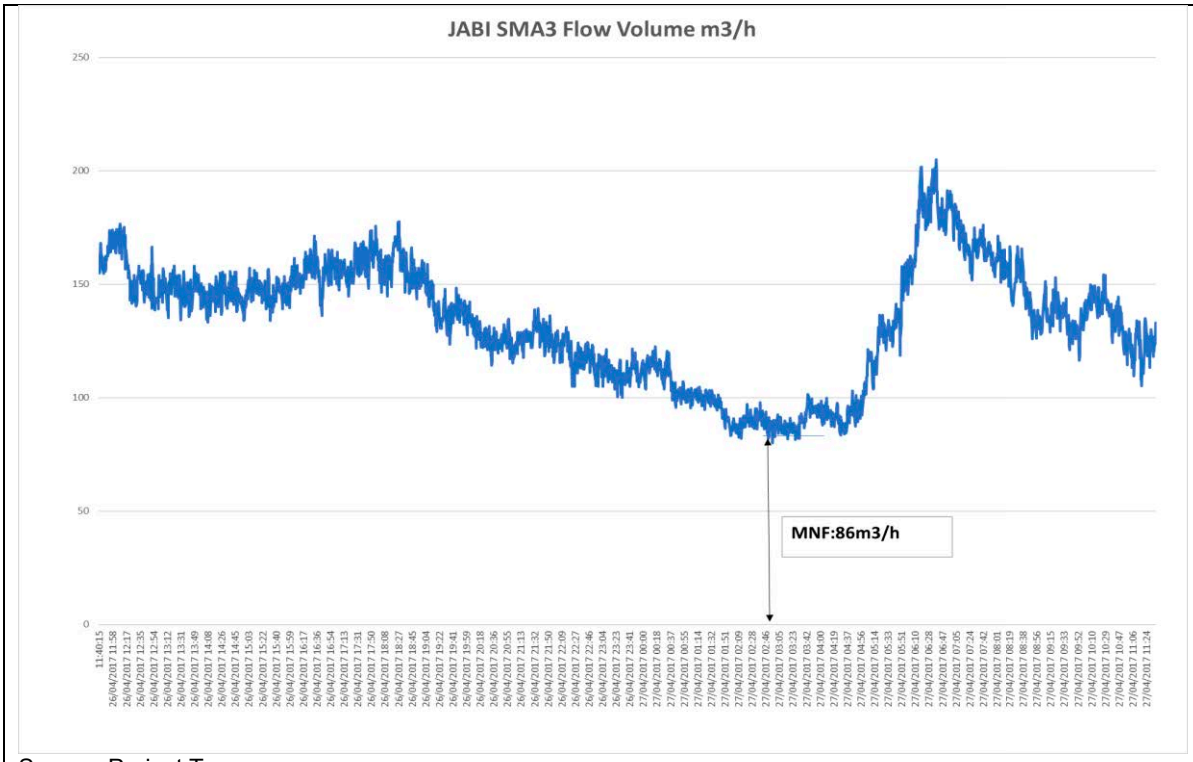
Source: Project Team

Figure 3.2-40: 24hrs Water Inflow and the MNF in Jabi PMA (SMA 2&3)



Source: Project Team

Figure 3.2-41: 24hrs Water Inflow and the MNF in Jabi PMA (SMA 2)



Source: Project Team

Figure 3.2-42: 24hrs Water Inflow and the MNF in Jabi PMA (SMA 3)

Table 3.2-65: 24hrs Water InfFlow and the MNF in Jabi PMA

	Total Inflow (m^3/day)	Average Inflow (m^3/hr)	MNF (m^3/hr)	MNF / Average Inflow (%)
PMA (SMA 2&3)	7,119	297	208	70%
SMA2	3,921	163	116	71%
SMA3	3,202	133	86	65%

Source: Project Team

The MNF of PMA is high and accounts for 70% of average flow. Despite high MNF, the Project has not detected such large amount of leakage by the leakage survey in this period, it is difficult to decide such amount of water is all leakage.

Table 3.2-66 to Table 3.2-68 show result of water balance as ex post stage. Result of NRW ratio was improved highly as 30.9% at PMA, 21.1% at SMA2 and 42.6% at SMA3. Improved points of NRW ratio became 39.1 at PMA, 24.4 at SMA2, 45.0 at SMA3 from baseline stage.

Table 3.2-66: Water Balance of Jabi PMA

Item				m^3/day	%	%
System Input Volume (SIV) 7,119	Authorized Consumption 5,105	Billed Authorized Consumption	a. Billed Metered Consumption	4,883.0	68.6	**37.1**
			b. Billed Unmetered Consumption	33.9	0.5	
			b. Billed Unmetered Consumption (Excess Use)	19.7	0.3	**62.9**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	168.2	2.4	
	Water Losses 2,015	Commercial Losses	f. Customer Metering Inaccuracies	0	0	
			e. Unauthorized Consumption	2,014.6	28.3	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-67: Water Balance of Jabi PMA (SMA 2)

Item				m^3/day	%	%
System Input Volume (SIV) 3,722	Authorized Consumption 2,794	Billed Authorized Consumption	a. Billed Metered Consumption	3,066.6	78.2	**69.8**
			b. Billed Unmetered Consumption	24.9	0.6	
			b. Billed Unmetered Consumption (Excess Use)	19.7	0.5	**30.2**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	168.2	4.3	
	Water Losses 926	Commercial Losses	f. Customer Metering Inaccuracies	0	0	
			e. Unauthorized Consumption	641.2	16.4	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

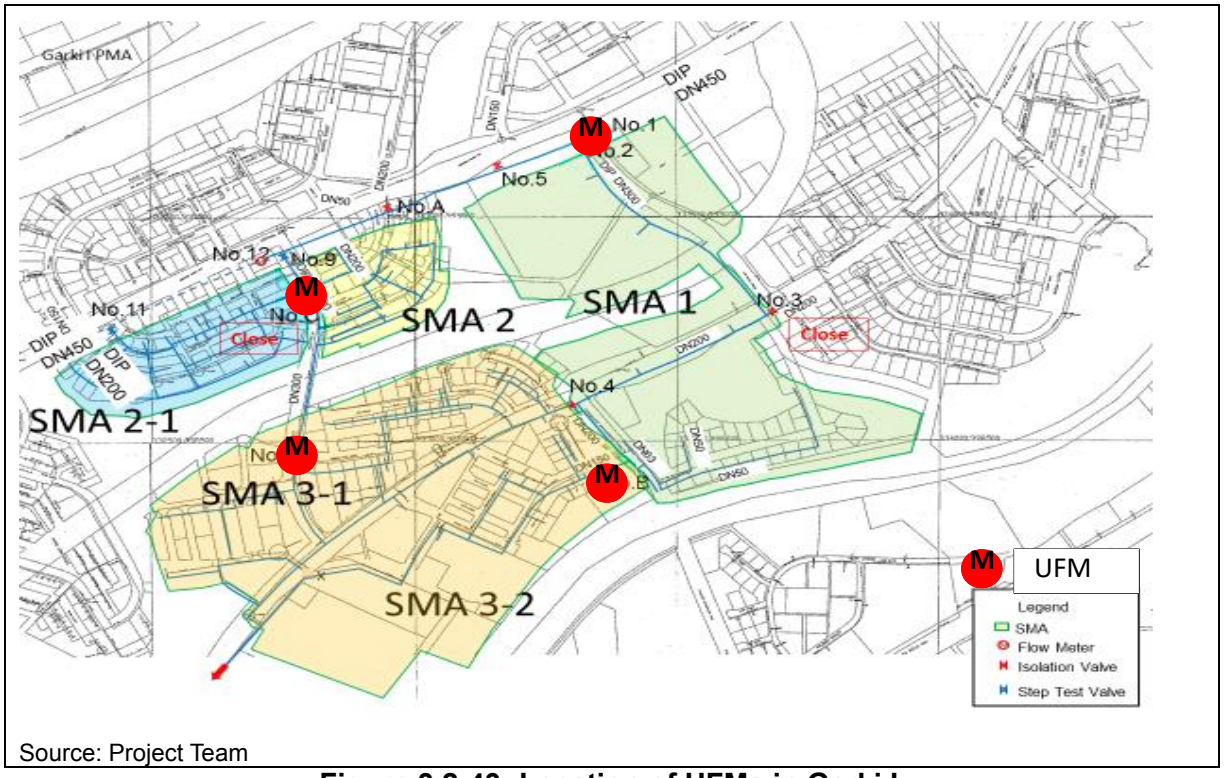
Table 3.2-68: Water Balance of Jabi PMA (SMA 3)

Item				m^3/day	%	%
System Input Volume (SIV) 5,031	Authorized Consumption 678	Billed Authorized Consumption	a. Billed Metered Consumption	1,828.1	57.1	**57.4**
			b. Billed Unmetered Consumption	9.1	0.3	
			b. Billed Unmetered Consumption (Excess Use)	0	0	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	0	0	
	Water Losses 4,353	Commercial Losses	f. Customer Metering Inaccuracies	0	0	**42.6**
			e. Unauthorized Consumption	1,356.1	42.6	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

3) Ex post stage Analysis in Garki I PMA

The project conducted 24hrs measurement of flow volume of PMA and SMAs using ultrasonic flow meter (UFM), location of installation is shown as Figure 3.2-43.



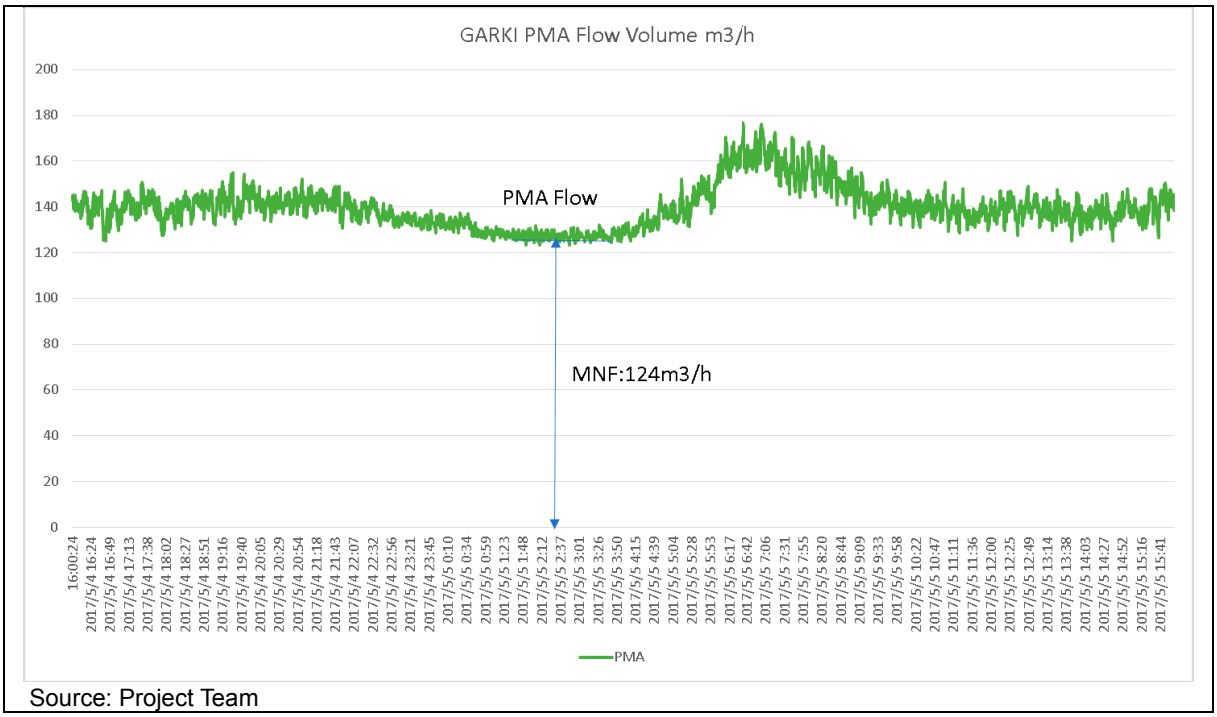
Source: Project Team

Figure 3.2-43: Location of UFMs in Garki I

In Garki I, after several times attempt to find uncertain distribution pipe connection, the Project end up discovered 200mm diameter PVC pipe which brunching from 450mm diameter DI pipe in SMA2.

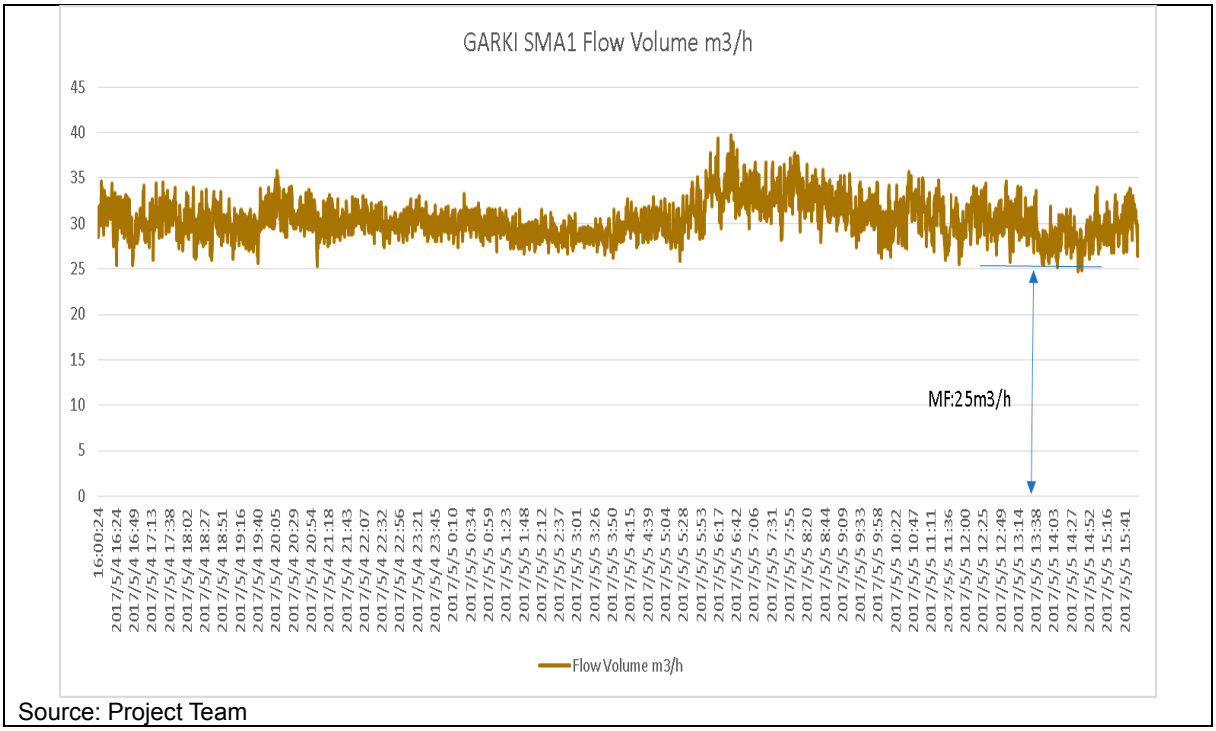
The results of measurement of 24hrs water inflow of PMA and SMAs as well the MNF are shown in Figure 3.2-44 to Figure 3.2-47 and Table 3.2-69 PMA1 and PMA2 have MN (Minimum Flow) instead of MNF, the reason of this phenomenon was not clear. The MNF of 3-SMA are remarkably high and accounts for 76%, 82% and 89% of average flow respectively. Therefore, the Project conducted

additional survey after confirmed the registration record of existing household and listed customer in PMA completely. The result is showed next section.



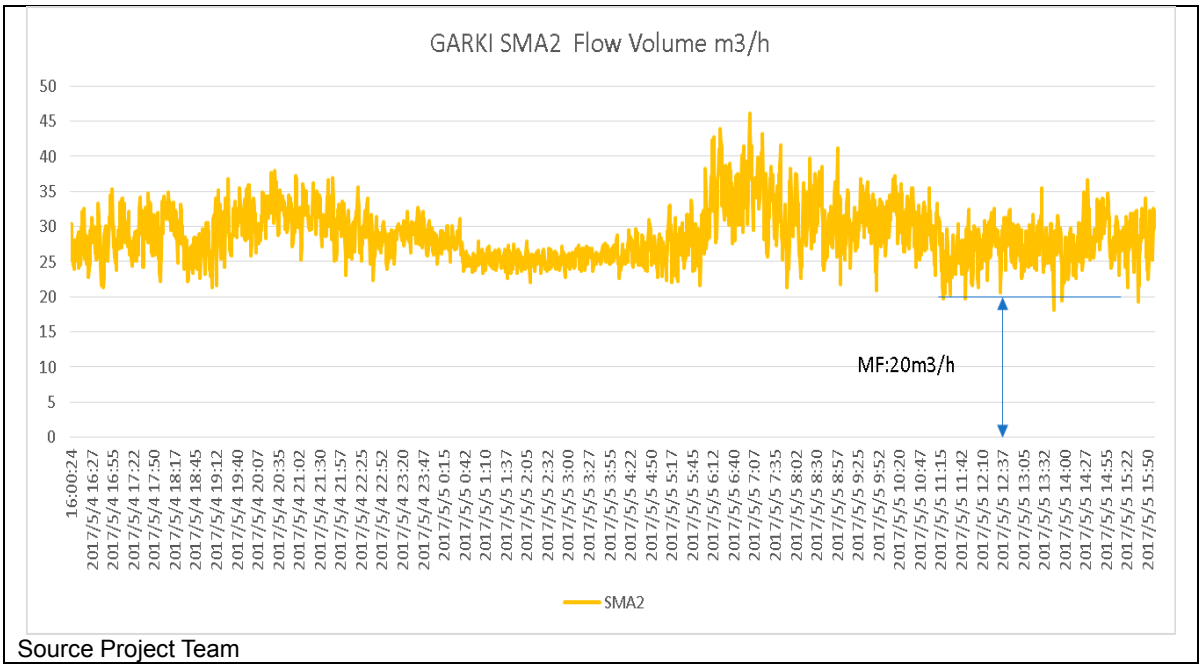
Source: Project Team

Figure 3.2-44: 24hrs Water Inflow and the MNF in Garki I PMA



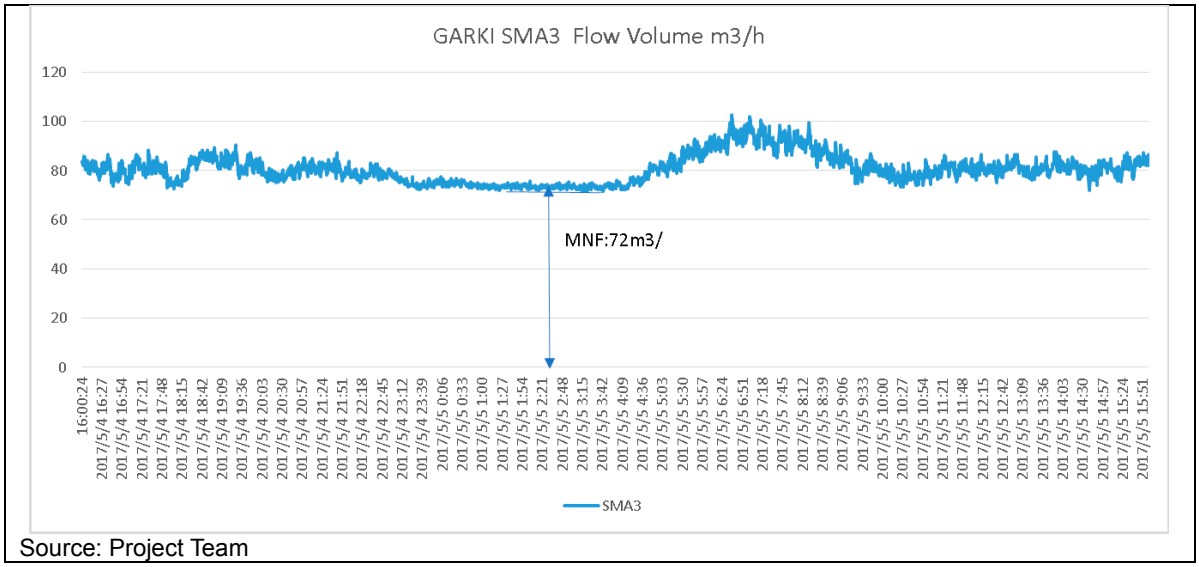
Source: Project Team

Figure 3.2-45: 24hrs Water Inflow and the MF in Garki I PMA (SMA 1)



Source Project Team

Figure 3.2-46: 24hrs Water Inflow and the MF in Garki I PMA (SMA 2)



Source: Project Team

Figure 3.2-47: 24hrs Water Inflow and the MNF in Garki I PMA (SMA 3)

Table 3.2-69: 24hrs Water Inflow and the MNF in Garki I PMA

	Total Inflow (m^3/day)	Average Inflow (m^3/hr)	MNF (m^3/hr)	MNF / Average Inflow (%)
PMA	3,356	140	124	89%
SMA1	731	31	MF 25	82%
SMA2	692	29	MF 20	69%
SMA3	1,933	81	72	89%

Source: Project Team

Although MNF is very high, it is hard to believe that such volume is all leakage.

Table 3.2-70 to Table 3.1-73 show water balance sheet of ex post stage. NRW ratio still high as 63.8% at PMA and 78.0% at SMA1, 79.4% at SMA2, 38.4% at SMA3. NRW ratio of SMA3was reduced 19.3 points from the previous stage. NRW ratio is very high, however, it seems that this figure include unidentified consumption, since there is no category of unidentified consumption in water balance sheet,

therefore, it was included in leakage. However leakage survey had not detected such large amount of leakage.

Table 3.2-70: Water Balance of Garki I PMA

Item				m^3/day	%	%
System Input Volume (SIV) 3,356	Authorized Consumption 1,546	Billed Authorized Consumption	a. Billed Metered Consumption	1,236.4	36.8	**39.7**
			b. Billed Unmetered Consumption	95.6	2.8	
			b. Billed Unmetered Consumption (Excess Use)	85.7	2.6	**60.3**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	3.9	0.1	
			d. Unbilled Unmetered Consumption	124.3	3.7	
	Water Losses 1,810	Commercial Losses	f. Customer Metering Inaccuracies	1,809.7	53.9	
			e. Unauthorized Consumption			
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-71: Water Balance of Garki I SMA1

Item				m^3/day	%	%
System Input Volume (SIV) 731	Authorized Consumption 326	Billed Authorized Consumption	a. Billed Metered Consumption	266.1	15.4	**37.8**
			b. Billed Unmetered Consumption	10.0	1.4	
			b. Billed Unmetered Consumption (Excess Use)	20.0	2.7	**62.2**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	30.0	4.1	
	Water Losses 405	Commercial Losses	f. Customer Metering Inaccuracies	0	0	
			e. Unauthorized Consumption	405.0	55.4	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

*Leakage were found in SMA3
Source: Project Team

Table 3.2-72: Water Balance of Garki I SMA2

Item				m^3/day	%	%
System Input Volume (SIV) 692	Authorized Consumption 326	Billed Authorized Consumption	a. Billed Metered Consumption	145.7	21.1	**21.8**
			b. Billed Unmetered Consumption	4.9	0.7	
			b. Billed Unmetered Consumption (Excess Use)	4.0	36.4	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	1.2	1.4	
			d. Unbilled Unmetered Consumption	-	-	
	Water Losses 405	Commercial Losses	f. Customer Metering Inaccuracies	6.0	0.9	**78.2**
			e. Unauthorized Consumption	530.2	76.6	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-73: Water Balance of Garki I SMA 3

Item				m^3/day	%	%
System Input Volume (SIV) 1,788	Authorized Consumption 1,441	Billed Authorized Consumption	a. Billed Metered Consumption	819.0	42.2	**46.5**
			b. Billed Unmetered Consumption	80.7	4.2	
			b. Billed Unmetered Consumption (Excess Use)	61.7	3.2	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	98.2	5.1	
	Water Losses 347	Commercial Losses	f. Customer Metering Inaccuracies	0	0	**53.5**
			e. Unauthorized Consumption	873.1	45.2	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

4) 2nd Ex Post Stage Analysis in Garki I PMA

The 1st ex post stage result was the less ratio than the Project Team expected, therefore, the Project Team examined the cause. The Project Team suspected that the customer list which supplied from FCTWB have not been listed up all water user in the area, some of the water users may be missing in the list. Therefore, the Project Team conducted through survey in the field to find passed customer. After the through survey, the Project Team found many customers haven't been listed on the project list. Deal with this result, the Project Team decided to do the 2nd analysis. Number of customer increased about 120.

Table 3.2-74: 2nd Ex post Customer List of Garki I PMA

Category	Meter Type	SMA 1	SMA 2	SMA 3	Total	Remarks
Domestic Customer	Conventional	0	43	49	**92**	
	Flat-Rate	0	2	7	**9**	
	AMR	21	124	256	**401**	
	Prepaid	0	0	0	**0**	
	Unknown	0	0	0	**0**	
	Sub-Total	**21**	**167**	**305**	**493**	
Commercial Customer	Conventional	0	0	1	**1**	
	Flat-Rate	0	1	0	**1**	
	AMR	5	2	16	**23**	
	Prepaid	0	0	0	**0**	
	Unknown	0	0	0	**0**	
	Sub-Total	**5**	**2**	**16**	**23**	
Major Consumers	Conventional	1	0	10	**11**	
	Flat-Rate	1	0	3	**4**	
	AMR	8	5	23	**36**	
	Prepaid	0	0	0	**0**	
	Unknown	2	0	4	**6**	
	Sub-Total	**12**	**5**	**40**	**57**	
Total		**38**	**174**	**361**	**573**	

Source: Project Team

The Project Team curried out 24hrs water flow measurement and the results are shown below.

Table 3.2-75: 2nd Ex post 24hrs Water Inflow and the MNF in Garki I PMA

	Total Inflow (m^3/day)	Average Inflow (m^3/hr)	MNF (m^3/hr)	MNF / Average Inflow (%)
PMA	2,852	118.8	105	88%
SMA1	516	21.5	15	70%
SMA2	625	26.0	15	58%
SMA3	1,711	71.3	60	84%

Source: Project Team

Table 3.2-76 to Table 3.2-79 show water balance sheet of 2nd Ex post stage. NRW ratio of PMA was decreased dramatically as 34.8% from 60.3% of 1st Ex post stage analysis and 74.8% from previous stage. NRW ratio of each SMAs were also deceased largely at SMA1 was 45.2%, 49.3% at SMA2, 27.4% at SMA3.

Table 3.2-76: 2nd Ex-post Water Balance of Garki I PMA

Item				m^3/day	%	%
System Input Volume (SIV) 3,356	Authorized Consumption 1,546	Billed Authorized Consumption	a. Billed Metered Consumption	1,582.2	55.4	**65.2**
			b. Billed Unmetered Consumption	280.6	9.8	
			b. Billed Unmetered Consumption (Excess Use)	135.2	4.7	**34.8**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	167.7	5.9	
	Water Losses 1,810	Commercial Losses	f. Customer Metering Inaccuracies	688.3	24.1	
			e. Unauthorized Consumption			
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-77: 2nd Ex-post Water Balance of Garki I PMA (SMA1)

Item				m^3/day	%	%
System Input Volume (SIV) 2,852	Authorized Consumption 1,861	Billed Authorized Consumption	a. Billed Metered Consumption	248.4	48.1	**54.9**
			b. Billed Unmetered Consumption	35.0	6.8	
			b. Billed Unmetered Consumption (Excess Use)	20.0	3.9	**45.1**
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	61.5	11.9	
	Water Losses 991	Commercial Losses	f. Customer Metering Inaccuracies	0	0	
			e. Unauthorized Consumption	151.2	29.3	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

*Leakage were found in SMA3
Source: Project Team

Table 3.2-78: 2nd Ex-post Water Balance of Garki I PMA (SMA2)

Item				m³/day	%	%
System Input Volume (SIV) 625	Authorized Consumption 317	Billed Authorized Consumption	a. Billed Metered Consumption	205.4	32.9	**50.7**
			b. Billed Unmetered Consumption	111.3	17.8	
			b. Billed Unmetered Consumption (Excess Use)	48.4	7.7	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	1.2	0.2	
			d. Unbilled Unmetered Consumption	-	-	
	Water Losses 308	Commercial Losses	f. Customer Metering Inaccuracies	0	0	**49.3**
			e. Unauthorized Consumption	258.8	41.4	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

Table 3.2-79: 2nd Water Balance of Garki I SMA 3

Item				m³/day	%	%
System Input Volume (SIV) 1,711	Authorized Consumption 1,243	Billed Authorized Consumption	a. Billed Metered Consumption	1,108.6	64.8	**72.6**
			b. Billed Unmetered Consumption	134.3	7.8	
			b. Billed Unmetered Consumption (Excess Use)	66.8	3.9	
		Unbilled Authorized Consumption	c. Unbilled Metered Consumption	-	-	
			d. Unbilled Unmetered Consumption	105.0	6.1	
	Water Losses 468	Commercial Losses	f. Customer Metering Inaccuracies	0	0	**27.4**
			e. Unauthorized Consumption	296.2	17.3	
		Physical Losses	g. Leakage on Distribution Network			
			i. Leakage on Service Connections up to Point of Customer Use			

Source: Project Team

(12) Summary of Results

Table 3.2-80 and Table 3.2-81 show summary of the achieved results by the pilot project. NRW ratio was improved remarkably.

- Leaks at valves and along service pipes as well as illegal connections were detected and repaired in all PMAs. Hence, regardless of areas, NRW reduction operations against leaks at valves and along service pipes as well as illegal connections are effective.
- A number of illegal connections were observed in Gudu PMA. Hence, in the area where prepaid meters exists such as Gudu PMA, NRW reduction operations against illegal connections are effective.
- Leaks along distribution networks were detected and repaired particularly in Gudu PMA. Hence, in the area which was developed by a private developer, NRW reduction operations against distribution networks are effective, while Jabi and Garki I PMAs were developed by FCDA.

- Meter replacement improved meter inaccuracy particularly in Jabi PMA. Hence, in the area a lot of conventional meters exist, meter replacement as a NRW reduction operation is effective.
- Regardless of area, elimination of flat rate customers progressed by meter installation.
- Accurate information of customers including major consumers as well as accurate distribution network information are keys to accurate water balance analysis, particularly in the Phase 1 development areas such as Garki I which are old.
- Improvement in AMR data capturing is a key to accurate water balance analysis, particularly in the Phase 1 development area such as Garki I.

Table 3.2-80: Implemented NRW Reduction Operations

Item		Gudu	Jabi	Garki I
Meter replacement	Type of meter	Prepaid	Conventional	AMR
	No. of meters	193	600	150
Reduction of flat rate customer	Customer	Not clear	4	57
	Major Consumers	1	13	13
Detected illegal connection		37	10	23
Detected leakage	Distribution line	34	0	4
	Service pipe	36	37	39
NRW improvement of PMA	Previous⇒Ex post stage	53.3⇒20.4	70.0⇒30.9	74.8⇒34.7

Source: Project Team

Table 3.2-81: Achieved NRW Improvement

PMA/SMAs Area	Previous NRW %	Ex post NRW %	Factor/Operation to reduce NRW
Gudu			
PMA	53.3	20.4	- Factor/Operation-1 (1.94⇒2.87m³/customer/day) - Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (network, valves and service pipes) - Factor/Operation-5
SMA1	52.0	12.1	- Factor/Operation-1 (1.73⇒2.82m³/customer/day) - Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (network, valves and service pipes)
SMA2	53.9	29.9	- Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (valves and service pipes)
Jabi			
PMA	70.0	30.9	- Factor/Operation-1 (3.89⇒5.58m³/customer/day) - Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (valves and service pipes) - Unbilled large scale shopping mall
SMA2	45.6	21.1	- Factor/Operation-1 (3.89⇒5.58m³/customer/day) - Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (valves and service pipes) - Unbilled large scale shopping mall
SMA3	87.6	42.6	- Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (valves and service pipes)
Garki I			
PMA	75.7	34.7	- Factor/Operation-1 (1.05⇒1.48 m³/customer/day) - Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (network, valves and service pipes) - Factor/Operation-5 (domestic customers and major consumers) - Missing of customers in pilot project's customer list which was found out by thorough investigation
SMA1	85.1	45.2	- Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (network and service pipes) - Factor/Operation-5 (domestic customers and major consumers)
SMA2	74.8	49.3	- Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (valves and service pipes) - Missing of customers in pilot project's customer list which was found out by thorough investigation
SMA3	70.0	27.4	- Factor/Operation-1 (0.90⇒1.38m³/customer/day) - Factor/Operation-2 - Factor/Operation-3 - Factor/Operation-4 (network, valves and service pipes) - Factor/Operation-5 (major consumers)
Remarks Factor/Operation-1: By meter installation and reading, estimated billed customers had consumed more water than estimated billed water volume (calculated by N80/m³ or			

PMA/SMAs Area	Previous NRW %	Ex post NRW %	Factor/Operation to reduce NRW
			N150/m^3), and this greatly influenced to increasing average water consumption (per-customer per-day). Factor/Operation-2: Meter installation/replacement & accurate meter reading Factor/Operation-3: Disconnection of illegal connections Factor/Operation-4: Leakage detection & repair Factor/Operation-5: Conversion from flat-rate customer to metered customers (Nominal Excess Use)

Source: Project Team

(13) Prepare a report on pilot projects, covering Activity 2-1~2-15. (Activity 2-16)

The following contents of the pilot projects were reported in workshop, technical meetings and JCC.

1) Outline of PMAs and SMAs

Basic Information and Features, Locations, Boundary, Network Drawings, Position of PMA Flow-meters and Isolation Valves, etc.

2) Baseline Survey (before NRW Reduction Operations)

Workflow, Procedures, Customer Listing, Results of 1-week Customer Meter Reading, Customer Meter Error Test and Illegal Connection Survey, Results of Measurement of 24-hours Flow, Minimum Night Flow and Step Test (Area), Water Balance Analysis, etc.

3) NRW Reduction Operations Plan and Implementation

Workflow, Procedures, Prioritization, Operations against Commercial Loss (Replacement or Newly-installation of Customer Meters, Disconnection or Legalization of Illegal Connections), Operations against Physical Loss (Step Test (Line), Detection of Leaks and Repair of Leaks), Scheduling, Cost Estimation and Logistics, etc.

4) Ex-post Survey (after NRW Reduction Operations)

Workflow, Procedures, Updated Network Drawing, Updated Customer Listing, Results of 1-week Customer Meter Reading, Results of Measurement of 24-hours Flow, Minimum Night Flow and Step Test if necessary, Water Balance Analysis, etc.

5) Evaluation of Pilot Project

Comparison of NRW Ratio before and after NRW Reduction Operations, Calculation of Actual Cost, Benefit of NRW Reduction Operations, Cost-Effectiveness Analysis, etc.

6) Develop manuals for NRW reduction for Area Office managers and field operators (i.e. technical officers and meter readers), including audio visual materials. (Activity 2-17)

In order for staff of Area office to take NRW reduction operations by themselves, the Project completed to make the manuals for NRW reduction based on implementation of the pilot project. Refer to Annex 15.

3.2.3 Activities for Output-3

(1) Establish a Working Group for NRW planning. (Activity 3-1)

Prior to the Phase 2 of the Project aiming at development of a medium-term strategic plan on NRW reduction, the Project established a Working Group for NRW planned in the first JCC meeting. At the beginning of the Phase2, the Project had a review of the appointed members as the Working Group in order to clarify the responsibilities of members and to enhance the ownership according to the results of the Phase 1. Table 3-2-82 shows members of Working Group.

Table 3.2-82: Members of Working Group for NRW Reduction Planning

Member	Position in FCTWB (as of the time of establishment)
Advisory Level Sub-Group	
FCTA	
Mr. Sani Pai	Chairperson, Director, EPRS
Mr. Lawal Abubakar	Deputy Director, EPRS
FCTWB	
Mr. Hudu Bello	Director (retired)
Engr. A. A. Nahuche	HoD: Distribution (currently General Manager)
Mr. Adis S. Muhammad	HoD: Commerce (transferred)
Mrs. Hafsat Ahmed Lawi	HoD: Finance
Mr. Sunday Agbonthane	HoD: Reservoir and Production
Mrs. Lola Okobi	HoD: Quality Control
Engr. Abolade R. Lawal	Head of Unit of Special Project (currently HoD: Distribution)
Mr. Dele Olatunji	HoU: Multilateral Relations
Mrs. Bunmi Olowookere	HoU: Planning, Research and Statistics (transferred)
Mr. Musa Dikko	HoU: Pipeline/Distribution
Engr. F. O. Ezeoha	Deputy Director: Water & Sewage, Engineering Service
Engr. J. U. Osayande	Deputy Director: Design, Design & Evaluation
FMWR	
Mr. Adebanjo Adebayo J.	Deputy Director: TSS/C&P
Working Level Sub-Group	
FCTWB	
Engr. Moh. Kabir Rabiu	Leader, HoU: NRW Reduction
Engr. Abdullahi Masaud	Sub-Leader, HoU: Metering General (currently, Gwarimpa Area Manager9
Mrs. Rose A. Akpan	Sub-Leader, HoU: Billing
Mr. Isah Danjuma	HoU: Monitoring and Detection (transferred)
Mr. Shehu Suleiman	HoU: GIS
Mr. Habib Ahmed Kiru	Gudu Area Manager (transferred)
Mr. Muhammed A. S. Ramat	Jabi Area Manager (transferred)
Mr. Adesoji Adenuga	Garki I Area Manager (transferred)
Mr. Abdulrahman Muhammed	NRW Reduction Unit
Mr. Igbinosa Courage	NRW Reduction Unit
Mr. Mohammed Dauda	Pipeline Unit
Mr. Abubakar Ubabe Abuba	NRW Reduction Unit
Mr. Abdulrahman Shehu Sani	Metering Unit
Mr. Abdul Ozumi	Gudu Assistant Area Manager
FCTA	
Engr. Solomon Udoh	Principal Engineer, Engineering Services, FCDA

Source: Project Team

(2) Review existing plans, implementation structure, on-the-job training mechanism, etc. related to NRW reduction at FCTWB. (Activity 3-2)

For NRW reduction, FCTWB has no existing plans apart from the one for zonal meter installation prepared in 2009, no systematic implementing structures and procedures by dedicated Departments or Units, no trainings and equipment. Because of limited understanding and capacity of NRW reduction, that is, FCTWB had took countermeasures unsystematically or in a passive manner against NRW, mostly repair of surface water leaks as a physical loss, as shown in Table 3.2-83.

Table 3.2-83: Existing Countermeasures against NRW in FCTWB (Before the Project)

Category	Status
Unbilled Unmetered Consumption	● FCTWB has not measured water for maintenance, fire-fighting and discharging from washout or air valves along transmission or distribution mains for breaking pressure. ● FCTWB staff is exempt from billing as welfare. ● 15% of total customers and major consumers remains in flat rate. Meters are supposed to be installed by Metering Unit, but it has little been done due to lack of budget, though FCTWB has collected registration fee from customers including meter installation.
Unauthorized Consumption	● Pipeline Unit has sometimes identified illegal connections at air valves and drain/washout valves along transmission mains in maintenance, and disconnected them ad hoc. ● Monitoring and Detection Unit and Area Offices are in charge of illegal connections and tampering in distribution networks, but actually they do not have systematical ways in an active manner such as standard operating procedures. ● Track record of billed consumption and amount of customers are useful to identify irregularity but the existing billing system cannot help it due to its limited capability.
Customer Metering Inaccuracies and Data Handling Errors	● FCTWB does not have only equipment or laboratory to test customer meters but also meter standardization. Particularly, the aged meters, of which accuracy get worse, are supposed to be replaced by new ones by Metering Unit, but it is not the rule in FCTWB. ● Data handling errors may arise in the manual process such as meter reading, writing in memo paper, transcription to billing form in the office and then data entry to billing system. But existing billing system and structure of FCTWB cannot detect them effectively.
Leakage on Transmission and/or Distribution Mains	● Pipeline Unit and Area Offices do not have equipment and skilled staff for leakage detection, and especially Area Offices are not equipped for prompt and smooth repair of leaks. ● Pipeline Unit is in charge of transmission and distribution mains or network of D300mm or more. Whenever obviously-visible considerable leaks and pipe bursts occur along the mains or someone reports, the Unit repairs them. The Unit has often faced difficulty in repair glass-reinforced plastic pipes. ● Area Offices take care of distribution network of less than D300mm. Whenever obviously-visible considerable leaks and pipe bursts occur along the pipelines or someone reports, Area Offices repairs them.
Leakage and Overflows at Utility's Storage Tanks	● Overflow from storage tanks seems to be less common, but some specific tanks have constant leak which is inconsiderable unless amount of leak is severe. ● Tank Unit is in charge of maintenance, but has little awareness of leaks as NRW.
Leakage on Service Connections up to Point of Customer Use	● Area Offices in charge of service connections do not have equipment and skilled staff for leakage detection, and they are not equipped for prompt and smooth repair of leaks. ● Whenever obviously-visible considerable leaks and pipe bursts occur along the pipelines or someone reports, Area Offices repairs them. However, because of limited budget and stock for repair materials in Area Offices, leaks are not repaired immediately and repair is not always appropriate in quality. ● Staff of Area Offices has little awareness of leaks as NRW.

Source: Project Team

(3) Conduct hydraulic and water pressure distribution analyses of the pipeline networks. (Activity 3-3)

Before the commencement of the Project, FCTWB did not carry out hydraulic analysis officially by any Units except personal effort by using EPANET at particular individual level, but appointed Logistics Unit of Distribution Department for hydraulic analysis.

Hydraulic analysis requires information of existing distribution mains and networks such as length, diameter and material, water demand and elevation as input data. However, drawings and GIS map have not been developed sufficiently in FCTWB, so it is very difficult to get the information. Hence, the Project Team requested Area Offices to provide the information and make a sketch on satellite image.

For water demand, the Census data is an information source but is not applicable to the Project because it helps to calculate domestic demand only, not commercial demand. Since FCTWB organizes meter reading data by the billed amount in monetary value rather than the billed amount of water volume, it is also difficult to determine water demand from meter reading results. Hence, Project Team requested Area Offices to aggregate and submit monthly water consumption data, as well as upgraded the billing system. Project Team also requested Area Offices to specify higher and lower water pressure areas on the satellite image, which may make it relatively easy to calibrate hydraulic analysis.

For elevation data, they are not included in the existing GIS database. Therefore, FCTWB needs to conduct survey in the field by using GPS terminal, or purchase geography data, or acquire data manually from Google Earth®, etc. Because of AGIS security, these data were not reflected in FCTWB's GIS and they are not combined with pipeline information.

In consideration of dearth of as-built drawings and limited/unreliable or less-accurate data in FCTWB including GIS database, the Project selected "Zone 4" and conducted hydraulic analysis for secondary and tertiary pipeline network by using EPANET as well as verification. The Project also developed the hydraulic analysis manual (refer to Annex 15).

1) Activity of Hydraulic Analysis

a. Setting-up model zone and confirmation of Boundary

The Project selected "Zone 4" including Central Area, Asokoro, Garki I and Garki II, where water is supplied from Tank No.4, as a model zone and also selected "Garki I PMA" for more detail analysis. The reasons to select these zone and PMA were:

- Information and map relatively exist or can be obtained.
- System input volume and billed consumption are available from zonal meter reading and pilot project results
- In Garki I, SIV and consumption data is existing.
- Boundary could be confirmed at the site by both the Headquarters and Area Offices in spite of discrepancy of information.

b. Mapping and data collection of system input volume and billed consumption

- Existing pipeline data from GIS Unit as well as information from both the Headquarters and Area Offices were utilized because of data inaccuracy and missing.
- System input volume was obtained by zonal meter reading.
- Billed consumption data of domestic/commerce customers was obtained from customer data book of Area Offices, particularly metered consumption, averaged consumption from available data and converted consumption from billed amount of both conventional and AMR meters.
- Billed consumption data of major customers was obtained from relevant sections of the Headquarters.

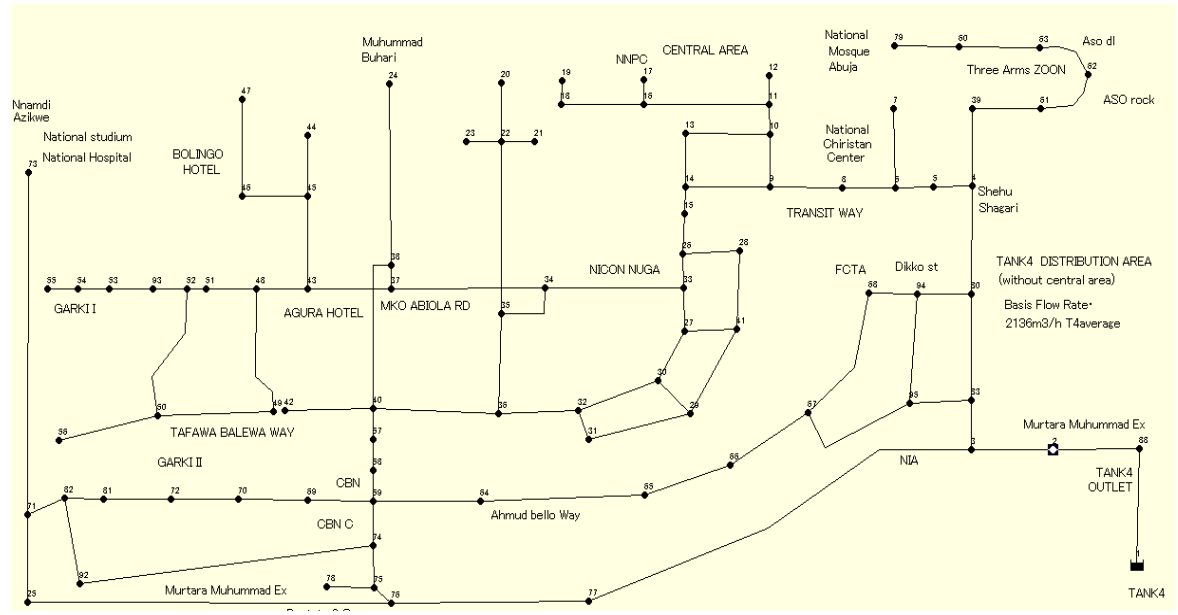
c. Verification of hydraulic analysis

- As a verification of hydraulic analysis, water pressure was measured to compare calculated results and actual measured data at the specific points.

2) Outcomes

a. Simulated pipeline network map in EPANET

Figure 3.2-48 shows the simulated pipeline network map of Zone 4 in EPANET, which was prepared by the Project Team with support from the JICA Expert Team.

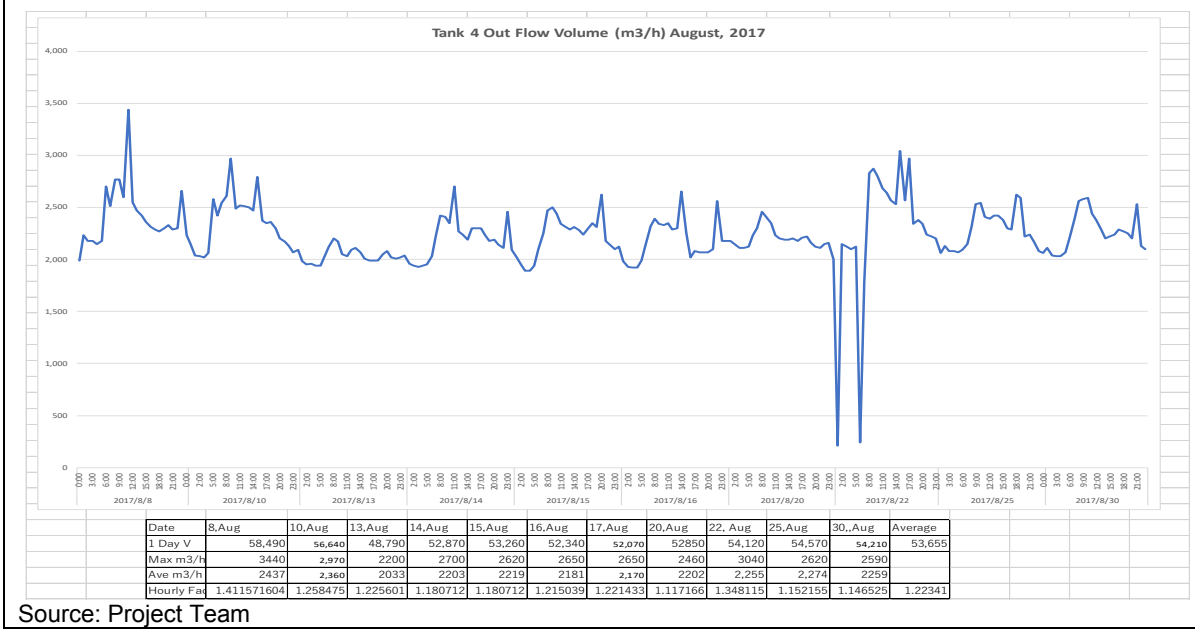


Source: Project Team

Figure 3.2-48: Simulated Pipeline Network Map of Zone 4 in EPANET

b. Calculation of System Input Volume

System input volume into Zone 4 was obtained from zonal meter reading and calculated by the Project Team with support from the JICA Expert Team.



Date	8,Aug	10,Aug	13,Aug	14,Aug	15,Aug	16,Aug	17,Aug	20,Aug	22, Aug	25,Aug	30,.Aug	Average
1 Day V	58,490	56,640	48,790	52,870	53,260	52,340	52,070	52850	54,120	54,570	54,210	53,655
Max m3/h	3440	2,970	2200	2700	2620	2650	2650	2460	3040	2620	2590	
Ave m3/h	2437	2,360	2033	2203	2219	2181	2,170	2202	2,255	2,274	2259	
Hourly Fa	1.411571604	1.258475	1.225601	1.180712	1.180712	1.215039	1.221433	1.117166	1.348115	1.152155	1.146525	1.22341

Source: Project Team

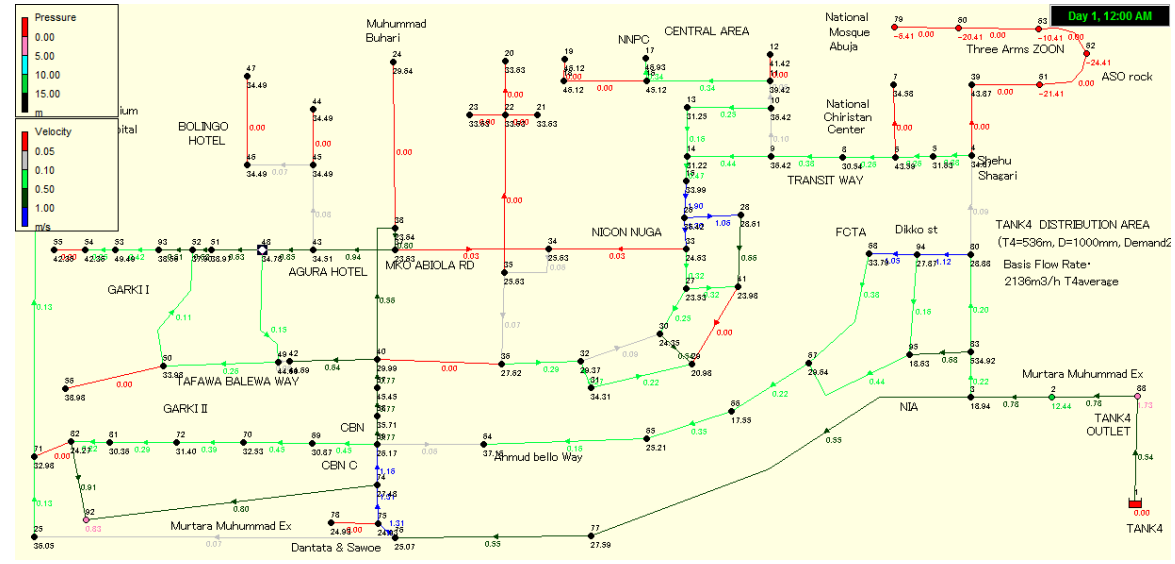
Figure 3.2-49: System Input Volume into Zone 4 (August 2017)

c. Calculation of Billed Consumption

Based on data from the relevant sections of the Headquarters and Area Offices, billed consumption was calculated at each node by the Project Team with support from the JICA Expert Team.

d. Results of Hydraulic Analyse

Judging by the minimum water pressure at 0.15Mpa (tentative value) which can supply to customers who have own storage tank, the calculated pressure at every node was higher than 0.15Mpa.

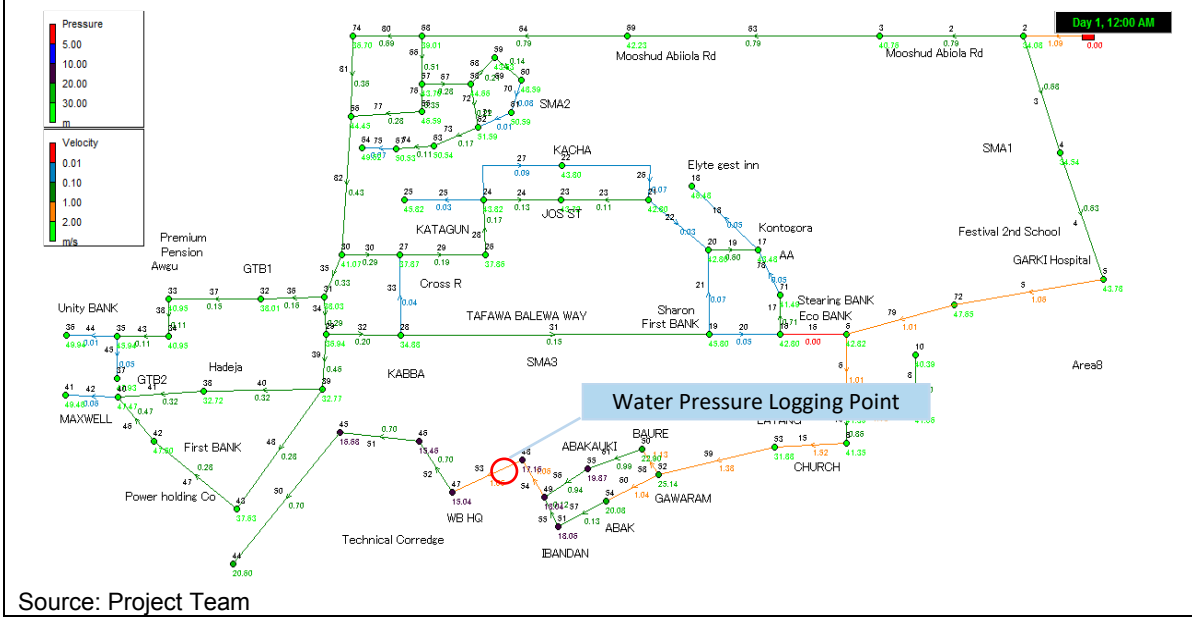


Source: Project Team

Figure 3.2-50: Simulation of Hydraulic Analysis of Zone 4

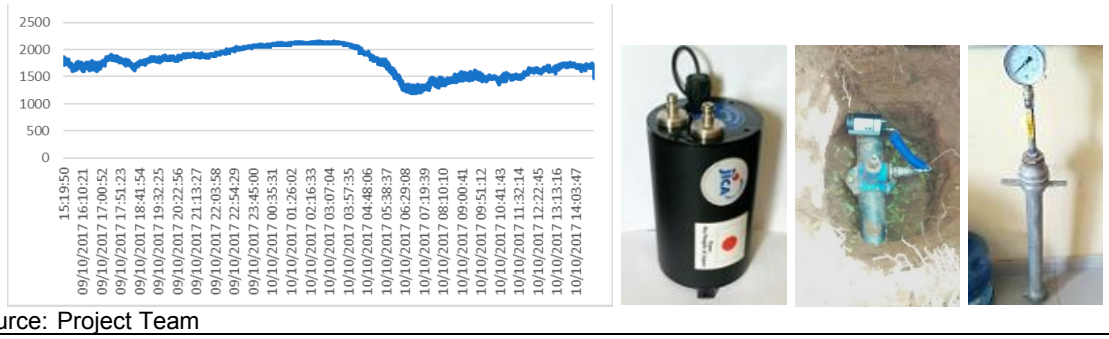
3) Verification by Water Pressure Measurement/Logging

Water pressure was measured and logged for 24 hours at the point along diameter 100mm pipeline shown in Figure 3.2-51. The calculated value was 0.1716Mpa, and the actual measured/logged data was 0.12Mpa to 2.2Mpa, therefore, this means the acceptable result was obtained through of hydraulic analysis.



Source: Project Team

Figure 3.2-51: Water Pressure Measurement/Logging Point in Zone 4



Source: Project Team

Figure 3.2-52: Result of Water Pressure Measurement/Logging in Zone 4 and Devices

(4) Develop outlines of the medium-term strategic plan and its annual NRW reduction plan. (Activity 3-4)

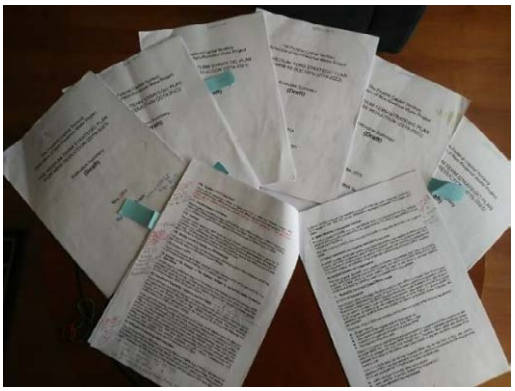
Prior to formulation of the medium-term strategic plan, the Project Team summarized the plan's contents containing assessment of the pilot projects, scenario, goal and cost-effectiveness, NRW reduction operations plan, implementing schedule and budget allocation, staffing plan and responsibility, human resource development program and recommendation.

(5) Develop the first medium-term strategic plan (2019-2023) for approval by FCTA. (Activity 3-5)

In order for FCTWB to take NRW reduction operations efficiently and smoothly from 2019, the Project formulated the medium-term strategic plan on NRW reduction (2019-2023) as an overall plan for an annual action plan (refer to Annex 16 for details).


Discussions


Read-through


Comments from Advisory Group


Explanation to Governing Board Members

Figure 3.2-53: Development of the Medium-term Strategic Plan

1) Five (5) Scenarios

From the lessons obtained through the pilot project, FCTWB needs to spend a certain amount of expenses

for NRW reduction operations. Therefore, the Project Team prepared five (5) scenarios of NRW reduction operations: Scenario-a to Scenario-e in the medium-term strategic plan to cope flexibly with influence due to various conditions such as budget release, appointment of trained staff, progress of database for the existing pipelines in future.

Table 3.2-84 summaries main operations and equipment procurement of each scenario as well as target NRW ratio ("X"-marked items to be implemented/procured). Refer to Annex 16 for details. The target NRW ratio indicates percentage unless scenario selected once is changed the year 2019 through 2023. Therefore, the target NRW ratio should be reviewed and setup in the annual action plan based on the first 6-month activities of the previous year. For the medium-term strategic plan, the Project estimated/applied NRW ratio of urban water supply system for the FCC at 48.3% for the year 2014-2017 as follows:

- System Input Volume: 113.38 million m^3 per year
- Revenue Water: 58.63 million m^3 per year
- NRW: 54.75 (113.38 – 58.63) million m^3 per year
- NRW Ratio: 54.75 / 113.38 = 48.3%

Regardless of scenario, the common objective of NRW reduction operation among five (5) scenarios is to monitor status of NRW ratio.

- Data collection of periodical/monthly billed consumption
- Data collection of periodical/monthly system input volume (SIV)
- Periodical/monthly water balance analysis

Table 3.2-84: Features of Scenarios for NRW Reduction Operations

Items	Scenario				
	a	b	c	d	e
1. Target					
1.1 Target Year	2023	2023	2023	2023	2023
1.2 Baseline NRW Ratio (%)	48.3	48.3	48.3	48.3	48.3
1.3 Target NRW Ratio in 2023 (%)	31.9	32.4	36.9	35.1	42.8
1.4 Reduction Approach	DMA	Zone	Zone	Zone	Zone
2. Main Body for NRW Reduction Operations					
2.1 Main Body for Operations (Supervision)	HQ's NRW Unit	HQ' NRW Unit	HQ's NRW Unit	HQ's NRW Unit	HQ's NRW Unit
2.2 Main Body for Operations (Field Actions)	Area Offices	Area Offices	Area Offices	HQ's NRW Unit	HQ's NRW Unit
3. NRW Reduction Operations					
(1) Network Drawings and Data	X	X	X	X	X
(2) Customer Enumeration					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
(3) DMA Design, Creation and Prioritization	X	-	-	-	-
(4) Zonal Prioritization	-	-	-	X	X
(5) Field Inspection	X	-	-	-	-
(6) Isolation by installing Flow Meters and Valves	X	-	-	-	-
(7) Step Test in DMA	X	-	-	-	-
(8) Zonal Measurement	-	-	-	X	X
(9) Leakage Detection					
a) by Area Office (DMA)	X	-	-	-	-
b) by Area Office (Zone)		X	-	-	
c) by NRW Unit (Zone)	-	-	-	X	X
(10) Patrol of Surface Leaks	-	-	X	-	-
(11) Repair of Leaks and Recording					
a) for (9)-a)	X	-	-	-	-
b) for (9)-b)	-	X	X	-	-
c) for (10)	-	-	X		-
d) for (9)-d)	-	-	-	X	X
(12) Identification of Illegal Connection and Inaccuracy Meters					
a) Illegal Connection (Area Office)	X	X	X	-	-
b) Illegal Connection (NRW Unit)	-	-	-	X	X
c) Inaccuracy Meters	X	X	X	X	-
d) Labo Test of Meter Inaccuracy for Meter Standardization	X	X	X	X	-
(13) Measures against Illegal Connection and Meter Inaccuracy					
a) Illegal Connection (Area Office)	X	X	X	-	-
b) Illegal Connection (NRW Unit)	-	-	-	X	X
c) Meter Inaccuracy	X	X	X	X	X
(14) Data Collection of Monthly Billed Consumption					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
(15) Data Collection of Monthly SIV					
a) DMA	X	-	-	-	-
b) Zone	X	X	X	X	X
c) Bulk Meters	X	X	X	X	X
(16) Monthly Water Balance Analysis	X	X	X	X	X
(17) Measurement of 1-week SIV (DMA)	X	-	-	-	-
(18) Installing Water Meters	X	X	X	X	-
(19) Survey on Trunk, Distribution Mains and Reservoirs	X	X	X	X	X
(20) Preparation for Pipe Replacement Plan	X	X	X	X	X
4. Procurement of Equipment					

Items	Scenario				
	a	b	c	d	e
4.1 Flow Meters and Valves for Isolation	X	-	-	-	-
4.2 Leak Detection Equipment	X	X	-	-	-
4.3 Water Meters	X	X	X	X	-
5. Place where equipment is stocked					
5.1 Existing Equipment	3 Pilot A.O.	3 Pilot A.O.	NRW Unit	NRW Unit	NRW Unit
5.2 Newly-procured Equipment	A.O.	A.O.	-	-	-

Source: Project Team

2) Cost-Effectiveness by Scenario

Table 3.2-85 shows the cost-effectiveness for five (5) years. "Scenario-d" indicates the highest cost-effectiveness at 18.9.

Table 3.2-85: Cost-Effectiveness by Scenario

Item		Scenario				
		a	b	c	d	e
Cost (mil. NGN)	i	882.2	804.5	326.9	222.7	123.5
Revenue yielded (mil. NGN)	ii	4,822.6	4,752.6	3,636.9	4,198.4	1,698.8
Direct Benefit （mil. NGN）	iii = ii – i	3,939.4	3,948.1	3,310.0	3,975.7	1,575.3
Cost-Effectiveness	iv = ii / i	5.5	5.9	11.1	18.9	13.8

Source: Project Team

3) Budget Allocation for Five (5) Years

Cost for NRW reduction operation is composed of the following expense items:

- Field Allowance for staff
- Equipment such as flow-meters, valves, water meters, leak detectors
- Materials such as fittings for leak repairs, 24hour-flow measurement, water meter error test, consumption survey, etc.
- Water meter laboratory
- Fuel for vehicles
- Vehicles
- Maintenance and insurance for Vehicles
- Training for human resource development

Table 3.2-86 shows the budget allocation (annual cost) for five (5) years.

Table 3.2-86: Budget Allocation for Five (5) Years by Scenario

Scenario	Cost (mil. NGN)	2019	2020	2021	2022	2023
Scenario-a	883.3	241.7	185.4	178.1	139.7	138.4
	100%	27%	21%	20%	16%	16%
Scenario-b	804.5	225.2	169.0	161.7	123.8	124.8
	100%	28%	21%	20%	15%	16%
Scenario-c	326.9	115.8	59.3	50.7	50.7	50.5
	100%	35%	18%	16%	16%	15%
Scenario-d	222.7	34.1	34.6	50.7	51.4	52.0
	100%	15%	16%	23%	23%	23%
Scenario-e	123.5	14.2	14.7	30.9	31.5	31.2
	100%	12%	12%	25%	26%	26%

Source: Project Team

4) Financial Consideration

The Financial statements of the five (5) scenarios such as "Profit and Loss" and "Cash Flow" were studied and summarized as below.

a. Conditions

Table 3.2-87 shows conditions set out for the study.

Table 3.2-87: Cost-Effectiveness by Scenario

Items	Conditions	Sources
1. Baseline of NRW ratio	48.3%	Estimated by Project Team as shown in Chapter 1.4
2. Incremental O&M expenditures	Scenario-wise	Estimated by Project Team as shown in Chapter 3.3
3 .Capital investment expenditures		
1) Construction works in 2019 for the switch-over of water supplied by LUD-WTP Phase-3&4	NGN673Mil.	Estimated by Project Team
2) Procurement in connection with the scenarios	Scenario-wise	Estimated by Project Team as shown in Chapter 3.3
4. Depreciation		
1) Procurement of above 3-2)	10 years	Estimated by Project Team mostly equipment and vehicle
2) Other assets including the construction of switch-over and LUD-WTP Phase-3&4	20 years	Estimated by Project Team (mostly facilities, installations, and pipelines)
5. Price escalation	Not applied	Judged by Project Team
6.Tariff: weighted average between the domestic and commercial customers	NGN90/m^3	Estimated by Project Team
7. Collection ratio of water tariff against bills raised	31.3%	Estimated by Project Team average rate of four years from 2014 to 2017
8. Allocation and remittance to FCTA	Not applied	Assumed by Project Team

Source: Project Team

b. Profit and Loss (P/L) Statement

Table 3.2-88 shows the summary of the P/L statement of the year 2023. With-project cases (5 scenarios) will obviously make a larger profit than without-project case (no scenario).

Table 3.2-88: Summary of P/L Statement of the Year 2023 by Scenario (Million Naira)

Account Items	No Scenario	Scenarios				
		A	b	c	d	E
1.Revenues	7,829	10,306	10,239	9,547	9,824	8,668
2.Expenditures	2,799	2,895	2,886	2,844	2,824	2,815
3.P/L = 1-2	5,030	7,411	7,353	6,703	7,000	5,853

Source: Project Team

c. Cash Flow (CDF) Statement

The C/F Statement refers to cash-inflows and cash-outflows in a given period categorizing such activities as operational, investment and financial. The difference between the cash-inflows and the cash-outflows comes out to "net cash flow" at the end. Table 3.2-89 shows the C/F Statement for the year 2023 estimated based on the above conditions.

With-project cases (five scenarios) will apparently generate the net C/F more than without-project case (no scenario). Moreover, the net C/F will surely soar if reducing the number of un-paid customers. The Scenario-a and Scenario-b could remain negative even though funded because of a heavier investment amount in the year than that of other scenarios; this negative amount should be raised for from the Government or other party accordingly.

Table 3.2-89: Summary of C/F Statement of Year 2023 by Scenario (Million Naira)

Activities	No Scenario	Scenarios				
		a	b	c	d	e
1.Operational	714.5	1,451.3	1,434.6	1,220.4	1,325.0	965.1
2.Investment	0	- 100.0	- 91.0	- 18.9	- 38.4	- 20.5
3.Financial	0	0	0	0	0	0
4. Net C/F = 1+2+3	714.5	1,351.3	1,343.6	1,201.5	1,286.6	944.7

Source: Project Team

5) Staffing Plan and Human Resource Development Plan

To implement NRW reduction operations, the strategic plan includes staffing plan for relevant Units and Area Offices as well as human resources development plan. Table 3.2-90 shows required number of staff by scenario.

Table 3.2-90: Required Number of Staff by Scenario

Unit	2019					2020					2021					2022					2023				
HQs	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e	a	b	c	d	e
NRW reduction	4	3	3	11	9	4	3	3	11	9	4	3	3	11	9	4	3	3	11	9	4	3	3	11	9
GIS	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Distribution	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2	3	2	2	2	2
Billing	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Commerce	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0
HQs Sub-total	**13**	**11**	**11**	**19**	**16**	**12**	**10**	**10**	**18**	**15**	**12**	**10**	**10**	**18**	**15**	**12**	**10**	**10**	**18**	**15**	**12**	**10**	**10**	**18**	**15**
Area Offices																									
Distribution	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Commerce	2	2	1	1	1	2	2	1	1	1	2	2	1	1	1	2	2	1	1	1	2	2	1	1	1
Area Office Sub-total	**8**	**8**	**7**	**7**	**7**	**8**	**8**	**7**	**7**	**7**	**8**	**8**	**7**	**7**	**7**	**8**	**8**	**7**	**7**	**7**	**8**	**8**	**7**	**7**	**7**
Total	**21**	**19**	**18**	**26**	**23**	**20**	**18**	**17**	**25**	**22**	**20**	**18**	**17**	**25**	**22**	**20**	**18**	**17**	**25**	**22**	**20**	**18**	**17**	**25**	**22**

Source: Project Team

Figure 3.2-54 shows training schedule.

Curriculums	2019				2020			
	1/4	2/4	3/4	4/4	1/4	2/4	3/4	4/4
Curriculum 1: Basic and Common Knowledge about NRW								
➢ Meaning of NRW Reduction								
➢ Outline of Water Balance analysis								
➢ Outline of NRW Reduction Operation								
Curriculum 2: Management of Pipelines								
➢ Outline of GIS								
➢ Outline of Water Balance analysis								
➢ Outline of NRW Reduction Operation								
Curriculum 3: Management of Data								
➢ Meter Reading								
➢ Meter Test								
Curriculum 4: Leakage and Illegal Connection Survey								
➢ Kinds of Illegal Survey Equipment								
➢ Leakage Survey Methods								
➢ Illegal Connection Survey								
Curriculum 5: Streamlining of billing system and examination on unifying water meters								
➢ Examination on unifying water meters								
➢ Streamlining of Meter reading & billing								
➢ Development of customer data								
Curriculum 6: Plumbing for repair and or replacing pipelines								
➢ Repair jointing for large scale and small scale								
➢ Laying pipelines								
➢ Install valves, flow-meters, saddle, etc.								
Curriculum 7: Basic operation of personal computer, graphing by using excel								
➢ PC operation								
➢ Calculation by using Excel								
➢ Drawing graph by using Excel								

Source: Project Team

Figure 3.2-54: Training Schedule to implement the NRW Reduction Operations

6) Scenario that FCTWB selected

To carry out NRW reduction operations, considering the following aspects, the Management of FCTWB selected "**Scenario-d**" which states that, "Only FCTWB HQ will take NRW reduction operations such as systematic leakage survey, illegal connection survey, and installation of water meters but NOT create DMAs. FCTWB will target on NRW ratio of 35.1% for the year 2023".

- Practical goal of NRW ratio and budget constraint
- Insufficient data of the existing water supply facilities
- Vulnerable structure and limited discretion in budget use of Area Offices
- Insufficient number of skilled staff of Area Offices
- Expected accommodation of disbursement due to the approved autonomy of FCTWB and appointment of the governing Board of FCTWB.
- Making the most use of skills and know-how which were obtained through the Project as much as possible so that FCTWB's capacity on NRW reduction especially at individual level is sustained.

(6) Develop an annual NRW reduction plan based on the strategic plan as an integral part of an annual recurrent and capital plan of FCTWB for approval by FCTA. (Activity 3-6)

The Project Team, particularly NRW Unit took an initiative and developed an annual NRW reduction plan for the year 2019 based on Scenario "d" as stated in the medium-term strategic plan (refer to Annex 17 for details).

(7) Develop a planning manual for NRW reduction. (Activity 3-7)

In order to enable FCTWB to review and formulate the medium-term strategic plan after 2023 by themselves continuously, the Project prepared a planning manual for NRW reduction containing the following with some templates. Refer to Annex 18.

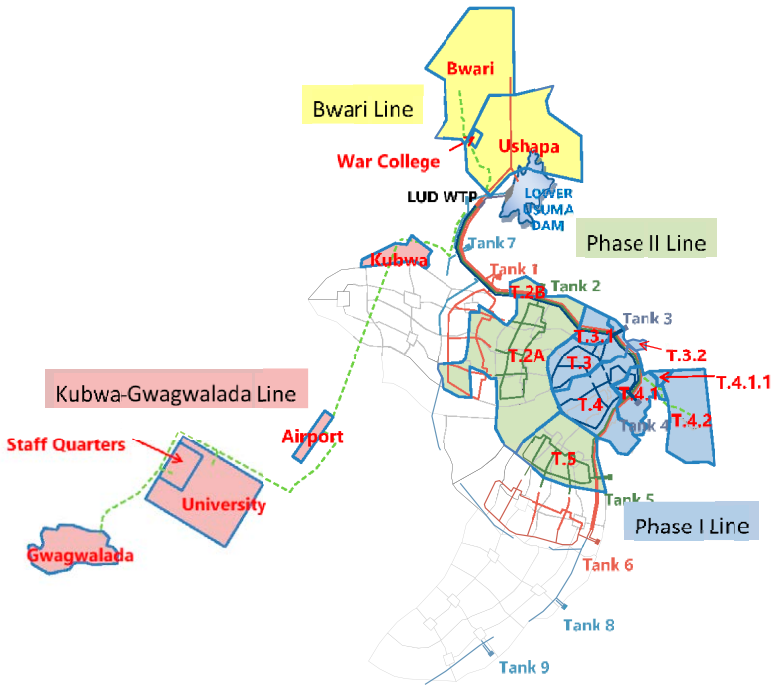
- Background of NRW Reduction
- Purpose of NRW Reduction and its Effect
- Composition of the Planning Manual for NRW Reduction
- Users of the Planning Manual for NRW Reduction
- Contents of the Planning Manual for NRW Reduction
- Results of NRW Reduction Operation for the Previous Four-year and Future Challenges

(8) Review existing plans, activities and implementing structure, etc. related to water distribution management. (Activity 3-8)

FCTWB has managed to operate facilities based on not quantitative but experiential manner. Therefore, present operation by FCTWB does not deserve to be called water distribution management. The Project Team could collect information from 8 out of 13 Area Offices, so had faced a difficulty in implementation due to dearth of as-built drawings including information on pipeline and appurtenances.

1) Zoning of Water Supply Areas

As shown in Figure 3.2-55, water supply areas can be zoned based on coverage area of each reservoir (tank). However, since flow-meters called "zonal meters" do not exist along transmission mains and water consumption by water supply area or even zone has not been calculated, zone-based water distribution management is currently impossible for FCTWB. Installation of zonal meters was proposed in 2009 by FCTWB itself but has not been implemented because of budget limitation.



Source: Project Team

Figure 3.2-55: Zoning of Water Supply Areas

2) Area Offices and Water Supply Areas in their charge

FCTWB has currently 13 Area Offices to operate and maintain less than Dia.300mm distribution mains or networks and service pipes in water supply areas in their charge. The boundary of Area Office is not always same as one of the zoning based on coverage of each reservoir (tank). Table 3.2-91 shows 18 Area Offices and water supply areas in their charge.

Table 3.2-91: Water Supply Areas in charge of Area Offices

Area Offices	Water Supply Areas
Asokoro	Asokoro
Bwari	Bwari, Ushapa
Garki I	Garki I, Central Area
Garki II	Garki II
Gudu	Gudu, Durumi, Kaura, Duboyi, Gaduwa, Apo, Dutse
Gwagwalada	Gwagwalada, University, Airport, CKC School
Gwarinpa,Jahi & Katampe	Gwarinpa I&II, Jahi, Katampe, Katampe Ext., part of Mabushi
Jabi & Utako	Jabi, Dakibiyu, Karmo, Utako, Kado, part of Mabushi
Karu / Nyanya	Karu, Nyanya
Kubwa I	Part of Kubwa
Kubwa II&III	Part of Kubwa
Maitama & Wuse II	Maitama (A5), Maitama (A6), Maitama Ext., Wuse II
Wuse I & Wuye	Wuse I, Wuye

Source: FCTWB

3) Present Situation of Water Distribution Management

Water distribution management is composed of three (3) aspects: water volume management, water pressure management and water quality management.

a. Water Volume Management

Because of non-existence of bulk and zonal meters and lack of understanding of the need, FCTWB has not measured water flow volume and not found out time-oriented water flow trend in the existing system to learn key factors for water supply such as the maximum water supply volume. In addition, existing billing system, which does not have function to calculate consumption in water volume, has not made FCTWB project water demand of customers.

Litter per capita per day (LCD) as design criteria of the existing piped system is 230 LCD set by FCDA.

b. Water Pressure Management

FCTWB has identified the areas having water pressure failures by customer complaints and reports from Area Offices, but has not been able to analyse them scientifically due to non-existence of pressure gauges to take effective actions.

An upper limit of water pressure at service points as design criteria of the existing piped system is 10 bar (1MPa) set by FCDA. However, FCTWB does not have any criteria to ensure operating water pressure at the proper level.

c. Water Quality Management

Except Lower Usuma Water Treatment Plant, there are no points for injection of chlorine even at reservoirs (tanks) in the existing piped system.

For checking concentration of residual chlorine in distribution network to be more than 0.2 mg/L, FCTWB has sampled and tested distributed water at the end users, for example, 20 customers' taps per

month in Garki I, a pilot Area Office. According to interview to Quality Control Department, it seems that FCTWB has managed to keep residual chlorine at proper level.

(9) Establish framework of water distribution management (Activity 3-9)

1) Water Distribution Management Committee

The Project established "Water Distribution Management Committee" temporarily, cross-organizational committee to discuss water distribution management in FCTWB, consisting of staff from Distribution, Commerce and Quality Control Departments (refer to Table 3.2-92). The JICA Expert Team introduced the case of Yokohama City, for example, several key factors and their concepts, facility development planning based on water demand projection, criteria of water pressure, water pressure map and residual chlorine map.

Table 3.2-92: Members of Water Distribution Management Committee

Member	Position in FCTWB (as of the time of establishment)
Engr. A. A. Nahuche	HoD: Distribution
Engr. Abolade R. Lawal	HoU: Special Project
Engr. Moh. Kabir Rabiu	HoU: Logistics (currently NRW Unit)
Mr. Abubakar Ubabe Abuba	NRW Unit
Mr. Shehu Suleiman	HoU: GIS
Engr. Douglas E. Oloton	HoU: Meter (General)
Engr. Abdullahi Masaud	HoU: Meter (Prepaid Meter)
Engr. Yetunde Olaniyan	HoU: Monitoring
Mr. Aminu Umar	HoU: Operation and Water Monitoring
Mr. Abdulrahman Mohammed	Operation and Water Monitoring Unit
Mr. Muazo Aliyu S. B.	Assistant Head of Department of Commerce
Mr. Isah Danjuma	HoU: Monitoring and Detection
Mr. Adeyemi Taiwo	Monitoring and Detection Unit
Mrs. Rose A. Akpan	HoU: Billing
Ms. Kanyi Wanaoo Mimi	HoU: Water Quality Monitoring

Source: Project Team

2) Approaches of Water Distribution Management

To realize and optimize water distribution management in FCTWB, the Project proposed approaches according to the above review.

The above Section 3.2.1 (6) "Install zonal meters, water pressure sensor and pilot remote monitoring (telemetry) system. (Activity 1-6)" describes concept and design, location of facilities and equipment required for water distribution management.

a. Water Volume Management

By installing bulk and zonal meters to measure and monitor water flow and upgrading the billing system to calculate water consumption, FCTWB can assess water volume of distribution quantitatively as well as adequacy of existing facilities against the actual requirement. The information obtained can be reflected to revision of facility development plan by FCDA as well as operation by FCTWB.

The Project empowered FCTWB to measure/monitor water flow and the billed water consumption to calculate/estimate NRW (refer to Section 3.2.1 for the results) and conduct hydraulic analysis, in consideration of telemetry system or SCADA in the future.

b. Water Pressure Management

By using portable water pressure loggers, FCTWB can measure water pressure at some points in distribution mains and networks. Then, FCTWB will be able to determine the target value of operating

water pressure, reflect it into the facility development plan and prepare facility operation plan to ensure operating water pressure at the proper level.

The Project selected the points to measure/monitor water pressure regularly in Zone 4 where hydraulic analysis could be conducted, in consideration of telemetry system or SCADA and water pressure map in the future.

c. Water Quality Management

By using data of ongoing sampling test of residual chlorine, FCTWB can identify distribution and degree of concentration of residual chlorine by water supply area and zone. Then, FCTWB will be able to reflect them into the facility development plan and prepare facility operation plan for better water quality at the proper level.

The Project selected the points to check/monitor water quality regularly in Zone 4 where hydraulic analysis could be conducted, in consideration of telemetry system or SCADA and residual chlorine map in the future.

(10) Supports to FCTWB for Autonomy and Medium-Term Strategic Planning of NRW Reduction

1) Suggestion of Framework in prospect of FCTWB Autonomy

The JICA Expert Team suggested ensuring the preparatory framework for FCTWB autonomy according to the legal basis which was actually enacted as the FCTWB Act by signing of the President of Nigeria on 29th December, 2017 during the Project period.

2) Understanding of Differences between Current (Old) FCTWB and New FCTWB

By the Act, FCTA takes a 100% stake in FCTWB and retains important authority. This means new FCTWB will be under the jurisdiction of FCTA and will NOT be autonomous completely.

Although the FCT Minister has a power of decision for primary important matters as a shareholder (owner), both the governing Board and the top management of FCTWB will be in charge of general important matters such as reorganization, financial decision-making and disbursement and so on. Therefore, FCTWB can act as an enabling water utility.

Table 3.2-93 shows comparison of major business aspects between current (old) FCTWB and new FCTWB, which are stipulated in the Act (refer to Annex 19 for details).

3) The Preparatory Framework for FCTWB Autonomy

It is imperative that FCTWB improves and strengthens own management system to conform to stipulation in the FCTWB Act, however it takes time and effort. The JICA Expert Team suggested establishing “Start-up Committee” for the preparatory framework for FCTWB autonomy in advance of the enactment. Roles and responsibilities of the start-up committee were:

a. Planning of the new management system and timeframe
b. Internal notification, instruction to staff and implementation
c. Follow-up of progress

Table 3.2-93: Differences between Current (Old) FCTWB and New FCTWB

Business Aspects		Current (Old)	New	
			Specified in the Act	Remarks
Nature of Body		An agency of FCTA (under Permanent Secretary)	Corporate body	100% owned by FCTA (Possibility of private capital induction and listing on the stock market in the future)
Authorization	Subjects of high importance	The FCT Minister National Assembly	The FCT Minister	● Board managing members: nomination, resignation and remuneration ● Nomination of Managing Director ● Capital investment plan ● Rates and charges ● Investment on property/security ● Organization ● Annual budget
		-	The National Assembly	● External borrowings ● Induction of private capital ● Listing on the stock market
	Subjects of general importance	-	The Governing Board	● Procure assets ● Fix rates and charges ● Prepare development and maintenance plan ● Recruiting and salary
Financial Subjects	Source of Funds for Operation	FCTA Treasury ● Recurrent expenditures (monthly allocation, salary payment and etc.) ● Capital expenditures	FCTWB own treasury ● Operational income ● Paid-up capital ● Government loan and subvention ● Government budget allocation	● FCTWB pays all expenditures instead. ● A large scale of capital expenditures.
	Reserved Funds	All earnings are retained at FCTA treasury.	Reserved at FCTWB own treasury	To be utilized for rehabilitation and capital expenditures
	Annual Report	Not prepared	Mandatory to submit the FCT Minister within 6 months after the end of preceding financial year.	The report shall contain the activities and the audited financial statements of FCTWB.
	External Audit	None but FY2012 and FY2013 were audited.	Mandatory to be audited within 6 months after the end of preceding financial year.	The auditors shall be appointed in accordance with the official guidelines.
	Water tariff	Not changed for long term (no review)	To be revised/set to meet the economic and financial objectives.	Cost recovery policy is required.

4) Calculation of Water Supply Cost and Water Tariff

With support from the JICA Expert Team, the Project Team and staff of the Finance Department and the Planning, Research and Statistics Unit conducted financial review for FCTWB autonomy as well as the medium-term strategic planning of NRW Reduction, as below:

a. To all Departments, an orientation meeting was held to explain
   - Necessity of calculation
   - How to calculate, and
   - Cooperation for the data required.

b. In addition to financial statements, the data required (from FY2012) were collected such as
   - Revenue water (estimated)
   - Number of customers, billed amount and revenue
   - Personnel costs, and
   - Chemical, operational costs and depreciation

c. The results calculated/analysed from the data collected were presented such as
   - Water supply cost and revenue of revenue water
   - Profitable water tariff, and
   - Financial forecast until 2023.

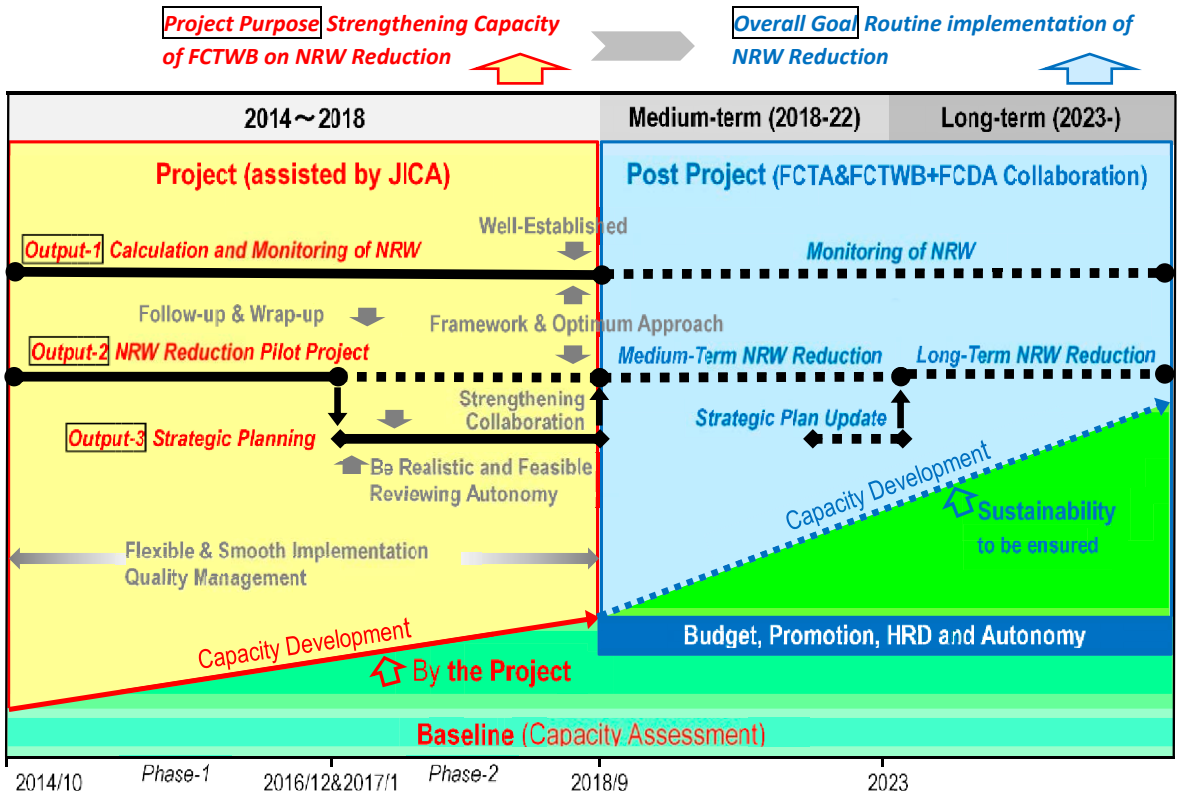
d. Outcomes were recognized and shared among Project members and participants such as
   - Basic knowledge for system input volume, revenue water, water supply cost and price
   - Necessity of depreciation of water treatment plant III & IV
   - Possible increase in revenue and profit by NRW reduction, relocation of pipeline interconnection at the upstream of bulk meters and improvement in tariff collection, and accordingly
   - Possible lowering of water tariff

3.3 Achievements of the Project

3.3.1 Outputs and Indicators (Target values and actual values achieved at completion)

As shown in Figure 3.3-1, the Project achieved indicators of three (3) Outputs with outcomes through activities, for example:

- Output 1: Establishment of the system calculating/estimating NRW ratio by bulk/zonal flow meters and billing system
- Output 2: Development of methods/operational procedures for effective NRW reduction with manuals, and also the fact of NRW reduction in pilot projects contributing revenue increase
- Output 3: Development of the medium-term strategic plan on NRW reduction based on calculated/estimated NRW ratio and the results of pilot projects.



Source: Project Team

Figure 3.3-1: Achievements in Project Timeframe

Table 3.3-1 summarizes achievements of Output-1.

Table 3.3-1: Achievements of Output-1

No	Indicator	Status
Output-1: Level of NRW of both the service area of FCWTB and water distribution areas is monitored and estimated.		
1a	Record of NRW ratio is kept by NRW Unit.	Done. NRW ratio was calculated or estimated because of data deficiency at bulk/zonal meters and also difficulty in calculating the billed consumption due to non-periodic (monthly) billing cycle and estimate bills.
1b	NRW ratio of the service area of FCTWB is reported to its Joint Management Meeting.	Ditto
1c	NRW ratio of the service area of FCTWB is reported to Management of FCTWB.	Ditto
1d	Periodic records of data and estimation on water distribution management such as water flow of zonal meters and water pressure are kept by NRW Unit.	Ditto

Source: Project Team

Table 3.2-2 and Table 3.2-3 summarize achievements of Output-2.

Table 3.3-2: Achievements of Output-2

No	Indicator	Status
Output-2: Methods/operational procedures for effective NRW reduction are established through pilot projects at Pilot Metering Areas (PMAs) under pilot Area Offices.		
2a	Decrease rate of NRW ratio for each Sub Metering Area of a PMA reaches at least 80% of its target at the end of the respective NRW reduction operations.	Not successful in SMA-2 of Garki I due to difficulty in identifying the installed pipeline, however the Project concluded indicator was generally achieved in all three PMAs. Pilot project spent the period between Nov. 2014 and Dec. 2016 intermittently and the follow up between Mar. and Oct. 2017.
2b	Technical manuals for Area Office managers and field operators (i.e. technical officers and meter readers), including audio visual materials, are approved by Head of Department (HoD) for Distribution and HoD for Commerce.	Technical manuals were approved on 13th August 2018. Refer to Annex-20.

Source: Project Team

Table 3.3-3: Results of Pilot Project

	Before (%)	After (%)	Reduction Point	Target (%)	Status	Initial Cost + Recurrent Cost (million/3yrs)	Estimated Revenue Increase (million/3yrs)
Gudu							
SMA-1	52.0	12.1	39.9	31.2	OK		
SMA-2	53.9	29.9	24.0	32.3	OK		
PMA	53.3	20.4	32.9	32.0	OK	N81.9	N100.6
Jabi							
SMA-2	45.6	21.1	24.5	27.4	OK		
SMA-3	87.6	42.6	45.0	52.6	OK		
PMA	70.0	30.9	39.1	42.0	OK	N95.0	N274.3
Garki I							
SMA-1	85.1	45.2	39.9	51.1	OK		
SMA-2	74.8	49.3	25.5	44.9	Non		
SMA-3	70.0	27.4	42.6	42.0	OK		
PMA	74.8	34.7	40.1	44.9	OK	N97.9	N112.4

Source: Project Team

Table 3.3-4 summarizes achievements of Output-3.

Table 3.3-4: Achievements of Output-3

No	Indicator	Status
Output-3: A medium-term strategic plan of FCTWB for NRW reduction is developed, utilizing the results of Output 1-2.		
3a	Draft medium-term strategic plan for NRW reduction (2019-2023) is submitted by FCTWB to FCTA for review and approval.	Draft medium-term strategic plan for NRW reduction (2019-2023) was submitted by FCTWB to the governing Board of FCTWB on behalf of FCTA for review and approval, on 30th July 2018.
3b	An annual NRW reduction plan (2019) is committed by the governing Board of FCTWB, to be incorporated in FCWTB's annual recurrent and capital budget plan (2019) for submission to FCTA for review and approval.	The incorporation was committed by the governing Board of FCTWB on behalf of FCTA on 5th September 2018, in response to the official request letter by FCTWB. Refer to Annex-20.
3c	A planning manual for NRW reduction is approved by the General Manager of FCTWB.	A planning manual was approved on 13th August 2018. Refer to Annex-20.
3d	Framework of water distribution management is established.	Framework of water distribution management was established in September 2018.

Source: Project Team

3.3.2 Project Purpose and Indicators (Target values and actual values achieved at completion)

Based on the achievement of the above Outputs, the Project achieved the following indicators of Project Purpose as shown in Table 3.3-5, particularly official approval of the medium-term strategic plan for NRW reduction (2019-2023) is a significant step toward growth of FCTWB as an autonomous water utility.

Table 3.3-5: Project Purpose and Achievement

No	Indicator	Status
Project Purpose: Capacity of FCTWB for NRW reduction is strengthened		
a.	The medium-term strategic plan for NRW reduction (2019-2023) is approved by FCTA by the end of the Project.	The medium-term strategic plan was reviewed and approved by the governing Board of FCTWB on behalf of FCTA on 5th September 2018.
b.	Relevant staff of FCTWB (i.e. members of NRW Management Team and Pilot NRW Action Teams) become equipped with skills and knowledge necessary for NRW reduction according to the criteria set by the Project for each level.	Relevant staff's capacity for NRW reduction became equipped with skills and knowledge necessary for NRW reduction, which was confirmed by the final assessment (see Chapter 2). NRW Unit was newly created during the Project.
c.	NRW ratio of each PMA is monitored.	NRW ratio of each PMA has been monitored (refer to Table 3.2-4) since PMA meter problems were solved and PMA coding in the billing system was completed.

Source: Project Team

CHAPTER 4. RESULT OF JOINT REVIEW

4.1 Key Factors Affecting Implementation and Outcomes

The following key factors were observed through implementation of the pilot projects.

(1) Lack of Feedback between FCTWB and FCDA

The pilot project observed that as-built drawings of the laid pipeline networks have not been handed over from FCDA to FCTWB properly, and also problems and issues in O&M have not been fed back to FCDA for improvement in services.

(2) As-Built Drawings

Drawings of pipelines are supposed to be managed and stored in Pipeline Unit of FCTWB HQs and/or Area Offices. However, most of existing drawings are not soft copies but hard copies and are not well organized. Most of drawing copies are only one set in FCTWB.

For the Phase-1 Development Area including Garki I where land development and construction of water supply facilities were mostly completed, FCTWB has converted manually as-built drawings into digital form in map book by GIS, and accomplished 95% of data input of pipeline information including valves, hydrants and service pipelines. However, the map book shows only location and size of pipelines but does not show materials, installation year and covering depth. Even as-built drawings or the map books exist, discrepancy of information such as pipeline location, size and branching point has happened often. In addition, stop cocks supposed to be on installed service pipelines are shown on water distribution networks by mistake, so it leads to difficulty in distinguishing valve from stop cock. At intersections of two pipelines, it is not clear that if they have been connected or not.

For the Phase-2&3 Development Areas including Gudu and Jabi and other satellite towns where land development and construction of water supply facilities are still ongoing by FCDA or private developers, the constructed facilities have been operated by FCTWB without as-built drawings often because of provisional transfer and other reasons.

As far as it goes, FCTWB has maintained the facilities by relying on pipeline information based on individual knowledge or using design drawings which is often different from actual situation of the constructed facilities.

This was one of facts which forced the pilot projects to redo NRW reduction operations.

(3) GIS

During pilot projects, FCTWB shifted own GIS system being free from AGIS security which was an obstacle for smooth GIS operation and data transfer. However, GIS Unit of FCTWB is still an interim Unit consisting of one staff plus a casual staff. It is essential to update GIS database by reinforcing GIS Unit together with relevant Units and Area Offices.

(4) Inefficient Management of Customer Data

Management of customer data including meter-reading data and payment records has not unified timely among HQs and Area Offices. While HQs staff make use of customer data computed from database (billing system), Area Offices manually deal with customer data by using “Customer Notes (List)” transcribed from printed bills by Commerce staff in Area Offices, which is an inefficient procedure and causes data handling errors, then may lead to wrong billing.

This was one of facts which forced the pilot project to redo NRW reduction operations.

(5) Complexity in Customer Category

Customers are categorized as domestic, commercial (un-coded), major consumer (co-operate body, mini-hotel / restaurant, major consumer, petrol station / plaza, private school / clinic), institution (embassy / high commission, ministry / parastatals, liaison office, religion), public tap / convenience &

kiosk, and lifting point (bulk selling. This mixture caused difficulty in data assembling in the pilot project.

(6) Several Types of Customer Meter

Customer meter types are in; conventional including flat-rate, AMR and prepaid meters. This mixture makes O&M and financial analysis difficult. Different types and products of conventional meters exist in the market without accuracy check and licensing for quality assurance.

Staff do not need manually read AMR and prepaid meters because of automatically-recording, but often suffer from communication failure with AMR meters due to trees or other obstacles such as grasses, and also malfunction with prepaid meters because of battery lifetime. In addition, prepaid meters cause free water if valve remains open or illegal bypassing as NRW unless customers report or FCTWB monitors properly.

(7) Estimate Billing System

A considerable number of estimate bills caused by no meter reading, which sometimes lead to unexpected billed amount to customers and then their complaints, hamper calculation of revenue water. No meter reading usually results from absence of customer, inaccessibility to customer meter, infrequent meter reading due to non-provision logistics, and probably dereliction of meter readers.

(8) Duplicated / Return Bills

A number of duplicated/return bills exist in billing system of FCTWB, which make analysis inaccurate. "duplicated/return bills" mean the bills which are supposed to be eliminated or deactivated from billing system but have remained, then have resulted in being returned or not delivered. Existence of duplicated/return bills in billing system causes wastefulness and unreliable financial analysis statement, NRW and collection ratio.

A main cause is negligence of duty in FCTWB, but the reasons why duplicated/return bills have remained are:

- In spite of conversion of meter types including flat-rate, the duplicated customer accounts have remained.
- In spite of address modification or re-subscription, old customer accounts have remained.
- In spite of move of customers or their displacement/demolition by the Government, uninhabited customer accounts have remained.
- As long as these bills have remained, billing system keeps on issuing the bills by automated estimating programme.

FCTWB has worked on elimination or deactivation by upgraded billing system, but has still kept on issuing a certain number of those bills.

(9) Complexity in Water Tariff

Water tariff are, as standard, N80/m^3 or N5,500/month for domestic, N150/m^3 or N45,000/month for commercial, and N150/m^3 or various prices per month for major consumers. This mixture makes financial analysis complicated.

(10) Customer Meter Inaccuracy

Inaccuracy of conventional meters is higher than that of AMR and prepaid meters. After replacement of those meters in the pilot projects, NRW ratio was improved certainly. However, meters will be getting inaccurate gradually without regular maintenance and periodical replacement, for example every eight years (in case of Japan), regardless of meter types and well-condition. Conventional meters available in local markets vary in quality.

(11) Unauthorized Consumption

Illegal bypassing/connections were found in all the three PMAs, particularly often in Gudu and Garki I PMAs where prepaid or AMR meters were installed. These were caused by non-reading or non-inspection by water board's staff and non-existent regular monitoring in the field.

(12) Leakage

Network pipelines and service pipes in Gudu PMA (an estate) and also inflow pipeline branched from a distribution main were installed by private developers. The pilot project observed water leaks on both network pipelines and service pipes up to customer meters surface leakage because of low-quality in appurtenant/meter materials, installation and workmanship, and non-standard situations such as service pipes laid from the back side. The pilot project also observed an inflow pipeline over a ditch without a sheath pipe and bursts due to substandard materials and no thrust block.

In Jabi and Garki I PMAs, the pilot project observed water leaks mainly on service pipes up to customer meters as surface leakage because of low-quality in appurtenant/meter materials, installation and workmanship. Also, because of installation depth of network pipelines in these PMAs, particularly in Jabi (e.g. 6m in depth) and also pipeline/valve conditions, leakage detection equipment could be fully utilized.

(13) Quality Failure in Facility and Workmanship

Low quality in construction and plumbing works including materials was observed across the pilot projects, which causes pipe burst and leakage.

4.2 History of PDM Revision

Table 4.2-1 shows the history of PDM and PO revisions during the Project, which were approved in the JCC meetings. Refer to Annex 2 for PDM revision.

Table 4.2-1: PDM Revision

Revision	Approval	Date	Main Points Revised	Change or Addition in Inputs
Ver.0 toVer.1	1st JCC	2nd Dec. 2014	- Minor changes of some words.	- None
Ver.1 toVer.2	3rd JCC	12th Nov. 2015	- Changes in Outputs, Activities and Inputs related to additional procurement/installation of zonal meters and support for water distribution management - Minor changes in timeframe of indicator's achievement due to delay	Nigerian side - Chambers for bulk meters for water treatment plants, flow meters and valves for the selected PMAs/SMAs*1 - Electric wiring to bulk/zonal meters, loggers and pressure sensors*2 - Demurrage at local customs point, licensing cost of radio application*1 - Cost for communication of telemetric device for selected zonal meter(s) and water pressure sensor(s)*2 Japanese side - JICA Experts (water distribution management, facility design / construction supervision, equipment design / installation, remote monitoring)*2 - Generator for project office*2 - Zonal meters, loggers and water pressure sensors*2 - Telemetric monitoring system with standby power generating facility for selected zonal meter(s) and/or water pressure sensor(s)*2 - Modification of existing billing system*1 - Chambers for zonal meters and water pressure sensors*2 - GIS training in Nigeria*1
Ver.2 toVer.3	4th JCC	22nd Sep. 2016	- Changes in Inputs, particularly chamber construction for the bulk meters at Usuma Treatment Plant from the Nigerian side to the Japanese side based on the request of the Nigerian side due to a delay of counterpart funding release.	Nigerian side - Chambers for flow meters and valves for the selected PMAs/SMAs*3 Japanese side - Chambers for bulk meters for water treatment plants, zonal meters and water pressure sensors*4
Ver.3 toVer.4	7th JCC	24th Aug. 2017	- Changes in the Activities and timeframe of indicator's achievement in accordance with extension of the Project period for six (6) months. - Change in Overall Goal in consideration of realistic situation and sustainability.	Japanese side - JICA Experts (Remote Monitoring Device Installation / Training, Financial Analysis / Organization)*2 - Telemetric monitoring system for selected zonal meters(s)*5 - Solar powering systems for zonal meters*5 - Chambers for bulk meters for water treatment plants, and zonal meters*5

Revision	Approval	Date	Main Points Revised	Change or Addition in Inputs
				- Eighteen persons mutually agreed upon will be trained in Japan.*5
Ver.4 toVer.5	8th JCC	28th Jun. 2018	- Change in an Indicator and its means for Output-3 in consideration of recent timeline of FCTWB's budget process	Nigerian side - Project Manager: General Manager of FCTWB*5

Remarks:
*1: This input was supposed to be stated in the previous PDM, but not stated. Hence, it was added for
*2: This input was added newly
*3: This input was partially removed.
*4: This input was partially added newly.
*5: This input was updated or corrected.

Source: Project Team

4.3 Evaluation on the Results of the Project Risk Management

The Project was implemented properly with the project risk management by JICA based on checklist of project risk management shown in Table 4.3-1.

Table 4.3-1: Checklist of Project Risk Management

Management Items	Summary of Items Prospective Risks	Risk Y/N	Remarks
Overall Management	Consolidated management of items (e.g. Revision of R/D caused by delay in procurement, time management, cost management, human resources management		
	Suspension by political or security conditions	Y	[2014] Collecting Information [September 2016] Politics and security in Abuja are peaceful, however the Project should be operated with security information in consideration of the risk of suspension. [August 2017] Same as previous situation, politics and security in Abuja are peaceful, however the Project should be operated with security information in consideration of the risk of suspension.
	Major modification or cancellation by significant policy change of the Nigerian government	N	
	Difficulty in continuity due to the lack of commitment of the Nigerian government or the implementing agencies	N	
	Nonobservance/noncompliance of Nigerian laws or regulations	N	
	Nonobservance/noncompliance of Japanese laws or regulations	N	
	Disincentive for sustainability after the Project	N	[2014] N/A [September 2016] FCDA in charge of planning/development of Abuja should be involved to reduce non-revenue water continuously. Therefore, it is of importance to minimize the risk by cooperation with FCDA through training in Japan and regular meetings. [August 2017] Cooperation with FCDA has been enhanced through participation in working group of medium-term strategic plan as well as in the 3rd training in Japan. However, proper budget allocation to FCTWB including counterpart fund has been a critical issue, and also enactment of the FCTWB Bill and organizational enhancement are keys to sustainability.
Scope Management	Overall goal, project purpose, outputs, activities and plan of operations		
	Modification of overall goal, project purpose and outputs due to policy change of the Nigerian government	N⇒Y	[August 2017] Overall goal was modified to be evaluated realistically in consideration of non-release of counterpart fund, delay in activities for Output-1 and Output-2, and also problems and lessons learnt.

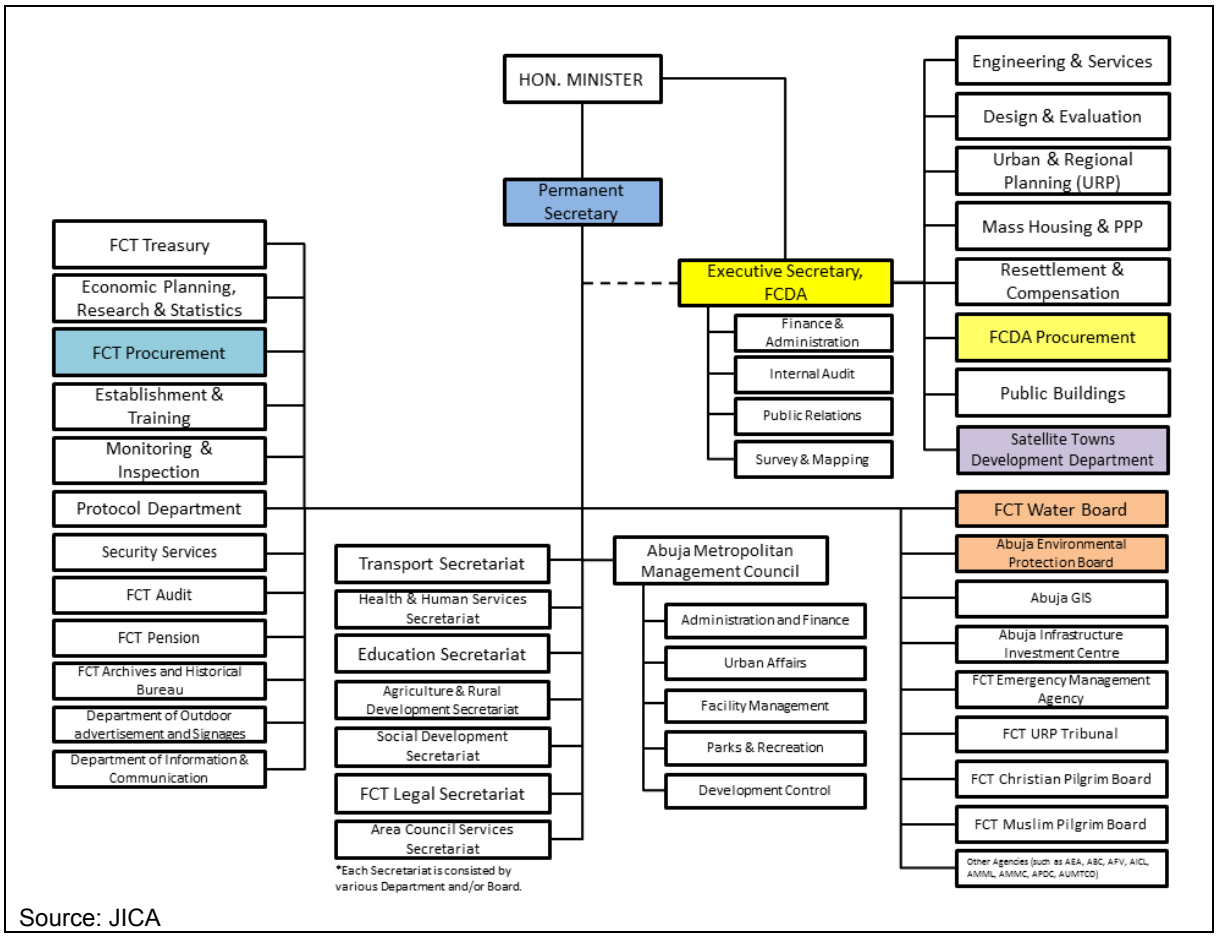
Management Items	Summary of Items Prospective Risks	Risk Y/N	Remarks
	Modification of overall goal, project purpose and outputs due to delay in inputs from the Nigerian side	Y	[2014] What needs to be done was done. [September 2016] This risk occurred due to non-release of counterpart fund, so the Japanese side took over inputs from the Nigerian side. When supporting oil-producing countries such as Nigeria, their inputs should be determined after considering the risk of fall in oil price. All inputs of the Nigerian side, which may affect the Project activities critically, will be executed, so the same risk won't occur any longer. [August 2017] In Phase-2 from January 2017, non-release of counterpart fund has happened again, this has caused delay in implementing activities and insufficient logistics of the Nigerian side. The Japanese side has covered the cost temporally, which will be paid back as soon as counterpart fund is released. Even though the cost of inputs is not much, the same risk has remained.
	Modification of overall goal, project purpose and outputs due to capacity of counterpart	N⇒Y	[August 2017] Interference of water flow at the connection point from water treatment plant No.3&4 at the upstream of bulk flow meters has caused inadequate water flow into the water supply system. This has led to the situation that water demand surpasses supply, then this has caused non full flow of water in pipelines, data deficiency and overflow from clear water tanks of water treatment plant No.3&4. Estimation was added to measurement and monitoring of NRW in Output-1 activities to deal with this challenge.
	Modification of overall goal, project purpose, outputs due to delay in inputs from the Japanese side	N	
	Modification of overall goal, project purpose and outputs due to capacity of the JICA Experts	Y⇒N	[2014] Adequate preparation of terms of reference [September 2016] JICA Experts are capable, and it was confirmed that the Project has been implemented with ownership of the Nigerian side and counterpart has trusted JICA Experts.
	Modification of overall goal, project purpose and outputs due to difference or changes in the pre-conditions	N⇒Y	[September 2016] Although there is no negative effect to PDM, two SMAs were eliminated/cancelled under Output-2 activities due to non-existence of accurate/reliable drawings and maps. The fundamental reason seems to be insufficient information sharing and cooperation between FCDA in charge of planning/development and FCTWB in charge of O&M. Unless feedback system from FCTWB to FCDA is established properly, similar cases may happen and also affect the future projects negatively.

Management Items	Summary of Items Prospective Risks	Risk Y/N	Remarks
			[August 2017] As stated above, cooperation with FCDA has been enhanced through participation in working group of medium-term strategic plan as well as in the 3rd training in Japan.
Time management	Schedule management of activities		
	Delay in Activities due to delay in inputs from the Nigerian side	Y	[2014] What needs to be done was done. [September 2016] The activities has been delayed due delay in inputs because of non-release of counterpart fund. [August 2017] As stated above, non-release of counterpart fund has caused delay in implementing activities and insufficient logistics of the Nigerian side. The Japanese side has covered the cost temporally, which will be paid back as soon as counterpart fund is released. By this arrangement, the delay has been minimized.
	Delay in Activities due to capacity of C/P	N	
	Delay in Activities due to delay in inputs from the Japanese side	N	
	Delay in Activities due to capacity of the JICA Experts	N	
Cost management	Cost planning/management by JICA, budget and cost planning/management for the Nigerian side		
	Insufficiency of budget of the Nigeria side.	Y	[2014] What needs to be done was done. [September 2016] Stated above. [August 2017] Stated above.
	Insufficiency of budget of the Japanese side.	N	
Quality management	Quality management of activities and outputs		
	Decline in outputs due to capacity of counterpart	N	
	Decline in development impact to the end beneficiaries	N	
	Decline in outputs due to lack of inputs of JICA Experts and its period	N	
	Decline in outputs due to capacity of the JICA Experts	Y⇒N	[2014] Adequate preparation of terms of reference [September 2016] Stated above
Human resources management	Assignment plan and performance of JICA Experts, and assignment, formation and performance of counterpart		

Management Items	Summary of Items / Prospective Risks	Risk Y/N	Remarks
	Delay or change in assignment of C/P	N⇒Y	[August 2017] There was loss of a counterpart by traffic accident in March 2017, and some project members at the management level of FCTWB were resigned/transferred in June 2017. Therefore, continuity of the Project under the new implementing structure is an issue.
	Delay in dispatching JICA Experts	Y⇒N	[2014] It depends on tender. [September 2016] This risk has not occurred. [August 2017] Although trip of JICA Experts was restricted during Abuja airport closure period in March and April 2017, this risk did not occur.
	Difficulty to secure appropriate Expert	N	
Communication Management	Management of communication among JICA Experts, C/P and relevant persons involved.		
	Difficulty in communication with the Nigerian government and C/P	N	
	Difficulty in communication with persons involved in Japan	N	
Procurement management	Management of procurement/contract procedures		
	Delay in procurement procedures of JICA Experts	Y⇒N	[2014] It depends on tender. [September 2016] This risk has not occurred. [August 2017] This risk has not occurred.
	Delay in procurement procedures of equipment	Y⇒N	[September 2016] Procurement has been delayed for 6 months in comparison to initial schedule because it took time to finalize equipment specification, but this does not affect the overall project schedule. [August 2017] This risk has not occurred.
	Delay in preparation of training in Japan	Y⇒N	[September 2016] Training was prepared smoothly. [August 2017] Training was prepared smoothly.
Other risks			
	Delay in enactment of the FCTWB Bill, or its repeal which may cause decrease in necessity of NRW reduction	Y	[In 2014] To check situation as required. [September 2016] The FCTWB Bill has not been enacted as since 2014. The Bill is in Nigerian cabinet, but it's beyond the control of both of FCTA and FCTWB. Therefore, it is necessary to make sure of the Project outputs to lobby the Bill. [August 2017] The FCTWB Bill has passed the House of Representatives, followed by the Senate and the President. In prospect of enactment, establishment of a preparatory committee and other actions have been suggested by the JICA Experts.

4.4 Lessons Learnt

Table 4.4-1 shows lessons learnt which were obtained through implementation of the Project. Also, Figure 4.4-1 shows organogram of FCTA for understanding situation well.



Source: JICA

Figure 4.4-1: Organogram of FCTA

Table 4.4-1: Issues and Lessons learnt

Outline	Issues	Lesson Learnt
(1) Organization		
Position of FCTWB in FCTA	■ Authorization ● There is a sense of distance between the authorization level and FCTWB when FCTWB needs approval of requests/ outcomes. (The governing Board of FCTWB became an authorization body, which represents FCTA after its establishment.	■ Realistic way or approach for authorization ● Actual authorization must be determined in consideration with impact and feasibility in case that requests/outcomes are approved by supervisory Ministries and National Assembly
Development and O&M	■ Separation of Development and Operation & Maintenance ● As-built drawings and required information have not been shared smoothly with FCTWB because of separation of infrastructure development (FCDA) and Operation & Maintenance (FCTWB)	■ Collaboration between Development and O&M ● In order to ensure efficient implementation of projects and its sustainability, collaboration between FCDA and FCTWB must be strengthened.
Infrastructure Development in FCT	■ Expansion of FCC to be planned ● FCC located in FCT which is the capital city was transferred from Lagos in 1991. Abuja is the urban area where FCDA plans based on The Master Plan for Abuja, the New Federal Capital of Nigeria (AMP) as the top overall plan. ● 40-years has passed since the Master Plan was prepared. This has caused a gap between the Master Plan and actual situation. In addition, water service area of FCTWB has expanded to the outskirts of FCC.	■ Water supply services in conjunction with the Master Plan ● The scope stated in Master Plan should be met with that of water supply service. * In Abuja, administrative area, FCT (= water service area of FCTWB) is larger than the urban development area, FCC (= the area covered by the Master Plan). Area Councils of STDD is responsible for development of the six (6) areas including the satellite areas other than FCC. Accordingly, organization in charge of maintenance of the water supply facilities in the six areas must be clarified especially in terms of NRW.
	■ Water Supply Infrastructure ● Basic infrastructures such as road, electricity, water supply and sewers by district (block) have been developed as a unit after development of main infrastructures by development phase. ● Basically, FCDA develops infrastructures by using official budget but has recently focused on PPP and private fund as trial. ● Construction of water treatment plant, transmission & distribution mains and network pipelines has been delayed and this has caused delay in development of transmission & distribution main in Phase 2 to 4 (currently under	■ Consideration towards urban development by using various funds ● Methods of infrastructure development and its features with loan & PPP projects should be considered. ● Points to be approached efficiently in terms of development timing of water supply facilities such as water treatment plant, transmission, distribution mains and network pipelines should be reviewed.

Outline	Issues	Lesson Learnt
	development), while, FCDA has prioritized extension of water treatment plant in Phase 5&6.	
Personnel Affairs in FCTWB	■ Personnel relocation/transfer in FCTWB ● Without notice, HoD: Commerce and all Area Office Managers including some Project members were relocated to the task group to focus on collecting debt from the customers who have a large amount of arrears, for better management of FCTWB.	■ A wide range of involvement and clarification of responsibilities ● It is necessary to avoid relying on particular individuals for sustainability. ● It is necessary to clarify responsibilities of sections for key functions such as tariff collection.
(2) Finance		
Budget Release	■ Non-release or delay of counterpart fund ● The pilot projects had suffered from non-release or delay of the counterpart fund to implement NRW reduction operations such as chamber construction for flow-meters and valves to create PMA (DMA), leak repair by using materials and logistics including fuel. Budget constraint always hampered implementation of the Project. ● It is envisaged that the budget was not released smoothly due to lack of national budget by drop-off of oil price and complicated budget application process, etc.	■ Inputs by counterpart considering financial status ● Budget application process should be confirmed, and scope of inputs by counterpart should be set up properly not to hamper the project implementation.
	■ Budget process and delay of budget release ● Approval of budget plan in the Federal Government, approval by National Assembly and approval by the President ● Approval of budget release in FCTA by the FCT Minister, the Permanent Secretary and Treasury	■ Budget process ● Budget process should be confirmed, and as an external condition, budget approval and its release process must be verified.
	■ Counterpart fund ● Counterpart fund was requested as not recurrent budget (conditionally disbursed based on previous year's record even if non budget approval) but capital budget.	■ Capital and recurrent budgets ● Budget types such as capital and recurrent budget must be clarified for appropriate procedures.
(3) NRW Reduction Operation		
Customer Management	■ Irregular/complicated water meter reading, billing and collection system ● Water meter reading groups depend on types of customers such as domestic/commercial, major consumers, institutions, public taps, etc. In addition, billing divisions, and	■ Unification of meter reading, billing and tariff collection system and its SOP ● FCTWB must unify the management for types of water meters and customer registration book as Management Information System so that there are no data discrepancies among headquarters and branches.

Outline	Issues	Lesson Learnt
	billing system also depend on conventional, AMR and pre-paid meters. ● [Meter reading] Area Office or Headquarters (work) -> Headquarters (Reading data control) -> [Billing] Headquarters (Data extraction)->Area Offices (Billing) -> Customers -> [Collection] Customers (Payment at the bank or electronic settlement)-> Bank (Input of data in payment) -> Headquarters (Control of data in payment) / Area Office (Receipt control) In this way, work process is so long that it has not been unified among the Area Offices. ● There are lots of gaps between actual water consumption and billed water due to application of flat rate and the estimated water consumption. Because FCTWB has faced some challenges that they can neither enter premises of customers during their absence nor receive transportation expense for monthly meter reading. ● FCTWB cannot provide the bill with customers monthly because of lack of printing-papers being provided by FCTA for billing and that of power supply. This results in lack of periodical monitoring of water consumption as well as NRW. ● Since there are inappropriate invoices without attention and duplicated invoices, the Project Team found it very difficult for FCTWB to sort out accurate revenue water properly. ■ Meter Reading Divisions and Flat-Rate ● Several divisions of FCTWB, such as Area Offices, AMR Unit, Prepaid Unit and nine Units for major consumers in HQs are responsible for meter reading or monitoring which has been not done adequately. This kind of segmentation causes inefficiency of the billing. ● Flat-rate customers tend to consume water more than the expected as excess use, a part of NRW. ■ Billed Unmetered Consumption (Nominal Excess Use) ● A certain number of flat-rate (unmetered) customers existed and resulted in spending much time on calculation of revenue water in baseline analysis. They tend to consume	● It is essential that SOP on a series of works for meter reading, billing and tariff collection should be prepared so that governance, work efficiency and customer service are improved. In addition, there is future challenge that FCTWB takes activities on water meter reading and billing, every two months considering current situations

Outline	Issues	Lesson Learnt
	water more than one which is converted from set tariff as nominal excess use according to measurement in the pilot projects, so installing meters to flat-rate customers contributes to NRW reduction. ■ Unbilled Unmetered Consumption ● The pilot projects observed some unbilled unmetered consumption from major consumers, public institutions because of procedural omission and also from FCTWB offices and its staff quarters. FCTWB needs to install meters, shift them to the billed or unbilled metered consumers at least by installing meters to measure water consumption.	
Distribution Management	■ Discrepancies between network drawings and actual situations at the Site ● The pilot projects faced difficulties in isolating PMAs and SMAs due to lack or discrepancy of the existing pipeline information among existing drawings and staff's knowledge. The existing GIS pipeline network data had never been updated and didn't reflect correct information in Garki I, meanwhile FCTWB doesn't have any drawings and GIS data in Gudu and Jabi. ● Customer location maps are not available because FCTWB has never positioned customers on drawings or GIS. This also caused difficulties in identifying customers inside PMAs and SMAs. ● Since Abuja GIS under FCTA provides GIS with other relevant organizations, FCTWB cannot update the GIS database Abuja GIS has because of security restriction.	■ Continuous drawing/GIS management ● FCTWB must obtain as-built drawings after completion of construction and develop database, update it as its quality is verified. Thus, the work on periodical updating database such as attribute and drawings must be regulated and carried out. * In case of Abuja, there are Abuja GIS and the division of FCDA Urban & Regional Planning who have GIS database. GIS database of FCDA Urban & Regional Planning is used for a building permit. The database of FCDA Urban & Regional Planning is not linked into that of Abuja GIS. Accordingly, database on pipeline' drawings which are submitted for a building permit is not useful. ● FCTWB started developing own GIS database
	■ Disturbance by potable ultra-sonic flow meter as suspicious items at the site because its installation is one of the typical bomb in terrorism	■ Security in outdoor and information collection should be ensured.
	■ Cost-effectiveness analysis of pilot project ● It was a primary purpose to find out appropriate NRW reduction methods and prepare its SOP. However, analysis of cost effectiveness and water balance were delayed	■ Implementation of strategic pilot projects ● In order to scale-up NRW reduction operations to the areas other than PMAs considering number of DMAs the required input and challenges, pilot activities including analysis, cost-

Outline	Issues	Lesson Learnt
	because it took time for the Project Team to setup SMAs and to obtain budget.	effectiveness, challenges, scheduling, and preparation of water balance must be recorded in time series.
Utilization of Equipment donated by Japan	■ Poor electric condition ● Equipment required for water flow rate measurement occurred extensively due to unstable electric condition. In order to avoid damage of equipment, the Project Team installed a surge arrestor as well as a UPS and a stabilizer, but trouble on equipment has still been suspicious.	■ Examination on external condition for installing equipment ● In case of procuring electrical equipment, normal protectors such as stabilizer, etc. cannot protect damage on the equipment. Therefore, the Project Team must have examine specification of equipment carefully through a dialogue on current power condition with a local power supply authority.
	■ Defective measurement due to non-full flow of water ● Absence of data measured by an ultra-sonic flow meter occurred in the particular places due to intermittent non-full flow of water.	■ Selection of Equipment considering non-full flow of water ● FCTWB must determine specification of water flow meters considering possibilities of non-full water.
	■ Burglary of photovoltaic system ● The solar panel of photovoltaic system procured by JICA was stolen in February 2018. Currently, solar panels which were installed in other site were substituted for it.	■ Thorough measures to prevent burglary of equipment ● FCTWB must take preventive measure at the sites where photovoltaic system are installed. For instance, a rigid way of panels.
	■ Appropriating the vehicles donated through the Project ● While the donated vehicles were steady used for private purpose by the management of FCTWB, the particular staff of FCTWB passed away in accident with the donated vehicle used in private. Unfortunately, the vehicle was not insured.	■ Thorough management of vehicles donated through the Project ● Donated vehicles must be managed strictly and insured by a recipient, and handed over at the end of the Project. The Project Team encourage the recipient to use the donated vehicle for the purpose of NRW reduction operations.
	■ Responsibility of equipment management.	■ Minutes of understanding or equivalent to ensure responsibility of proper management before procurement
(4) Others (Activities related to the Project indirectly)		
Construction of Transmission Pipe Switching Over (Relocation of Connection Point)	■ Loss of production water and non-full flow of water ● FCDA provisionally connected the pipelines from Phase 3&4 to Phase 1&2 in the past to secure flow rate of clear water. As the result of connection, it was observed that interference point where the pipelines were connected because water pressure is different between the pipelines from Phase 1&2 and those from Phase 3&4. The interference caused non-full water in some transmission pipelines and over flow from the clear water tank of Phase 3&4.	■ Comprehensive development of water supply facilities ● FCTWB must examine efficient measures for increasing supply of water considering intake volume, treatment design capacity, flow rate of transferred & distributed water and water demand. ● FCTWB must formulate future plans not only for individual facilities such as treatment plant, transmission pipelines, etc. but also comprehensive plans.

Outline	Issues	Lesson Learnt
	● Afterward, FCDA implemented provisional pipelines' switching over construction (relocation of connection point) and over flow was stopped definitely, in other word, FCTWB has been save a large amount of water. However, non-full flow of water may have not been solved yet because it was envisaged that diameter of the existing pipelines too large compared of flow rate.	
Area Office's Capability	■ Area office's capability, logistics and staff skills ● Budget allocation is limited for the routine services which Area Offices are in charge, and as an organization capacity, Area Offices are not equipped well with personal computer, material stocks, tools and devices, as well as their logistics including vehicles, fuel, electricity and in-house power generator are not enough at all to provide adequate and quality services for O&M and meter reading. ● As an individual capacity, staff such as plumbers and water meter readers have attended limited systematic employee training under the HRD programme of FCTWB. They can learn skills through on-the-job training or apprenticeship from superiors. In addition, most of staff are not good at mathematics, reading drawings, maps and operate personal computer, even basic word-processing and spreadsheet programmes due to their educational background and no training. It was also observed that, although staff are willing to learn and contribute, staff have little responsibility and motivation because of no incentives, poor logistics and working conditions of Area Offices. Consequently, skill development was limited to some staff each pilot Area Office.	■ Strengthening area office's capability at respective individual and organizational level ● In order not to block activities of Area Offices, Headquarters of FCTWB must give regular rights and allocate appropriate budget to manage water supply service in terms of procurement of vehicles, PC, printers, generators and purchase of fuel. ● Staff working in Area Office should be trained for meter reading, monitoring leakage illegal connections, maintenance record and PC operation under leadership of Headquarters.

CHAPTER 5. FOR THE ACHIEVEMENT OF OVERALL GOALS AFTER THE PROJECT COMPLETION

5.1 Prospects to Achieve Overall Goal

In the Project, as fundamental preparation for NRW reduction operation, flow meters required for measuring distributed water (System Input Volume: SIV) in particular areas were installed in outlets of 13 tanks. In addition, some other equipment such as leak detectors required for finding out leak points were procured.

FCTWB must organize the following system apart from survey equipment such as leak detectors and flow meters in order to implement NRW reduction operation.

- Set-up the dedicated team for NRW reduction operation considering backup staff to be appointed for each activity.
- Ensure smooth release system of budget
- Deploy vehicle
- Establish monitoring system (Regular meeting takes place, activity report and discussion about improvement in activities)
- Appoint persons who are in charge of equipment inventory including vehicle

Non-Revenue Water reduction activities are routinely implemented in the service area of FCTWB.

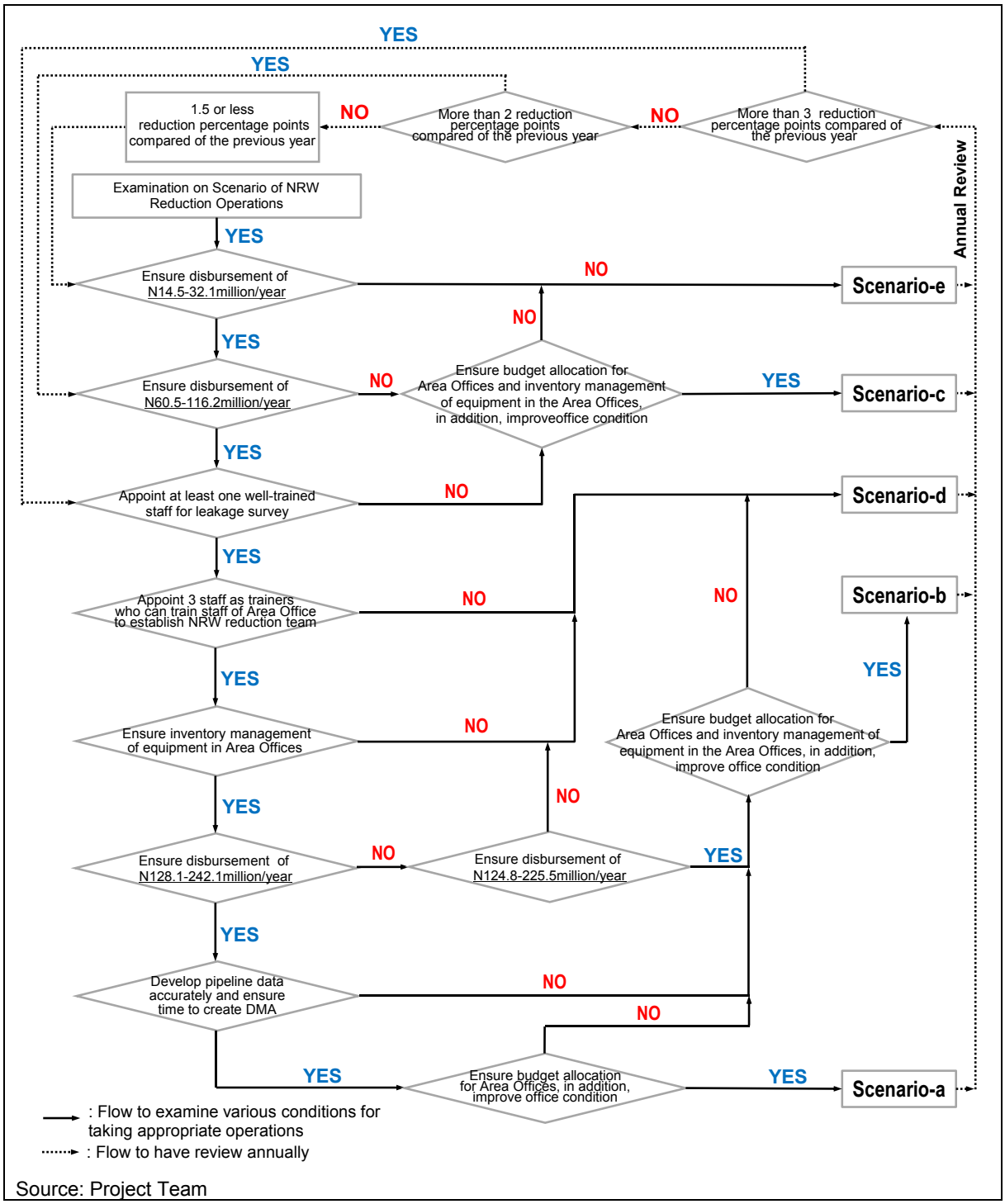
5.2 Plan of Operation and Implementation Structure of the Nigerian side to Achieve Overall Goal

As mentioned in Section 3.2.3 (5), the Project Team prepared five (5) scenarios such as Scenario-a to Scenario-e for NRW reduction operations in the medium-term strategic plan to cope flexibly with influence due to various conditions such as budget release, appointment of trained appropriate staff, progress of database for the existing pipelines in future.

To review The Project Team set conditions for the criteria in terms of the following aspects:

- Budget release
- Appointment of well-trained staff for leakage survey
- Appointment of trainers required for Area Office's staff
- Inventory management of equipment in Area Office
- Development of pipeline data

Figure 5.2-1 shows criteria for reviewing/selecting scenario of NRW reduction operations as aspects of financial condition, human resources, etc. The target NRW ratio shown in Table 3.2.86 indicates percentage unless scenario selected once is changed the year 2019 through 2023. Therefore, target NRW ratio should be reviewed and setup in the annual action plan based on the first 6-month activities of the previous year.



Source: Project Team

Figure 5.2-1: Criteria for selecting Scenario of NRW Reduction Operation

5.3 Recommendations for the Nigerian side

The JICA Expert Team had found out issues and challenges through the implementation of the Project since the beginning, and then had presented recommendations to FCTWB as shown Table 5.3-1.

As of the termination of the Project in November 2018, in consideration of "Enactment of the FCTWB Act" and official approval of "the medium-term strategic plan on NRW reduction (2019-2023)" by the governing Board of FCTWB, JICA prepared actions to be taken for improvement in water services by FCTWB as shown in Figure 5.3-1. This figure describes the necessity of the sound business and

management of FCTWB, and optimization of water supply services as an autonomous water utility by reaching the following goals set through the Project implementation.

- Improvement in water service coverage
- Revenue increase and improvement in financial situation
- Autonomous organization and workplace

Particularly, improvement in network drawings, GIS database, customer database, reading/billing/ collection system, rules and regulations, etc. is a key to the success and sustainability of the medium-term strategic plan on NRW reduction.

Table 5.3-1: Issues, Challenges and Recommendations

No	Classification		Issues and Challenges	Recommendations	Term
	Main Item	Sub-Item			
Commerce					
1.	General		**Complication** and **over-segmentation** in all aspects have caused **inefficiency** of all routine works.	- **Streamlining**, **simplification**, **uniform management** and **wide-ranging approaches** as keywords.	- Long
2.	Customer Category		Customers are categorized as **domestic**, **commercial** (un-coded), **major consumers** (co-operate body, mini hotel/restaurant, major consumer, petrol station/plaza, private school/ clinic), **institution** (embassy/high commission, ministry/ parastatals, liaison office, religion), **public tap/convenience & kiosk**, lifting point (bulk selling).	- **Lessening** of category for **simplified** customer management	- Medium
3.	Customer Meter Type		Customer meter types are; **conventional** including **flat-rate**, **AMR** and **prepaid**. This mixture makes O&M and analysis complicated. Different types of conventional meter without accuracy check exist across service area.	- Review of existing customer meter type - Decision-making on **metering policy** and strong spearhead of implementation with budget - **Meter workshop/laboratory** - **Standardization** of customer meter for FCTWB and **approval** or **licensing** by FCTWB	- Short - Medium - Medium - Long
4.	Meter Reading	Meter reading divisions	**Many divisions** of FCTWB, such as Area Offices, AMR Unit, Prepaid Unit and 9 Units for major consumers in HQs are **involved** in meter reading, so data assembling is quite **troublesome**.	- Review of meter reading, roles and responsibility. - Meter reading by Area Offices in principle and **supervision by HQs**	- Short - Medium
5.		Flat-rate	**Flat-rate** customers account for 15% of all bills as well as 18% of total billed amount. Flat-rate customers may consume water more than the expected as **excess use**, a part of NRW.	- **Elimination** of flat-rate customers by meter installation	- Medium
6.		AMR and prepaid	Although it is not necessary for meter readers to read AMR and prepaid meters manually as an advantage, AMR meters often suffer from **communication failure** by trees or other obstacles and also prepaid meters **malfunction** because of **battery lifetime**. In	- Review of actual **features** of AMR and prepaid meters - **Periodical field monitoring** with function check of AMR and prepaid meters - Monitoring of **bank statement** for prepaid	- Short - Medium - Medium

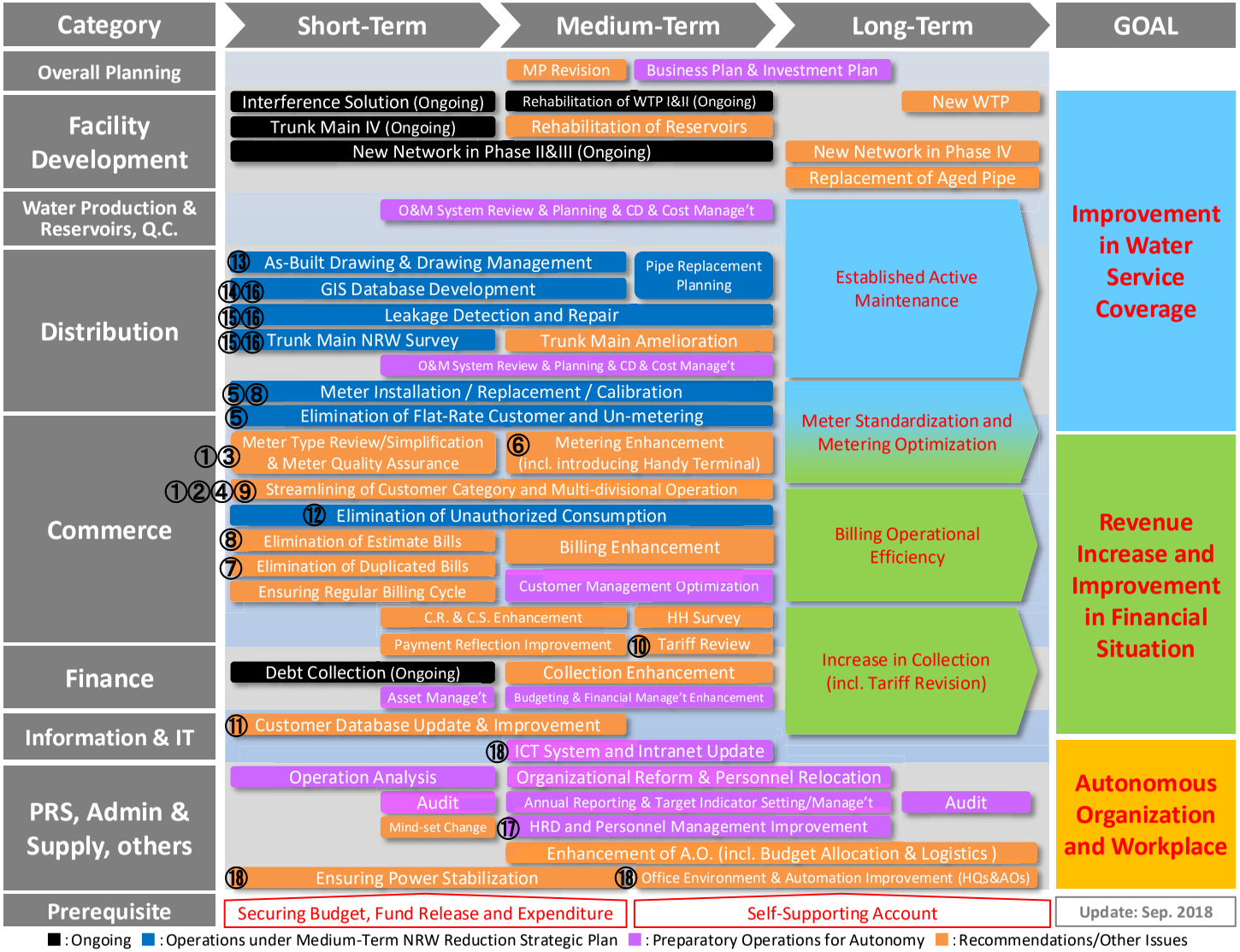
No	Classification		Issues and Challenges	Recommendations	Term
	Main Item	Sub-Item			
			addition, prepaid meters cause **free water** if valve remains open or **illegal bypassing** as NRW unless customers report or FCTWB monitors properly.	meters	
7.	Billing	Return/ duplicated bills	Approximately 4,800 nos. of **return bills** (10% of total bills) exist widely across service areas, and amount to 75 million Naira (16% of total billed charge). Existence of return bills in billing system causes **wastefulness and unreliable financial analysis** including NRW. Causes of return bills are: disconnected, demolished, non-existing, vacant/abandoned, own water source (borehole), duplication generated from meter conversion, etc.	- Prompt countermeasures against return bills such as **deactivation** and **elimination**. - **Proper addressing** on the bills - **Proper procedures and management** of billing information	- Short - Short - Short
8.		Estimate bills	43% of conventional meter bills and 50% of AMR bills have been generated averagely as **estimate bills**, this is, **no meter reading**. A considerable number of estimate bills **hamper** calculation of billed amount and NRW based on actual water consumption. No meter reading is caused by **absence** of customer, **inaccessibility** to customer property where meter is positioned, **limited time** for meter reading, and also maybe **dereliction** of meter reader.	To aim at billing based on **100% reading**, the following are necessary: - Staff's performance of duties with **awareness-rising**, - **Discipline** and **training** - Review of **frequency of reading**, e.g. once a month to once in two months - Enhancement of **logistics** - Thorough **monitoring** of reading regardless of any types of meter. - **Meter installation** and **replacement** of malfunctioning meters - **Meter reposition** to outside of property for accessibility	- Short - Short - Short - Medium - Medium - Medium - Long
9.		Billing Divisions and Billing system	**Divisions for billing** are three; Billing Unit for conventional & flat-rate, AMR Unit for AMR, Prepaid Unit for prepaid (ad-hoc).	- Review of billing systems and **orientation** of FCTWB - **Upgrade** of billing system enabling FCWTB to **analyse** and **monitor** billing data properly and	- Short - Short

No	Classification		Issues and Challenges	Recommendations	Term
	Main Item	Sub-Item			
			Billing systems are; Puma I for conventional & flat-rate, Puma III for AMR and stand-alone system for prepaid (straight to bank account). Billing system Puma I for conventional meter & flat-rate customers has been **outdated**, and does **not** have function or automated programme to **extract, tally or sort data** as for regular monitoring or analysis of billing cycle. FCTWB can obtain tallied/sorted data only by paying extra to private IT programmer, however, the data is not billed consumption based but billed amount based, and there may be **no sustainability**.	sustainably (*The Project upgraded the billing system for conventional meter and AMR.)	
10.	Water tariff		**Water tariff** are, as standard, N80/m^3 or N5,500/month for domestic, N150/m^3 or N45,000/month for commercial, and N150/m^3 or various price per month for major consumers. This mixture makes analysis complicated.	- Review of water tariff - **Simplification** and **comprehensive** water tariff	- Short - Medium
11.	Other	Customer database	Customer information has been not necessarily updated and shared properly among relevant divisions, so FCTWB has faced difficulty in various cases.	- Update/improve customer database and management	- Short
12.		Illegal connections	Some customers or non-customers refuse entering to their properties by FCTWB staff on the ground that they have their own water sources such as borehole.	- **Law enabling or empowering FCTWB** to act as service provider (*The FCTWB Act is ready now.)	
Distribution					
13.	As-built Drawing		Drawings of pipelines are supposed to be managed and stored in Pipeline Unit of FCTWB HQs and/or Area Offices. However, most of existing drawings are **not soft copies** but hard copies, and as-plan, as-design and as-built drawings are **all mixed up** together and **not well organized**. Most of drawing copies are only one set in FCTWB.	- Review and improve **procedures of drawing collection** from FCDA and **feedback** issues in O&M to FCDA - Regularize **complete submission** of as-built drawings and penalize discrepancy. - Review and improve **quality management** such as existing procedures of inspection and hand-	- Short - Medium - Medium

No	Classification		Issues and Challenges	Recommendations	Term
	Main Item	Sub-Item			
			For the Phase-1 Development Area where land development and construction of water supply facilities were mostly completed, FCTWB has converted manually as-built drawings into digital form in map book by GIS, and accomplished 95% of data input of pipeline information including valves, hydrants and service pipelines. However, the map book shows only location and size of pipelines but not show materials, installation year and depth. Even as-built drawings or the map books exist, **discrepancy** of information such as pipeline location, size and branching point has happened often. Also, stop cocks supposed to be on service pipelines are shown on water distribution networks by mistake, so it leads to **difficulty in distinguishing** valve from stop cock. At intersections of two pipelines, whether they are connected or crossed is unclear. For the Phase-2 and Phase-3 Development Areas and other satellite towns where land development and construction of water supply facilities are still ongoing by FCDA or private developers, the constructed facilities have been operated by FCTWB **without as-built drawings** often because of provisional transfer and other reasons. FCTWB has maintained the facilities by using as-plan or as-design drawings which is mostly different from actual situation of the constructed facilities.	over. - Review and improve be **design criteria or standard, guideline** of supervision on particularly networks, service pipe, and meter installation - Establish **archive** of all documents with proper storing of drawings in the HQs and develop **rule** for accessing information and avoiding monopolization by individuals. - Establish **drawing management** by each Area Office for routine maintenance works and updating pipeline information - Prepare **service connection inventory** showing locations of service pipelines, customer meters, valves, size, material, year of installation and etc.	- Medium - Medium - Short - Medium
14.	GIS		GIS Unit of FCTWB is an **interim** Unit consisting of two staff selected from other Units plus a casual staff. A parastatal of FCTA, Abuja Geographic Information System (AGIS) has developed GIS database of FCT	- Create a permanent **Unit or section for GIS** to input intensively in short term and update continuously in long term - Review **attribute** to be recorded and input, and	- Short/ Medium - Short

No	Classification		Issues and Challenges	Recommendations	Term
	Main Item	Sub-Item			
			by using GIS software GeoMedia since 2003, which FCTWB has adopted. Existing AGIS database has satellite image as background taken in 2010, street information, land use (residential, commercial, industrial and etc.), plot data and the number of bedroom of each plot. However, though AGIS is supposed to update these data **once in six months** based on information provision from infrastructure sectors, it has been **not done by rule**. Also, AGIS database does not have contour and altitudinal information required for hydraulic analysis. In this regards, existing AGIS database is **not necessarily useful** for practical operation and maintenance of water supply facilities. In addition, **security of AGIS** is too strict to **access to external networks as well as export/import data** through any devices. Also, all information on AGIS database including newly-input one by FCTWB **cannot be taken out by e-data** such as PDF file but paper printing. That is, FCTWB **cannot utilize GIS functions** such as visual reporting, analysing and data coupling with Microsoft Excel and positional information obtained by GPS handy terminal. This security challenge is a major bottleneck.	create workflow and procedures of systematic update of GIS (*The Project developed attributes.) - Remove or relax **AGIS security**, or if difficult, to build up **own GIS database** of FCTWB. (*FCTWB has built up own GIS database.) - Develop secured **IT network** in FCTWB	- Short/ Medium - Medium
15.	Leakage Detection		NRW along at reservoirs, along trunk and distribution mains, at wash-out and air valves, etc. seems to be considerable amount in the whole water supply system.	- Focus on NRW at reservoirs, along trunk and distribution mains, at wash-out and air valves, etc. by Pipeline Unit and Area Offices (*Newly-established NRW Unit will be in charge.)	- Short/ Medium
Organization					
16.			- GIS Unit of FCTWB is an interim Unit consisting of two staff selected from other Units plus a casual staff.	- Create a permanent **Unit or section for GIS** to input intensively in short term and update continuously in long term	- Short Medium

No	Classification		Issues and Challenges	Recommendations	Term
	Main Item	Sub-Item			
			- FCTWB does not have any Units which are clearly authorized for water distribution management. - FCTWB does not have any Units which take the lead in leakage detection. - FCTWB does not have any Units which monitor, analyse NRW and take the lead maintenance scientifically.	- Create a **Unit for water distribution management** in Distribution to monitor, analyse and make a plan together with Quality Control Department and Area Offices (*Currently, newly-established NRW Unit is in charge.) - Create a **Unit for leakage detection** in Distribution to expand it into the whole water service areas. (*Currently, newly-established NRW Unit is in charge.) - Create a **Unit for NRW monitoring and maintenance** cross-organizationally in Commerce and Distribution (*NRW Unit was established newly.)	- Short/ Medium - Short/ Medium - Short/ Medium
17.			- FCTWB does not have any plans or systems of human resources development.	- Prepare **comprehensive training programme** based on assessment fir each level of staff in accordance with business plan	- Short/ Medium
18.			- FCTWB does not have IT network and communication. - Office is composed of small rooms.	- Develop secured **IT network** in FCTWB - Improve **office environment** and **utilities**	- Medium - Long



Source: Project Team (Remarks: Circled numbers correspond or are related to the numbers in Table 5.3-1)

Figure 5.3-1: Actions to be taken for Improvement in Water Services by FCTWB

5.4 Monitoring Plan from the end of the Project to Ex-Post Evaluation

As monitoring, FCTWB has followed up to accelerate/ensure NRW reduction according to the selected "Scenario-d" of the medium-term strategic plan, and also to deal with unsolved problems.

In particular,

- FCTWB submitted "the letter to the Director of FCT Treasury" on 19th October 2018, which explains that the medium-term strategic plan by the governing Board of FCTWB was approved and incorporation of annual NRW reduction plan into FCTWB's recurrent & capital budget was committed by the governing Board of FCTWB.
- FCTWB and the JICA Expert Team prepared "the Communique of the final seminar on 22nd October 2018 to be submitted to the Permanent Secretary of FCTWB as well as the FCT Minister".
- FCTWB and the JICA Expert Team exchanged "the Memorandum of Understanding" on 1st November 2018 to follow up unsolved problems including malfunctioning equipment.

Refer to Annex 21 for details the official documents.

It is of importance that FCTWB continues following up the above to implement the medium-strategic plan on NRW reduction, and also that the above recommendations and actions will be put in practice (refer to Table 5.3-1 and Figure 5.3-1).

Furthermore, FCTWB should review the results of capacity assessment and capacity development plan under the Project and utilize them to enhance organization and individuals, and also should share the progress, issues and challenges with JICA through regular meetings for further collaboration.