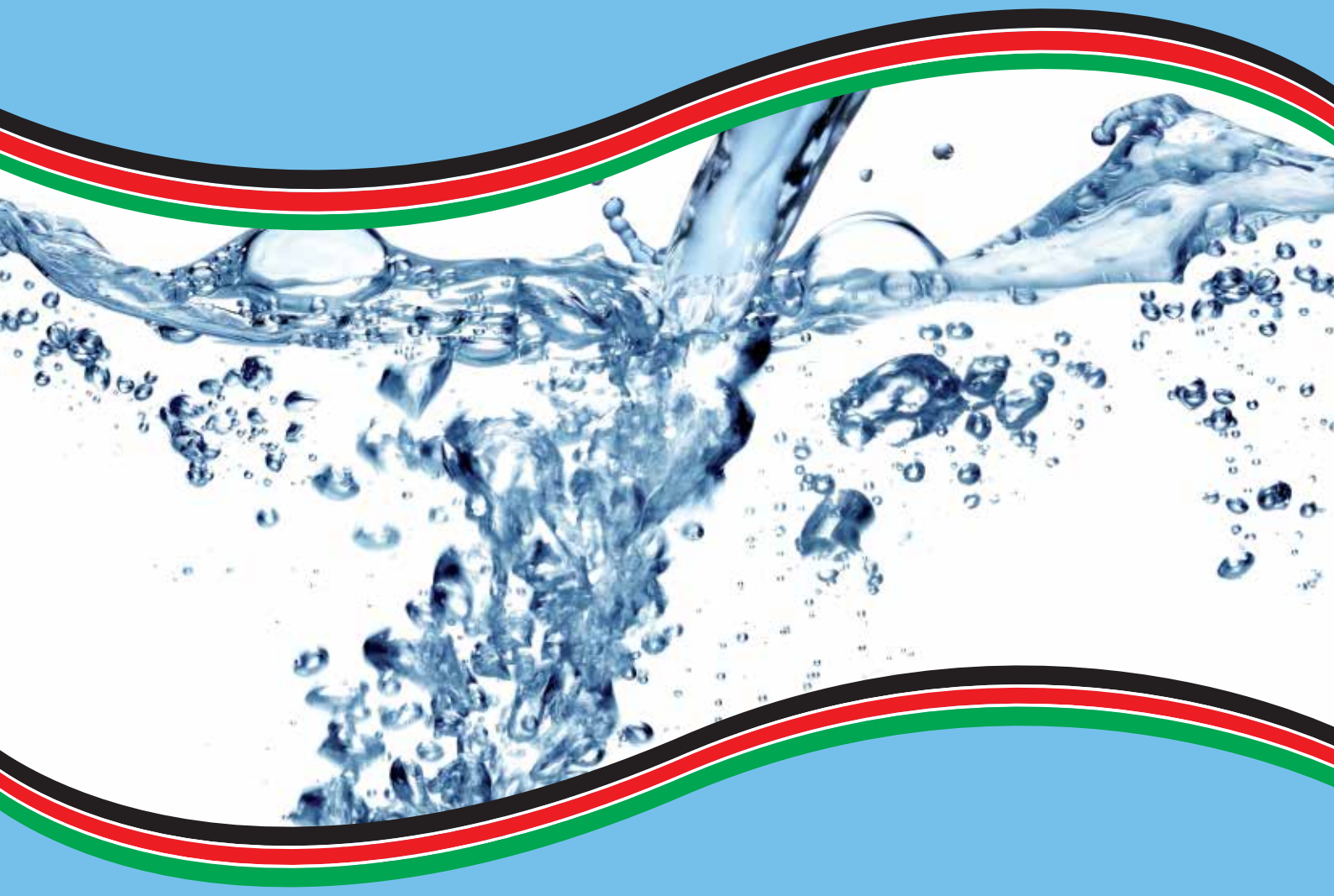
Standards for Non-Revenue Water Management in Kenya



Case Studies

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Foreword

Water is an important natural resource to all forms of life and for mankind. It is the backbone of economic growth and a nation's prosperity. Kenya as the rest of the world is becoming more and more water scarce due to deterioration of water sources resulting mainly from global warming and population explosion. Construction of new water schemes to meet the growing demand for water services is expensive, requires more time to develop and comes with new challenges. Alternative sources of water are water re-use, desalination and rain water harvesting. However, reduction of non revenue water is the cheapest way to alleviate the water stress.

The Government of the Republic of Kenya is committed to ensuring sustainability of Water Service delivery in order to realize the aspirations of the Jubilee Coalition of achieving universal access by the year 2020 and to the right to water and sanitation as envisaged under the bill of rights in the constitution. However, among the challenges to achieving the Kenyan dream includes a high level of Non Revenue Water (NRW) which is estimated at an average of 45% of the total water production in the country. The water services provision has been devolved to the County Government and therefore, it is timely to ensure an elaborate mechanism is put in place for the proper management of Non-Revenue Water in the country.

Kenya Vision 2030 recognizes that Kenya is a water scarce country and therefore emphasizes water conservation and prudent use for the limited available portable water. In this regard, the Government of Kenya has instituted specific strategies to raise the standards of the country's overall water supply and resource management among others. The National Water Resources Management Strategy and the National Water Services Strategy aim at ensuring that water resources are conserved and maintained and Non Revenue Water at water supply and Sanitation systems is reduced to acceptable levels. Accordingly, the Ministry of Environment, Water and Natural resources in conjunction with Japanese International Cooperation Agency (JICA) has developed standards for Non Revenue Water management in order to cut down on Operation and Maintenance (O&M) costs and avail more water that could otherwise be lost to consumers.

The Non-Revenue Water (NRW) reduction management standards consisting of manual, guidelines and handbook is meant to provide a practical approach to reduction of NRW in Kenya. The effective utilization of the standards will result in significant reduction of NRW and all the Water Services Boards and Water Service Providers are encouraged to use them.

James Teko Lopoyetum, HSC
Principal Secretary
State Department of Water

Executive Summary

"At current levels of NRW, urban WSPs are losing approximately KSh 9.9 billion annually, slightly less than one third of the sector budget. This not only threatens the financial sustainability of the sector but also wastes funds, which could otherwise be used to increase access and improve service delivery. In short, current under performance on NRW is at the direct expense of the customer and undermines Kenya's aspiration to move towards higher living standards."(IMPACT REPORT NO 6 -2013)

The performance indicator with respect to NRW reduction has improved marginally from 47% in 2008/9, 45% in 2010/11 to 44% in 2011/12. The improvement remains very poor, considering the acceptable sector benchmark of 25% and national target in the national water services Strategy (NWSS 2007-2015) of 30% by 2015.

Out of 66 urban WSPs, 64 or 97% have unacceptably high levels of water losses. With 16 WSPs losing more water on the way than they actually manage to sell. These figures are a clear indication of the lack of professional management and good corporate governance in many WSPs.

High levels of NRW result from poor infrastructure maintenance and, above all, poor commercial practices (corruption). They are detrimental to the commercial viability of the WSP as well as the safety of the water it supplies (where related to leakages). Also, coupled with the overall reduction in water production, they result in less water being available for an increasing number of consumers.

This Non-Revenue Water (NRW) management standard aims to provide a practical approach to reduction of NRW in Kenya. The target group is the Utility Managers, technical personnel and those who are in charge of NRW management in the Water Service Provider (WSP).

The standard is based on experiences in management of NRW from pilot studies in four areas (Meru, Embu, Narok and Kapsabet Nandi) with diverse terrain in Kenya. It aims to provide a basis to address current challenges of NRW management that exist in Kenya and suggest procedures and measures that do not require use of sophisticated equipment, high level of skills and major investments.

The standard is comprised of: **Manual, Guideline, Handbook** and **Case Studies** for NRW reduction. The Manual, Handbook and Case Studies are for use by the WSPs. The Guideline is for use by the WSB in evaluating and guiding the NRW reduction activities implemented by WSPs.

Each WSP should prepare its own NRW Reduction Plan, based on the information and practical guidelines as enumerated in the standards. The WSPs should take into consideration the characteristics and conditions of its service area to ensure that procedures and measures established in the Reduction Plan prepared in this manner will be "custom made" and therefore best suited to reduce NRW most effectively.

The effective utilization of the standards will result in significant reduction of NRW in Kenya. This will further contribute to the progressive realization to the right to water and sanitation as envisaged under the bill of rights in the Constitution of Kenya (CoK-2010)

The standard is structured with a view to creating understanding of the basic concepts of NRW management through a diagnostic approach, quantifying NRW and then developing strategy to address it. The following is a brief outline of the standard.

a) Manual

Chapter 1: This seeks to impart the Basic Concept of NRW Management, the overall picture of NRW reduction is explained, and basic knowledge of NRW reduction is provided.

Chapter 2: Before embarking on any NRW reduction measures, it is necessary to determine the **volume of water that is being lost**. In Kenya, many utilities lack necessary data or necessary devices such as flow meters. This chapter explains how such utilities could begin to estimate the volume of water being lost.

Chapter 3: The chapter explains the causes of Physical Losses, methods of measuring volume of leakages, methods for detecting underground leakages, and the methods of reducing leakages etc.

Chapter 4: The Chapter explains the significance of Commercial Losses in NRW. Explanations are given on the causes and methods for reducing commercial losses. It is possible to bring the NRW ratio down to approximately 30% by just reducing Commercial Losses.

Chapter 5: This chapter explains what need to be done to manage effectively NRW reduction. NRW reduction activities implemented in a Pilot Area are explained. Thereafter, the most suitable measures for the entire service area are determined.

Chapter 6: It explains the mechanism of meters and the importance of maintaining customer meters in order to maintain accuracy and efficiency of meters.

Chapter 7: This chapter explains the importance of good quality construction work and supervision of construction work. Unless good quality construction is assured, replacing pipes will be pointless, as new leakages from poor construction will occur.

Chapter 8: It explains the importance of zoning in order to closely manage NRW. However, zoning requires significant funds, and therefore many utilities may not manage to implement zoning all at once.

Chapter 9: Managing water pressure is one of the most effective methods of NRW management. Water pressure is a common problem seen in utilities located around the Mt. Kenya region. This chapter provides explanation on how to manage water pressure. In the Pilot Project implemented in Embu WSP, positive results were obtained through managing water pressure.

Chapter 10: GIS: This chapter is provided as the next step forward to those utilities that are already implementing some level of NRW reduction measures. It is not necessary to immediately implement activities in these Chapter, but to improve effects of NRW reduction; these will be necessary activities to implement in the future.

Chapter 11: Cost-Benefit Analysis : It is important for water utilities to consider conducting Cost-Benefit Analysis when they are trying to determine the scope of the NRW reduction measures that should be implemented. Cost-Benefit Analysis will show the effects of the invested cost by comparing the benefit obtained with the cost invested.

Chapter 12: Provides the procedures necessary to make a Plan. The purpose of a NRW Reduction Plan is to determine the most suitable measures to reduce NRW and to use the available budget effectively.

b) Guideline

This Guideline is intended for use by WSB in assessing and evaluating the WSP and giving direction and guidance in the utilities' implementation of Non-Revenue Water (NRW) reduction activities. This Guideline is structured as follows:

Chapter 1: The Self-Assessment Matrix proposed in this Guideline will help each utility to understand its current situation of NRW, and assist the WSB prioritize NRW activities to implement in order to reduce and manage NRW. The focus of the WSB should be on policy direction, leadership and providing necessary materials, equipment and funding for selected activities.
Therefore to use this guideline effectively, the first requirement of the WSB is to request all WSP under its jurisdiction, to conduct a Self-Assessment

Chapter 2: The basic information will be used in calculating the Performance Indicators (PI). This involves the collection, correlation, analysis and summarizing of the basic information of each WSP. This collected data is vital as it will form the basis on which important decisions will be based, including those related to capacity building.

Chapter 3: The Performance Indicators (PI) are indicators that evaluate NRW reduction activities. Using the "Process Benchmarking Method", which is the continuous monitoring of the PI, the importance of each indicator, the relationship between the indicators can be understood and it will also help to clarify problems and issues.
The Performance Indicators will also allow comparisons of WSP, eventually leading to the improvement of the water service, increasing efficiency and strengthening operational fundamentals and providing a basis for better planning for the future.

c) Handbook

This is a simplified NRW reduction manual with many illustrations in the form of diagrams and photographs. The handbook is intended for all staff contributing to NRW management in the WSPs and specifically, the technicians and field personnel for use in their daily activities.

d) Case Studies

The Case Studies involve the activities of NRW management project in Meru Embu , and Narok WSP. The Case studies represent actual work done on a pilot scale by the WSPs working with the JICA Experts in developing and implementing NRW Plans. Using the water balance, site activities and review of practices, issues are identified and interventions categorised into technical, financial, social and institutional. These interventions were then prioritized and activity plans developed for immediate, midterm and long term implementation.

The case studies show that it is possible to identify a pilot area in which all or most of the interventions can be applied and impact monitored. The results of this particular area can then be scaled up to cover the whole operational areas of the water utility.

The philosophies, concepts, and recommendations contained in this standard reflect international best practice. It is recommended that all Water utilities in Kenya apply the approach in order to rapidly benefit from a greater understanding of their networks' performance, and knowledge of the tools available to identify and reduce their levels of NRW.

Abbreviations

/c/d	per capita per day
DMA	District Meter Area
DMAs	District Meter Areas
EWASCO	Embu Water and Sewerage Services Company Ltd.
GIS	Geographic Information System
IWA	International Water Association
JICA	Japan International Cooperation Agency
KEWI	Kenya Water Institute
Km	Kilometer
KNWSC	Kapsabet Nandi Water Sanitation Company Ltd
Kshs	Kenya Shillings
Ksh/m	Kenya shillings per month
l/c/d	litre per capita per day
M^3	Cubic Meter
MEWASS	Meru Water and Sewerage Services
Mio	Million
MNF	Minimum Night Flow
Mpa	Mega Pascal
No.	Number
NARWASCO	Narok Water and Sewerage Services Company Ltd
NRW	Non-Revenue Water
MWI	Ministry of Water and Irrigation
O&M	Operation and Maintenance
PI	Performance Indicators
RVWSB	Rift Valley Water Service Board
WARIS	Water Regulation Information System
WASREB	Water Services Regulatory Board
WSB	Water Services Board
WSP	Water Service Provider

Part 1
Case study in Meru Water and Sewerage Services (MEWASS)

Contents

Location of MEWASS..... 11

1. Water Balance Flowchart..... 12
1.1 Overall Water Flow Map..... 12
1.2 Mapping..... 13
1.3 Pipeline Information by CAD..... 13
1.4 Pipe information..... 15

2. Basic Information..... 16

3. Transition of Non-Revenue Water Ratio of MEWASS..... 19
3.1 Transition of Non-Revenue Water Ratio from2003 to2006..... 19

4. Commercial Loss Reduction..... 21
4.1 Installation..... 21
4.2 Management of NRW in MEWASS..... 23
4.2.1 General Condition..... 23
4.2.2 Management of NRW..... 25
4.3 MEWASS Billing & Revenue Collection System..... 27
4.4 Introduction of Computer System..... 29

5. Physical Loss Reduction..... 30
5.1 Leakage Management..... 30
5.2 Estimated Physical Loss through Water Demand Characteristic Curve..... 34
5.3 Construction Works..... 34
5.4 Water Pressure Management..... 35
5.5 Standardization of material of pipes..... 37

Part 2
Case Study in Embu Water and Sewerage Services Company (EWASCO)

Contents

Location of EWASCO (EMBU) **40**

1. Water Balance Flowchart **41**
1.1 Basic Information 41
1.2 Transition of Non-Revenue Water Ratio from 2003 to 2006 43
1.3 Mapping 44
1.4 Service Meter information 45

2. Activity for Reduction of Non-Revenue Water on Pilot Project **47**
2.1 Preparatory Work 47
2.2 Implementation of NRW activities in Pilot Project 50

3. Output of Pilot Project **61**
3.1 Reduction of NRW of Pilot Project 61
3.2 Ongoing work 61

Part 3
Case study in Narok Water and Sewerage Services Company (NARWASSCO)

Contents

Location of NARWASCO 66

1. Outline of NAROK WSP 67
1.1 Basic Information 67
1.2 Selection of Pilot Project Area 69

2. Preparation of the Pilot Project 70
2.1 Selection of Pilot Project Area 70
2.2 Outline of Majengo Area 71
2.3 Preparation of Distribution Pipe Map 71
2.4 Rationalisation of complex Pipe Network 73
2.5 Confirmation of Valves for Maintenance of Water Distribution 74

3. Reduction of Physical Loss 75
3.1 Installation of Bulk Meter 75
3.2 Analysis of Volume of Distributed Water Through LMB 76
3.3 Activities for Uniform Distribution of Water 77
3.4 Improvement in Construction Standards 79
3.5 Routine for Leak Detection 80

4. Reduction of Commercial Loss 81
4.1 Organizing of Billing Data 81
4.2 Standardisation of Service Line 81
4.3 Replacement of Faulty Meter and List Records 82
4.4 Technology of Water Accuracy Test 83
4.5 Measurement of Minimum Night Flow-Q_{MNF} 84
4.6 Maintenance of Bulk Meter 85

5. Output of Pilot Project 86
5.1 Preparation of Distribution Network Map 86
5.2 OJT of Distribution Volume Analysis 87
5.3 Result of Monitoring 87
5.4 Activities Ongoing 90
5.5 Developing of NRW Reduction Plan for Narok WSP 91

Part 1

Case Study MEWASS

Location of MEWASS

Meru town is located on middle of what used to be Eastern Province and on the North Eastern slopes of Mt. Kenya Highlands.
It is topographically a hilly area.
Most of WSPs under Tana WSB are in similar conditions.
Meru town is a Business, Agricultural and Educational hub for Eastern Kenya.

1
Water Balance Flow Chart

1.1 Overall Water Flow Map

It is necessary to prepare a map in order to understand the whole water balance of the distribution area. In this map, the following water works facilities are included.

Point of intake, Raw Water pipeline, WTP, Zoning, Storage Tank, Master Meter, Transmission Pipe line, Distribution Pipe Network, BPT, PRV, etc.

It is important to determine whether flow meters are installed or not. If flow meters have not been installed, it is advisable to install them at an early stage.

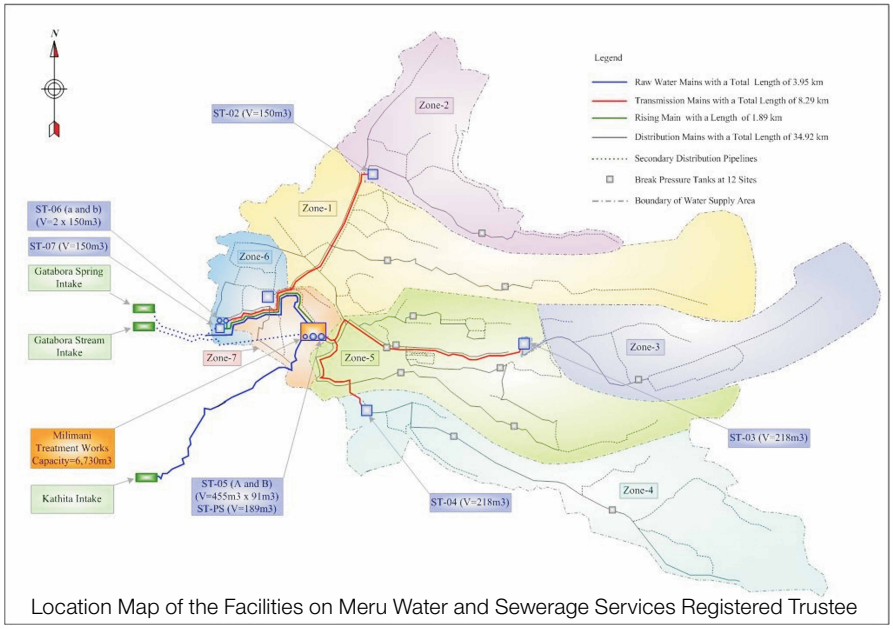


Figure 1.1 Location Map of the facility

Next, the installed flow meters must be tested for accuracy. If any of the flow meters show inaccuracy, they must be replaced them as early as possible.

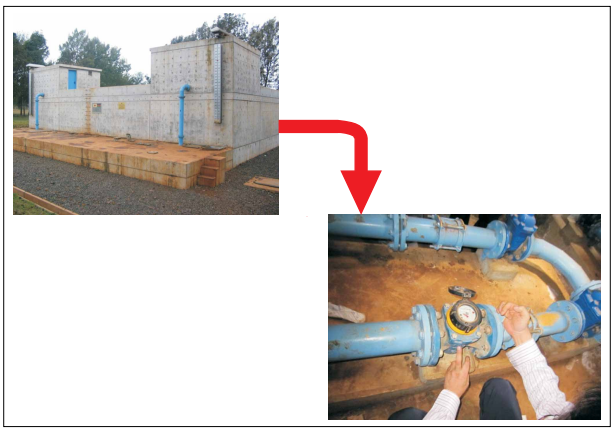


Photo 1.1: Installation of Flow Meter

1.2 Mapping

For sustainable management, it is fundamental to maintain and manage the pipeline network map. The map should include information on diameter of pipes, type of pipes, sluice valves, air valves, drain valve, hydrants, pressure reduction valves, safety valves, water pipe bridge, tunnels, box carvert, types of joints and the age of pipes.

As long as the necessary maps and ledgers are not fully prepared, it will be difficult to map an accurate pipeline network map. It is important to first determine what degree of accuracy and information and details are necessary to be reflected in the pipeline network map and related ledgers. Information gathering thereafter and maintenance of the information is part of Information System Management, and should be updated regularly. The information in the map should be categorized and well coded so that necessary information can be easily extracted. At the same time, the mapping system should be able to easily reflect all the necessary information. In the recent years, the CAD (Computer Aided Design and Drafting) and the GIS (Geographic Information System) database have become more and more popular and they have also become very user friendly. These programs have been used to show the MEWASS mapping as shown below.

1.3 Pipeline Information by CAD

Pipeline information has been mapped using CAD and data input is maintained using Excel sheets.
The pipes are categorized by type, and each pipeline is given a code.

Figure 1.2 Shows the diagram of Pipeline mapping in Meru.

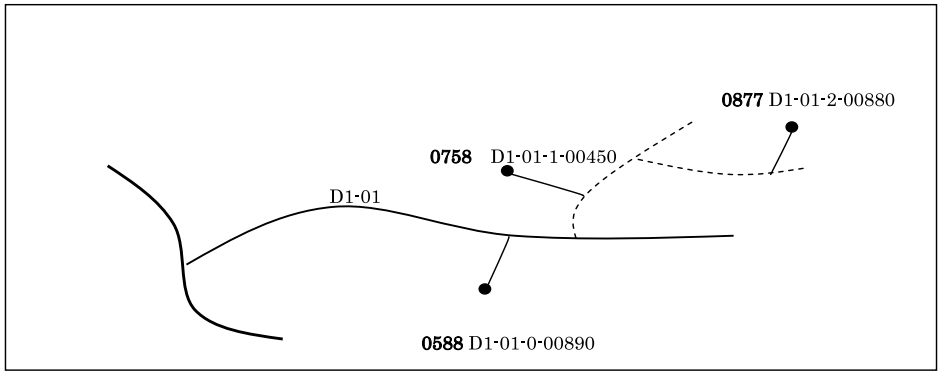


Figure 1.2 Diagram of Pipeline Mapping

Table 1.1: Pipe Coding of MEWASS

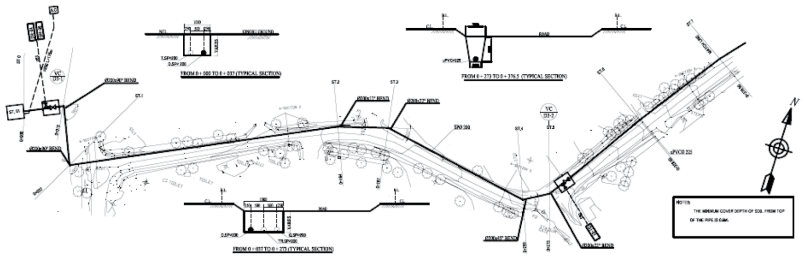
	Pipe Codes	**Description**
Distribution Main	J-01-04	This indicates main pipe
Secondary	D1-01	This indicates secondary pipes
Connection from Secondary	**0588** D1-01-0-00890	**0588**=Indicates Connection No
Tertiary	D1-01-1, D1-01-2-	This indicates tertiary pipes
Connection From Tertiary	**0877** D1-01-2-00880	This indicates distance of 88.0m From Tertiary 02
Connection	0588, 0758, 0877	This Indicates Connection No

Maintenance of Pipeline Information through Detailed Pipeline Map

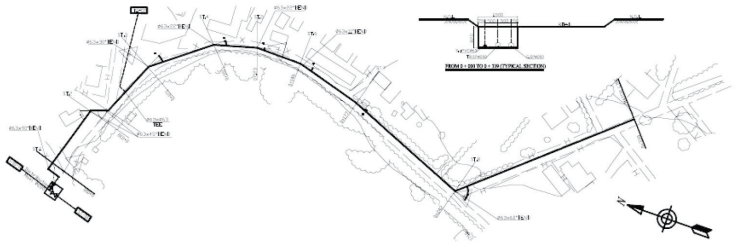
Detailed Pipeline Map is shown in Figure 1.3. Routing segments are shown in the Figure 1.2. Information on the location and type of pipes are mapped with CAD. Figure 1.3 shows various data on pipeline such as location of pipes, extension, diameter, pipe material and special fittings. In regards to the meters, the map shows the location of meters and the meter numbers.

Sample Pipeline Details

Distribution Main



Secondary



Secondary and Tertiary

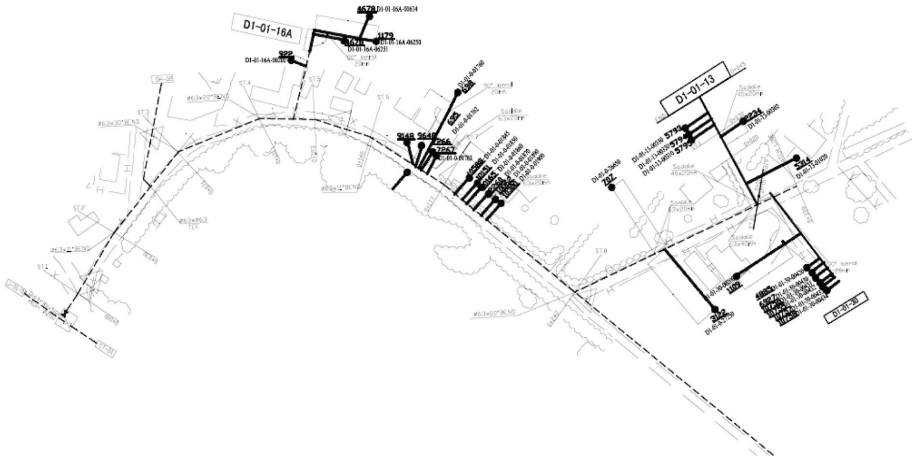


Figure 1.3 Example of Mapping of distribution pipes in MEWASS

1.4 Pipe Information

Pipe information provides the pipe type, the diameter and the extensions of the pipes installed. In addition to these, information such as year of installation of pipes, number of leakage occurrences on pipes, diagnosis of pipe deterioration and water pressure would provide enough information to develop a medium to long term plan of pipe replacement.

Table 1.2 Classification of pipeline

Category	Material	Diameter(mm)
Rising Main	Steel	200~300
Transmission Main	Steel	90~225
Distribution Main	uPVC, Steel	90~200
Secondary Pipe	uPVC, Steel	50, 63
Tertiary Pipe	uPVC	40
Service Pipe	uPVC	13, 20, 25, 40

Table 1.3 Distribution System Lengths MEWASS September 2010

DISTRIBUTION SYSTEM LENGTHS September 2010

Diameter (mm) / Zone	225	200	150	140	110	90	63	50	40	Total Length (m)
Zone 1	777	250		1,705	2,868	868	11,747		19,167	37,382
Zone 2					3,153	1,011	13,417		40,849	58,429
Zone 3					3,206	2,536	10,645	1,500	2,830	20,717
Zone 4					3,253	2,672	22,036		32,648	60,609
Zone 5			306	1,214	1,479	9,102	8,107		17,742	37,950
Zone 6				436	902		3,217		5,461	10,016
Zone 7				1,854		370	2,984		7,212	12,420
Total	777	250	306	5,209	14,861	16,559	72,152	1,500	125,909	237,523
Zone 8									1,728	(1728)

2
Basic Information

Table 2.1 shows Performance Indicators used by MEWASS (December 2009 - July 2010). The indicators include almost all indicators that are necessary for the management of water works. In regards to MEWASS, a special mention must be made, that the Performance Indicators are updated on a monthly basis. As Performance Indicators are very important for the management of water works, it is highly recommended that all WSPs prepare this kind of table.

In Table 2.1, the indicators related to MEWASS NRW Management are categorized as below.

A:	Water Distributed Volume (A1 : System Input Volume) (A1a ~ A1g : by Zone)
B:	Ratio of NRW (B2 : Actual UfW)
C:	Connections
D:	Billed Water Volume (Technical means water billed as per customer water meter reading) (Commercial is adjusted by the Billing system)
G:	Customer Services (Complaints, illegal connections)
H:	Expenditure and Revenue (Data necessary for Financial Analysis)

Table 2.1: Performance Indicator in MEWASS

MEWASS Performance Indicators - July 2010

Code	Area	Month	Unit	Jul/10	jun/10	10/mai	abr/10	mar/10	fev/10	jan/10	dez/09
				153.827	156.811	150.921	157.077	151.507	141.414	148.368	149.607
A 1aa	Treatment	Total raw water	m^3	148.385	152.786	147.398	153.030	148.300	137.286	144.483	145.365
A	and Supply	Kathita River Raw Water	m^3	75.540	85.529	86.127	80.921	78.353	75.014	74.304	74.358
A	facilities	Gatabora Spring Raw Water	m^3	72.845	67.257	61.269	72.109	69.947	62.272	70.179	71.015
		Gatabora Stream Raw Water	m^3	0	0	0	0	0	0	0	0
A 1	4.047	Water production (total treated,metered)	m^3	144.110	147.944	142.514	148.431	143.758	133.044	140.164	141.046
		Water production including Z-08	m^3	149.552	151.969	146.037	152.478	146.965	137.172	144.049	145.288
		Water distributed	m^3					141.683	131.390	138.041	138.788
A 1a		Water supplied Z-01 Zone	m^3					33.740	24.824	47021	37.635
A 1b		Water supplied Z-02 Zone	m^3	14.871	16.635	13.975	17.395	15.041	11.453	18.291	15.586
A 1c		Water supplied Z-03 Zone	m^3	-	-	-	-	-	-	-	-
A 1d		Water supplied Z-04 Zone	m^3	14.889	14.915	12.946	15.891	13.855	12.976	16.797	12.632
A 1e		Water supplied Z-05 Zone	m^3	54.504	40.008	42.067	53.059	40.484	26.405	64.725	45.846
A 1f		Water supplied Z-06 Zone	m^3	7.116	7.267	5.824	7.084	7.377	6.157	6.887	7.580
A 1g		Water supplied Z-07 Zone	m^3	13.380	12.783	11.636	14.695	14.775	11.490	16.279	14.270
A 1i		Backwash water	m^3	1.785	1.782	1.975	2.073	2.075	1.654	2.123	2.258
A 2		Chlorine dosing	kg	378	315	343	344	308	308	336	336
		Chlorine dosing (gram)	gm	378.000	315.000	343.000	344.000	308.000	308.000	336.000	329.000
A 3		Stock of chlorine at the end month(PO,WP)	kg	1.052	1.426	1.741	2.084	2.428	936	1.244	1.580
A 4		Alum dosing	kg	1.650	1.525	2.475	2.450	3.100	1.950	2.025	2.425
		Alum dosing (Dekagram)	Dg	165.000	152.500	247.500	245.000	310.000	195.000	202.500	242.500
A 5		Stock of Alum at the end of month(PO,WP)	kg	8.350	1.000	2.525	5.000	7.450	2.550	4.500	6.525
A 6		Abnormal turbidity test result	Nrs.	0	0	0	0	0	0	0	0
A 7		Abnormal chlorine residual test result-consumer	Nrs.	1	2	1	4	4	4	4	2
B 1	Distribution	Average no. of hrs/day water available	hours	24	24	24	24	24	24	24	24
B 2	facilities	Actual Unaccounted for Water	%	26	22	23	25	22	14	26	24
		Projected Unaccounted for water	%	20	20	20	20	20	20	20	20
		Technical									
B 2a	23	UFW in Z-01 Zone	%	25	21	27	19	20	12	29	19
B 2b	29	UFW in Z-02 Zone	%	34	18	37	34	33	22	31	30
B 2c		UFW in Z-03 Zone	%	-	-	-	-	-	-	-	-
B 2d		UFW in Z-04 Zone	%	25	31	32	28	31	31	31	35
B 2e		UFW in Z-05 Zone	%	28	16	10	24	17	1	27	17
B 2f		UFW in Z-06 Zone	%	17			7	8	10	16	15
B 2g		UFW in Z-07 Zone	%	18			24	22	14	27	30
B 2h		Commercial									
B 2i		UFW in Z-01 Zone	%	24%	20%	27%	18%	20%	10%	32%	18%
B 2j		UFW in Z-02 Zone	%	31%	16%	34%	33%	30%	19%	29%	29%
B 2k		UFW in Z-03 Zone	%	-	-	-	-	-	-	-	-
B 2l		UFW in Z-04 Zone	%	24%	30%	31%	27%	30%	30%	30%	34%
B 2m		UFW in Z-05 Zone	%	27%	9%	4%	25%	20%	-1%	27%	17%
B 2n		UFW in Z-06 Zone	%	16%	10%	10%	6%	8%	10%	14%	14%
B 2p		UFW in Z-07 Zone	%	17%	23%	22%	23%	24%	12%	26%	29%
B 3		Repair of leaks and Bursts	Nrs.	413	468	443	437	437	436	385	443
C 1	Service	Total Connections	Nrs.	7.653	7.590	7.549	7.490	7.457	7.389	7.342	7.276
C 1a	installation	Total Connections Z-01	Nrs.	1.697	1.677	1.668	1.664	1.650	1.646	1.637	1.634
C 1b		Total Connections Z-02	Nrs.	929	922	909	907	901	892	882	852
C 1c		Total Connections Z-03	Nrs.	171	171	171	171	171	171	171	171
C 1d		Total Connections Z-04	Nrs.	962	950	940	924	923	913	909	903
C 1e		Total Connections Z-05	Nrs.	1.950	1.945	1.937	1.920	1.913	1.900	1.884	1.880
C 1f		Total Connections Z-06	Nrs.	600	592	590	585	582	570	563	560
C 1g		Total Connections Z-07	Nrs.	779	772	758	744	742	730	730	710
C 1h		Total Connections Z-08 - ASK System	Nrs.			2	271	271	271	270	270
C 1h		Total Connections After Phase II shut-down	Nrs.	7		5	7.186	7.153	7.093	7.046	6.980
C 1i		Total connections changed over to Phase II	Nrs.	4.012	3.988	3.957	3.922	3.908	3.876	3.846	3.806
C 1j		Total connections Phase I	Nrs.	3.076	3.041	3.016	2.993	2.974	2.946	2.930	2.904
C 2		Total New applicants	Nrs.	57	25	54	45	52	43	55	55
C 2a		Application-Phase I	Nrs.	20	42	19	17	34	13	19	20
C 2b		Application-Phase II	Nrs.	33	3	35	28	17	30	35	33
C 3		New cons connected-monthly total(MI,DM,CC)	Nrs.	63	41	59	33	68	47	66	20

Water Distributed Volume

Ratio of NRW

Connections

Code	Area	Month	Unit	Jul/10	jun/10	10/mai	abr/10	mar/10	fev/10	jan/10	dez/09
C 4		New meter installed-monthly total-(MI,DM,CC)	Nrs.	63	43	59	33	68	47	66	23
C 5		Total meters installed to date	Nrs.	7.610	7.547	7.504	7.445	7.412	7.344	7.297	7.231
C 6		Illegal conns detected (Lines+Recons)(CC,MI,DR	Nrs.	0	0	0	0	0	0	0	0
C 7		Illegal service lines uprooted(MI,CC,WD)	Nrs.	0	Connections		0	0	0	0	0
C 8		Disconnection	Nrs.	343			389	560	522	0	342
C 9		Reconnection	Nrs.	303	271	140	382	402	335	92	259
C 10		Faulty meters recovered from field	Nrs.	12	6	0	0	0	0	6	9
C 11		Faulty meters repaired	Nrs.	22	0	25	10	28	4	8	13
C 12		Customer meters serviced	Nrs.	100	87	127	102	71	70	63	51
D 1	Billing and	Meters read	Nrs.	7.278	7.315	7.287	7.252	7.179	7.004	7.015	6.862
D 2	collection	Water bills issued	Nrs.	6.161	6.128	6.073	6.052	6.026	5.995	5.990	5.916
D 3		Billed water volume	m3	109.713	106.706	103.680	112.294	99.461	85.461	124.576	107.585
		Technical									
		Consumption Z-01	m3	27.718	26.975	28.919	28.554	27.158	21.833	33.239	30.543
		Consumption Z-02	m3	9.759	13.708	9.094	11.400	10.114	8.970	12.629	10.912
		Consumption Z-03	m3	-	-	-	-	-	-	-	-
		Consumption Z-04	m3	11.096	10.235	8.786	11.425	9.581	8.939	11.512	8.176
		Consumption Z-05	m3	39.233	33.603	37.720	39.877	33.484	26.188	50.244	38.233
		Consumption Z-06	m3	5.921	6.436	5.170	6.585	6.783	5.529	5.808	6.420
		Consumption Z-07	m3	10.977	9.687	8.862	11.220	11.471	9.898	11.833	9.984
		Commercial									
D 3a		Billed water volume Z-01 Zone	m3	28.142	27.194	28.935	28.841	27.011	22.287	32.114	30.804
D 3b		Billed water volume Z-02 Zone	m3		Billed Water Volume			10.570	9.311	13.005	11.031
D 3c		Billed water volume Z-03 Zone	m3					0	0	0	0
D 3d		Billed water volume Z-04 Zone	m3	11.361	10.381	8.877	11.563	9.667	9.129	11686	8.285
D 3e		Billed water volume Z-05 Zone	m3	39.590	36.260	40.260	39.754	32.264	26.618	47.468	38.271
D 3f		Billed water volume Z-06 Zone	m3	5.992	6.528	5.269	6.679	6.782	5.569	5.898	6.509
D 3g		Billed water volume Z-07 Zone	m3	11.157	9.882	9.059	11.358	11.243	10.070	12.074	10.140
		Total billed volume		106.448	104.291	101.566	109.866	97.537	82.984	122.245	105.040
D 3h		Billed water volume Z-08 Zone	m3	3.265	2.415	2.114	2.428	1.924	2.477	2.331	2.545
D 4		Water Billed amount/revenue earned in month	Kshs 000	6.713	5.636	5.513	7.176	5.787	5.245	8.089	7.270
D 5		Total billed amount	Kshs 000	44.524	42.848	42.637	42.333	40.753	40.323	42.616	40.871
D 6		Water Revenue collected	Kshs 000	5.037	5.425	5.209	5.596	5.357	7.538	6.344	5.291
D 7		Customers who paid during the month	Nrs.	5.147	5.438	5.232	4.934	5.344	5.316	4.937	4.581
E 1	Sewerage	Connections-Sewer	Nrs.	644	644	644	644	644	644	644	644
E 2		New applicants	Nrs.	0	0	0	0	0	0	0	0
E 3		New connections	Nrs.	0	0	0	0	0	0	0	0
E 4		Illegal connections detected	Nrs.	0	0	0	0	0	0	0	0
E 5		Illegal connections removed/legalised	Nrs.	0	0	0	0	0	0	0	0
E 6		Bills with sewerage component printed	Nrs.	751		751	742	729	728	729	729
E 7		Total billed amount	Kshs 000	26.180	25.272	24.545	23.502	22.368	21.641	21.114	20.048
E 8		Sewer Billed amount/revenue earned for the	Kshs 000	1.589	1.539	1.714	1.745	1.583	1.458	1.938	1.827
E 9		Customers who paid during the month-Sewer	Nrs.	452	655	590	467	641	612	573	457
E 10		Sewer Revenue collected	Kshs 000	681	812	671	611	856	931	872	516
F 1	Sewerage improvement works										
G 1	Customer	No. of complaints reported	Nrs.	78	59	72	97	90	168	163	115
G 2	services	No. of complaints resolved	Nrs.		Customer Services			62	131	134	108
G 3		No. of vandalisms reported	Nrs.					0	0	0	0
G 4		No. of water kiosks in operation	Nrs.	14	14	14	14	14	13	13	13
G 5		Water volume sold at kiosk	m3	277	231	275	194	198	189	191	412
H 1	Expenditure	Personnel	Kshs 000	3.314	3.246	2.656	2.799	2.587	2.698	2.327	3.417
H 1a	& revenue	No. of staffs	Nrs.	72	72	72	67	67	67	67	69
H 2		Administrative	Kshs 000	2.206	3.557	1.057	1.732	1.734	2.157	1.628	1.457
H 3		Water production	Kshs 000					158	160	152	285
H 4		Water Distribution	Kshs 000		Expenditure and Revenue			730	811	602	500
H 5		Sewerage Maintenance	Kshs 000	26	24	36	85	187	30	69	25
H 6		Total expenditure	Kshs 000	6.475	7.681	4.588	7.292	5.396	5.856	4.778	5.684
H 7		Total cash collected (D6+E10+fees&deposits)	Kshs 000	6.372	6.806	6.441	7.156	6.951	14.905	7.959	6.422

*1: Facilities constructed in the phase 1 started full operation.

*2: MEWASS started its first fiscal year after its undertakership was approved.

*3:

*4: Period before the Meru District Water Office started the action plan.

*5: In May 2007 the policy on recognisation of revenue was changed from billing cycle month to calender month to facilitate reporting to WSB

3
Transition of Non-Revenue Water Ratio of MEWASS

3.1 Transition of Non-Revenue Water Ratio from 2003 to 2006

From 2003 to 2006, MEWASS improved Billing & Revenue collection system in proceeding period and further reduced commercial losses. And Distribution System was changed to a totally new system in July 2004 through JICA GRANT AID.

Fig. 3.1 explains how MEWASS reduced NRW and the activities involved. It shows transition of ratio of NRW from year 2003 to 2006. In this period, the ratio of NRW reduced from 67% to around 25%. As a result, NRW ratio drastically reduced to about 40%.This was achieved because of Switch-over from old system to new system. Afterwards they have managed to stabilize at a NRW Ratio of 25% by reducing physical loss.

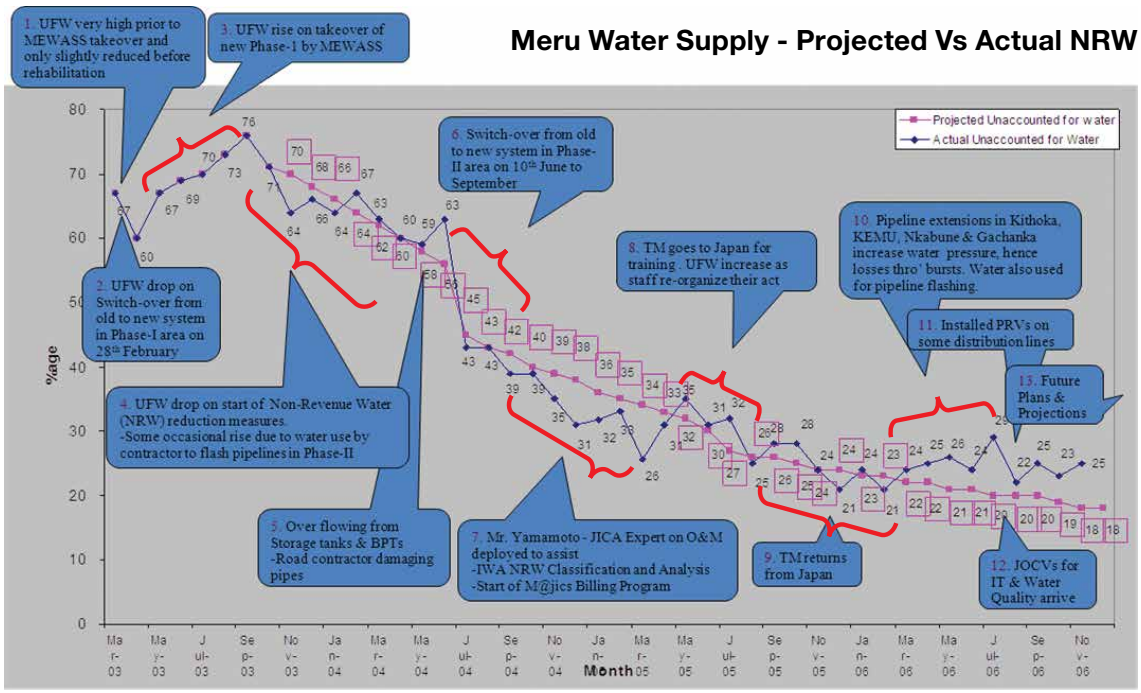


Fig 3.1 Transition of Non-Revenue Water Ratio of MEWASS from 2003 to 2006

Main data transition regarding NRW management are shown in table 3.1

Table 3.1 Overview of MEWASS

	Unit	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010
Population Served by MEWASS	Nrs.			50959	61000	66527	83354	85271
Connection Number	Nrs.	3698	4142	4680	5475	6196	6899	7590
Distribution Area	Km^2	9	31	33	38	50,5	61,6	61,6
Distribution Pipe Extention	Km				181,622	201,672	218,253	234,381
Volume of Water Supplied	Km^3	2459422	1488157	1297273	1517989	1637144	1868823	1799018
Ratio of NRW	%	66	35	25	25	27	29	25
Number of Staff	Nrs.	76	74	75	70	68	70	69

MEWASS has continued to increase its number of customers since July 2004 when the system was changed. Currently, it is increasing the number of customers at a rate of approximately 800 per year.

Table 3.2 Connections and Meters Installed

	2002/2003	**2003/2004**	**2004/2005**	**2005/2006**	**2006/2007**	**2007/2008**	**2008/2009**	**2009/2010**
Total connection	3,178	3,698	3,967	4,680	5,475	6,196	6,899	7,653
New meter Installed	3,178	498	743	624	848	776	719	706
Total meter installed	2,744	3,242	3,874	4,498	5,346	6,122	6,841	7,547
Disconnection	2,715	5,341	3,657	3,095	4,120	4,085	4,346	3,894
Reconnection	1,004	3,307	2,739	2,844	3,783	3,691	3,714	3,316
Faulty meters recovers from field		7	18	32	44	59	63	33
Faulty meters repaired		0	38	62	37	31	6	98
Customer meters serviced		183	390	267	160	167	443	811

The Water Balance Table made by MEWASS is shown in Table 3.3

<table>
<tr><td rowspan="2">Authorized Consumption
71.9 %</td><td colspan="2">Billed Authorized Consumption
69.4 %</td><td>Revenue Water
69.4%</td></tr>
<tr><td colspan="2">Unbilled Authorized Consumption 2.5 %</td><td rowspan="3">Non-Revenue Water
30.6 %</td></tr>
<tr><td rowspan="3">Water Losses (UFW)
28.1 %</td><td rowspan="2">Apparent Losses (Non-technical or Commercial Losses)
3.6 %</td><td>Unauthorized Consumption (Illegal connection)
3.2 %</td></tr>
<tr><td>Metering Inaccuracies
0.4 %</td></tr>
<tr><td colspan="2">Real Losses (technical Losses) 24.5 %</td></tr>
</table>

Table 3.3 Water Balance table of 2010 of MEWASS

4
Commercial Loss Reduction

4.1 Installation

It is first necessary to confirm the installation and the working conditions of the equipments listed below. If these are found to be non-operational, they must be replaced or new equipment installed as quickly as possible.

1) **Strainer:** This will trap suspended materials in the water, which causes problems in the water meters.

Photo 4.1 installation of Strainer

2) **Master Meter:** Installation of Master Meters will measure the volume of water distributed in the distribution area.

3) **Household Connections:** There are many WSPs that are still using flat rate billing instead of metering. Generally, flat rate system results in wastage of water use. As the supply of water through water service work grows, tendency for wastage will also grow with the use of unbilled water increasing. This means that there will be unnecessary increase in the demand for water leading to further expansion and development of facilities and water supply, for which more funds will be required. Both big users and small users are paying the same flat rate, which is also unfair. By applying the metering system, wastage of water can be greatly decreased and accurate volume of water use can be measured which will lead to a more effective management of the water works service.

It is important for the public to understand the financial merits of changing to metering system in the long term, and 100% metering of customers must be achieved. Prior to changing to the metering system, the following must be considered.

a) **Installation Period:** The period of meter installation must be carefully considered in relation to the water works service distribution. Preparation prior to installation and the process must also be considered.

b) **Inspection System** must be put in place

c) **Meter Maintenance:** Meter replacements, meter repairs and accuracy inspections must be considered.

d) **Billing & Collection System, Financial Planning:** Meter installation of meters and maintenance require funds**.**

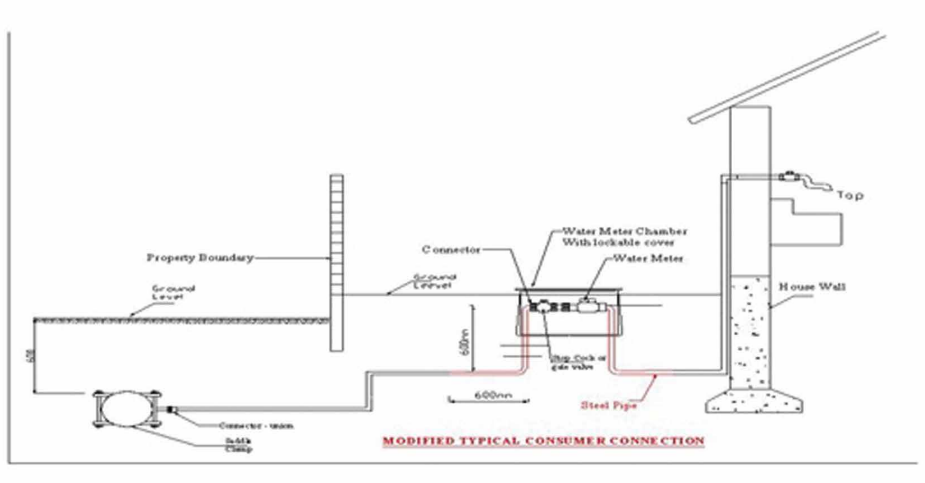


Figure 4.1 Typical Customer Connection Arrangement

4) **Customer Water Meter:** Customer Meters must be installed 100%. It is important that the ledgers for the Master Meter for the distributed area and the ledger for the Customer Meters must correspond with each other, so that System Input Volume (Supplied Volume) and the Consumption Volume can be compared.

Photo 4.2, 4.3, 4.4: Example of Water meter

- The meter is installed preferably 1m inside the plot at a location away from waste water and obstructions for easy access by meter readers

- The meters are installed at a position lower than the house water tap to avoid intrusion of air into water meter, which will influence accuracy of water meter.

- The meter is installed horizontally (for rotary meters) and horizontally or vertically (for piston meters) in order to keep it in good quality and enhance its durability. A household connection including the meter is installed at the following places:
  - At every individual household dwelling
  - At community points or water kiosks

- The existing water meters are checked for accuracy/ functionality by a meter testing equipment stationed at the water treatment plant.

- If the meter is found to be faulty, it is repaired or replaced.

Age of Water Meters

It is the standard procedure in Japan to change water meters after every eight (8) years. There are very few countries in the world, where the life of water meters is set like in Japan. Regular replacements of meters require funds and manpower, however if NRW is to be controlled, it is necessary to regularly replace the water meters as the accuracy of meters will drastically drop after eight years. It is for this reason that data concerning the meter installation date, as shown in Table 4.1, must be maintained.

Elapsed years	Quantity
Under1 year	706
Over1 year	719
Over2 year	776
Over3 year	848
Over4 year	624
Over5 year	632
Over6 year	498
Over7 year	2.744
Over8 year	0
TOTAL	**7.547**

Table 4.1 Meter elapsed years

The efficiency of water meters will be greatly affected by the presence of mud, rust, bacteria and other objects in the water. Presence of air in the water can create unnecessary stress on the water meter, which will affect the meter reading. It is therefore necessary to place strainers and air valves in appropriate locations.

4.2 Management of NRW in MEWASS

4.2.1 General Condition

In order to improve its operation and sustainable management structure, MEWASS focused on the following.

a) Restoration of customer trust
b) Reduction of non-payment from single big users
c) Improvement in work efficiency

a) Restoration of customer trust

The cause of lack of customers was determined to be the general dissatisfaction of customers of the water service. MEWASS undertook to analyze customer complaints and at the same time handle swiftly all customer complaints. MEWASS went out to the community to show them practically, through microscopes, the existence of germs in community water and explained to them the link between water borne diseases and water quality. In addition, they explained how it would be possible for the community to save on medical fees from using safe tap water. Through community meetings and churches, efforts were made to reform community beliefs

in community water. Various benefits of tap water, which would provide stable flow of safe water was explained linking this to the need for volition to pay for water. Through such activities, 100% metering was achieved in year 2003. By analyzing customer complaints it was realized that complaints could be categorized into the following; a) Application related problems, b) Problems related to invoice amount, c) Problems related to repairs, d) Others. An internal structure was set up to find the cause of complaint and clarifying the problem, to tackle complaints in a timely manner.

These efforts have resulted in increased customer numbers from 3178 customers in year 2002/2003, to 7653 customers in 2009/2010, showing an increase of 2.4 times. In the recent years there have been approximately 800 new customers annually, with a revenue collection ratio improving to 89% in 2009/2010 from 59% in 1999.

b) Reduction of non-payments from single big users

According to MEWASS, the most effective way to urge payments from payment defaulters is disconnection of water supply. As the number of disconnection rises, the amount of payment collected will also increase. The two single big users that are posing a problem in payment collection are the Prisons and the public hospital. In 2003, the disconnection of water supply to this hospital caused a nationwide uproar. Currently, the Ministry in charge is setting budgets and paying on their behalf therefore they are no longer in a non-payment status, however this continues to be a point of concern.

c) Improvement in work efficiency

With the participation of its Board of Directors and the Management, MEWASS made changes to improve its work efficiency.

- **Performance Indicator**

  As shown in Table 1-1, Indicators are produced every month. By studying these indicators, the volume of distributed water, volume of water used, number of supply pipes and NRW management units can all be understood easily. It is strongly recommended that other WSP follow this example and introduce Performance Indicators.

- **Monthly Reports / Annual Reports**

  In the Monthly Reports, Meru WSP's own evaluation of its work and management evaluations are done through the Performance Indicators.
  In the Annual Reports, in addition to a compilation of the Monthly Reports, other areas such as management status, customer service, invoicing, revenue collection system and general operation and management are all evaluated.

- **Maintenance of Accounting System**

  Since the introduction of a French software, MAJIK in the year 2004, a comprehensive system has been made possible starting with computer data logging using a data logger, billing set up, to invoicing. As mentioned in Part 4 of this report, staffs involved in meter reading to invoicing have been well trained, hence according to the Commercial Manager, commercial loss is almost zero.
  A customer ledger maintains information on customers.

- **Management System**

  A commercialised system has been adopted in keeping accounting books that serve as basis for financial information, and since year 2003 the systems has been managed through Balance Sheets (BS), Profit & Loss (PL) and Cash Flow.

• GIS Database

Information management is mostly computerised but not yet GIS based. This will be one of the future issues to be looked into.

4.2.2 Management of NRW

The strategies adopted by MEWASS in the management of NRW are as follows.

1) Metering all active connection in the supply area
2) Reading of meter on a monthly basis
3) Billing customers on a monthly basis
4) Having a meter servicing and abnormal consumption personnel
5) Location of the customer at a position where detection for leakages is easy
6) Integrating the customer complaints to the customer management and billing software
7) Establishment of the NRW monitoring section

The explanations of the above are the follows;

1) Metering of all the active connections in the supply area

The Japanese governments grant provided over 2000 meters which helped in our initial effort to meter the active connection totaling to 3140 by March 2004. Since then all new connection are installed with a meter to maintain the 100% metering ratio

2) Reading of meters on a monthly basis

MEWASS has a meter reading section, which is responsible for reading all customer meter every month for billing purposes. During meter reading, the meter readers checks for any visible leakage in the system and reports to the distribution system maintenance section for repairs. They also check for any tampering of the meter or connection and report for investigation to be done.

3) Billing customers on a monthly basis

When meter reading are by the meter reading section a meter reading is submitted for billing. Several activities are undertaken in billing section like

a. Printing / preparation of the meter reading book
b. Capturing of the meter reading
c. Processing Consumption
d. Generation of the unread meters report for the second attempt reading
e. Abnormal Consumption reports for investigation before the billing to ensure:
   - Accurate billing by detecting misreading
   - Detect leakage after the meter to advice the customer to repair promptly
   - To reduce customer complaints resulting from high bills caused by either leakages or misreading of the meter
f. Consumption Adjustment – this done as a result of previous reading / bill estimate or misreading of the meter
g. Draft billing summary. This report facilitates detection of the unread meters, any abnormality through observation.
h. Final Consumption Adjustment - After the reading of the unread metes, any abnormality detected from the draft billing summary and investigations of the abnormal consumptions, the customer accounts affected are adjusted accordingly.

i. Bill Adjustments – Where there is an error in billing, a debt or credit is recorded in the consumer account. Before bills are processed, previous month´s estimated bills, no bills or wrong readings may require adjustments given the current meter readings.
j. Bill simulation – On selecting Bill simulation for billing, a group the system will apply the tariff to all the consumption and calculate the bills. This is a simulation function and does not actually create the bills.
k. Process Bills – The function allows bill processing for every customer in a billing Group.

4) Having a meter servicing and abnormal consumption personnel

Under the meter reading section two technicians are dedicated to investigating abnormal consumptions as reported from the billing system. Any deviation from the average water consumption by more than ±80% is immediately investigated. This is done before billing to ensure that:

a. All misreads are corrected before billing the customers
b. Leakage detected at the customer services are reported to the customer and advice offered on the repair required
c. All zero consumption or lower than normal consumptions are investigate for accuracy of the meter and servicing done promptly where necessary of meter change recommendation forwarded where the meter is unserviceable
d. Any leakage in the meter box report for immediate reports by a maintenance team
e. In case of high consumption which is justifiable the caused is reported for future reference in case the customer complaints of the high bill.

This section also tests for accuracy at the request of the customer and when management deems necessary. MEWASS has a meter testing bench for such meter testing. If the existing meters are fond to be faulty, they are repaired or replaced.

5) Location of the customer at a position where detection for leakages is easy

Normal meter are located close the road, premises boundary and the customer entry point to be the compound to ensure easy access and detection of leakages. The principal is that the longer the service line between the tertiary pipeline and the meter the higher the risk of leakages which go undetected and the also is difficult to detected such leakage given that they are in the customers compound

6) Integrating the customer complaints to the customer management and billing software

All leakages at the customer service lines are reported at the customer relation desk and logged into the customer management software and such issues can only be resolved when they have been attended to. Given that the system monitors the time taken to resolve the complaints this ensure that such leakages are attended to promptly and also the do not go unattended

7) Establishment of the NRW monitoring section

The unit ensures constant monitoring of NRW activities and compiles data, which is useful in strategizing on NRW reduction. They liaise with other section like billing to ensure data correctness and analysis.

For the Impact of NRW management, majority of the residents in Meru Town and is environs MEWASS customers are in agreement that the water provided is not only of good quality but also of adequate.

The impact of MEWASS can be shown through the response from the customers to the organization through the number of complaints, number of new applications.

8) Decrease in new connection fee

Service pipes and new connections fees were always at the cost of the customer (average of KES 7,000; currently in October 2010 is KES 5,500). This fee has always been a burden to the customers. By partially sharing labor costs with the customer has decreased the costs by about 10% to the customer.

4.3 MEWASS Billing & Revenue Collection System

MEWASS uses a management information system called MAJIC system for its billing and revenue collection. The system has high security features with authority and control, restricting changes made to the installed data by the Commercial Manager, Billing Officer and Customer Relations Officer.

The process of billing starts with the meter reading. Once the data is collected from the field, the data is recorded onto the reading sheet and inputted into data loggers by the staff in the metering section. The inputted data is rechecked for errors then subsequently sent to the billing section. A draft water bill is drafted by the billing section, which is sent to the Customer Relations Officer where the final water bill for the customers are generated. The water bills are sent to the consumers by post. The bills are paid at the MEWASS cashier office.

Water bill complaints are received at the Customer Relations Officer. Each complaint is recorded in the Complaints File and followed up.

For new connections, the customer submits a connection application form. MEWASS technical staff conducts a site survey of the applicant's and a cost calculation is done. The customer is required to pay the portion of costs attributable to the customer, for the new connection to be finalized.

Consumers are given a notice of twenty-one (21) days for the payment of the bills. Water will be disconnected if the consumer fails to pay within the 21 days. For reconnection to be effected, the consumer is required to clear the pending bill and pay a fine of 500 shillings.

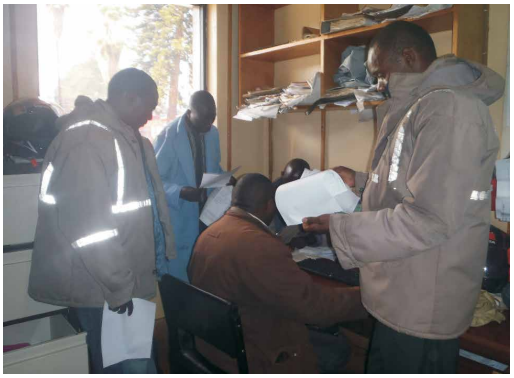


Photo 4.5: Meeting of Metering Section

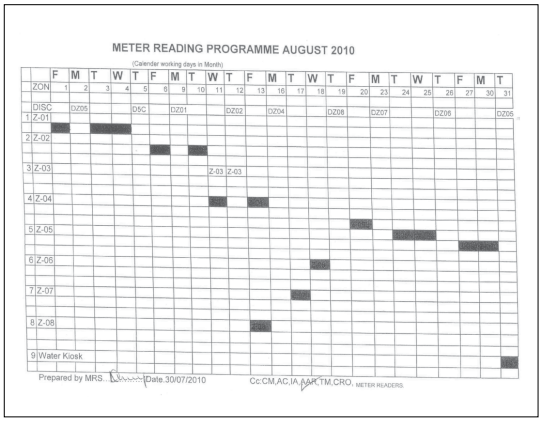


Fig. 4.2: Monthly Reading Schedule

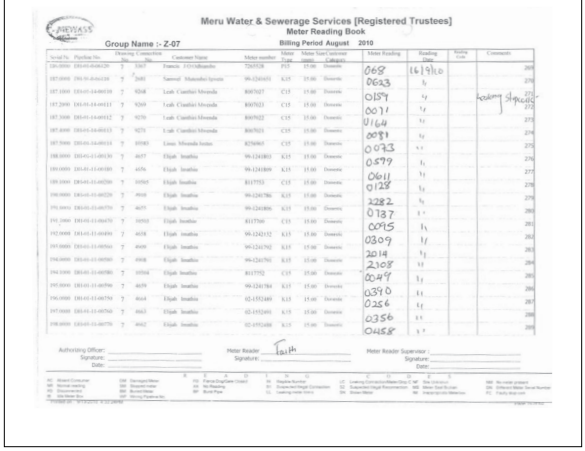

Meru Water & Sewerage Services [Registered Trustees]
Meter Reading Book
Group Name :- Z-07
Billing Period August 2010

Fig 4.3: Meter Reading Sheet

Photo 4.6: Data logger

Photo 4.7: Meter Reading

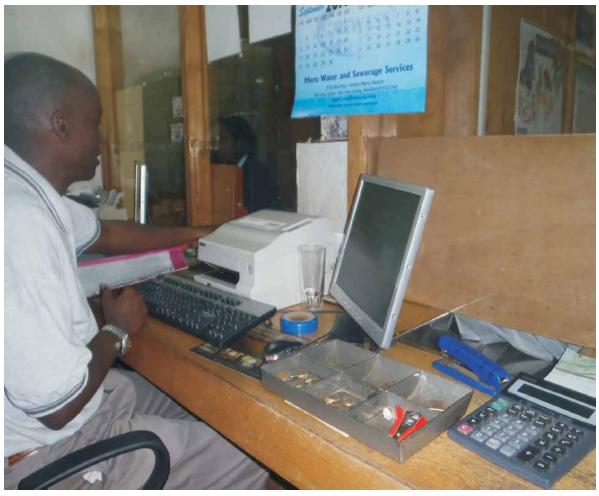


Photo 4.8: Cashiers Office (left: outside, right: inside)

4.4 Introduction of Computer System

Introduction of a computer system is very useful to increase the effectiveness of flow of work from metering to billing, up to customer service. It can also be very effective in decreasing the commercial loss. It is important to not only generally understand the computer system but for each staff to understand the related operations and for each staff to build sufficient capability to take full advantage of the system. It is therefore important for staff in the commercial department to be sufficiently trained in the computer system.

Figure 4.4 shows the Billing & Revenue Collection Flow Chart using the computer system.

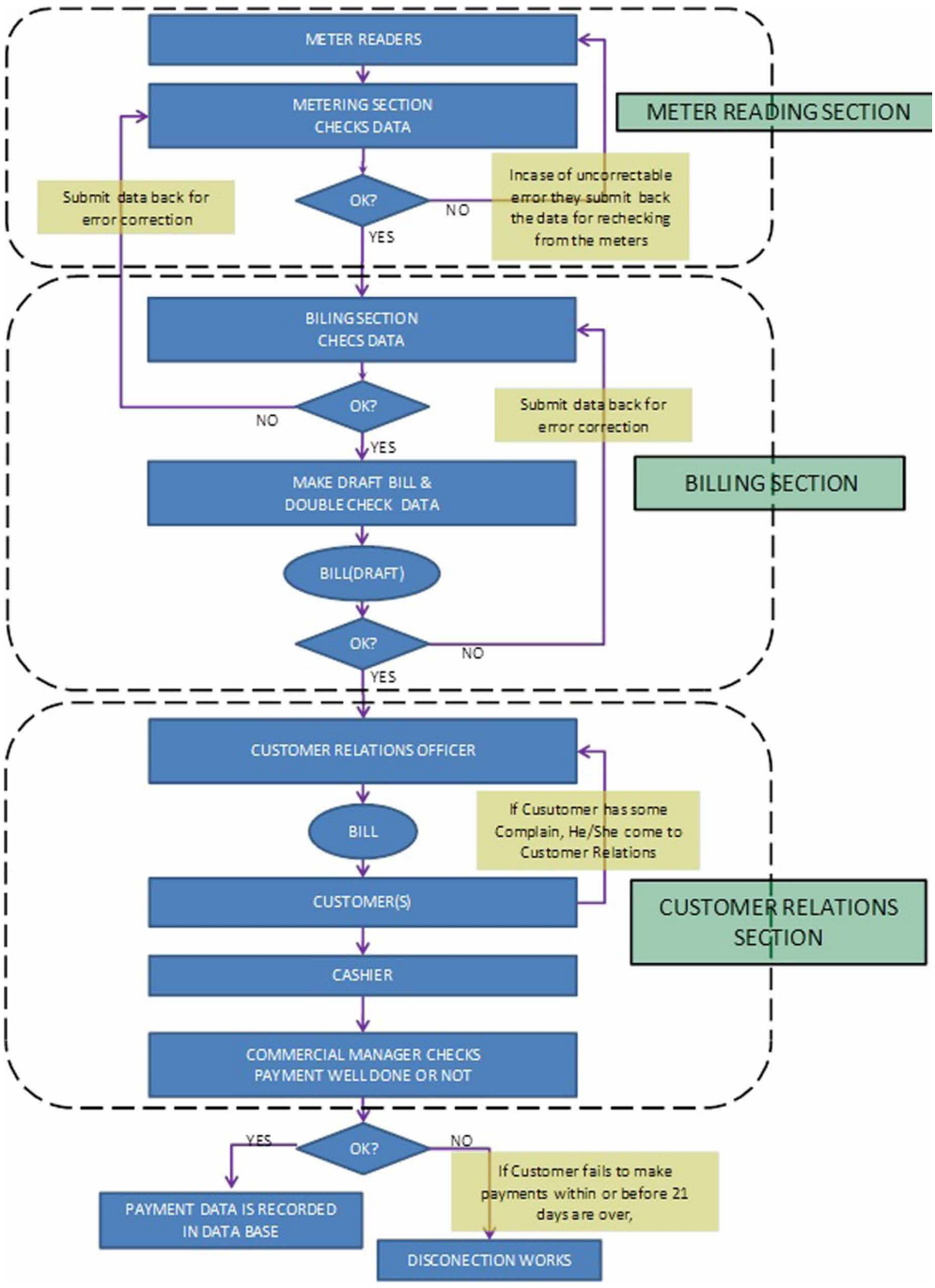


Figure 4.4 Flowchart of Billing and Revenue Collection System of MEWASS

5
Physical Loss Reduction

5.1 Leakage Management

(1) Leakage Information

Table 5.1 Number of burst and leakages from July 2009 to June 2010

NO-OF BURST AND LEAKAGES FROM JULY 2009-JUNE 2010

		BPT	20mm	40mm	50mm	63mm	90mm	110mm	stopcork	Total
1	July		285	77		4	1	2	45	447
2	August	1	246	53		9		2	38	348
3	September		92	84		6		2	38	535
4	October	5	180	82	3	10	2	11	30	319
5	November		300	48	1	12		5	45	411
6	December		273	69	1	2		4	42	391
7	January	2	264	47		8		1	33	355
8	February	17	308	40		5	1	18	39	428
9	March	6	305	39		7		5	44	406
10	April	5	281	61		15	1	8	35	406
11	May	5	323	41	2	5		5	31	412
12	June	6	329	64		8	1	5	41	413
						91				
	TOTAL=	49	3498	705	7	91	6	68	461	4871

Table 5.1 shows the number repairs done due to bursts and leakages, from July 2009 to June 2010.
The Table shows that 86% of the occurrences are in the 20mm service pipes and 40mm tertiary distribution pipes. Number of occurrences seems to be increasing each year. Pipes with diameters 63mm, 90mm and 110mm that distribute most volume of water were observed closely for bursts and leakages.

Table 5.2 Number of burst and leakage from July 2006 to June 2010

NO-OF BURST AND LEAKAGES FROM JULY 2006-JUNE 2010

	uPVC-E PIPE 63mm	uPVC-E 90mm	uPVC-E 110mm	Total
Major Repairs Form July 2009 to June 2010	91	6	68	165
Major Repairs Form July 2008 to June 2009	67	38	24	129
Major Repairs Form July 2007 to June 2008	27	8	23	58
Major Repairs Form July 2006 to June 2007	28	5	25	58

Pipes of diameters uPVC-E 63mm to 110mm had 58 cases of bursts and leakages in 2006/2007, while in 2009 there were 165 cases.
It is necessary to find the cause of the increase in the number of cases, whether it is due to inferior pipe material or due to water pressure, and find measures to tackle the problem. Records of cases are kept on a daily and monthly basis, giving information such as Distribution Section, number of visits, number of leakage repairs, diameter of pipes where leakages occurred, location of occurrence, and reported to the Distribution Manager. It is however difficult to state that there is full understanding of data concerning leakage accidents. For information such as occurrence date and time, pipe number, and distribution pipes, it is necessary to have records of the cause of leakage, the status of leakage, and materials used for repairs.

(2) Leakage Detection

a. Detection Plan

The section handling leakage within NRW reduction is called UFW Section and currently has 4 staff members.

The table 5.3 shows the activities of this section

Table 5.3 Activities of leakage detection in MEWASS

Item	Frequency	Remark
Measuring during the night, volume of abnormal flow	Maximum eight (8) times per month	Leak detection conducted depending on volume of abnormal flow
Detection of water leakage	1~2 days per week	Detection conducted with listening stick
Pipeline patrol	1~2 days per week	

b. Equipment

There is a general lack of equipment for leakage survey. There are very few sounding devices for detecting leakage in supply pipes and they are handmade.

Table 5.4 shows the quantities of leakage in Meru.

Detection Equipment	Quantity	Remark
Ultra sonic flow meter	One	The liquid in the liquid screen is leaking
Sounding bar	A few	Handmade therefore difficult to hear

Photo 5.1 Listening Stick

(3) Step test measurement

Measuring of abnormal flow by Zone Sub Blockage

On 26th October 2010, the JICA Expert Team participated in the Step Test Measurement. The aim of measuring the night flow of Zone 5 was to measure the amount of physical loss and thereafter to reduce the volume of leakage.

A method called the “Step Test” was used, where water flow was temporarily and deliberately stopped from the downstream parts of the pipe network, and the abnormal flow of these sub zones were measured.

Taking the map of Zone 5 as an example shown in Figure 5.1, by closing V01, the volume of night flow for the downstream areas can be measured. V02 and V03 are closed off in turn and the night flow recorded and the abnormal flow can be calculated from these measurements.

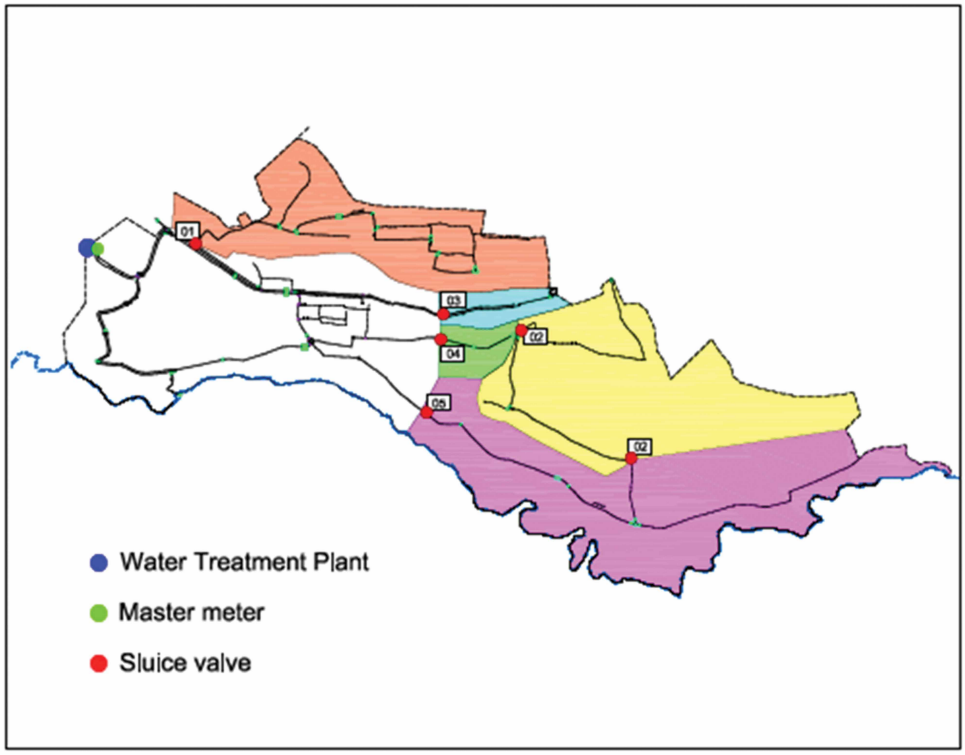


Figure 5.1 Zone5 Step Test

Time line of Step Test

The activity started at 24:00 and measurements were taken until 3:30 a.m. These measurements provide details of abnormal flow of the 17 sub zones.

Photo 5.2 Step test measurement (Left: measuring flow volume, Right: Closing gate valve)

Table 5.5 indicates the results of the measurements.

Table 5.5 Results of Night Measurement Zone 5

Result of Night Measurement Z-05 27-10-10

slno.	Pipeline No	pipeline route		Time to be measured		Meter Reading		Flow (3)	Flow (4)	Flow in Pipeline M^3/hr (5)	Priority
		From	To	Starting	Stopage	At starting time (1)	At stopage time (2)	(2)-(1) M^3/10min	(3)*6 M^3/hr		
1	Whole			23:56	0:06	2430506.00	2430512.30	6.30	37.80		
2	JW-01	DWO	End	0:10	0:20	2430514.00	2430518.01	4.01	24.06	13.74	measurement
3	Con 70 Police line	at the meter		0:22	0:32	2430518.90	2430522.31	3.41	20.46	3.60	status i.e burst
4	JW-05& DW-07	Sv @ BPT	End	0:34	0:44	2430522.95	2430526.45	3.50	21.00	-0.54	
5	JW-06 Lower & JW-05	@chamber	Sv @ BP	0:46	0:56	2430527.30	2430530.66	3.36	20.16	0.84	
6	DW-06E	Origin	End	1:04	1:14	2430533.30	2430536.30	3.00	18.00	2.16	5
7	JW-03 Lower	Backlays	End	1:16	1:26	2430536.80	2430539.51	2.71	16.26	1.74	6
8	JW-08	Origin	Sv Mid	1:28	1:38	2430540.00	2430542.52	2.52	15.12	1.14	
9	JW-06 Upper	Origin	@cham	1:40	1:50	2430542.90	2430544.82	1.92	11.52	3.60	1
10	DW-06D	Origin	End	1:52	2:02	2430545.25	2430546.94	1.69	10.14	1.38	7
11	DW-06B& DW-06C	Origin	End	2:04	2:14	2430547.25	2430548.71	1.46	8.76	1.38	7
12	DW-06A	Origin	End	2:16	2:26	2430548.95	2430550.29	1.34	8.04	0.72	
13	JW-03 Upper	Origin	Backlay	2:28	2:38	2430550.60	2430551.51	0.91	5.46	2.58	4
14	DW-05,	Origin	End	2:40	2:50	2430552.15	2430553.11	0.96	5.76	-0.30	
15	DW-04 & JW-02	SV @ DWO	End	2:53	3:03	2430553.30	2430553.82	0.52	3.12	2.64	3
16	JW-09	Origin	End	3:06	3:16	2430553.85	2430553.85	0.00	0.00	3.12	2
17	JW-02& JW-07	Origin	SV @ DWO							0.00	

Step test measurements were taken in 17 sub zones. Sub zones can be optionally sectioned, therefore comparisons can be made with previously selected sub zones and it is also possible to divide the sub zones in more details in those areas that are deemed to be priority. With these measurements as basis, sub zones with high abnormal flow can be prioritized and a survey can be conducted. From the Table, it can be seen that the upper route of JW-06 of No. 9 sub zone and JW-09 No. 16 sub zone are priorities 1 and 2.

The Step Test is a method that may include a margin of human error; however, taking into consideration the current structure, available survey equipment and status of equipments in general, this method is thought to be the most suitable.

Photo 5.3 Detecting leakage using sound stick

Photo 5.4 Leakage from distribution pipe after detecting

5.2 Estimated Physical Loss through Water Demand Characteristic Curve

Estimation of approximate volume of Physical Loss in Zone 1

In order to calculate the NRW components, it is important to emphasize that measured data is the basis of calculation. During the years 2004 and 2005, MEWASS conducted hourly readings of water flow of each zone to produce the water demand characteristic curve. This characteristic curve is used the management of water works, but the Night Flow Measurement is an effective tool to estimate the NRW Physical Loss. It is recommended that all WSP prepare the water demand characteristic curve, but it is important for each WSP to understand that Night Flow Measurement is not equivalent to Physical Loss.

Photo 5.5 Night Flow measurement

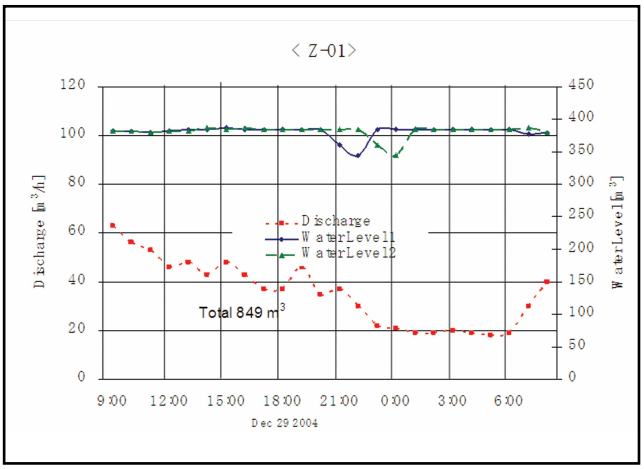


Figure 5.2 Water demand characteristic curve in MEWASS Zone 01

5.3 Construction Works

Meter Location and Placement

As much as possible, meters are installed along the highway or major roads as shown in Photo 5.6. Installing meters near the parameters of customer land and the major road should be encouraged.

Photo 5.6 Placement of the meter

Service Pipe Construction Management in the field

Placement of Service Pipes

Photo 5.7 shows a recent meter installation construction. This meter is being placed about 5 meters from the boundary. Unless there are problems, it is recommended that the meter be placed about 1~2 meters from the boundary. By placing these meters as recommended, management of leakage and management of sub zones will become much easier.

Photo 5.7 Placement of Service Pipe

As shown in Photo 5.7 (right photo), service pipes are normally connected from 40mm tertiary pipes, one next to the other and saddle clamped.

5.4 Water Pressure Management

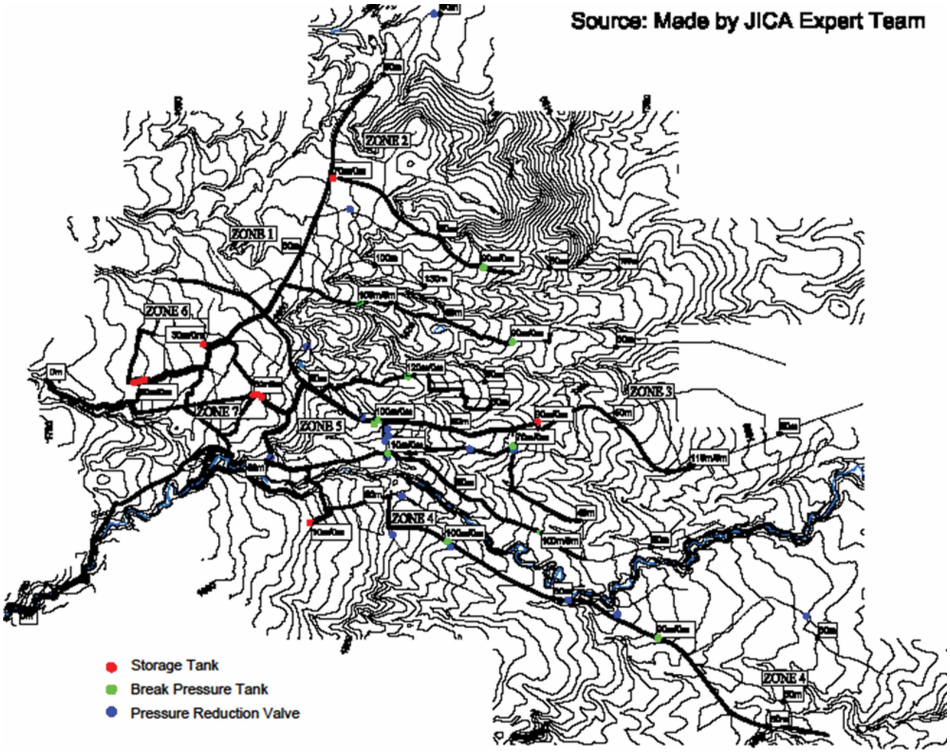


Figure 5.3 Networks of MEWASS

As shown in the figure 5.3, MEWASS network is within a topographically hilly area. At most, there is an elevation

difference of 400 meters within its network area. From the Milimani Treatment Plant, MEWASS network is divided into seven (7) zones as shown in Figure 5.4 with the objective of utilizing its topography to decrease the water pressure in pipes and also for easy maintenance of its network.

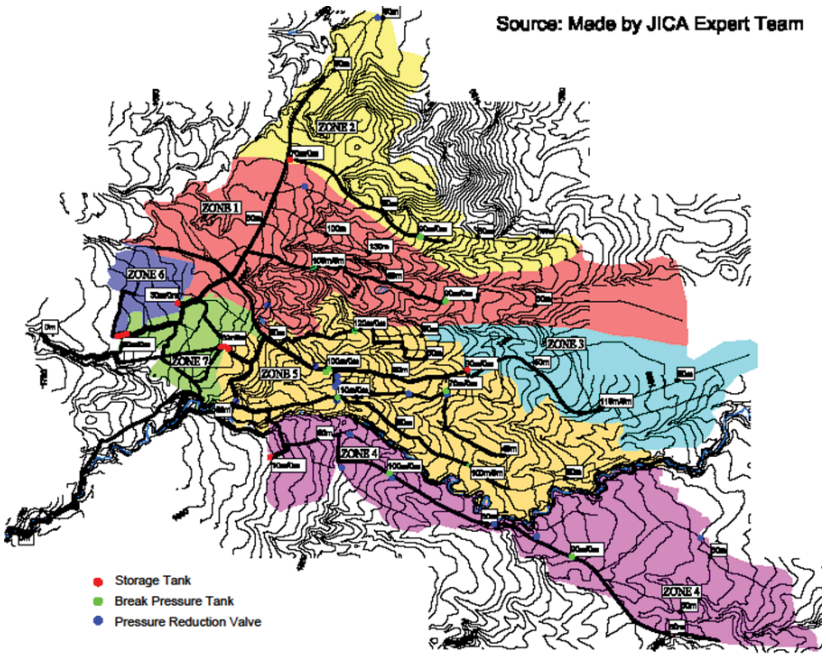


Figure 5.4 Zoning Network of MEWASS

Ancillary Water Facilities

Table 5.6 Network Facilities

	2003	2004	2005	2006	2007	2008	2009	Total
BPT Break Pressure Tank	4	8	0	0	0	0	0	12
PRV Pressure Reduction Valve								33
Reservoir	7	3	0	0	0	0	0	10
Bulk Meter	7	3	0	0	0	0	0	10

The seven zones have a total of 12 Break Pressure Tanks (BPT) and 33 Pressure Reduction Valves (PRV) to reduce water pressure and water is being distributed by zones.

Pressure reducing Valve

Inner of break pressure tank

Pressure reducing Valve

Photo 5.8 Network Facilities

Measures against high water pressure and water hammer

Break Pressure Tanks are installed on main pipes with over 90mm diameter with the aim to have not more than average of 100 meter elevation difference. Pressure Reduction Valves are installed in secondary pipes of less than 60 mm diameter to decrease high pressure in the pipes.

There is no water pressure data on tertiary extension pipes, therefore it would be difficult to devise measures for water pressure management. The network relies on natural gravitational flow therefore water hammers are not often seen, but there are some cases of customer complaints of water not flowing readily. It can therefore be assumed that pressure is not controlled at a steady level.

Water hammers can arise from sudden increase in pressure and also sudden decrease in pressure. There are cases where water hammers can arise due to presence of air in pipes therefore it is necessary to install air valves in appropriate positions. Water pressure data is critical for management of data pressure.

5.5 Standardization of Material of Pipes

The Kenya Standard was utilized in JICA Project Phase 1 and 2, but thereafter, MEWASS has recommended the use of International Standard (ISO). This however is not yet regularized. Under such circumstances, MEWASS is utilizing various flexible joints for pipes over 60mm diameter.

Photo 5.9: Measuring pipe diameter

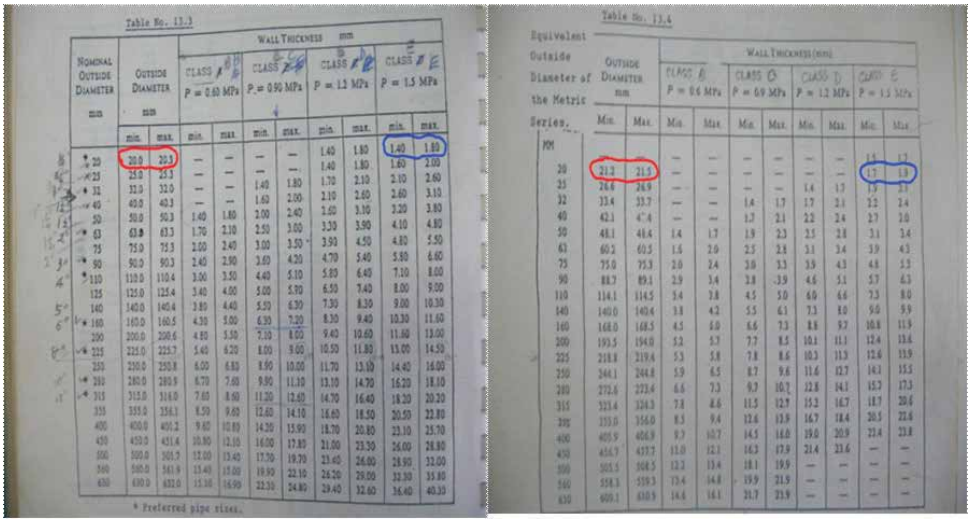


Photo 5.10: ISSO metric and inch serie

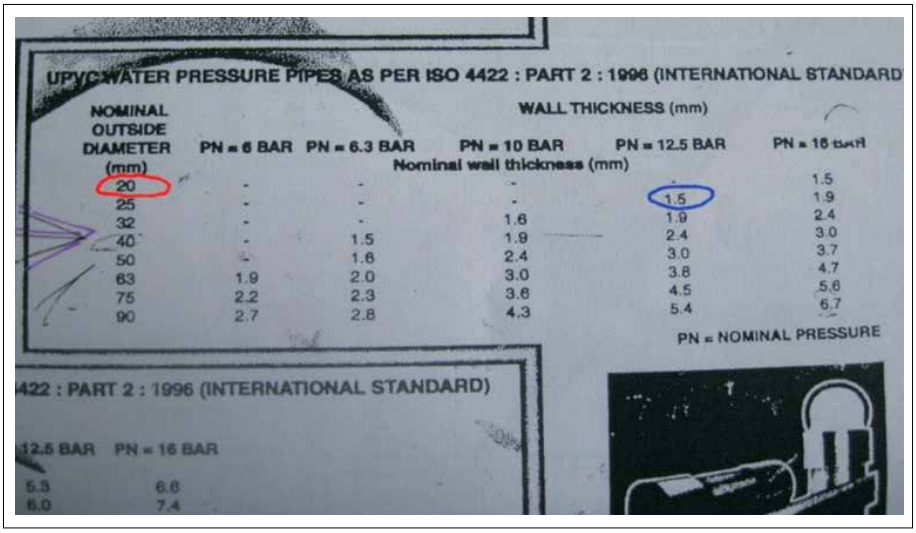


Photo 5.11: ISSO-4422 Standard

Photo 5.12: Fire Coupling

Photo 5.13: Plastic Paper Bend

As shown in Photo 5.12 and Photo 5.13, when different thicknesses of pipes or internal pipe diameters do not match, fire couplings, rubber and / or plastic paper bends are still being used.

Photo 5.14, 5.15 and 5.16 show pipe fitting parts that were developed by MEWASS

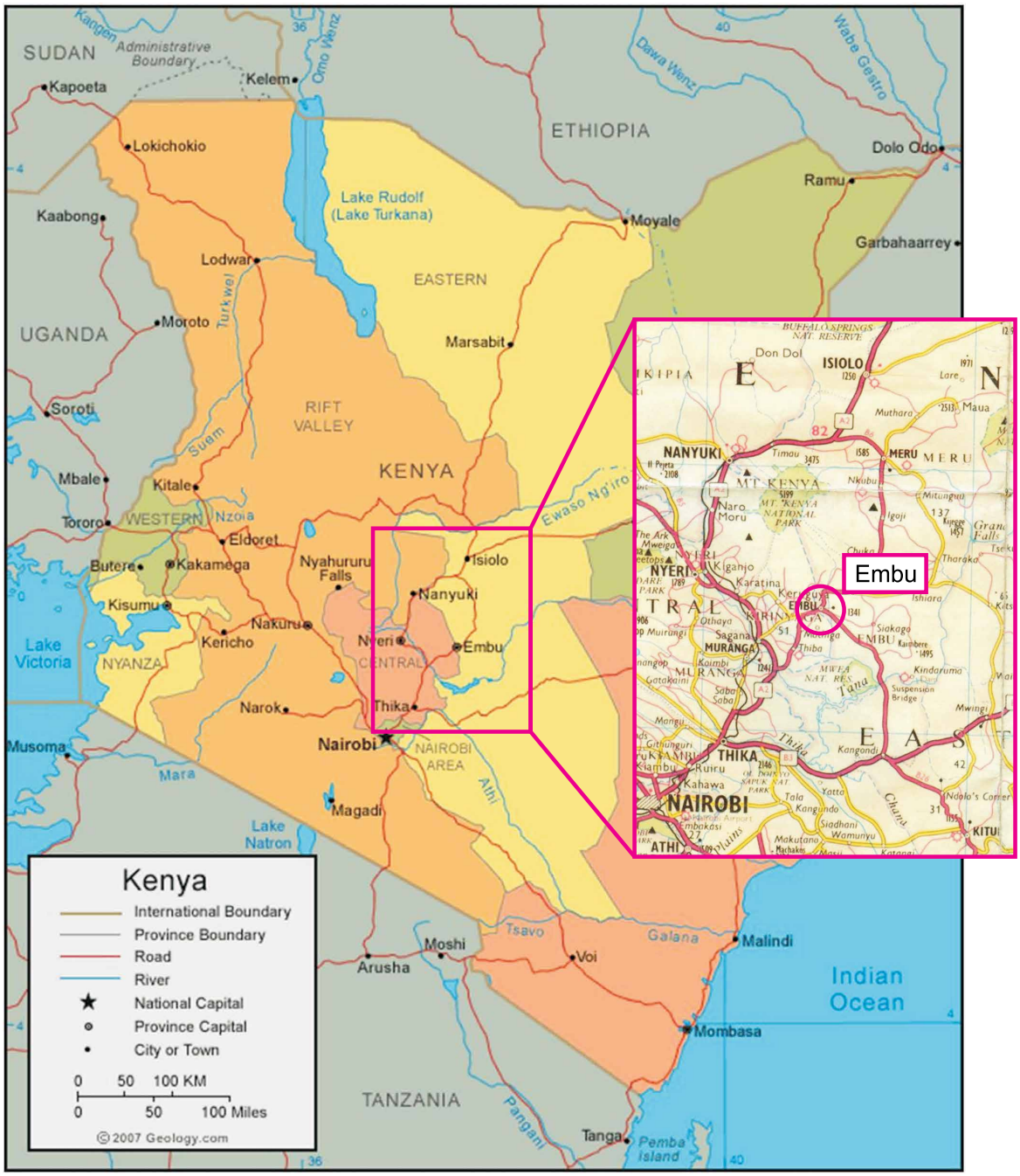
Photo 5.14: Various Angles & Diameter Bends

Photo 5.15: Socketed & Plain Repair Couplings

Photo 5.16: Tread seal PTF used with uPVC & GI Threaded Fitting

Part 2

Case Study EWASCO



Location of EWASCO

Embu town is located in Eastern Province and on the Southern slopes of Mt. Kenya Highlands.

EWASCO (Embu WSP) under TANA WSB is in Embu town. It is topographically a hilly area. Most of WSPs under Tana WSB are in similar conditions. Embu town is a Business, Agricultural and Educational hub for Midland of Kenya.

1
Water Balance Flowchart

1.1 Basic Information

It is necessary to prepare a map in order to understand the whole water balance of the distribution area. In this map, the following water works facilities are included. Point of intake, Raw Water pipeline, WTP, Zoning, Storage Tank, Master Meter, Transmission Pipe line, Distribution Pipe Network, BPT, PRV, etc. It is important to determine whether flow meters are installed or not. If flow meters have not been installed, it is advisable to install them at an early stage. Table 1.1 shows transition of status of EWASCO service area in the Embu city.

Table 1.1 Overview of EWASCO (from 2008 to 2011)

	2008	**2009**	**2010**	**2011**
Population served	50 000	60 000	78 000	86000
Connections Numbers	6290	7650	10105	12000
Distribution Area	120 km^2	120 km^2	900km^2	900km^2
Consumption Water Volume	125000 m^3/m	130 000 m^3	148 000 m^3	199000m^3
Distributed Water Volume	290 000 m^3/m	316 000 m^3	320 000 m^3	320000 m^3
Ratio of water meter Connectivity	100 %	100	100	100
Ratio of NRW	57%	54%	45%	38%
Numbers of staff	56		81	80

Connection number is increasing year by year and increase volume of water supply. The Non-Revenue Water ratio still high (45%) on 2010 with expanding service area. EWASCO has water distribution system and has responsible to their maintenance. They have one intake at MWIRIA area that locate 3km upstream from the town and draw water by gravity. And they have two treatment plants on the way to town (MUKANG and KANGARU treatment plant). After treated, water is storage in five tanks, then distribute to 15 areas of the town. Figure 1.1 is system diagram of EWASCO water distribution network.

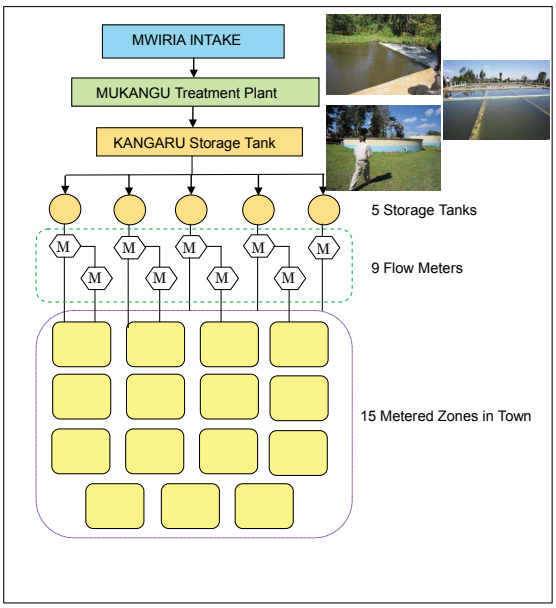


Figure 1.1 System Diagram of EWASCO Water Distributions

Figure 1.2 shows EWASCO's water facilities location, distribution pipes and 15 areas of the service areas in Embu town.

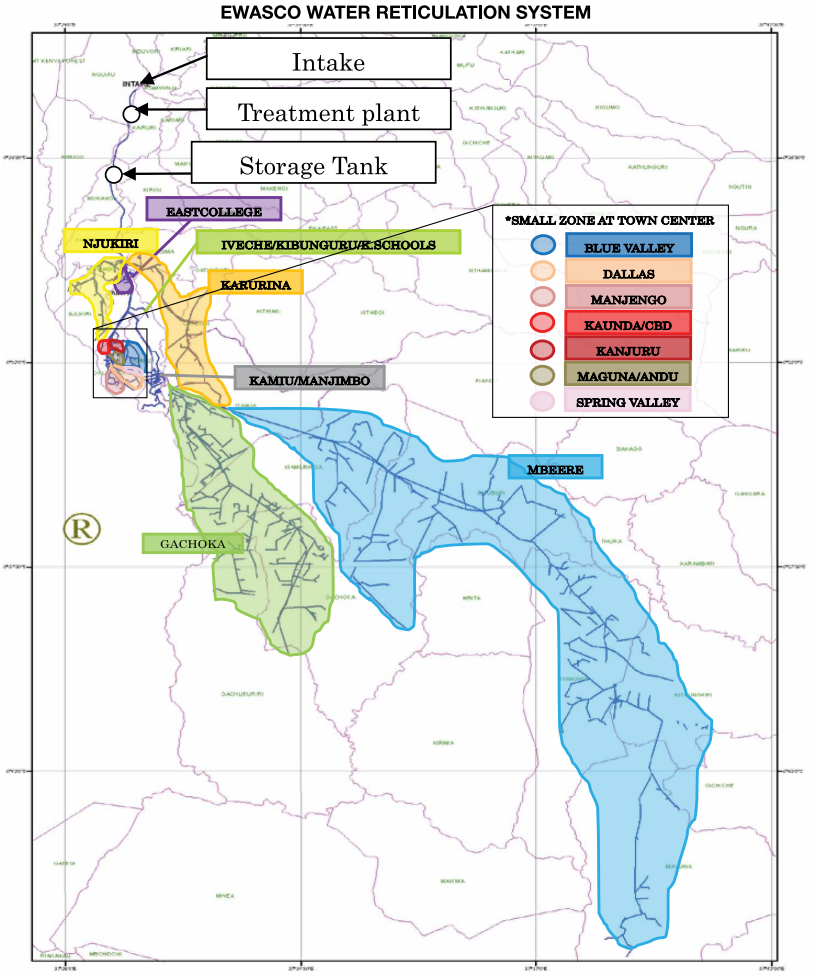


Figure 1.2 Location Map of the facility

The installed flow meters must be tested for accuracy. If any of the flow meters show inaccuracy, they must be replaced them as early as possible.

Photo 1.1: Installation of Flow Meter at Outlet of Storage Tanks

1.2 Non-Revenue Water History of EWASCO

EWASCO has been under rapid change in terms of NRW/UFW management for the purpose of efficiency of the water supply system, embracing modern technology, fast and quality services and to be the leading water service provider in the country through application innovative means/ procedures and by use of available resources.

Table 1.2 explains how EWASCO tried against NRW and the activities involved. On the period from 2005 to 2006, they had good ratio of NRW at 25%, but that figure is suspicious because they had not good database. In 2006, the ratio of NRW was around 60% that was result from wide expansion their service area. In 2008, NRW ratio decreased to 50% as a result of upgrading line. In 2009, they continuously did burst/leak management, but NRW ratio still high around 50%. From 2010, NRW management program was started. They keep trying to reduce NRW ratio with various act. At the March of 2011, NRW ratio decreased up to 35%.

Table 1.2 EWASCO's NRW History

YEAR	ANNUAL AVERAGE NRW/CONDITIONS
2005 – 2006	No good Database, Active EWASCO Organization was Implemented Changing of consumer Meters. i.e. 4000 meters replaced, The NRW levels were at 25%
2007	NRW at 60% due to major road expansion in town area and high pressure and increased water supply to poor pipe classes.
2008	1st half NRW dropped to 50% due to line upgrading and Leak /BPT Overflow controls 2nd half. NRW at 60% due to expansion to Mbeere which consisted of old pipelines
2009	NRW was at 50% due to expansion and construction to Mbeere in old pipeline but lower than previous year as a result of rehabilitation/leak and burst management
2010	NRW at 45% to 46%, 1st half Master Meter Calibration and Leak Survey. Daily Patrols case studies implementation, GIS mapping, Meter phasing cycle.
2010 JULY-NOV	NRW at 42% to 45%.Rapid response to bursts and leakages Further leak controls and case studies.Meter survey, Active NRW unit
2010 DEC	42% Pressure control, Improved Billing, Master meter daily flow monitoring,good database Line replacement, Active NRW unit
2011 JAN	41%Pressure control, Improved Billing, Master meter daily flow monitoring, good database Line replacement, Active NRW unit, implementing lessons learnt from JICA NRW team
2011 FEB	38% Pressure control, Improved Billing, Master meter daily flow monitoring good database, Line replacement, Active NRW unit Flow monitoring and acquisition of NRW equipments
2011 MARCH	Projected 35%, Pressure control, Improved Billing Master meter daily flow monitoring, good database, Line replacement, Active NRW unit

The Water Balance Table made by EWASCO is shown in Table 1.3. In this table they estimate unbilled authorized consumption as 0%, and also estimate each figure by inaccuracy meter record. The project team started from to define accuracy of data from meters and consumption volume.

Table 1.3 Water Balance table at the end of 1st half of 2010 by EWASCO

<table>
<tr><td rowspan="2">Authorized Consumption
54%</td><td colspan="2">Billed Authorized Consumption
54%</td><td>Revenue Water
54%</td></tr>
<tr><td colspan="2">Unbilled Authorized Consumption 0%</td><td rowspan="4">Non-Revenue Water
46%</td></tr>
<tr><td rowspan="3">Water Losses (UFW)
46%</td><td rowspan="2">Apparent Losses (Non-technical or Commercial Losses)
22%</td><td>Unauthorized Consumption (Illegal connection)
2%</td></tr>
<tr><td>Metering Inaccuracies
20%</td></tr>
<tr><td colspan="2">Real Losses (technical Losses) 24%</td></tr>
</table>

1.3 Mapping

For sustainable management, it is fundamental to maintain and manage the pipeline network map. The map should include information on diameter of pipes, type of pipes, sluice valves, air valves, drain valve, hydrants, pressure reduction valves, safety valves, water pipe bridges, tunnels, box carver, types of joints and the age of pipes.

As long as the necessary maps and ledgers are not fully prepared, it will be difficult to map an accurate pipeline network map. It is important to first determine what degree of accuracy and information and details are necessary to be reflected in the pipeline network map and related ledgers. Information gathering thereafter and maintenance of the information is part of Information System Management, and should be updated regularly. The information in the map should be categorized and well coded so that necessary information can be easily extracted. At the same time, the mapping system should be able to easily reflect all the necessary information. In the recent years, the CAD (Computer Aided Design and Drafting) and the GIS (Geographic Information System) database have become more and more popular and they have also become very user friendly. These programs have been used to show the GIS mapping in EWASCO as shown below.

Table 1.4: Pipe Coding of EWASCO

	Pipe Codes	**Description**
Distribution Main	D-	This indicates main pipe
Secondary	S-	This indicates secondary pipes
Tertiary	T-	This indicates tertiary pipes
Diameter	X-090-	This indicates pipe diameter
Block (Sub zone) Number	X-000-32-	This indicates block (sub zone) number
Blanch number	X-000-00-01	This indicates blanch number of pipes

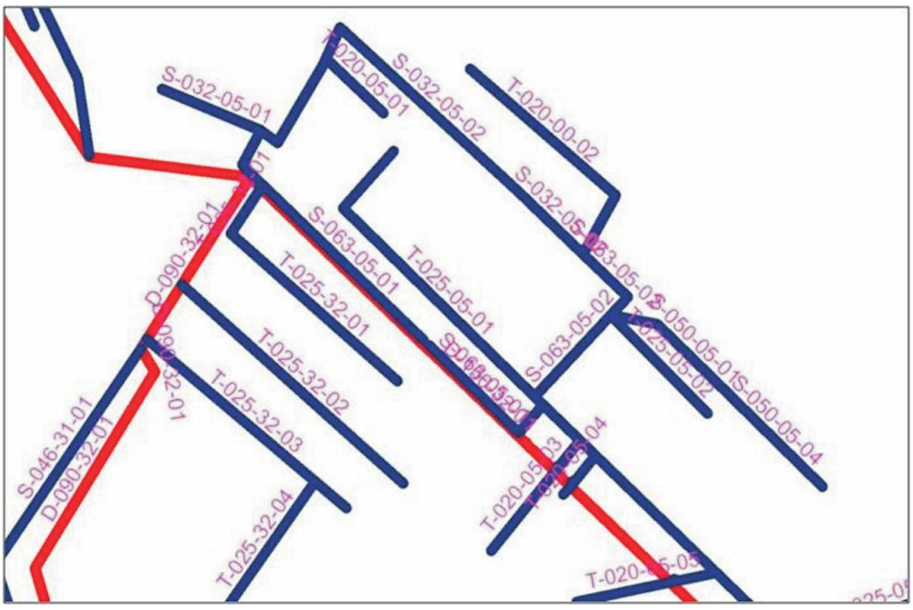


Figure 1.2 Example of Diagram about Naming on Pipeline by EWASCO

1.4 Service Meter Information

Service meter information provides the connection number, the type, the diameter and meters was installed. In addition to these, information such as year of installation of meters, number of abnormal figure on readings, diagnosis of meter deterioration and water pressure would provide enough information to develop a medium to long term plan of meter replacement.

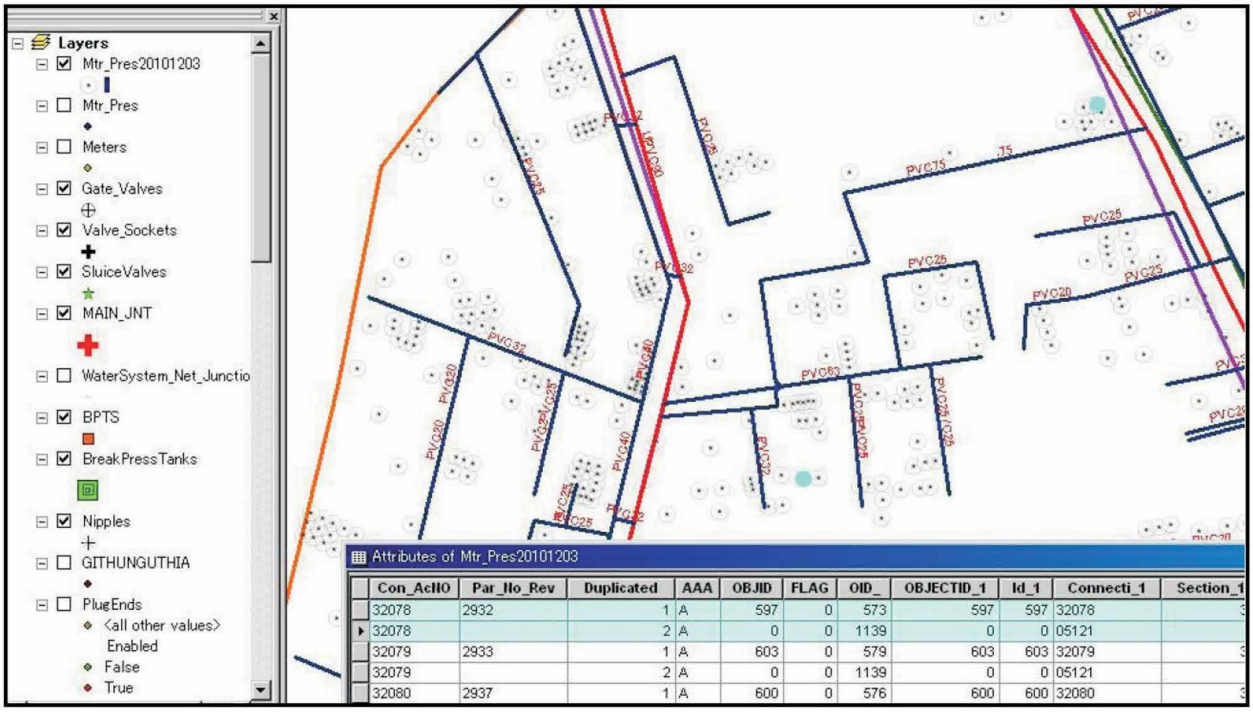
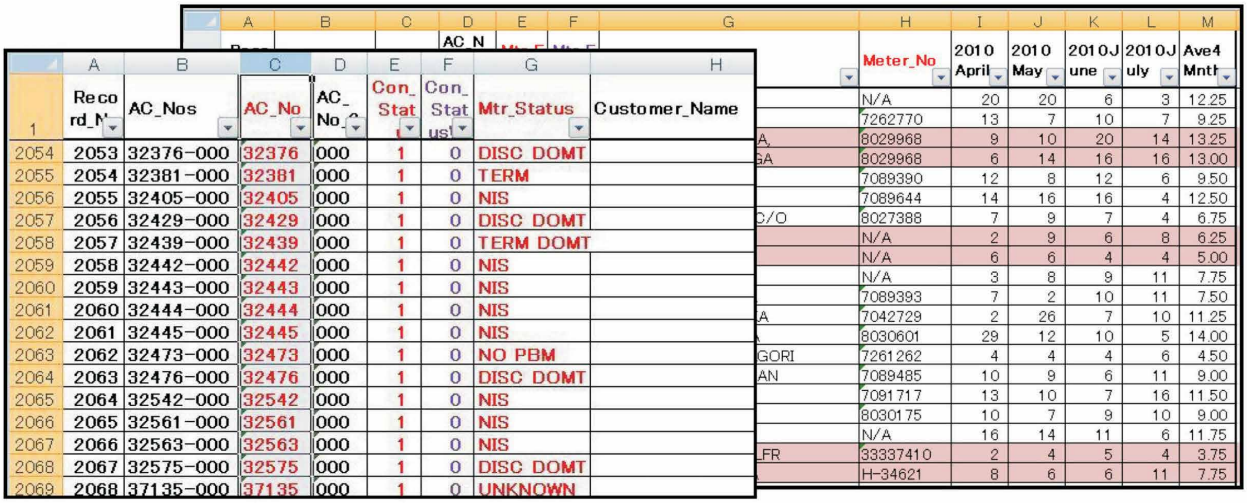


Figure 1.3 Service Meter database on GIS system of EWASCO

In EWASCO, they also established management system of billing with database to prevent from commercial loss. Figure 1.4 shows table of customer information. There are attribute such as connection number, customer name, consumption volume per month and meter status (Run, disconnect, terminate and more).



	A	B	C	D	E	F	G	H
1	Record_N	AC_Nos	AC_No	AC_No_2	Con_Stat	Con_Status	Mtr_Status	Customer_Name
2054	2053	32376-000	32376	000	1	0	DISC DOMT	
2055	2054	32381-000	32381	000	1	0	TERM	
2056	2055	32405-000	32405	000	1	0	NIS	
2057	2056	32429-000	32429	000	1	0	DISC DOMT	
2058	2057	32439-000	32439	000	1	0	TERM DOMT	
2059	2058	32442-000	32442	000	1	0	NIS	
2060	2059	32443-000	32443	000	1	0	NIS	
2061	2060	32444-000	32444	000	1	0	NIS	
2062	2061	32445-000	32445	000	1	0	NIS	
2063	2062	32473-000	32473	000	1	0	NO PBM	
2064	2063	32476-000	32476	000	1	0	DISC DOMT	
2065	2064	32542-000	32542	000	1	0	NIS	
2066	2065	32561-000	32561	000	1	0	NIS	
2067	2066	32563-000	32563	000	1	0	NIS	
2068	2067	32575-000	32575	000	1	0	DISC DOMT	
2069	2068	37135-000	37135	000	1	0	UNKNOWN	

	H	I	J	K	L	M
	Meter_No	2010 April	2010 May	2010 June	2010 July	Ave4 Mnth
	N/A	20	20	6	3	12.25
	7262770	13	7	10	7	9.25
A,	8029968	9	10	20	14	13.25
GA	8029968	6	14	16	16	13.00
	7089390	12	8	12	6	9.50
	7089644	14	16	16	4	12.50
C/O	8027388	7	9	7	4	6.75
	N/A	2	9	6	8	6.25
	N/A	6	6	4	4	5.00
	N/A	3	8	9	11	7.75
	7089393	7	2	10	11	7.50
A	7042729	2	26	7	10	11.25
	8030601	29	12	10	5	14.00
GORI	7261262	4	4	4	6	4.50
AN	7089485	10	9	6	11	9.00
	7091717	13	10	7	16	11.50
	8030175	10	7	9	10	9.00
	N/A	16	14	11	6	11.75
FR	33337410	2	4	5	4	3.75
	H-34621	8	6	6	11	7.75

Figure 1.4 Customer information in EWASCO Database

2
Activity for Reduction of Non-Revenue Water on Pilot Project

2.1 Preparatory Work

Preparatory works on pilot project are as follows;

(1) Selection of pilot project area (2.1.2)
(2) Installation of master meter (2.1.2)
(3) Installation of data transferring system (2.1.3)
(4) Inspection of all customer meters (2.1.4)
(5) Installation of customer water meter (2.1.5)
(6) Isolation of sub-block (2.1.6)

2.1.1 Selection of Pilot Project

In order to learn how to reduce Non-revenue water, EWASCO started their work from select area for pilot project. The project area “Blue valley” was selected for reasons that are isolated from another area. This area has two specific characters to easy operation for monitoring. One is that it has only one entrance of pipe, the Second is that all end of pipe is not connected anywhere.

Figure 2.1 shows map of blue valley area.

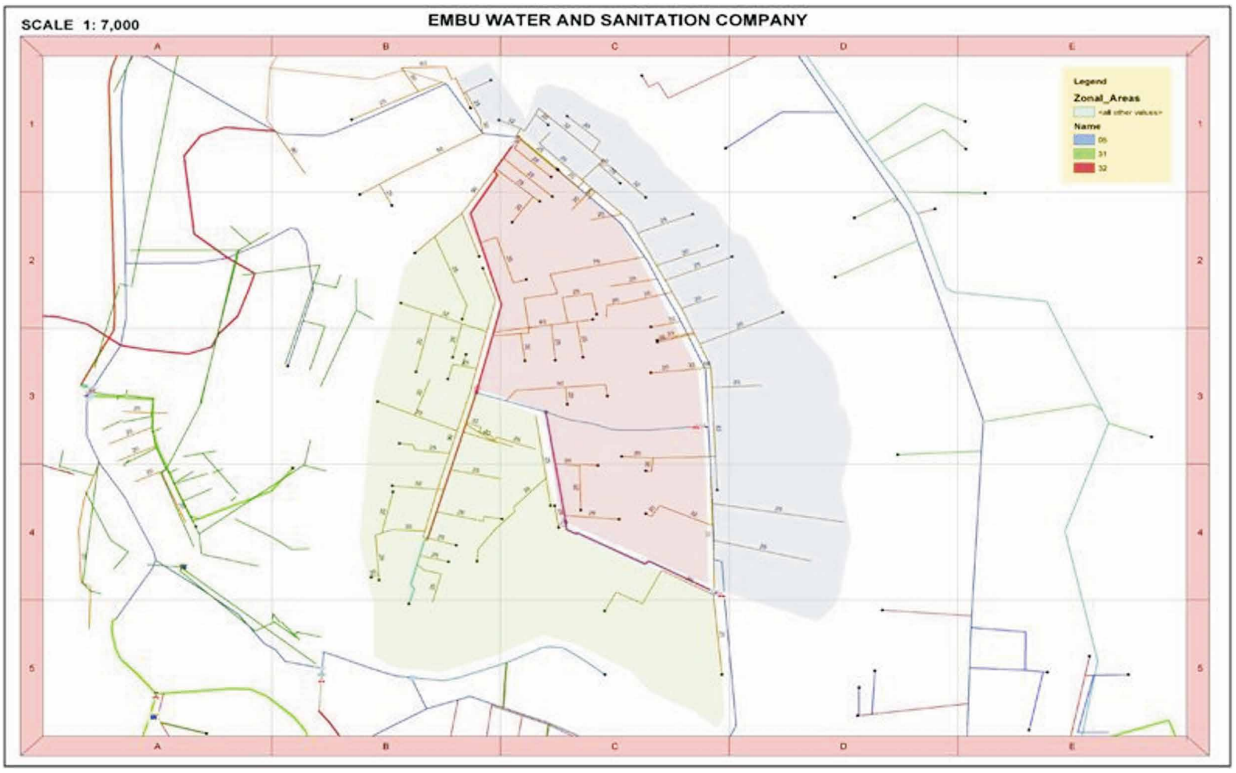


Figure 2.1 The map of “Blue Valley” (Pilot area)

2.1.2 Installation of Master Meter

Master meter chamber is constructed to install flow meters that measure water flow into all areas of pilot project. It is necessary to secure joint materials for the installation of measure water flow using ultrasonic flow meter.

Photo 2.1 Construction and install of New Master meter and chamber

2.1.3 Installation of Data Transferring System

EWASCO install Data Transferring System at the gate of pilot project work with flow meter. At first, the flow quantity data was stored in data logger, and data was transferring through mobile line. This device runs on solar energy. Data Logger, solar panel and Data Logger box was shown in Photo 2.2.

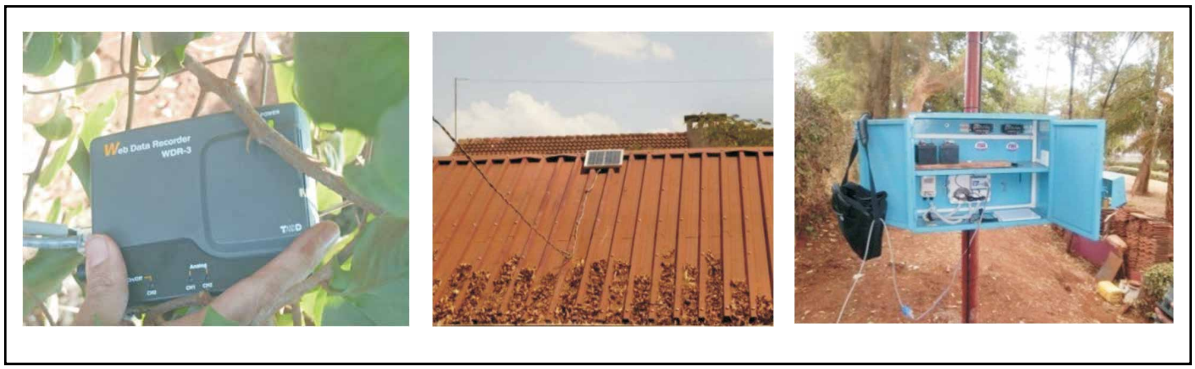


Photo 2.2: Data Transferring System

2.1.4 Inspection of all Customer Meters

Inspection of customer meter is conducted through sight survey include register, non-functional meter, non-visible meter, illegal connection, leakage etc.

Photo 2.3: Survey of Customer Water Meter

2.1.5 Installation of Customer Water Meter

Customer Meters must be installed 100%. It is important that the ledgers for the Master Meter for the distributed area and the ledger for the Customer Meters must correspond with each other, so that Distributed Water Volume and the Consumption Volume can be compared.

Photo 2.4: Customer Water Meters in Embu

When install water meter, be care follow items;

- The meter is installed preferably 1m inside the plot at a location away from waste water and obstructions for easy access by meter readers
- The meters are installed at a position lower than the house water tap to avoid intrusion of air into water meter, which will influence accuracy of water meter.
- The meter is installed horizontally (for rotary meters) and horizontally or vertically (for piston meters) in order to keep it in good quality and enhance its durability. A household connection including the meter is installed at the following places:
  - At every individual household dwelling
  - At community points or water kiosks
- The existing water meters are checked for accuracy/ functionality by a meter testing equipment stationed at the water treatment plant.
- If the a meters is found to be faulty, it is repaired or replaced

2.1.6 Isolation of Sub-Block

To grasp the existing NRW volume in sub-block by Minimum Night Flow (MNF) measurement work after confirming complete isolation of pilot project area.

To knowing accuracy distribution and consumption volume in sub-block, zoning work is important. Considerable works for zoning one sub-section from another sub-block are installation gate valve and replace of pipe.

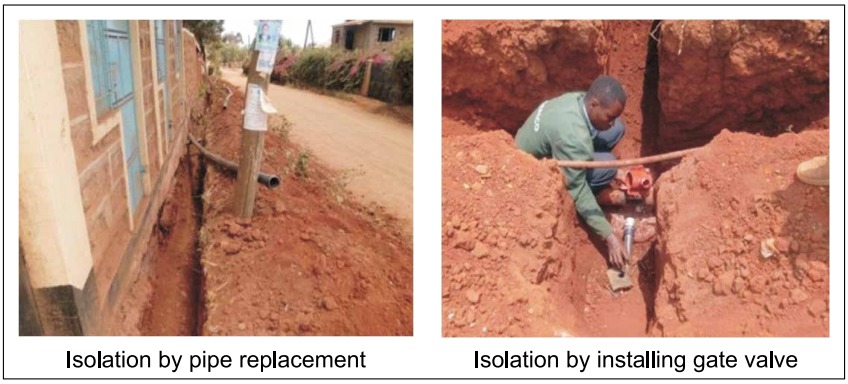


Photo 2.5: Isolation Work

2.2 Implementation of NRW Reduction Activities in Pilot Project

Contents of Activities

The strategies adopted by EWASCO in the implementation of NRW are as follows.

(1) Replacement of water meter in project area (2.2.1)
(2) Collect data and analysis of water balance (2.2.2)
(3) Detection of illegal connection (2.2.3)
(4) Detection of leakage (2.2.4)
(5) Repair of leakage (2.2.5)
(6) Water Pressure management (2.2.6)
(7) Replacement of distribution pipes and service pipes
(8) Specified qualification test (2.2.7)

After each activity, it is important to compare before and after through observation of quantity of flow-meter. The explanations of the above are the follows;

2.2.1 Replacement of Water Meter in Project Area

EWASCO had replacement water meter such as old or broken. The old and broken meter will take inaccuracy data of consumption volume of each residence.

Photo 2.4: Replacement of Customer Water Meters

2.2.2 Collect Data and Analysis of Water Balance

To Reducing Non-revenue water, we need to know accuracy water volume of distribution. EWASCO built balk meter and valve chamber at the entrance of sub-block. After build chamber and bulk meter installed, they can read each meter in chamber and they can do monitoring volume of water that flow into sub-block individually with bulk meter

Photo 2.5: Measurement of water volume at bulk meter

1) Direct Measurement

Set the measuring block with 3 to 5 kilometers of distribution pipes, close all peripheral valves of the block completely, followed by shutting all the customer valves completely, then, measure the flow rate into the block at the one point. The work is usually carried out during midnight to avoid inconvenience of customers. This method can measure the existing leakage volume in the block rather precisely but it may include losses by water theft, and takes a lot of time and needs much manpower. For these reasons, this method is unpopular nowadays.

Photo 2.6: Close all peripheral valves of the block and all the customer valves completely

Photo 2.7: Measure the flow rate into the block

2) Minimum Night Flow Measurement

EWASCO measured minimum night flow (MNF) volume by using ultra-sonic flow meter. Ultra-sonic flow meter is portable, so it can collect data on purpose. MNF is one of the indicators of leakage volume in sub-section called DMA (District)

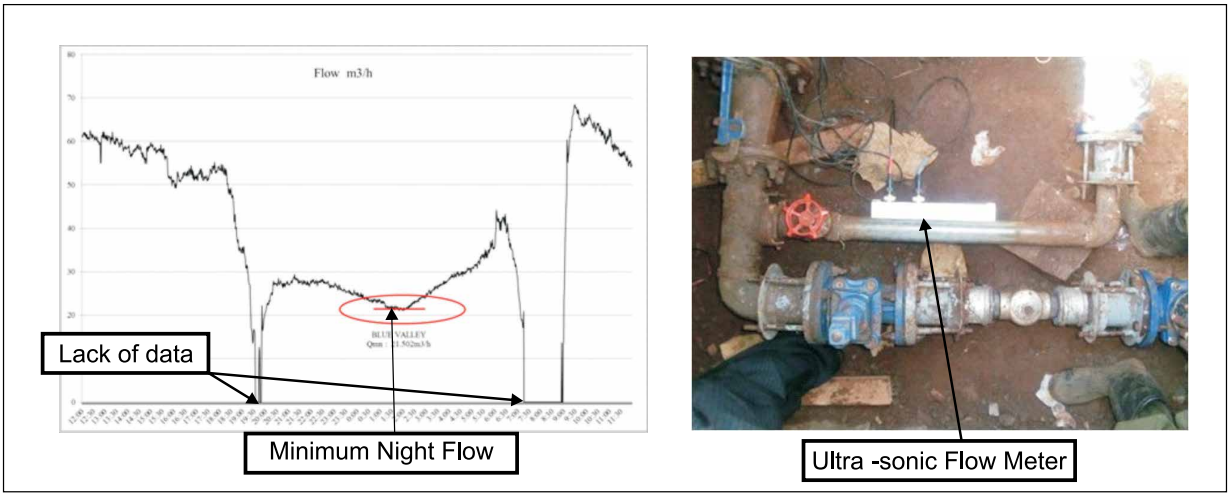


Figure 2.2 Data of daily transition of volume to sub-section

2.2.3 Detection for illegal connections

EWASCO carried out patrol work for detecting of illegal connection and defective meter by sounding and door-to-door checkout. After finding water-theft losses and metering error losses, they stopped valve and correct illegal connections and replacement defective customer meters.



Photo 2.9: Detection of Illegal Connections

2.2.4 Detection of Leakage

The methods adopted by EWASCO in the detection of leakage are as follows.

1) Leak Detection with Listening Stick
2) Leak Detection with Electronic Leak Detector
3) Direct measure of Leakage Volume
4) Mapping of Leakage point

1) Leak Detection with Listening Stick

EWASCO also tried definition of leakage location by using listening stick. Listening Sticks have been used for a long time to simply detect leaks and the origin of the electronic leak detectors which are widely used at present.

Its mechanism is very simple and consists of steel rod and a small circular vibration plate which is connected to the end of the bar at a right angle. It is a kind of stethoscope without an electronic amplifier.

Photo 2.10:
Listening Stick

Photo 2.11:
Leak detection using
Listening Stick

Photo 2.12:
Leak detection using
Listening Stick

2) Leak Detection with Electronic Leak Detector

EWASCO also tried definition of leakage location by using Electronic Leak Detector. An electronic leak detector consists of a main unit, a pickup, a head phone and a remote control unit.

Photo 2.13:
Electronic leak detector

Photo 2.14:
Leak detection using
Electronic leak detector

Photo 2.15:
Leak detection using
Electronic leak detector

The result of leakage detection work in pilot project area is shown below diagram.

		Number of Leakage	Number of Leakage/km
1	Distribution Pipe	3	0.16
2	Service Pipe	19	1.05
3	Leak from Individual Gate Valve	52	2.80
4	Leak from Domestic Meter	24	1.30
	Total	98	5.41

(Blue Valley Area: EWASCO 2012)

3) Direct measure of Leakage volume

It is important to measure volume of leakage water at detected point as showed by Photo 2.16.

Photo 2.16: Direct measure of Leakage Volume

4) Mapping of Leakage location

EWASCO compiled Leakage map to make easy their pipeline management after leakage survey. Figure 2.3 shows map of leakage in pilot project area. This map helps them to make strategies to improve their facilities by replace pipe or controlling pressure.

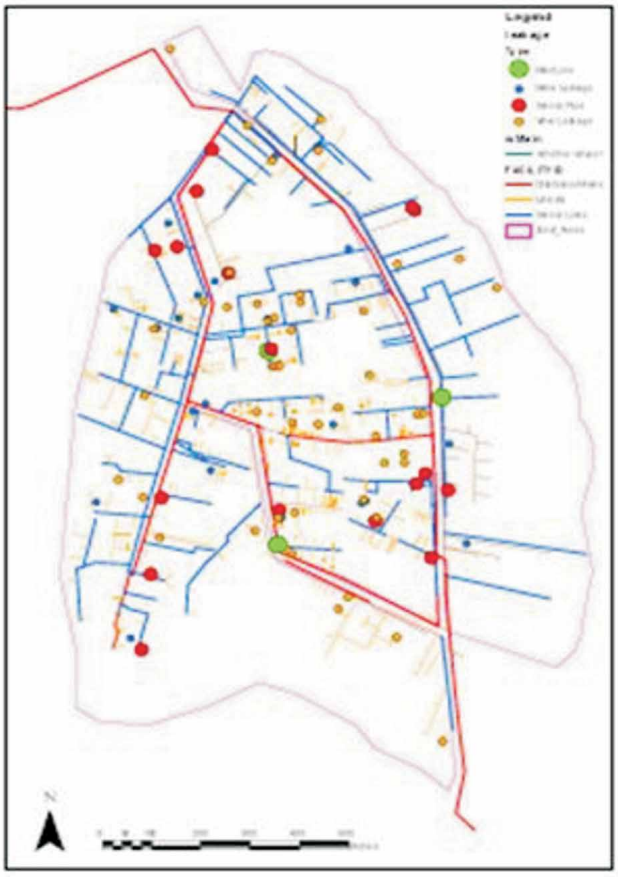


Figure 2.3 Map of Leakage by survey in Pilot project

2.2.5 Repair of Leakage

After detected location of Leakage, EWASCO repaired leakage by replacing broken pipe and change old and invalid customer meters.

Photo 2.17: Leak Repair and Replacement

2.2.6 Water Pressure Management

EMBU water distribution method can be categorized into gravity flow. But Embu has the large topographic variation and hard to control water pressure. Therefore, much leakage and burst can be seen from pipes. EWASCO start to know pressure status and manage appropriately to reduce leakage and burst using method as follow.

1) Measurement of Water Pressure in Distribution System
2) Water Pressure Mapping
3) Installing Pressure Reducing Valve (PRV)

1) Measurement of Water Pressure in Distribution System

EWASCO started their management of water pressure from measuring water in the pilot project area. They measured pressure by handy pressure gage and made a graph shown as Photo 2.18.
Water pressure can be measured daily, periodically or randomly.

Photo 2.18: Water Pressure Measurement

Daily measurement should measure daily water pressure at the focal point in the distribution main storage tank and pumping station. This will indicate whether the water pressure in the distribution area is being maintained at the correct range.

As water pressure varies with water demand, periodic measurement is taken at the pipe branching to survey variations in water pressure by volume of water demand, day/night, seasonal of yearly changes. It is important to understand the relationship between volume of water demand and water pressure. Random measurements are used to measure water pressure that is localized or as supplement to the daily and periodic measurements.

2) Water Pressure Mapping

As shown in Figure 2.4, the measured water pressure is indicated by area onto the map. This allows easy and quick understanding of the status of water pressure.

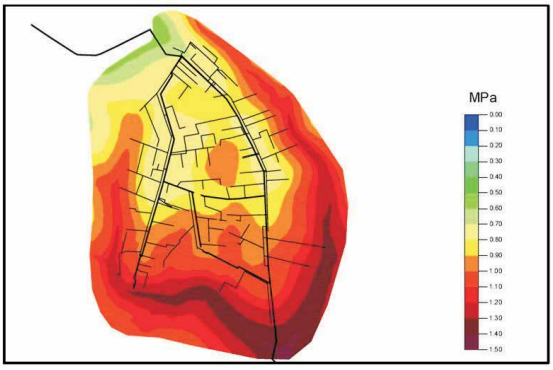


Figure 2.4: Distribution map of water pressure (Pilot area)

3) Installing Pressure Reducing Valve (PRV)

After understanding status of water pressure, EWASCO planed installing of Pressure Reducing Valve(PRV). They start to control pressure to 0.10 MPA by small PRV and measured pressure and water volume continuously; they tried to adjust appropriate pressure for each sub-zone of pilot project area. Small PRV has advantage cheap and affordable and easy to use small diameter pipes.

Photo 2.19:
Pressure Reducing Valve (PRV) small type

Photo 2.20:
Installed PRV

Photo 2.21:
PRV, testing pressure

High pressure cause burst and leakage, low pressure makes inconvenience such as luck of water to customer. They controlled pressure at the PRV and monitored water volume paying attention to customer complaints.

After finding the suitable pressure is 0.15MPA to the sub-zone, EWASCO installed 150mm large Auto PRV that can adjust pressure automatically. Large PRV has advantage to keep regular pressure during day and night (Small type PRV could not control high pressure at the night).

Photo 2.22: Installation of Auto PRV (large type)

Pressure reduction using PRV, the pressure map was changed like as Figure 2.5. The number of burst was reduced, as shown in Table 2.1 under controlled pressure without increasing the number of complaints that there is no water.

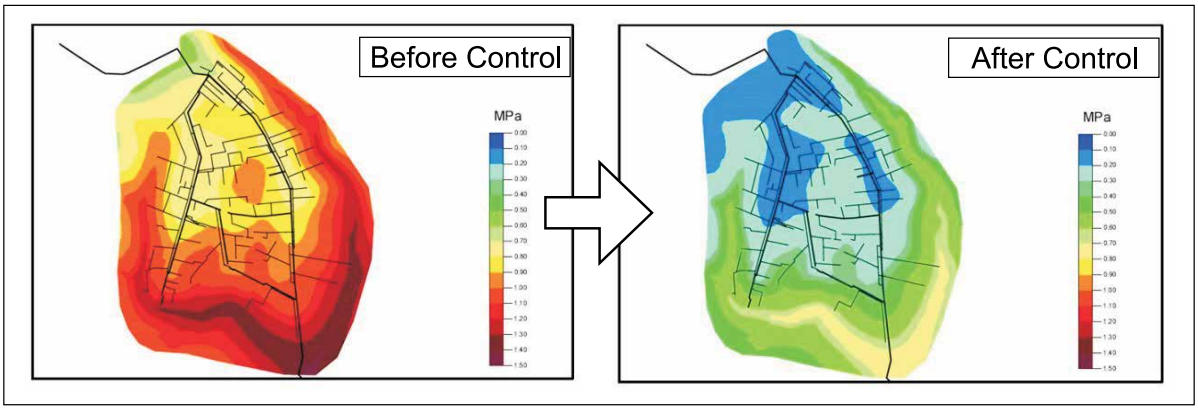


Figure 2.5: Distribution map of water pressure (pilot area)

Table 2.1 Condition before and after change in the Number of Burst and No Water in Pilot Area

	Bursts				No Water			
	April	May	June		April	May	June
2010	41	14	32	2010	26	18	16
2011	11	4	2	2011	11	13	17

2.2.7 Replacement of distribution and service pipe

EWASCO replaced old service pipes to new one in pilot project area as Non-revenue water reduction management. It helps to reduce leakage volume of water, and lead to reduce NRW ratio. Table 2.2 shows the result of replacement length of service pipes at three sub-blocks in pilot project area.

Table 2.2 Result of pipe replacement in Pilot project area (EWASCO)

Name of sub-block	**Area 5**		**Area 31**		**Area 32**		**All**	
Diameter (mm)	Number of replaced lines	Length (m)	Number of replaced lines	Length (m)	Number of replaced lines	Length (m)	Number of replaced lines	Length (m)
20	10	1027.2	8	1206.1	4	294.25	22	2549.5
25	2	284.3	2	341.6	6	854.3	10	1490.3
32	4	385.7	9	229.0	------	------	13	627.7
42	------	------	1	384.8	------	------	1	385.8
63	1	122.3	------	------	------	------	1	123.3
Total	17	1819.5	20	2161.5	10	1148.6	47	5176.6

2.2.8 Specified Qualification Test (Meter Test)

To create domestic water meter management plan, EWASCO tested old and invalid water meter by using test equipment of NYEWASCO(NYERI). Photo 2.23 shows the test equipment. Meter was removed from pilot area. There was chosen by high count of volume or seem to be broken old.

Photo 2.23: Meter Test

EWASCO is now trying to set standards for the management of domestic meter from the opinion shows as below.

1) How long is the domestic water meter changing cycle?
2) What type of domestic meter is better to measurement?
3) Between of class-B and class-C which one is appropriate?

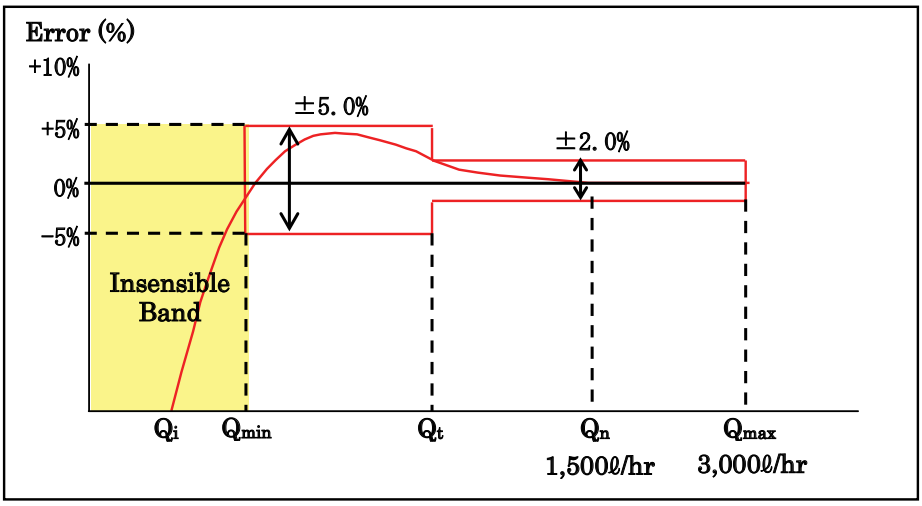


Figure 2.6 Appropriate Area of domestic water meter accuracy

EWASCO took data in this test show as below.

Data 1: Relative error by age
Data 2: Relation between relative error and water consumption
Data 3: Influence caused by high pressure
Data 4: Durability of meter by Class, Type, Age and manufacture

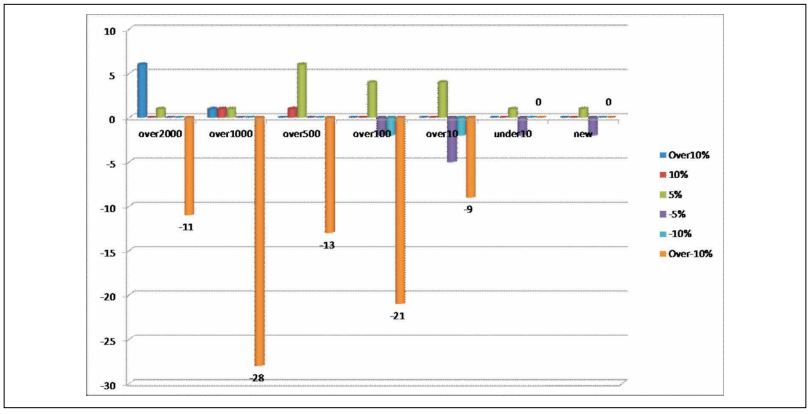


Figure 2.7 Test Result of Domestic Water Meter (Q: 15 liters/1 hour)

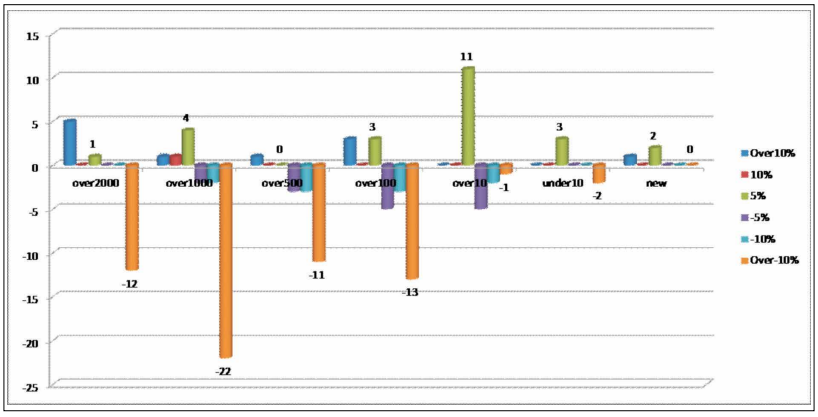


Figure 2.8 Test Result of Domestic Water Meter (Q: 22.5 liters/1 hour)

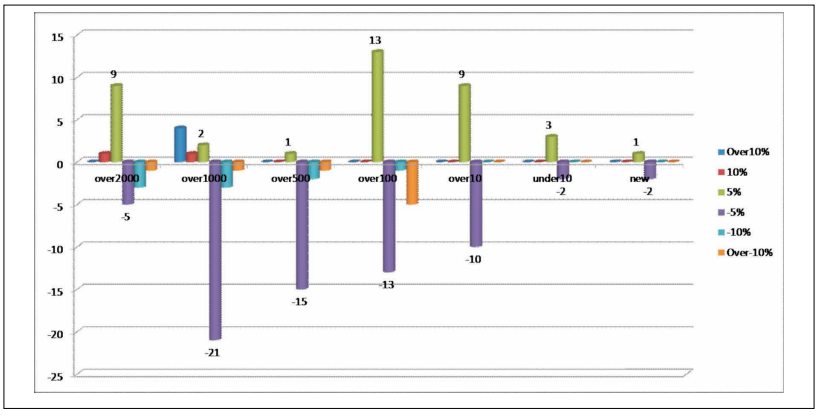


Figure 2.9 Test Result of Domestic Water Meter (Q: 950~1500 liters/1 hour)

To seeing this result (Figure 2.7 - 2.9), we can find that there is low counting appeared from over 100 m^3 meter counting in any type of volume and 1,000 counted meters have more over 20% error in there counting. So we should consider about changing meter to avoid missing to charge water tariff after counting 1,000m^3. About another standard of classification of meter changing, EWASCO is thinking and testing.

2.2.9 Pipeline Connecting and Water Tight Test

The Kenya Standard of pipes is not yet regularized. Under such circumstances, EWASCO is utilizing various flexible joints for pipes such as inches or meters. Photo 2.24 shows importance of measuring size before installing. Photo 2.25 is a sample of socket which connecting pipes.

Photo 2.24: Measuring pipe diameter

Photo 2.25: Socket of pipe connecting

To check of water tightness after repair or installing new pipes, EWASCO started to use hand pump shown by photo 2.26. EWASCO also try testing with model include some type of joint (PVC, steal, and etc). Photo 2.27 shows test with pipes and hand pump. In that's test, they learned where is the week point on the service line and consider what type of coupling is the best for it.

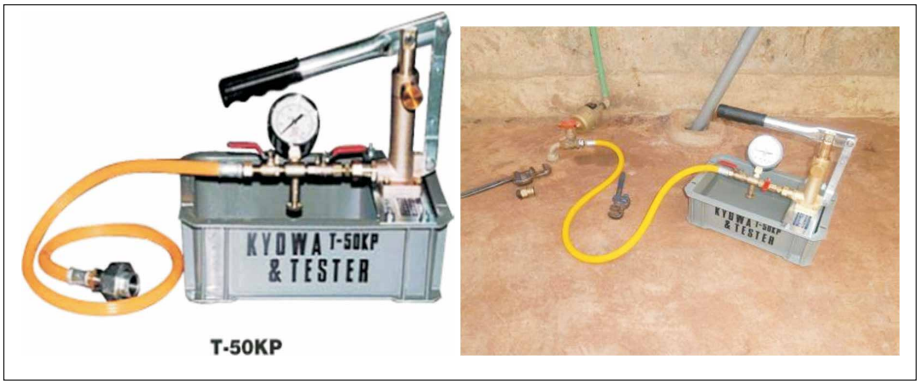


Photo 2.26: Hand pump for pressure test

Photo 2.27: Water pressure test on service line model

3
Output of Pilot Project

3.1 Reduction of NRW of Pilot Project

Through doing various activities, EWASCO get good result that NRW ratio come down from 68% to lowest 13%. Figure 3.1 shows a process of change from November 2010 to March 2013.

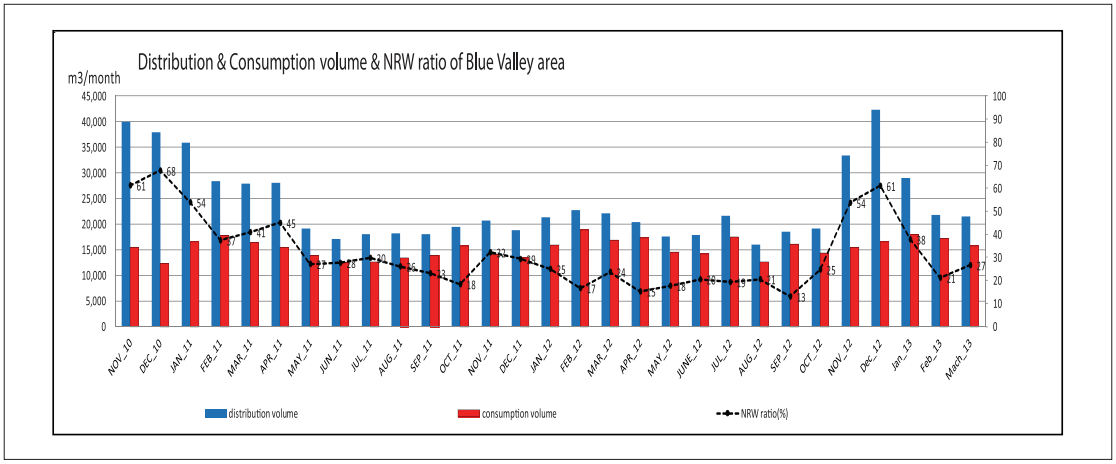


Figure 3.1 Distribution & Consumption Volume & NRW ratio of Blue Valley Area

On November 2012, December 2012, EWASCO had high distribution volume. It makes to result in high NRW ratio. The Blue Valley Auto PRV had failed at some point for a few days and due to poor monitoring at that particular moment and lack of knowledge that the PRV had broken down, a lot bursts were experienced downstream leading to an out of hand NRW ration figure as noted in that months. After controlling of water pressure from January 2013, they recovered low distribution volume and NRW ratio. This situation shows that most important work of this area to keep in law status of NRW ratio is the “controlling of water pressure”.

3.2 Ongoing work

EWASCO are continuing activity to reduce NRW ratio. They continue monitoring and analyzing of Blue Valley pilot area. And they try to reduce NRW ratio in other area from pilot project area with some opinion shown as below.

(1) Use of Meter Test Bench
(2) NRW Training
(3) Practice in Dallas area
(4) Management by GIS
(5) Updating of Mapping

(1) Use of Meter Test Bench

Since the meter test bench has been set up in EWASCO, a number of trainings have been conducted on its use and its full application implemented. They can now be tested consumer meters to ascertain its accuracy. If an error is noted in the meter functionality, appropriate action is carried out. This has increased in the accuracy of the meter readings.

(2) NRW Training

EWASCO were carried out two trainings to the plumbers and one to the management. This has seen an improvement in the handling of the NRW issues. There also came up an issue of targets setting where persons responsible for certain area set their own targets, forward to their supervisors and endeavor to achieve those targets within the given time frame. A score board will be set to fill the monthly NRW for all areas to show who is in the hall of fame and who is in the hall of shame.

(3) Practice in Dallas area

EWASCO start their new NRW activity in Dallas area next to former pilot project Blue Valley area. Figure 3.2 shows the Distribution & Consumption volume & NRW ratio of Dallas area. NRW reducing is not appear yet, but monitoring of distribution and consumption water volume leads to find effective method in this area. They are now planning pressure control by installing new PRV to most suitable location after analysis of this monitoring.

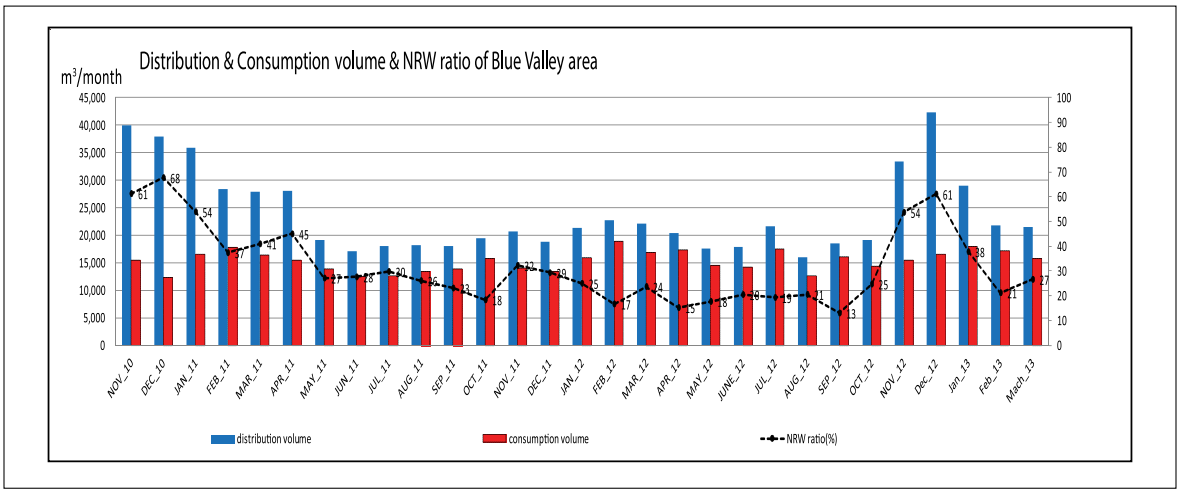


Figure 3.2 Distribution & Consumption Volume & NRW ratio of Dallas Area

(4) Management by GIS

And also, EWASCO start to management their Operation and Maintenance with Geographical Information System (GIS). Figure 3.3, 3.4 and 3.5 are some examples of these data.

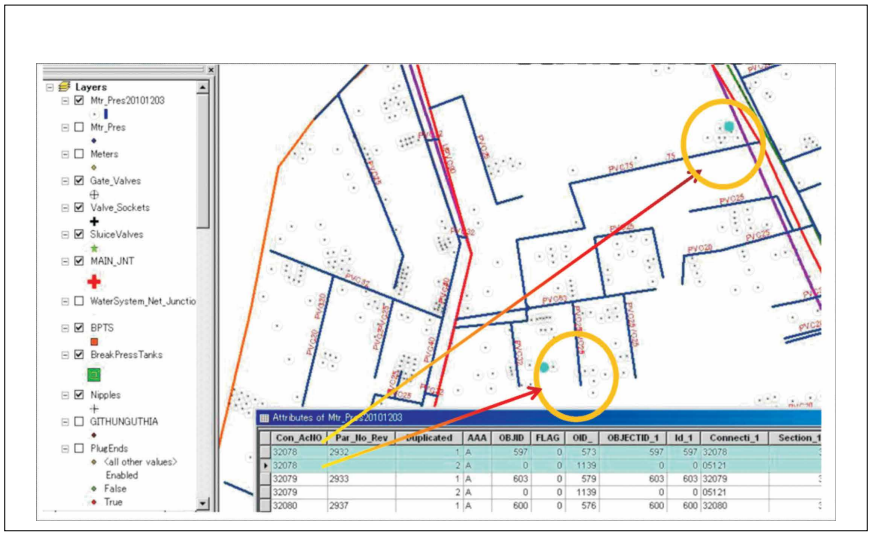
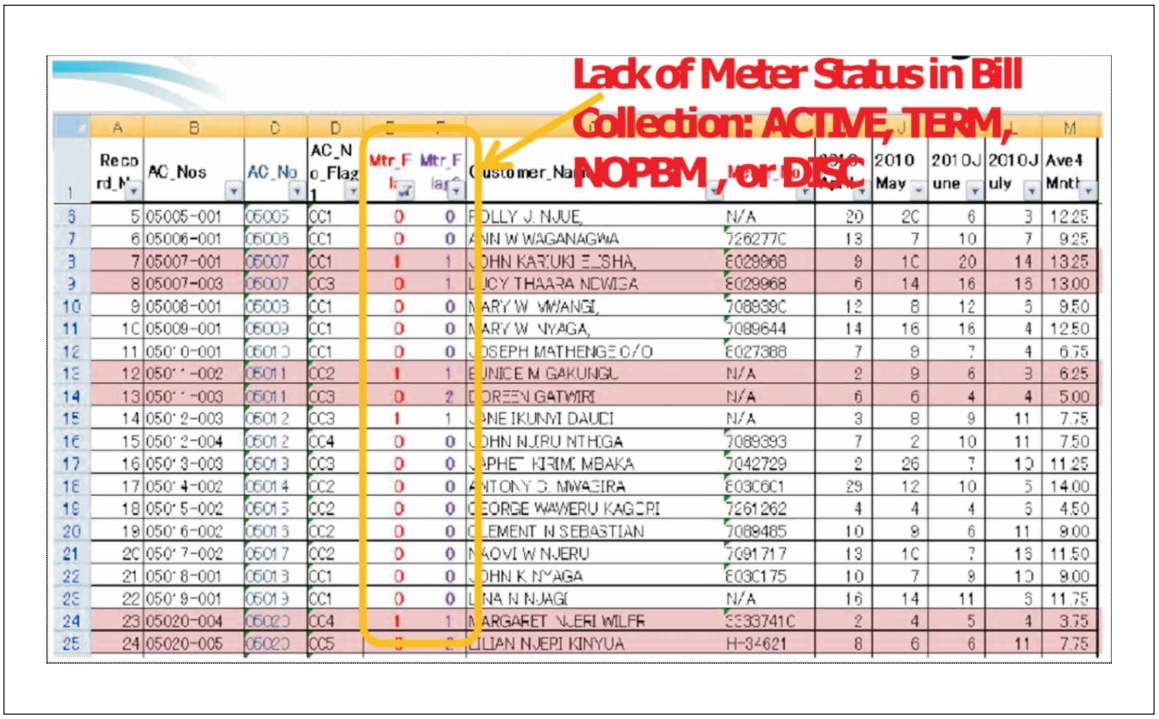


Figure 3.3 Service meter location map on GIS (EWASCO)



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Reco rd_N	AC_Nos	AC_No	AC_N o_Flag 1	Mtr_F la	Mtr_F lag	Customer_Na	Ma	2010 Apr	2010 May	2010 une	2010J uly	Ave4 Mnth
6	5	05005-001	05005	CC1	0	0	OLLY J. NJUE,	N/A	20	2C	6	3	12.25
7	6	05006-001	05006	CC1	0	0	ANN W WAGANAGWA	726277C	13	7	10	7	9.25
8	7	05007-001	05007	CC1	1	1	OHN KARUKI ELISHA,	E029868	9	1C	20	14	13.25
9	8	05007-003	05007	CC3	0	1	UCY THAARA NDWIGA	E029968	6	14	16	16	13.00
10	9	05008-001	05008	CC1	0	0	ARY W WANGI,	708839C	12	8	12	5	9.50
11	1C	05009-001	05009	CC1	0	0	ARY W NYAGA,	7089644	14	16	16	4	12.50
12	11	050' 0-001	05010	CC1	0	0	OSEPH MATHENGE C/O	E027388	7	9	7	4	6.75
13	12	050' '-002	05011	CC2	1	1	UNICE M GAKUNGU	N/A	2	9	6	3	6.25
14	13	050' '-003	05011	CC3	0	2	OREEN GATWIRI	N/A	6	6	4	4	5.00
15	14	050' 2-003	05012	CC3	1	1	NE IKUNYI DAUCI	N/A	3	8	9	11	7.75
16	15	050' 2-004	05012	CC4	0	0	OHN NJIRU NTHIGA	7089393	7	2	10	11	7.50
17	16	050' 3-003	05013	CC3	0	0	APHET KIRIMI MBAKA	7042729	2	26	7	1C	11.25
18	17	050' 4-002	05014	CC2	0	0	NTONY G. MWAGIRA	E03C6C1	29	12	10	5	14.00
19	18	050' 5-002	05015	CC2	0	0	EORGE WAWERU KAGCRI	7261262	4	4	4	5	4.50
20	19	050' 6-002	05016	CC2	0	0	LEMENT N SEBASTIAN	7088485	1C	9	6	11	9.00
21	2C	050' 7-002	05017	CC2	0	0	AOVI W NJERU	7091717	13	1C	7	13	11.50
22	21	050' 8-001	05018	CC1	0	0	OHN K NYAGA	E03C175	1C	7	9	1C	9.00
23	22	050' 9-001	05019	CC1	0	0	UNA N NJAGI	N/A	16	14	11	8	11.75
24	23	05020-004	05020	CC4	1	1	ARGARET WERI WILFR	E333741C	2	4	5	4	3.75
25	24	05020-005	05020	CC5	0	0	ILIAN NJERI KINYUA	H-34621	8	6	6	11	7.75

Figure 3.4 Meter status database on GIS (EWASCO)

Figure 3.5 Leak survey map on GIS (EWASCO)

(5) Updating of Mapping

Thing is that it must not use GIS, it is important to update and record these data when it changed status if your WSP use paper. GIS help this work easier and will look fun and beautiful.

EWASCO also try to updating service pipe information by checking as each residential built. They check status of service pipe with application form, and make offset map with by hand show as Figure 3.6. It will attach in GIS database.

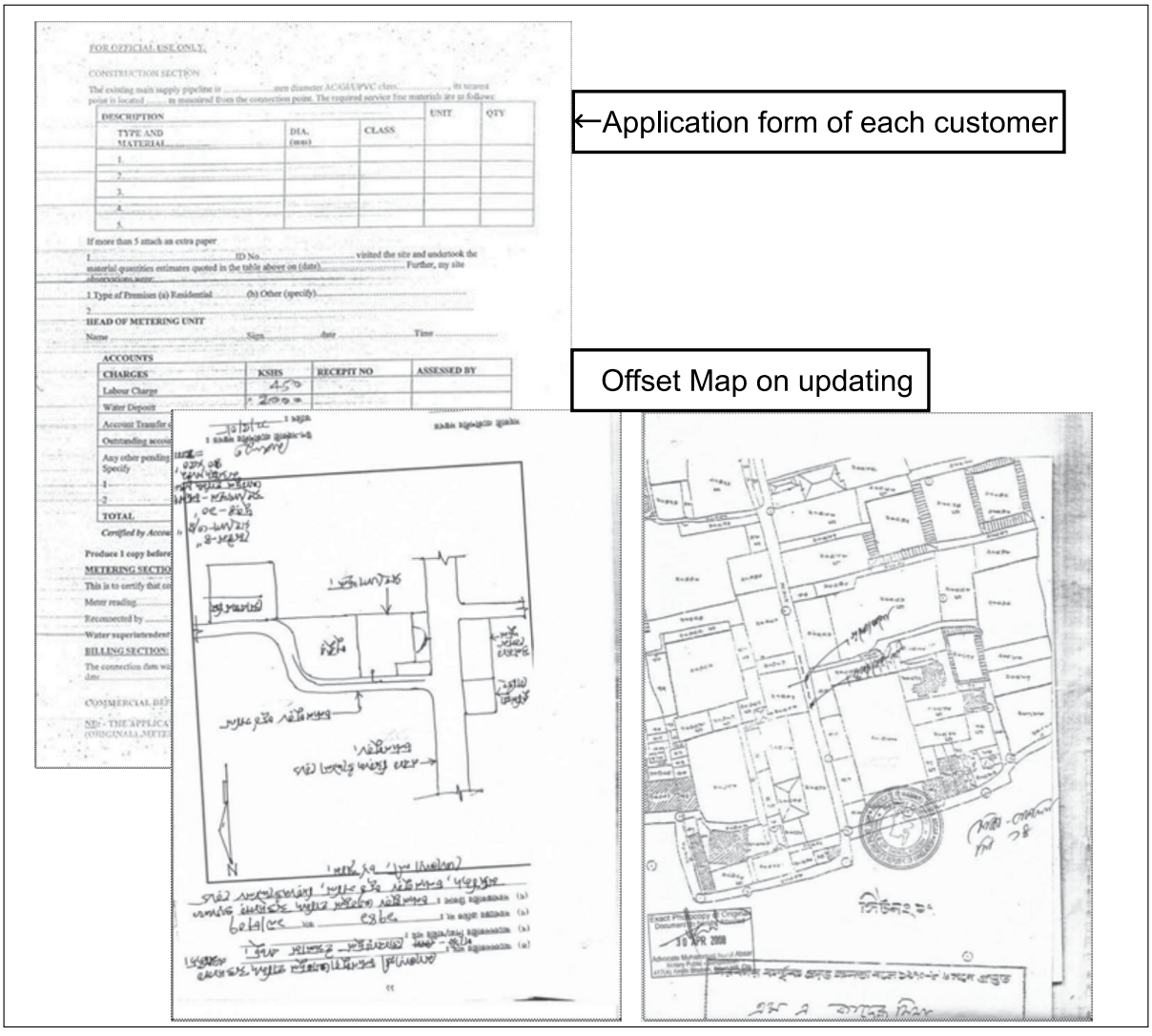


Figure 3.6 Service Pipe information is updating with check.

Part 3

Case Study
NARWASCO

Location of Narok

Narok is located in the southern part of the Rift Valley in the South western part of Kenya 144km from Nairobi and 136km to Maasai Mara Game reserve. Narok town is the headquarters of Narok County. The elevation of Narok is 1827m in Altitude and it lies between latitude 0°50' and 2°05' South and Longitudes 35°58' and 36°05' East and Topographically, Narok is relatively flat and receives an average rainfall of 1200mm to 1800mm annually. The main economic activity is tourism and wheat farming. Narok wsp is under Rift valley water services Board.

1
Outline of NAROK WSP

1.1 Basic Information

Basic information must be gathered as a precondition to implementing any NRW reduction activities. Basic Information consists of, the total population of the town, total area served with water, population density, population served with water, rate of water distribution, number of customers etc. In the case of Narok, the total population is 36,978 and the population served with water is 36,079. The diffusion ratio is 97.57%. For continued improvements and/or expansion in the future, it is necessary to accurately understand the population demography.

Population in Whole Town Data	
	As of 2009
Population in Whole Town	36,978
Population served with water	36,079
Diffusion Ratio (%)	97.57

Table 1.1 Population Data of NAROK Town

In terms of management, it is necessary next to understand the entire water facilities of the area. It would be preferable to understand the volume of water that passes through each facility. In order to have a management system that controls distribution network by water volume, it is necessary to have in place a "distribution pipe network" diagram (map) that shows the location of each water facility. Location of all facilities must be indicated on the diagram (map); location of water intake, transmission pipes, treatment plant, area of water distribution, service tank, customer meters, distribution pipes, pressure reducing chamber, pressure reducing valves, gate valves.

Next, it is necessary to locate the flow meter within the distribution network. Management will be more accurate with more flow meters installed. In cases where flow meters have not been installed, it is preferable to install a flow meter in the upstream such as at the water exit point of the treatment plant or at the water exit point of service tank. By establishing these, an effective management system will be possible.

Table 1.2 shows the volume of treated water that Narok WSP is able to produce against its current volume of treated water distributed. Table 1.3 shows the volume of distributed water to Narok Town between July 2011 and August 2012. It is possible for Narok WSP to have data shown in Table 1.2 and 1.3 as a result of a flow meter that is installed at the exit point of the treatment plant (Photo 1.1). A precondition for better operational control is the appropriate location of the installation of the flow meter.

Table 1.2 Water Production Volume (m3)

Full Operation	2,400m^3 per day
Actual Operation	2,066m^3 per day (Average)-(86%)

Photo 1.1 Water Treatment Plant

Photo 1.2 Pump

Table 1.2 Volume of Distribution Water in Whole Town

Month-Year	Production Volume(m3/day)
07-2011	52,878
08-2011	65,510
09-2011	51,641
10-2011	57,463
11-2011	66,525
12-2011	48,700
01-2012	65,229
02-2012	37,528
03-2012	75,554
04-2012	68,410
05-2012	51,981
06-2012	45,168
07-2012	56,102
08-2012	62,246

Next, it is necessary to have a distribution network diagram (map). Figure 1.1 shows an example of Narok WSP distribution network diagram (map).

In Narok Town, Water is abstracted from River Enkare Narok which runs through the town from south to North and a treatment plant is located adjacent to this. Treated water is distributed to seven (7) service tanks in town through the main distribution pipe. Each service tank provides treated water to nearby locations. The Pilot Project was implemented in the Majengo area, which is located in the eastern part of Narok Town. Treated water in this area is distributed from the service tank located in the north and distributed through distribution pipes that stretch to the western part of the town. As shown in Figure 1.1 the currently existing water pipeline network diagram is a hand-drawn diagram. This diagram was drawn during this Pilot Project and will be useful at the time of installing new flow meters or planning for future expansion. It is preferable that this diagram is digitized in the future.

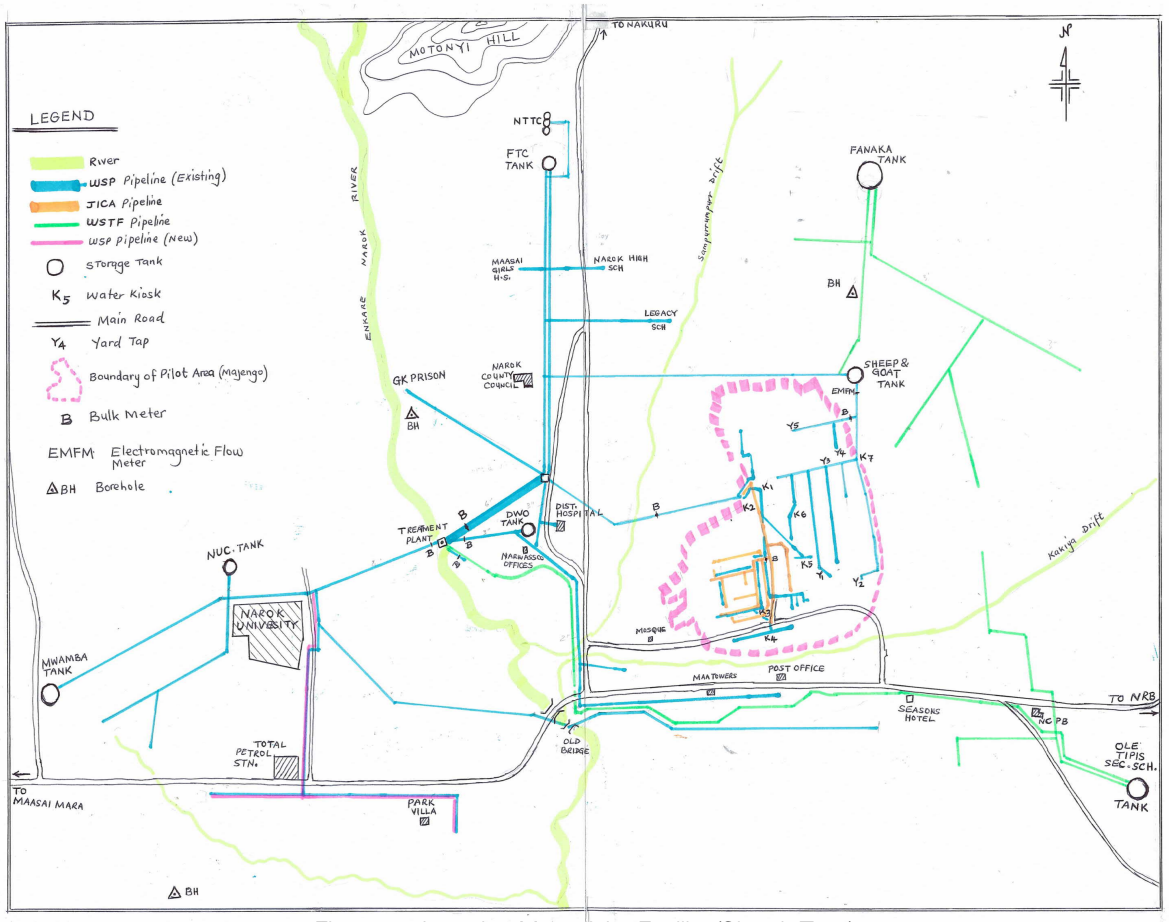


Figure 1.1 Location Map of the Facility (Sketch Type)

1.2 Selection of Pilot Project Area

It is important for the service provider to fully understand the current status of its service in order to ensure appropriate operational management. A small area within the total distribution area was selected as the Pilot Project site with the purpose of focusing on a small section of the total distribution area to conduct various experiments and measurements more efficiently and effectively. This selected section is referred to as the Pilot Project area. Results obtained through various experiments and measurements will be analyzed to produce the most suitable and effective methods that will be applicable eventually to the whole of the distribution area.

Criteria for selecting the Pilot Project area is

1. The selected area must be able to be completely isolated from other areas
2. Volume of inflow water must be measurable
3. Volume of used water must be measurable
4. Population and number of water taps must not be too high that may pose to be a burden on the water provider staff

In Narok, Majengo area of a population of about 19,000 was selected as the Pilot Project area. In Chapter 2, the selection process and the outline of the Majengo area and the activities conducted in the Pilot Project area will be explained.

2
Preparation for the Pilot Project

2.1 Selection of Pilot Project Area

Total water distribution area can often be very large, and when various NRW reduction activities are difficult to prioritize, it is advisable to select a Pilot Project area as it has been explained in Section 1.
The situation in Narok was such that there was no pipeline network diagram and the water volume measurements were inaccurate. Therefore, the following five (5) components were set as objectives to the Pilot Project.

1) To prepare a pipeline network diagram (Section 2.2)
2) To conduct analysis on volume of distributed water (Section 2.3)
3) To have a more uniform distribution of water by utilizing valves (Section 2.4)
4) To improve operation (Section 2.5)
5) To implement NRW reduction methods (Section 2.6)

In order to accomplish these objectives, it was first necessary to select the Pilot Project area. The following requirements were considered in the case for the selection of the Pilot Project area for Narok WSP.

1) That the area of distribution has a mid size population of around 19,000
2) That the pipes feed into the area through two locations only
3) That there are only few pipes connecting to pipes feeding the areas outside of the Pilot Project area
4) At the point of connection, that valves have either already been installed or can be easily installed

The above requirements were confirmed by way of survey on the ground after having provisionally mapped the area on paper.

The items confirmed on the ground were, the locations for the installation of flow meters, existence and locations of pipes connecting to areas outside of Pilot Project area, type of customer meters and the actual conditions of customer meters and water kiosks. Majengo zone was selected in this manner, as the Pilot Project area (Figure 2.1 shows the selected area in bold line).

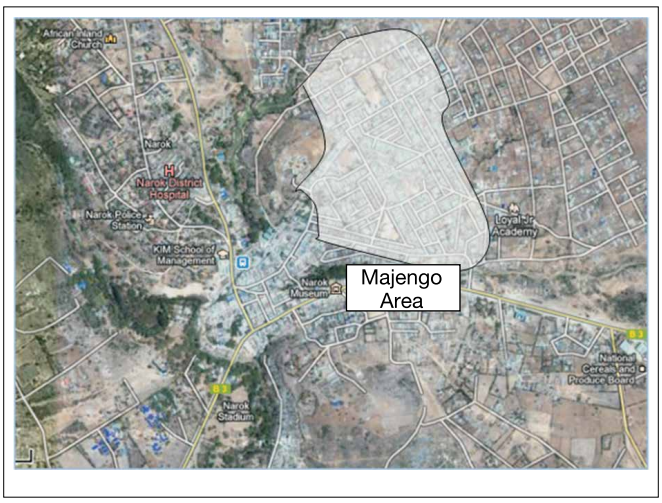


Figure 2.1 Location of Pilot Project Area ”Majengo” in NAROK Town

2.2 Outline of Majengo Area

The total number of water connections in Majengo including those metered, flat rate and those disconnected comes to approximately 500 connections. There are also seven (7) water kiosks and five (5) yard taps in the area.

Average monthly consumption of revenue water is approximately 7000 m^3, which amounts to approximately 12 liters per person per month. This is relatively low in comparison to average 50 liters consumption for an average Kenyan per month.

Table 1.3 Population & Customer Data in Majengo (Pilot Project Area in NAROK)

Population in Majengo	
	As of 2010
Population in Majengo	19,806
Population served with Water	No Data
Water coverage (%)	No Data
Customer Meter in Majengo Data	
	June-2012
Metered active	309
Flat rate	88
Cut Off (metered/flat rate)	119
Sub Total	516
KIOSK	7
YARD TAPS	5

2.3 Preparation of Distribution Pipe Map

Before any NRW reduction activities are planned, it is first necessary to fully and accurately understand the NRW ratio of the area. In order to understand the ratio, an accurate distribution map of the pipeline network is necessary. In the case of Narok, the only map that existed before the Pilot Project was a hard copy map with hand drawn pipeline network indicated. For maintenance and control it is also necessary to update pipe data. It is preferable to have information on pipes such as type of pipes, installation year, location of gate valves, air valves and pressure valves indicated on the map. It is important to update data on the map when there are changes in the data and/or information.

After the distribution pipe map has been prepared, information that is as detailed as possible was included as required (for example location of service pipes and customer meters) and as shown in Figure 2.2 (right picture) the map should be digitized by CAD and/or GIS for better control structure.

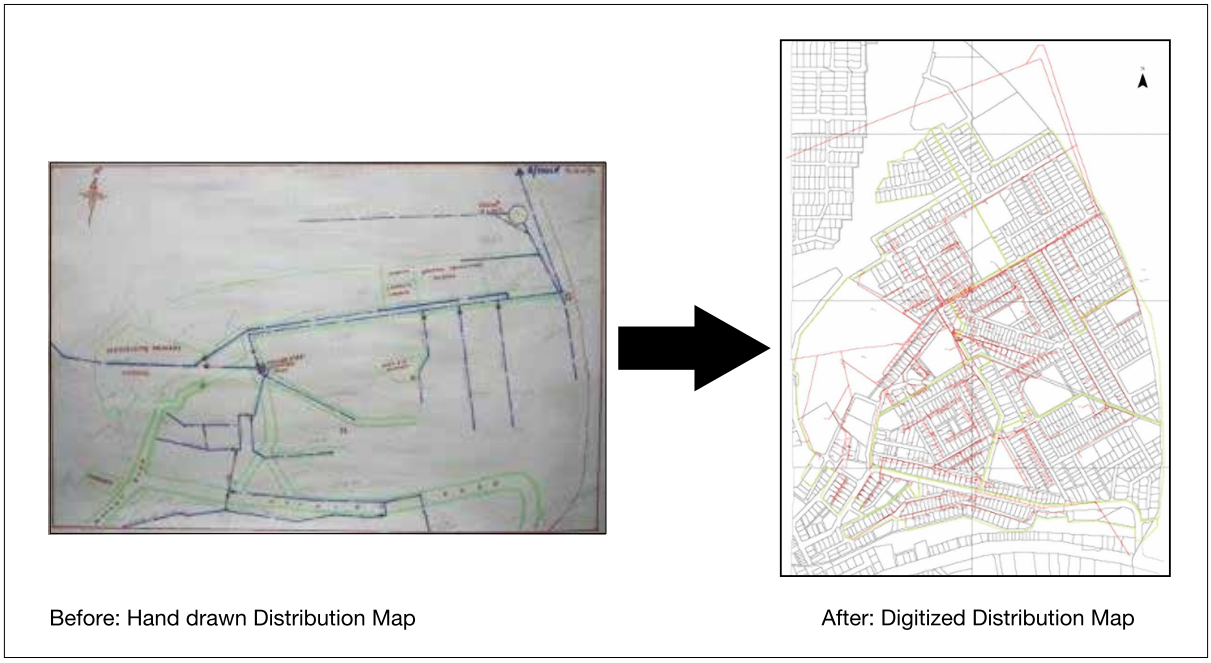


Figure 2.2 Distribution map before & after digitization (Majengo Area NAROK)

The procedure for the preparation of distribution pipe map was as follows. As shown in Photo 2.1, a meeting was first held to prepare a survey plan. The survey confirmed the location of pipes and types of pipes used and the location of gate valve was also confirmed.

Photo 2.1 Development of Distribution Map

The procedures for preparing the map in digital format were as indicated below.

(1) Preparation of hand drawn diagram based on the survey.
(2) Revising hand drawn diagram to make an accurate map
(3) Using GIS and/or CAD to make a digital format

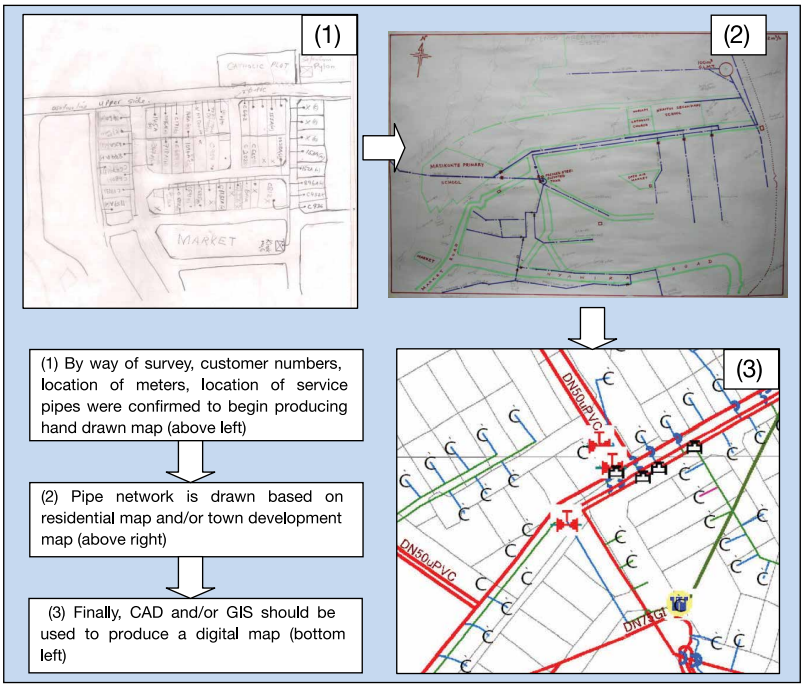
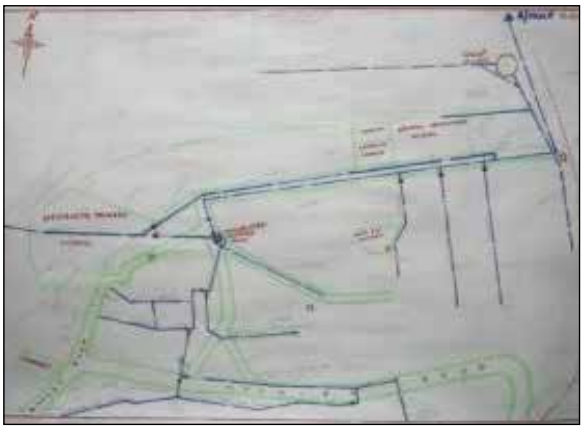


Figure 2.3 Steps to prepare digital map

2.4 Rationalisation of complex pipe network

Complex pipe networks that are commonly seen in many WSP make maintenance of water distribution very difficult. Less complex connections are preferable once water hydraulic functions are understood. Photo 2.2 shows the current complex pipe network in Narok WSP. In the future, a less complex network would be preferable.



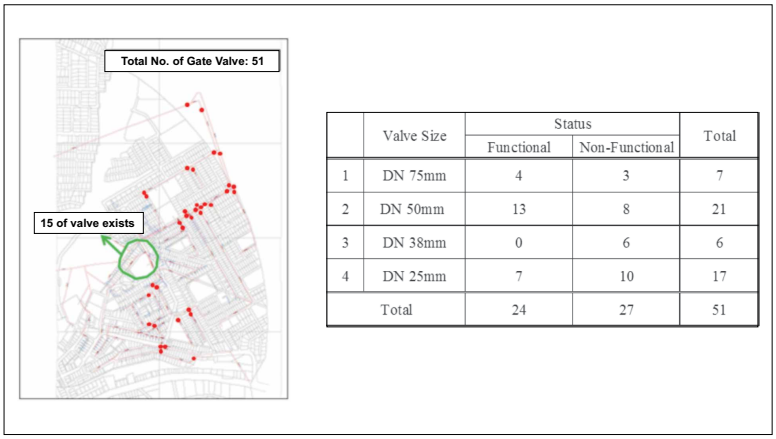
Hand drawn diagram of pipe branching details

Current status of complex pipe network

Photo 2.2 Status of complex pipe network

2.5 Confirmation of Valves for maintenance of water distribution

Before implementing any Pilot Project activities, it is necessary to confirm the locations of installed valves that will allow the Pilot Project area to be divided into smaller zones. The locations of the valves will determine whether the selected Pilot Project area is a suitable selection for obtaining measurements. It will also identify whether Leakage Monitoring Block (LMB) can be established in order to measure results. All valve locations in Majengo area in Narok were confirmed as shown in Figure 2.4 and mapped on diagram. Valves that were not functioning were replaced and new valves were installed in locations that were necessary.



	Valve Size	Status		Total
		Functional	Non-Functional	
1	DN 75mm	4	3	7
2	DN 50mm	13	8	21
3	DN 38mm	0	6	6
4	DN 25mm	7	10	17
Total		24	27	51

Figure 2.4 Location of Existing Gate Valve

Figure 2.5 Location of Replaced and Newly Installed Gate Valve

3
Reduction of Physical Loss

3.1 Installation of Bulk Meter

Prior to the implementation of Pilot Project activities, a bulk meter existed on the rising main from the treatment plant to the main tank. There were however meters that were not functioning and therefore accurate volume of distributed water could not be ascertained. Furthermore, the Pilot Project, Majengo area did not have an independent bulk meter therefore the volume of water serving Majengo area was unknown.

For the above reason, flow meters were installed in two locations at point of entry into Majengo area and two locations within Majengo area. This is shown in Figure 3.1. Currently in addition to the newly installed flow meters, one Electro Magnetic Meter and three bulk meters are operating in the area and as a result, the volume of water distributed into Majengo area can be ascertained.

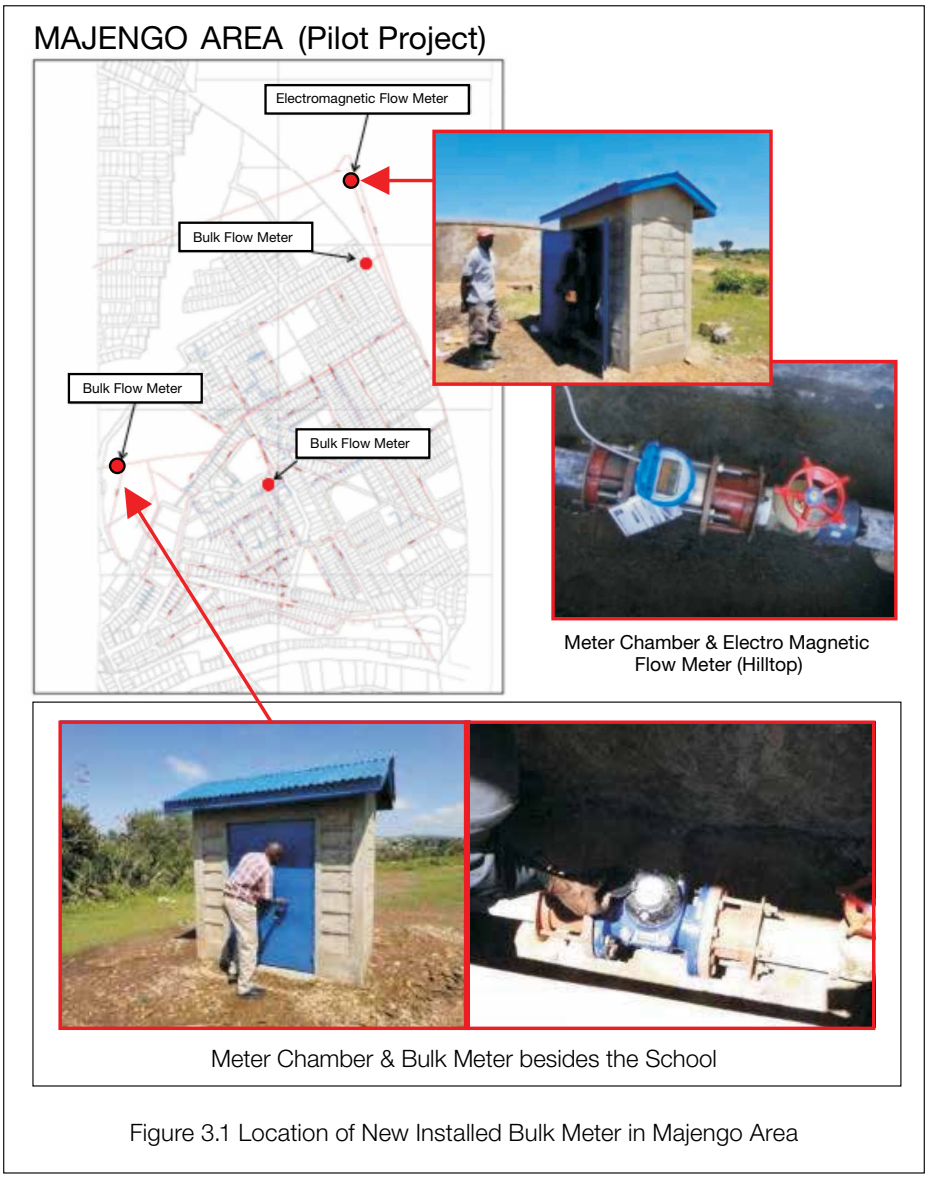


Figure 3.1 Location of New Installed Bulk Meter in Majengo Area

3.2 Analysis of volume of distributed water through LMB

Activities in the Pilot Project area included repairing of pipes and replacement of meters in order to obtain measurements of flowing water volume and understanding the results of the activities. Three areas that could be separated by gate valves were selected within Majengo area and were treated as Leakage Measurement Block (LMB). In these LMB, specifically identified activities were focused and implemented.
Figure 3.2 shows the locations of the LMB (1-3) in Majengo area and the activities that were carried out.

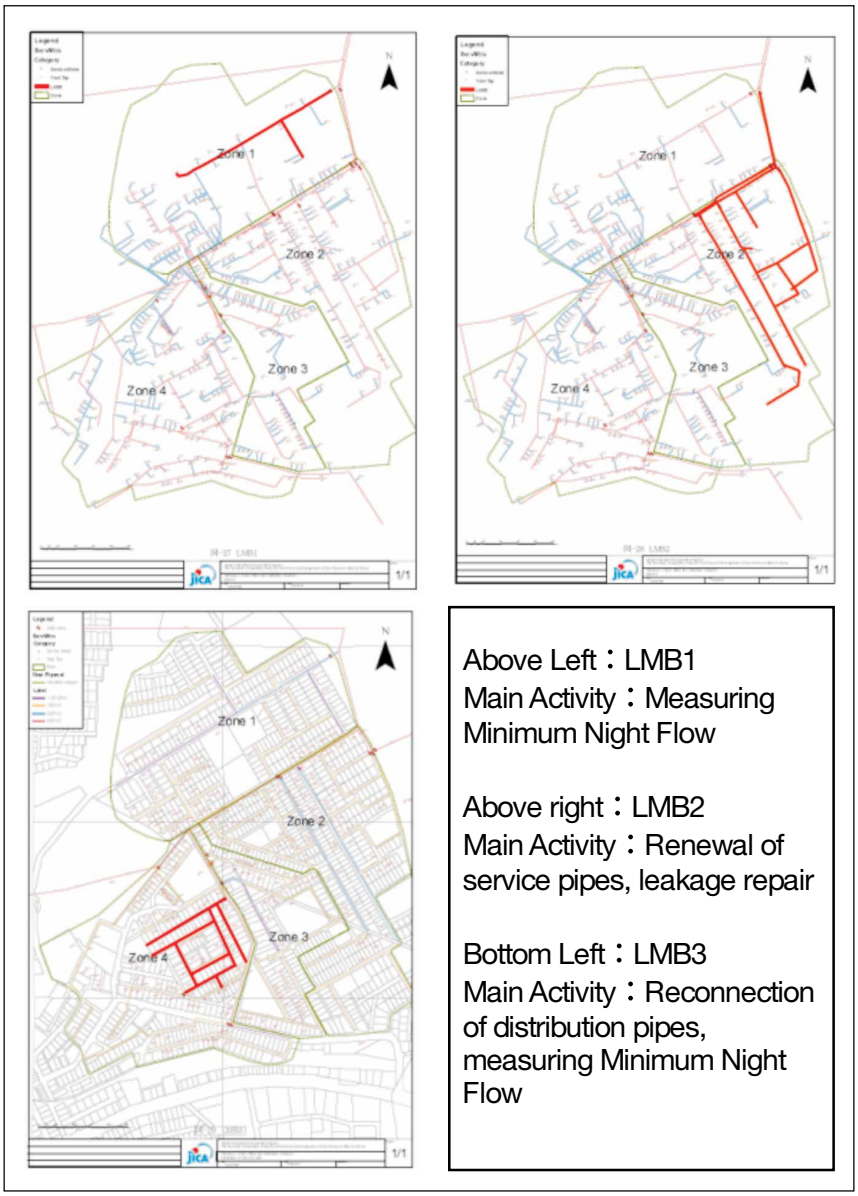


Figure 3.2 Locations of LMB and Activities

After sectioning the Pilot Project area into LMB, distribution volume analysis is conducted in each LMB. In order to compile data on used water volume of each LMB, it is necessary to ensure maintenance of Billing Data. With data on volume of water distributed and volume of water used, a graph can be prepared for entire pilot project area through after making each LMB graph and results of the activities can be monitored.

FID_	OBJECT	Serv_ID	Categori	Account	Acnt	Acnt_Zo	DigStatu	DrawStai	Descriptio	Duplicati	Status	Village	RPLACE	dd	Water_M	LMB
	0	0	Service	Me0107A	107		0	0		0	CO		1	0	Replaced M	LMB 1
	196	208	Service	Me0113A	113	A	1	1		0	CO	SILENT	0	0		LMB 3
	177	187	Service	Me0122A	122	A	1	1		0	ON	SILENT	2	0		LMB 3
	154	163	Service	Me0126A	126	A	1	1		0	ON	SILENT	0	0		LMB 3
	151	160	Service	Me0127A	127	A	1	1		0	ON	SILENT	0	0		LMB 3
	187	197	Service	Me0128A	128	A	1	1	0128A x 1	1	ON	SILENT	2	0		LMB 3
	195	207	Service	Me0129A	129	A	1	1		0	CO	SILENT	0	0		LMB 3
	250	274	Service	Me0130A	130	A	1	1		0	ON	SILENT	2	0		LMB 3
	201	214	Service	Me0131A	131	A	1	1		0	ON	SILENT	0	0		LMB 3
	192	203	Service	Me0132A	132	A	0	0		0	ON	SILENT	3	0		LMB 3
	186	196	Service	Me0134A	134	A	1	1		1	ON	SILENT	3	0		LMB 3
	189	199	Service	Me0135A	135	A	1	1		0	ON	SILENT	0	0		LMB 3
	178	188	Service	Me0136A	136	A	1	1		0	ON	SILENT	0	0		LMB 3

Figure 3.3 Data on volume of used water per LMB

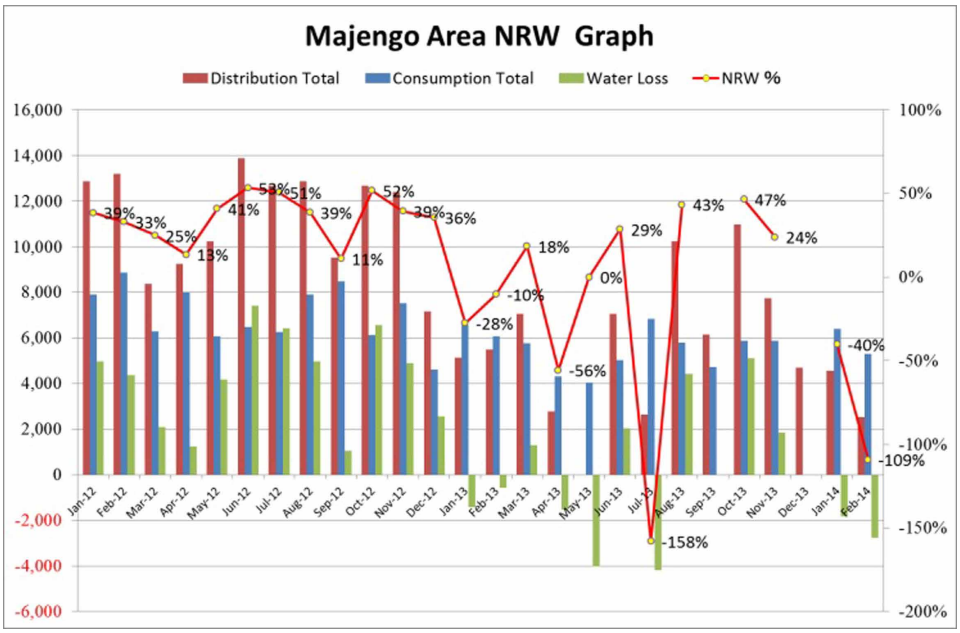


Figure 3.4 NRW of Pilot Project area

Analysis of volume of distributed water was conducted as outlined above. Although gate valves were installed, it was not possible to completely isolate the area, and as a result, the data obtained in the analysis is not accurate. In LMB3, there were several pipes that were not fully understood by the WSP therefore by way of installing gate valves could not solve the problem entirely. As measures for the future, activities must focus on rehabilitation of existing pipes, installation of new pipes and elimination of illegal connections.

3.3 Activities for Uniform Distribution of Water

It was observed during the preliminary study in Majengo area, that there were inconsistencies in water availability out of each customer tap, with some taps having chronic water shortage. Three possible reasons were given.

1) There were blockages in service pipes.
2) There was inadequate and inconsistent water supply.
3) There were scheduled rationing programs but due to inadequate/ non utilization of valves it was difficult to establish which areas were lacking water.

Inconsistencies in water flow may result from various factors such as decline in water treatment capacity, increase in water leakage, blockage in distribution/service pipes. Maintenance of valves alone cannot solve inconsistencies. It was therefore necessary to control the overall water volume.

1) Blockage in service pipes

As shown in Photo 3.1, blockages were seen in distribution pipes in Majengo area (zone) due to corrosion and/or sedimentation. As a measure to this problem, pipes were replaced experimentally in eight (8) locations shown in Figure 3.5. Results showed that there were improvements in water flow inconsistencies.

Photo 3.1 Blockages in Pipes
(left : corrosion inside metal; right : sedimentation inside pipes)

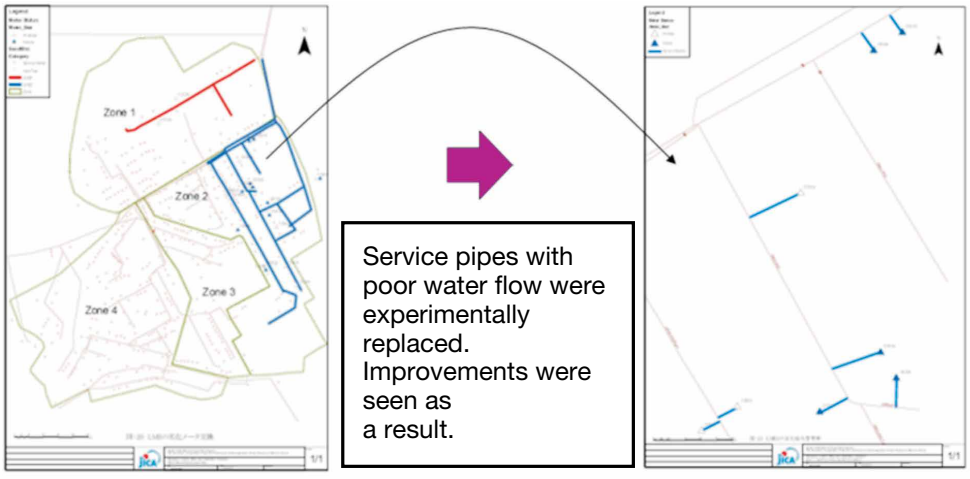


Figure 3.5 Location of Pipe Replacement

2) Measures for chronic water shortage

Due to chronic water shortage, there are regular scheduled rationing by time and area in Majengo area. Narok WSP had not fully understood the water needs of area within Majengo therefore the amount of water to be distributed to each area. The most effective measure for such situations is to fully understand the current situation.

Figure 3.6 shows the current volume of water used in Majengo area (zone). Mapping such data onto diagrams will immediately show the areas lacking water and continued mapping of more details will allow planning priority water distribution.

The most appropriate distribution schedule can be implemented based on the plan explained above. Valves play a vital role in maintenance and in cases where valves are not functioning, it is important to replace such

valves as a priority. In order to compile such data, water data must be constantly obtained for example from bulk meters.

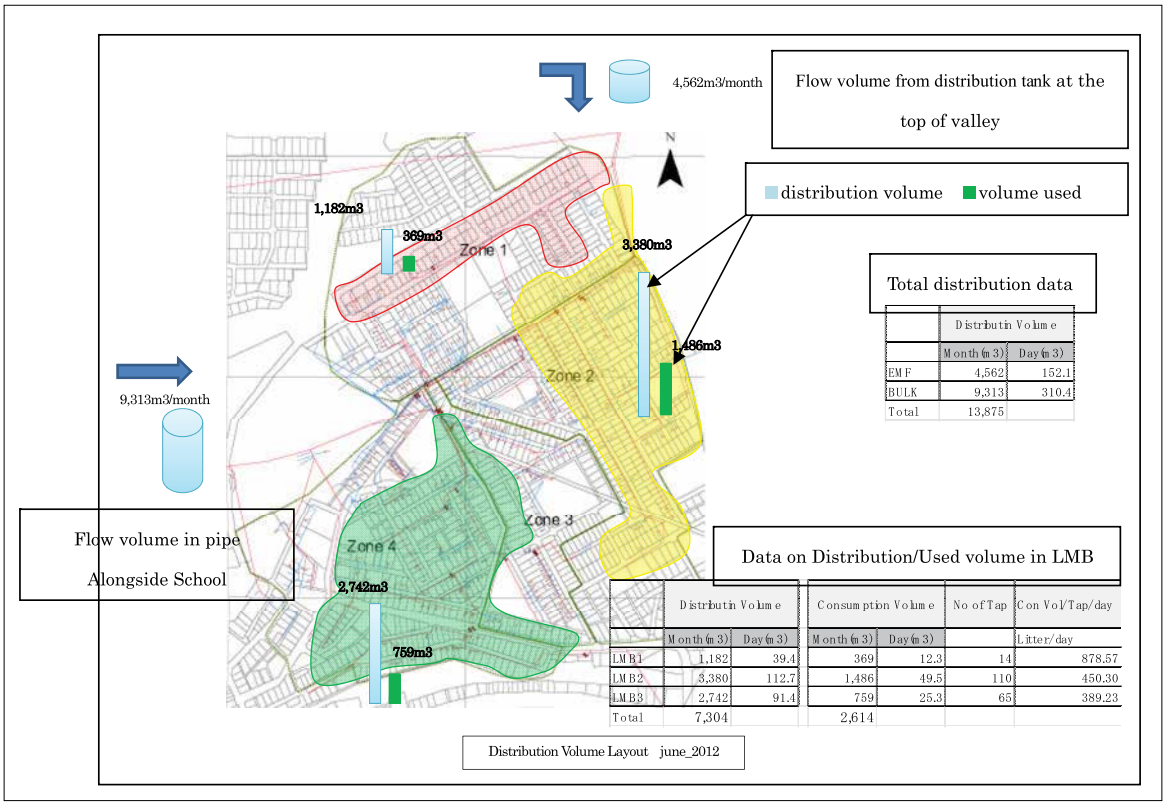


Figure 3.6 Volume of distributed water in Majengo Area

3.4 Improvements in Construction Standards

Narok WSP does not have a dedicated construction team. The WSP outsources its construction needs to local contractors. In order to improve standards in construction the WSP has to exercise its supervisory mandate for all construction works.

Construction Supervision | Construction Supervision | Flow testing device

Photo 3.2 Construction supervision and flow testing device

3.5 Routine for Leak Detection

One of the methods for reducing NRW is leak detection. In the Pilot Project area, Narok WSP has started to conduct leakage detection activities once a week as routine. Photo 3.3 shows leakage detection activities taking place, and Figure 3.7 shows records of leakage repair.

Leak detection using sounding stick

Photo 3.3 Leak detection activity

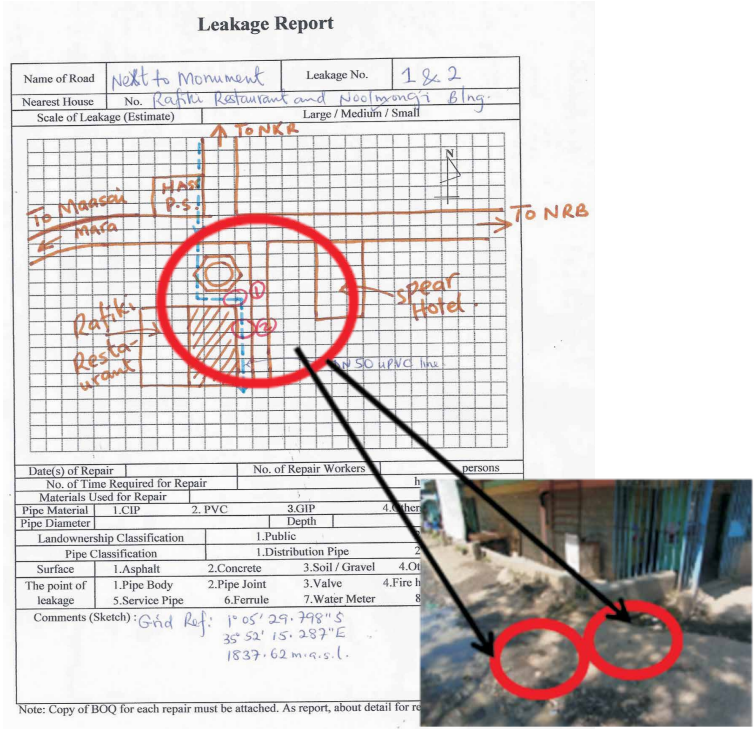


Figure 3.7 Leakage repair

4
Reduction of Commercial Loss

4.1 Organizing of Billing Data

Organizing billing data is the most effective method for reduction of Commercial Loss. WSP should have central management of ledger that describes information such as customer meter location, type, date of contract and payment status of each customer. NAROK WSP had customer information, but it had no organized customer meter records. In this regard, it had to organize meter data in the pilot project area.

Table 4.1 shows example of customer information after organizing data of Majengo area.

Village		Masikon	de/Block 9 Area				
				Aug-12		Aug-12	
				METER	STA	CONSUMP	Aug-12
SNO.	ZONE	CON	NAMES	READING	TUS	TION	ARREARS
00569	A	0098	TUFAHE SHERIFF	17	ON	1	1,000.00
00570	A	0099	AMINA ABDILLAH	116	AVG	16	710
00571	A	0100	MOHAMMED DAHIR	343	ON	13	600
00611	A	0140	REV. SAMMY OLE MOSIRO	58	ON	5	600
00615	A	0144	STANLEY L. OLE MALETO	214	AVG	6	600
00651	A	0180	SAMUEL N. OSORO	0	CO	0	9,500.00
00662	A	0191	GEORGE GICHOKA MWANGI	329	ON	14	950
00875	A	0404	MASIKONDE PR. SCHOOL	1192	ON	21	1,015.00
00876	A	0405	SIMON OLE TUYA	241	CO	0	3,651.00
00877	A	0406	NAROK CHURCH OF CHRIST	894	ON	44	7,280.00
00878	A	0407	JOHN NDERITU	0	CO	0	0
00879	A	0408	MARY MUGECHI KAMANDI	314	ON	6	200
00880	A	0409	GODFREY MACHARIA KERE	0	CO	0	8,380.00
00881	A	0410	NAROK OUTREACH CHURCH	795	ON	42	2,380.00

Table 4.1 Customer Information data (NAROK WSP)

In that data, contract number, meter number, names of customer, reading of meter, a state of meter, consumption volume and billing amount are organized for all customers. About meter status, they separate into 3 types such as ON (Charge system), AVG (Flat rate) and CO (Cut off). By organizing data, it could be possible for NAROK WSP to do further analysis.

Table 4.2 shows sample of data analysis by meter type.

Monthly Monitoring Sheet Part1 NRW Ratio									
Measurement Meter	Each Product (m^3)	Village Name	Consumption (m^3)	Kiosk (m^3)		Yard Taps (m^3)		Water Loss (m^3)	NRW Ratio(%)
Elctro Magnetic Meter	5,000	Masikonde	1,979	K1,K2	221	No5	52	-	-
Bulk Meter	7,967	Mungare	1,678	K5,K6	181	No3	252	-	-
-		Ogopa Mungu	1,166			No4	71	-	-
-		Silent Lucky Studio	961	K3	160			-	-
-		Osotua	1,795	K7	242	No1,No2	181	-	-
-		CBD-Pussy	320	K4	0			-	-
	Total Product (m^3)		Total Consumption (m^3)	Sub Total	804	Sub Total	556	Water Loss (m^3)	NRW Ratio(%)
Total	**12,967**		**7,899**					**5,068**	**39%**

Table 4.2 Sample of Data Analysis by Meter type (NAROK WSP)

When WSP classify water demand volume by customer meter type as Table 4.2, it is easy to understand the trend of variation.

4.2 Standardization of Service Line

In Narok, many customer meters are buried in the ground to prevent from theft. It is difficult for meter readers to read buried meters so they convert the connections to be flat rate. These meters account for

around 20% of revenue water volume, but this meter situation is a factor of variation of monthly revenue water volume. NAROK WSP has started to install the meters above the ground as shown in Figure 4.1 to correct the situation. Priority for above ground installation was given to pilot project area.

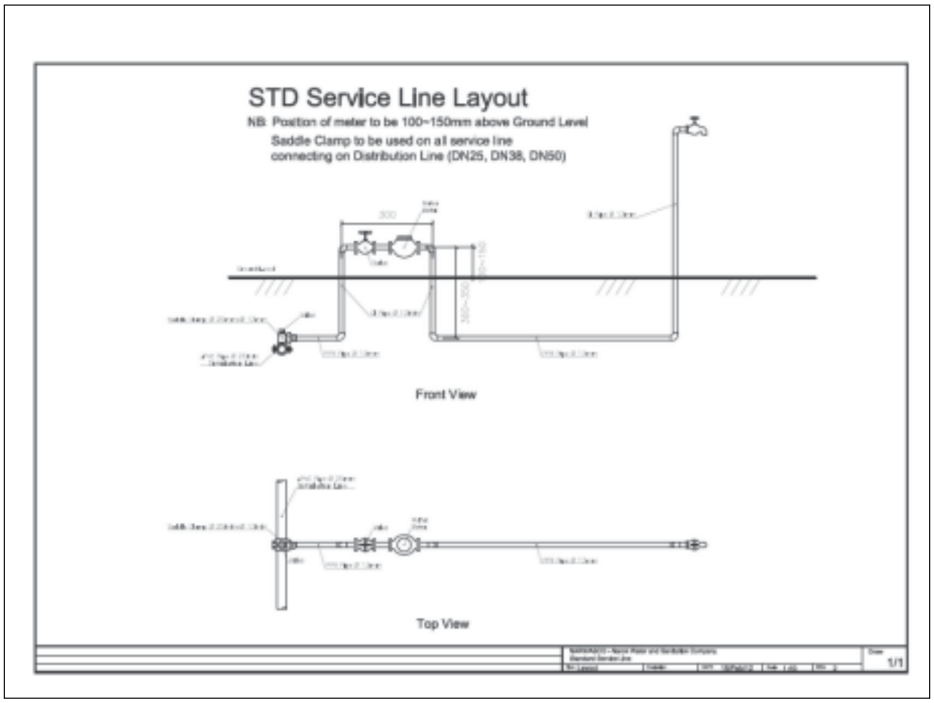


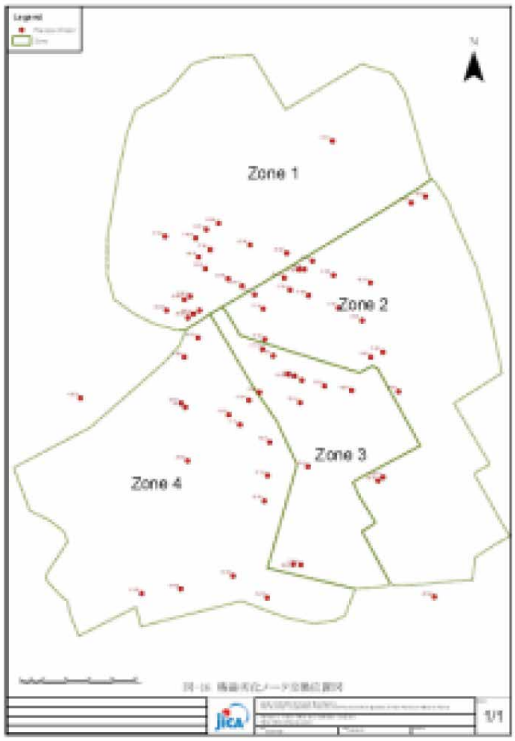
Figure 4.1 Model of the service line with exposed customer water meter

Meter Buried | Meter Exposed

Photo 4.1 Buried and exposed customer meter

4.3 Replacement of Faulty Meter and List Records

NAROK WSP replaced faulty meters with new ones when they found during patrol. Such works can reduce flat rate connections and they are working to save data by creating point map and list of replaced meter shown in Figure 4.2.



Account	Names	Village	Status
0143A	GEDION SALATON RUFUS	SILENT/LUCKY	AVG
0155A	HARUN THUO	MUNGARE	AVG
0168B	JOSEPH NCHORE	CDB PUSSY	AVG
0181A	MUCHUNKAMAU	MUNGARE	AVG
0183A	REBEKKA SWAKEI	MUNGARE	AVG
0429A	SIMON PORROR HSE 3	MASKONDE	AVG
0438A	SAMMY W.NKARI	MASKONDE	AVG
0534B	STEPHEN WAWERU THUO	CDB PUSSY	AVG
0567A	BERNARD THIND MANA	MASKONDE	AVG
0569A	ELIZABETH WANJA	MASKONDE	AVG
0588A	PETER MUREITHO NDERTU	MASKONDE	AVG
0609A	BRUNDL OMAE	MASKONDE	AVG
0731A	CHARLES M.NGARI	SILENT/LUCKY	AVG
0768A	CHRISTOPHER KAGEMA MANA	MASKONDE	AVG
0802A	JOSEPH GITAU THUO	MASKONDE	AVG
0860A	STEPHENE MURETHI	MUNGARE	AVG
0894A	GODFREY MACHARIA KERE	MASKONDE	AVG
0987A	COSMOS OJWONDI	MUNGARE	AVG
1060A	PARKESUIOLE NAIA	SILENT/LUCKY	AVG
1064A	EUNICE NYANCHAMA	SILENT/LUCKY	AVG
1104A	JOSEPH OLE SENO	MUNGARE	AVG
1164A	MICHAEL K.GATHUO	SILENT/LUCKY	AVG
1178A	JOSPHAT CHEGE CHOGI	OSOTUA	AVG
1205A	MERCY WAMBUIMACHARIA	OSOTUA	AVG
0661A	TENKES OLE PUNYUYA	MASKONDE	CO
1168A	CHARLES OGEGA - TEXAS	MUNGARE	CO
0075A	NAHASHON M.KABUGUA	Mungare Area	ON
0099A	AMINA ABDILLAH	Maskonde/Block 9 Area	ON
0105A	FELISTER NYAMBURA	Ogopa Mungu Area	ON
0119A	PIUS PETER KAMAU	Ogopa Mungu Area	ON
0122A	FRANCIS N. KAMAU	Silent/Lucky Studp Area	ON
0128A	PETER GATHERU	Silent/Lucky Studp Area	ON
0130A	LYDYA SUSAN WANGECI	Silent/Lucky Studp Area	ON
0156B	JOSEPH KHARA	CBD-Pussy Line	ON
0161B	ELIUD KOGWANG	CBD-Pussy Line	ON
0162B	PATRICK MARERA	CBD-Pussy Line	ON
0165B	JOHN TEEKA	CBD-Pussy Line	ON
0171B	JAMES KANAKE NGUYA	CBD-Pussy Line	ON
0406A	NAROK CHURCH OF CHRIST	Maskonde/Block 9 Area	ON
0420A	JACOB MERTEILOONKUSHU	Maskonde/Block 9 Area	ON
0424A	JOEL NCHOE	Maskonde/Block 9 Area	ON
0439A	SOLOMON MUNKE	Maskonde/Block 9 Area	ON
0440A	JANE NJERINKURUNAH	Maskonde/Block 9 Area	ON
0443A	PETER NDUA THUO	Mungare Area	ON
0481A	SIMON KIMENDERO	Silent/Lucky Studp Area	ON
0498A	MICHAEL KERORO	Silent/Lucky Studp Area	ON
0508A	SUSAN SETH	Silent/Lucky Studp Area	ON
0511A	JOSEPH OLE NKOTAL	Silent/Lucky Studp Area	ON
0559A	BETTY KOKAI	Maskonde/Block 9 Area	ON
0564A	JOSEPH NYAMORA	Maskonde/Block 9 Area	ON
0625A	PETER KAMUNYA MUREU	Mungare Area	ON
0652A	SOLOMON MUNKE	Maskonde/Block 9 Area	ON
0659A	GODFREY MUTUA MBOROGO	Maskonde/Block 9 Area	ON
0676A	PETER N. THUO	Maskonde/Block 9 Area	ON
0733A	ELIZABETH WANJA	Silent/Lucky Studp Area	ON
0737A	EDWIN OBONYO	Osotua Area	ON
0794A	GRACE KAPAN	Maskonde/Block 9 Area	ON
0811A	VERONICAH RUGUT	Osotua Area	ON
0813A	CHARLES OGETA	Mungare Area	ON
0815A	HENRY NYABUTO OMBABA	Osotua Area	ON
0832A	LYDYA SUSAN WANGECI	Osotua Area	ON
0955A	DANSON NDUMA (TEA ROOM)	Maskonde/Block 9 Area	ON
0960A	PAUL OCHENG	Osotua Area	ON
1011A	IRENE WANZA	Ogopa Mungu Area	ON
1047A	SR MARY STEPHEN NKOTOISEC	Osotua Area	ON
1066A	MOSES KIPLANGAT (MOSKO)	Osotua Area	ON
1083A	LUCAS KULUO	Silent/Lucky Studp Area	ON
1107A	EARNEST NGUGIWATHAKA	Mungare Area	ON
1117A	NATHAN OKEWA	Maskonde/Block 9 Area	ON
1130A	PHILIP OLE SANTEO	Mungare Area	ON

Figure 4.2 Meter Replacement Point Map & List

4.4 Technology of Meter Accuracy Test

It is desirable to replace customer meter by age or water volume that has passed through. But almost all WSPs have no plans of replacing aged water meters. WSPs need to understand and recognize that aged meters affect revenue water volume and contribute to errors. NAROK WSP had OJT about meter accuracy test for the purpose of making a plan of meter management.

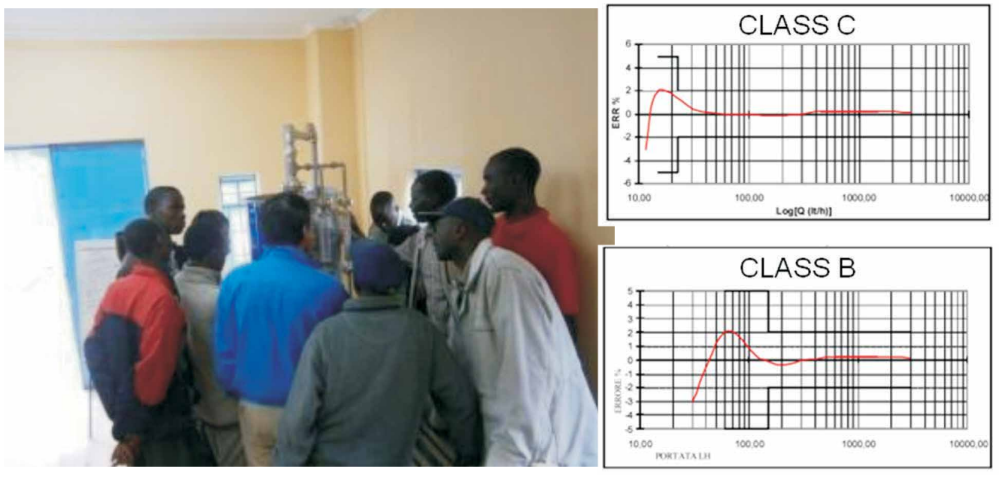


Figure 4.3 Performance curve by meter class B, C

4.5 Measurement of Minimum Night Flow-Q_{MNF}

In general, Quantity of Minimum Night Flow-Q_{MNF} is the water volume that in the time zone water consumption of household less at night (minimum night flow measurement is a method used to evaluate water loss in a water pipeline net-work). The Q_{MNF} can be obtained from continuous observation at night time in an area isolated by gate valve. This amount of water is an approximate leakage water volume in that area (but not equal). NAROK WSP did MNF tests in pilot project area after dividing into 4 LMB Leakage Measuring Block shown in Figure 4.4. Figure4.5 shows the result of test at LMB 1.

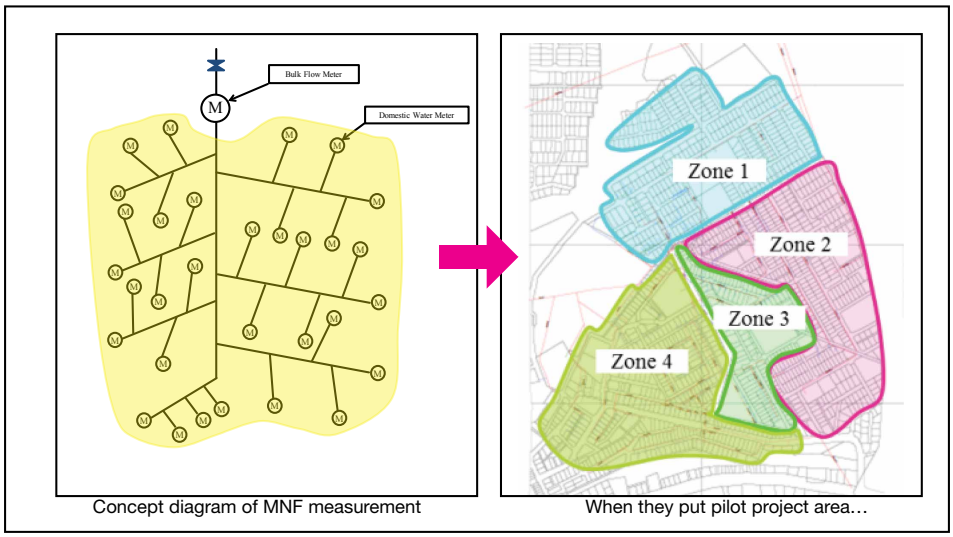


Figure 4.4 Concept of Q_{MNF} measurement and sub-dividing in pilot project

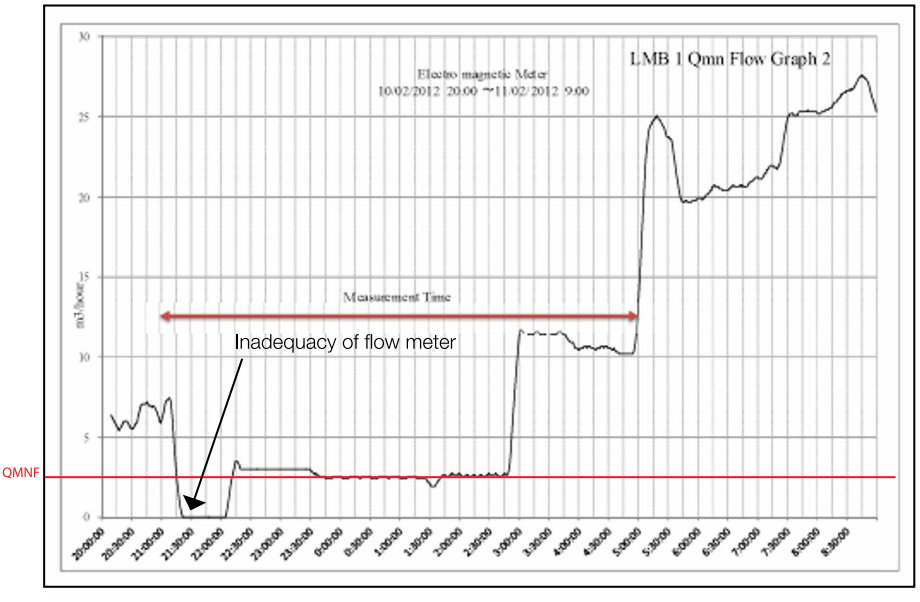


Figure 4.5 Result of Q_{MNF} measurement
(LMB1 in Majengo Area; 2012/2/10~2/11)

4.6 Maintenance of Bulk Meter

Bulk meter is important equipment for measuring the flow volume, day-to-day management of system and confirming the result of exchange of meter and pipes. However, if left unattended after installation, meter will break or malfunction due to water quality and wear. Hence correct flow volume can no longer be measured. Therefore, it is necessary to ensure improved water quality and regular servicing of the meters. NAROK WSP disassembled old bulk meters and found sediments as shown in photo 4.2. Regular servicing is necessary for accurate measurement of water volume.

Installed Bulk Meter in the chamber.

Inside of the Bulk Meter.

Sediments found inside the Meter.

Photo 4.2 Maintenance of Bulk Meter

5
Output of Pilot Project

5.1 Preparation of Distribution Network Map

As noted in the section of preliminary survey, NAROK WSP did not have clear pipeline network map. Majengo, the pilot project area was digitized by use of GIS mapping function from hand drawings. For the pipe network for the whole town, they started by making network map by hand as in Figure 5.1. Thereafter, they started making service pipeline network map of each route.

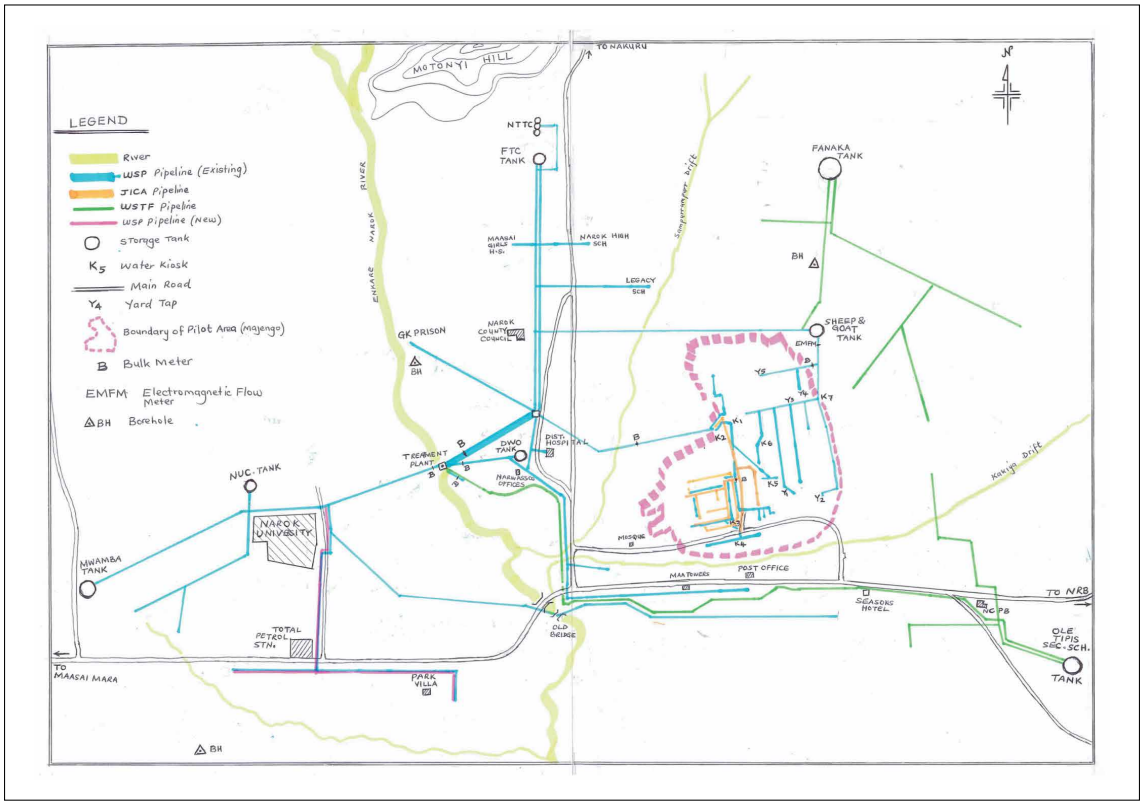


Figure 5.1 Hand drawn Pipeline Network Map of NAROK town.

Photo 5.1 Making of Pipeline Network Map

5.2 OJT of Distribution Volume Analysis

In order to monitor the results of activities of the pilot project, water distribution volume needed to be measured by the installation of the flow meter in the appropriate location and water consumption volume by organizing billing data. NAROK WSP established analyzing method by installing bulk meter, organizing billing data and setting of LMBs. They compiled analyzed results in graph presentation for each LMB for ease of understanding of the results as shown in Fig 5.2.

But, as mentioned in the section 2.5 of water distribution volume analysis, they have not been able to isolate the LMB completely due to the presence of illegal connection and unknown existing pipes. This situation had a bearing on the data accuracy. This should be corrected by replacing distribution pipeline and eliminating illegal connections to enhance data accuracy.

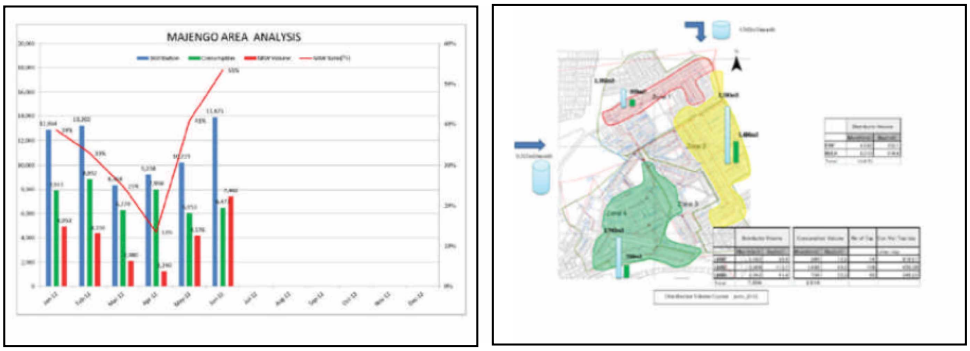
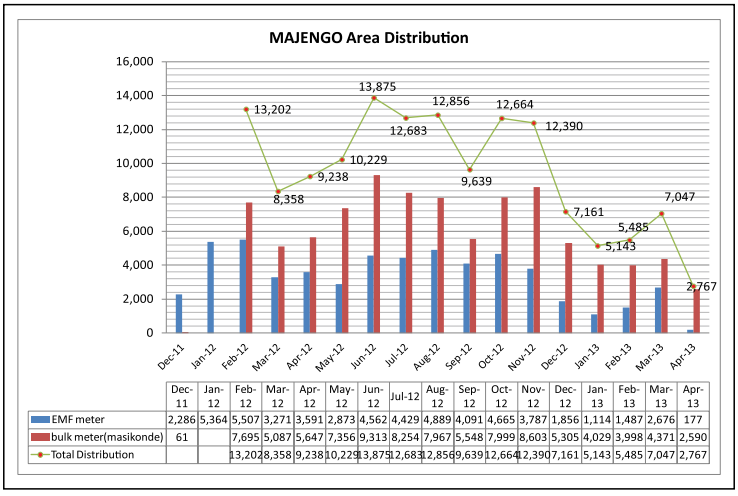


Figure 5.2 Visualizing of analyzed distribution water volume data

5.3 Result of Monitoring

5.3.1 Majengo Area

Figure 5.3 shows the trend of distribution water volume of Pilot Project area. In 2013 there was a reduction of water production due to broken pump at treatment plant. In order to improve, it is required to supply sufficient water volume. Hence the need to control water supply for each area and making a plan of upgrading the system and also they need to organize customer ledger.



	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13
EMF meter	2,286	5,364	5,507	3,271	3,591	2,873	4,562	4,429	4,889	4,091	4,665	3,787	1,856	1,114	1,487	2,676	177
bulk meter(masikonde)	61		7,695	5,087	5,647	7,356	9,313	8,254	7,967	5,548	7,999	8,603	5,305	4,029	3,998	4,371	2,590
Total Distribution			13,202	8,358	9,238	10,229	13,875	12,683	12,856	9,639	12,664	12,390	7,161	5,143	5,485	7,047	2,767

Figure 5.3 Trend of distribution volume in Majengo
(December 2011 April 2013)

The results of lower distribution volume are as shown in Figure 5.4. NRW was negative in January, February and April 2013 due to inclusion of estimated consumption of flat rate customers resulting in consumption volume exceeding distribution volume.

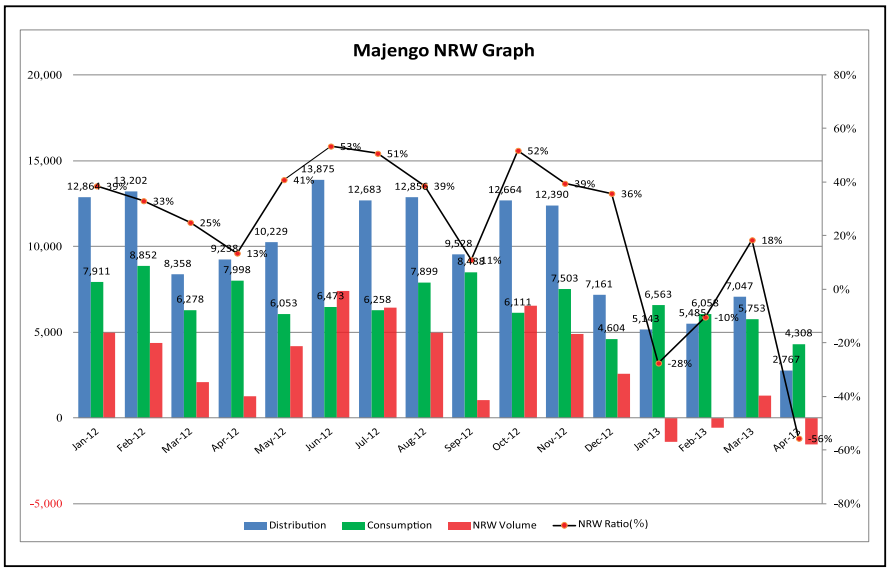


Figure 5.4 Trend of NRW Ratio of Majengo (Jan. 2012 - Apr. 2013)

5.3.2 Analysis of LMB

The project set 3 Leakage Monitoring Block-LMB in Pilot Project area to do detailed measurement. LMB 1 was set in upper area in Majengo. LMB 2 was in East side, and LMB 3 was in lower area.

Figure 5.5 shows the location of these LMB.

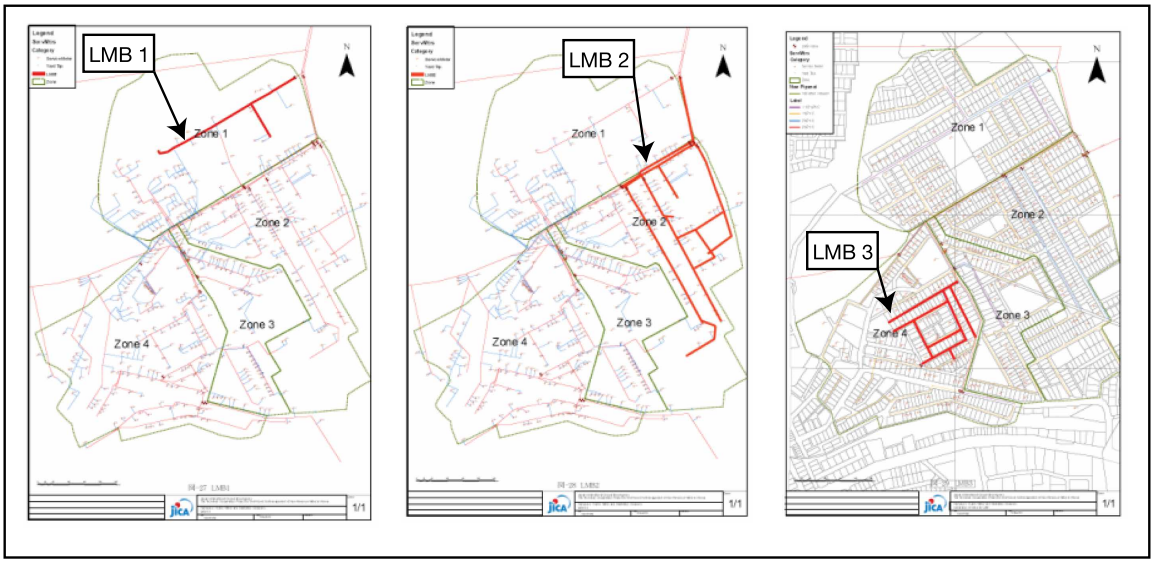


Figure 5.5 Locations of LMB

(1) LMB1

LMB1 was set in order to know status of small area. It has only 14 customer meters. NAROK WSP confirmed no leakage before start monitoring. Figure 5.6 shows the result.

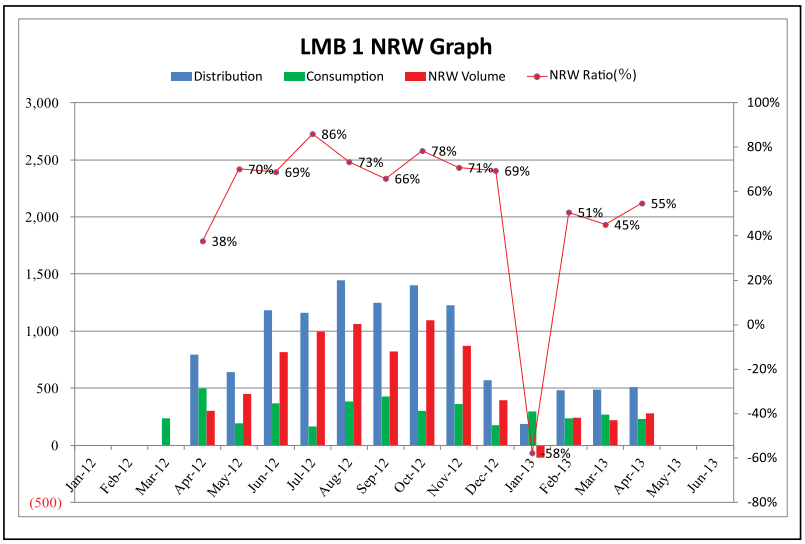


Figure 5.6 Result of monitoring at LMB1

LMB 1 has reduced distribution volume in 2013. LMB is in good status of monitoring and confirmed no leakage. NRW ratio comes down from around 70% to 50%. To reduce NRW further, NAROK WSP needs to search unknown pipes to connect another area (locate the unknown pipes connected to some areas) or illegal. But the most important thing is to deliver enough water, because this status do not represent the original trend.

(2) LMB2

LMB2 was set in order to know the effect of replacement of old GI pipes with new ones. NAROK WSP had work of detection of leakage and replacement of old pipes in this LMB. Figure 5.7 shows the result.

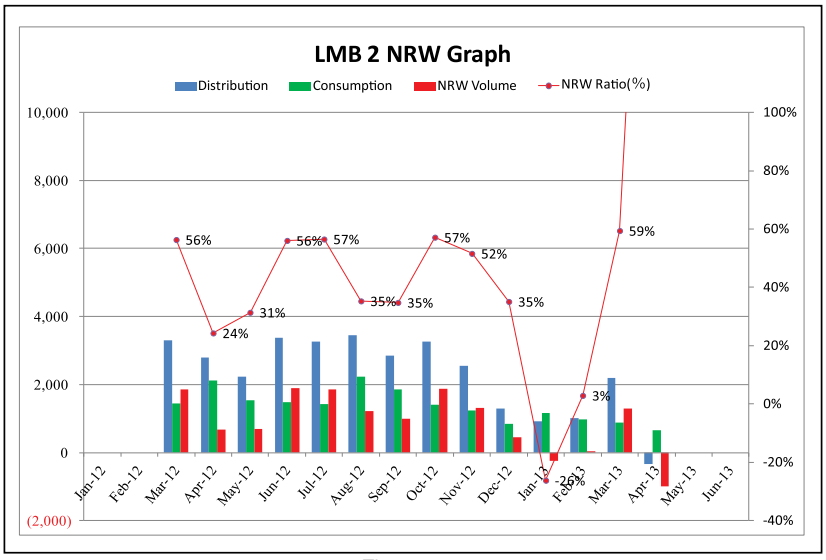


Figure 5.7

LMB 2 had low water distributed in 2013, and it received lower volume than LMB 1 because of preferential distribution of water in LMB 1. NRW Ratio did not stabilize because of low distribution volume.

(3) LMB 3

LMB 3 is monitoring for new pipeline and customer meters. NAROK WSP installed new pipe and 65 customer meters. On March 2013, they also tried to measure Q_{MNF} to estimate leakage volume.

Figure 5.8 shows the trend of data in Majengo.

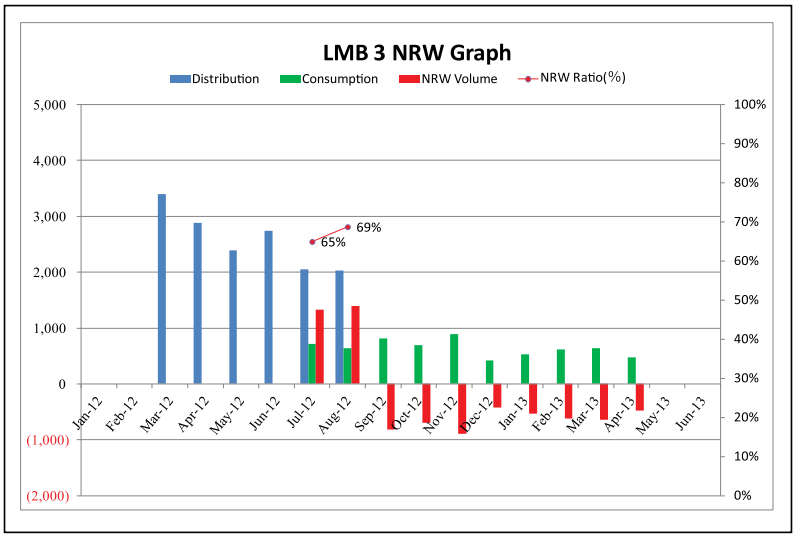


Figure 5.8 Result of monitoring at LMB3

LMB 3 has a problem of water shortage and spaghetti pipes. When NAROK WSP changed distribution line to new one, many complains of water shortage came from next area of LMB3. The WSP had not used the new pipeline and therefore no distribution volume was recorded from September 2012. In order to resolve that problem, they needed to rationalize the spaghetti pipe in upstream area, and get more water in the distribution system.

The WSP has a plan to carry out Q_{MNF} measurement and leakage monitoring following the completion of new pipeline and after repairing the existing dilapidated pipeline.

5.4 Ongoing Activities

The following Activities have been conducted continuously in NAROK WSP;

1) Developing and updating of distribution network maps
2) Analyzing of distribution water volume
3) Rationing of water supply distribution with gate valve control and analyzed data
4) Exposing customer meters to facilitate meter reading.
5) Rationalization of spaghetti connections pipe
6) Customer meter testing for accuracy.
7) Regular servicing of bulk meters.

5.5 Developing of NRW Reduction Plan for NAROK WSP

After monitoring in pilot project area Majengo, NAROK WSP learned current situation and distribution management. In this time (July 2013), they have a problem of water volume shortage, but method of management and detection of leakage will assist them greatly when they get enough water.

NAROK WSP has developed middle term NRW Reduction plan from 2013/2014 to 2015/2016.
The plan includes;

1. Installing new customer meters,
2. Flow meters,
3. Compiling information of customer ledger,
4. Distribution volume,
5. Consumption volume and development of new pipeline map.

These are output of NRW reduction activities on pilot project area.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