Attachment 10: 5YSP Reports

5-Year Strategic Action Plan for NRW Reduction

Gr No.	Components	Sub Gr No.	Countermeasures	Specific actions	Budget	Responsible TEAM for Specific actions					Priority	Necessary Resources	Period	Total amount (RWF)	Implementation Schedule and Estimated Budget																Comments
						Respon-sible UNIT	Action Section/Branch								2017/2018 1st Year												2018/2019 2nd Year	2019/2020 3rd Year	2020/2021 4th Year	2021/2022 5th Year	
															Jul	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June					
A. System Input Volume																															
A1	Volume input metering accuracy	A1.1	Establish the framework to ensure the system volume input accuracy	Inventory of bulk meters (GIS, Esri, Survey)	***NRW***	***NRW***	*Production*	*Distribution*	-	-	High	NA	already available	-	x																
				Set up a dedicated and experienced team to visit, analyze and report all bulk meters condition (meter age, size, installation, etc..)	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High	NA	1 month	-	x																
				Visit, analyze and detailed report of all bulk meters condition	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High	Consultant, Staff, Logistics	3 months	2,880,000		960,000	960,000	960,000													JICA expert will be required
				Installation of new meters / Replacement of faulty bulk meters / correcting of meters installation based on the result of meter condition analysis	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High	Staff, Bulk meters, Fittings, Logistics	5 months	204,000,000					41,000,000	41,000,000	41,000,000	41,000,000	40,000,000								This amount has been budgeted for the FY2017-2018
				Prepare a plan for bulk meter regular check up for the future.	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High	Staff	1 month	-				x													
				Implementation of the plan for bulk meter regular check up for the future.	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High		Regular	-					x	x	x	x	x	x	x	x	x	x	x	x	bulk meter check up will be yearly
				Bulk meter reading and analysis	***NRW***	***NRW***	*NRW*	*Production*	*Distribution*		High		Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	bulk meter readings should be monthly
A2	Water production (prevent intermittent supply)	A2.1	Increase water production to ensure Continuous supply for proper flow and pressure management	Assessment of water supply gap	***UP***	***UP***	*UP*	-	-	-	High	General expenses	already available	-	x																Increase of the production is very key for NRW reduction activities but this task is currently being implemented using development budget
				Identify project to address the current gap and future demand	***UP***	***UP***	*UP*	-	-	-	High	General expenses	already available	-	x																
				Implement of the identified project (Construction of new WTP, upgrade existing WTP, forwarding infrastructures and the Network)	***WO***	***WO***	*Production*	-	-	-	High	Development budget	on going	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Install backup generators at critical WTP and pumping station (Long term)	***WO***	***WO***	*Production*	-	-	-	Medium	Development budget	2 years	-															x	x	
B. Commercial Losses																															
B1	Meter reading and billing	B.1.1	Ensure correct and 100% customers meter reading	Sensitization of CFO's about the importance of accurate readings through workshops	***RM***	***RM***	*Billing*	*Branches*	-	-	High	Staff, Logistics	Regular	15,000,000				2,500,000						2,500,000			2,500,000	2,500,000	2,500,000	2,500,000	Twice a year
				Train CFO how to use map in meter reading	***RM***	***RM***	*Billing*	*Branches*	-	-	High	Staff, Logistics	3 months	720,000					240,000	240,000	240,000										
				Enforce billing supervision at branch level by recruiting billing and revenue collection supervisors	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	2 months	-						x	x										
				Regular Random re-reading of customer meters (by the branch management and also the senior management)	***RM***	***RM***	*Billing*	*Branches*	-	-	High	NA	Continuous	-						x	x	x	x	x	x	x	x	x	x	x	Activity in progress
				Make the business case for outsource meter reading	***RM***	***RM***	*Billing*	*Branches*	-	-	High	NA	2 months	-						x	x										
		B.1.2	Ensure Customer meter accuracy	Make a plan for Regular meter accuracy test.	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High		1 month	-						x											
				Implement of the plan for Regular meter accuracy test.	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High	Staff, Equipment, Logistic	Regular	4,800,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	85,000	1,000,000	1,000,000	1,000,000	1,000,000	Meter test by test bench & portable test meter
				Procure additional Portable meter test equipment (at least 1 per branch)	***CSM***	***CSM***	*Metering*	-	-	-	High	Meter test equipment	6 months	120,000,000		x	120,000,000														Procurement of portable test meters budgeted for FY2017-2018
				Replace default and old meters	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High	Meters, Staffs, Logistics	continuous	2,108,228,581	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	15,000,000	450,000,000	479,250,000	510,401,250	543,577,331	15000 meters /year
				Procure and install one water test bench per province	***CSM***	***CSM***	*Metering*	-	-	-	Low	Meter test bench	1 year	200,000,000																200,000,000	Estimated 50 Million for 1 meter test bench
		B.1.3	Improve technology and equipment for meter reading and billing	Procure portable bills printers	***CSM***	***DCS***	*Metering*	*ICT*	-	-	High	Printers and accessories	6 months	92,000,000		x	x	92,000,000													Budgeted for FY2017-2018
				Exposure visit for success stories and adapt if necessary	***CSM***	***DCS***	*Metering*	*ICT*	-	-	High	Staff, Logistics	1 months	8,000,000							8,000,000										The exposure visit can be organize in the region or other African countries
				Automatic meter reading or prepaid meters for big customers	***CSM***	***DCS***	*Metering*	*ICT*	-	-	High	Meters, Staffs, Logistics	1 years	200,000,000													200,000,000				
		B.1.4	Monitoring of customer consumption trends	Analysis of customer consumption Database	***RM***	***RM***	*Billing*	*Branches*	-	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	monthly analysis should be done
				Plan and visit customer with irregular consumption	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Analysis of estimated/constant bills	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Weekly meter reading for big customers (at least 200 big customers)	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x					Routine activity
				Regular follow up of big customers	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	Regular	-													x	x	x	x	After installation of prepaid meters
B2	Customers meter management (normal, larges and public tap)	B2.1	Continue customer mapping and inventory	Complete customer inventory and mapping in Upcountry Branches	***RM***	***RM***	*Billing*	*Branches*	*GIS*	*ICT*	High	Consultant, GIS staff, logistic	6 moths	-	x																On going activity
				Set up and implement a clear customer database update procedures in GIS and CMS	***RM***	***RM***	*Billing*	*Branches*	*GIS*	*ICT*	High	GIS staff	2 moths	-		x	x														
		B2.2	Ensure the quality of meter installation and replacement	Update meter installation and replacement policy	***CSM***	***CSM***	*Metering*	-	-	-	High	NA	2 months	-		x	x														2 months for policy set up and Continuous implementation
				Implement meter replacement according to the replacement policy	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High		Regular	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	Routine activity
				Supervision and inspection of meter installation for new connection works	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High	General expenses	Continuous	-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Routine activity
		B2.3	Reinforce public tap management	Public tap inventory and assessment of their condition (meter ,location ,etc..)	***RM***	***RM***	*Metering*	*Branches*	*GIS*	-	High	General expenses	2 months	-		x	x														
				Review the existing public tap management procedures	***RM***	***RM***	*Metering*	*Branches*	-	-	High	NA	1 month	-				x													
				Raise staff and community awareness through workshops, media show	***NRW***	***NRW***	*Inspe. & Enforce.*	-	-	-	High	Staff, Logistics	Regular	25,000,000						2,500,000						2,500,000	5,000,000	5,000,000	5,000,000	5,000,000	Twice an year workshop/tv show should be organized

5-Year Strategic Action Plan for NRW Reduction

Gr No.	Components	Sub Gr No.	Countermeasures	Specific actions	Budget	Responsible TEAM for Specific actions					Priority	Necessary Resources	Period	Total amount (RWF)	Implementation Schedule and Estimated Budget																Comments
						Respon-sible UNIT	Action Section/Branch								2017/2018												2018/2019	2019/2020	2020/2021	2021/2022	
															1st Year												2nd Year	3rd Year	4th Year	5th Year	
															Jul	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June					
B3	Illegal Connection (illegal water use)	B3.1	Prevention of illegal water usage	Enhance Incentive for informers (including staff)	**NRW**	**NRW**	Inspe. & Enforce.	-	-	-	High	Informers incentives	Continuous	5,800,000	50,000	50,000	50,000	50,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	1,200,000	1,200,000	1,200,000	1,200,000	Assume 2 reported illegal cases per months
				Inspection of suspected customer's and large consumer's connections based on customer data analysis	**NRW**	**NRW**	Inspe. & Enforce.	Branches	-	-	High	Staff, Logistics	Regular	13,300,000	125,000	125,000	125,000	125,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	2,700,000	2,700,000	2,700,000	2,700,000	
				Installation of meter protection boxes for suspected customers	**CSM**	**CSM**	Metering	Branches	-	-	High	Staff, Logistics	Regular	4,000,000			400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000					
				Complete disconnection of confirmed inactive customers	**RM**	**RM**	Billing	Branches	-	-	High	General expenses	continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
		B3.2	Charge fines for confirmed illegal water usage customers	Disconnection of confirmed illegal cases	**RM**	**RM**	Billing	Inspe. & Enforce.	Branches	-	High	Staff, Logistics	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Monitoring of fines payment	**NRW**	**NRW**	Inspe. & Enforce.	Branches	-	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
C. Physical Losses																															
C1	Pressure management	C1.1	Determination of high pressure zones	Review, analysis and regular update of existing map of water network, pumping station ,WTP installations, etc..	**WO**	**WO**	GIS	-	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	There should be hard copy showing the situation before and after changes
				Hydraulic calculation and modeling	**WO**	**WO**	GIS	-	-	-	High	General expenses	Regular	-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Identification, mapping and dissemination of higher pressure zones	**WO**	**WO**	GIS	-	-	-	High	GIS staff	1 year	-			x	x	x	x	x	x	x	x	x	x					
		C1.2	Determine the acceptable pressure range in the network and customer tap	Make a survey on the existing pressure in the network and on customer taps	**NRW**	**NRW**	LD&PM	-	-	-	High	Staff, Logistics	2 months	3,360,000				1,680,000	1,680,000												
				Propose the acceptable pressure range considering our local conditions	**NRW**	**NRW**	LD&PM	Distribution	-	-	High	Staff	3 months	-						x	x	x									
		C1.3	High pressure zones survey (from hydraulic analysis)	Identification of place to install pressure gauges ,dataloggers	**NRW**	**NRW**	LD&PM	Distribution	Branches	GIS	High	Staff, Logistics	3 months	-									x	x	x	x	x				
				Procure and install pressure gauges in the network	**NRW**	**NRW**	LD&PM	Distribution	Branches	GIS	High	Staff, Pressure gauges, Logistics	2 years	20,000,000													10,000,000	10,000,000			at least 10 gauges / branch
				Follow-up and Analysis of pressure measurement results	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	Staff, Logistics	Continuous	-						x	x	x	x	x	x	x	x	x	x	x	
		C1.4	Proper pressure management	Inventory of existing PRVs, Break Pressure Tanks (BPT)	**WO**	**WO**	Distribution	LD&PM	GIS	-	High		2 months	-	x	x															
				Identification and prioritization of actions to address pressure issues	**NRW**	**NRW**	LD&PM	Distribution	-	-	High	Staff	3 months	-		x	x	x													
				Set up a plan for pressure management	**NRW**	**NRW**	LD&PM	Distribution	-	-	High	Staff	3 months	-		x	x	x													
				Implementation of pressure management plan (PRV, BPT, rearrangement of pumping stations and pipeline network)	**NRW**	**NRW**	LD&PM	Distribution	-	-	High	Staff, Pressure reducer equipment, Logistics	Regular	324,800,000			5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	67,200,000	67,200,000	67,200,000	67,200,000	24 PRV will be installed in year one as planned in the 2017-2018 action plan
				Continuous pressure control	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	Staff, Logistics	Continuous	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	
C2	Asset Management (Rehabilitation)	C2.1	Asset data management by GIS	Inventory, drawing and mapping of water facilities	**WO**	**WO**	GIS	-	-	-	High	Consultant, GIS staff, Logistic	1 year	-	x	x	x	x	x	x	x	x	x	x	x	x					On going activity (Esri project)
				Regular update of GIS data	**WO**	**WO**	GIS	-	-	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
		C2.2	Network maintenance and rehabilitation	Inventory of infrastructures to be rehabilitated	**WO**	**WO**	Distribution		-	-	High		3 months	-	x	x	x														
				Analysis for optimal use of water infrastructure	**WO**	**WO**	Distribution	-	-	-	High	GIS staff, Logistics, GIS software	2 moths	-	x	x															Eg. pipe replacement ,
				Prioritization of areas for rehabilitation	**WO**	**WO**	Distribution	-	-	-	High	Staff	Yearly	-		x	x										x	x	x	x	
				Preparation of maintenance and rehabilitation plan	**WO**	**WO**	Distribution	-	-	-	High	Staff	Yearly	-		x	x										x	x	x	x	
				Implementation of the maintenance and rehabilitation plan	**WO**	**WO**	Distribution	-	-	-	High	Staff, Material, Logistics	Continuous	750,000,000			13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	155,000,000	155,000,000	155,000,000	155,000,000	we referred to the rehabilitation budget allocated to the FY2017-2018
				Monitor and evaluation of the implementation of the maintenance plan	**WO**	**WO**	Distribution	-	-	-	High	Staff, Logistics	Continuous	2,400,000						240,000						240,000	480,000	480,000	480,000	480,000	twice a year
		C2.3	Infrastructure protection	Installation of protective facilities (manhole covers , fences …)	**WO**	**WO**	Distribution	Branches	-	-	Low	Staff, Protective equipment, Logistics	Continuous	15,000,000						1,500,000						1,500,000	3,000,000	3,000,000	3,000,000	3,000,000	mainly installation of air valves
				organize public awareness for infrastructure protection against vandalism	**WO**	**WO**	Distribution	Metering	Branches	-	Low	General expenses	Regular	-							x						x	x	x	x	Once a year
C3	Leaks and burst repair	C3.1	Quick and good quality repairs	Sensitization for leak reporting (meeting , TV show , rewarding informers , etc..)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	Regular	10,000,000							2,000,000						2,000,000	2,000,000	2,000,000	2,000,000	Once a year
				Daily monitoring of leaks reported and repair (wtsp, LIS)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Avail minimum stock at the branch level	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	1 year	-		x	x	x	x	x	x	x	x	x	x	x					availability of material is Continuous process
				Regular inspection of leaks repaired	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Dissemination of standard for leak repair	**QA**	**QA**	Standard	NRW	-	-	High	NA	Continuous	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Train staff for leak repair	**NRW**	**NRW**	LD&PM	Branches	-	-	High	Staff, Logistics	Continuous	15,000,000			3,000,000										3,000,000	3,000,000	3,000,000	3,000,000	once a year
		C3.2	Active leakage control	Make historical analysis of leakages (location, diameter, material etc..)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Prepare an yearly plan of visible leakage and invisible survey (including reservoir)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	Regular	-	x												x	x	x	x	
				Implement the yearly plan of visible leakage survey (including reservoir)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	2160000
				Train staff for leakage survey and leak detection	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	Staff, Logistics, Equipment	Regular	15,000,000			3,000,000										3,000,000	3,000,000	3,000,000	3,000,000	JICA NRW Project
				Procure and dispatch leak detection equipment to branches	**NRW**	**NRW**	LD&PM	Branches	-	-	High	Leak detection equipment	2 years	400,000,000														200,000,000	200,000,000		Leak detection for branches
				Select critical areas to detect invisible leaks	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	Continuous		x												x	x	x	x	Analysis and survey are required.
				Conduct leak detection activities in all branches and make estimation of water lost through leakages	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	Staff, Logistics, Equipment	Continuous	2,160,000	x	x	x	x	x	x							2,160,000	x	x	x	year 1 HQ staff to be trained by JICA . For next years HQ staff will train branches staff
		C3.3	Establish water supply monitoring system (DMA, SCADA ,etc..)	Complete the isolation of Kigali branches	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	Middle	Staff, Equipment	1 year	-	x	x	x	x	x	x	x	x	x	x	x	x	x				Ongoing activity (JICA NRW Project)
				Creation and management of DMA within branches	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	Middle	Development budget	Continuous								x	x	x	x	x	x	x	x	x	x	Can be financed by the development budget
				Establish a network monitoring system including reservoirs	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	Middle	Development budget	5 years	-													x	x	x	x	Can be financed by the development budget
		C3.4	Reporting and recording of leakages	Review and harmonize leaks reporting and repairs format	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	High	NA	3 months	-	x																
				Daily report of leakages with Location, diameter , materials and so on	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	High	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Routine activity
D. Unbilled Authorized Consumption																															

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															Jul	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June					
D1	Unbilled metered authorized consumption	D1.1	Ensure proper fire hydrant management	General inventory of all fire hydrants and confirmed if metered and billed	RM	RM	Billing	Metering	Distribution	Branches	High	General expenses	2 months	-	x	x															
				policy establishment for fire hydrants installation and management	RM	RM	Billing	Metering	Distribution	Branches	High	NA	1 month	-			x														
				calculation and analysis of water used by fire hydrants	RM	RM	Billing	Metering	Distribution	Branches	High	NA	Regular	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	
D2	Unbilled unmetered authorized consumption	D2.1	Have a plan for network and reservoirs flushing	Preparation of network flushing plan	WO	WO	Distribution	Branches	-	-	Low	NA	Regular	-	x												x	x	x	x	Every year
				Implementation of the network flushing plan	WO	WO	Distribution	Branches	-	-	Low	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Estimation of water uses in network flushing , reservoir cleaning	WO	WO	Distribution	Branches	-	-	Low	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Monthly report
E. Fundamental Measures																															
E1	GIS and CMS database	E1.1	link GIS and Customer Management System (CMS)	Harmonize customer data in GIS and CMS	WO	WO	GIS	ICT	RM	-	High	NA	1 year	-	x	x	x	x	x	x	x	x	x	x	x	x					
				Regular updates of both Systems (GIS, CMS) simultaneously	WO	WO	GIS	ICT	RM	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
		E1.2	Avail GIS staff up to branch level	Recruit and affect GIS staff in branches	HR	HR	HRM	-	-	-	Low	General expenses	1 year	-														x			
				Train branch GIS staff	NRW	NRW	GIS	Branches	-	-	Low	Staff, Logistics	Continuous	15,000,000						1,500,000						1,500,000	3,000,000	3,000,000	3,000,000	3,000,000	
E2	Planning, design and implementation of quality works	E2.1	Develop long term master plan of water network	Prepare a study of WASAC water network master plan	UP	UP	UP	-	-	-	High	Development budget	2 years	-	x	x	x	x	x	x	x	x	x	x	x	x	x				The preparation and elaboration of Kigali water supply and sanitation master
				Elaboration of WASAC water network master plan	UP	UP	UP	-	-	-	High	Development budget	2years	-													x				
				Implementation of the water network master plan	UP	UP	UP	-	-	-	High	Development budget	Continuous	-													x	x	x	x	
		E2.2	Disseminate existing standard of design and installation of water works	Inventory of all standards and design available	QA	QA	Standard	-	-	-	High	NA	1 month	-		x															
				Procure missing needed standards	QA	QA	Standard	-	-	-	High	General expenses	2 months	-			x	x													
				training and workshop for Dissemination of standards of design and installation	QA	QA	Standard	-	-	-	High	Staff and logistics	1 months	9,000,000					3,000,000										3,000,000	3,000,000	
		E2.3	Ensure the quality of designs and water works	Establish and maintain material specification (meter, pipes, fittings, etc..)	QA	QA	Standard	Metering	Distribution	Branches	High	NA	2 months	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Establish design validation procedures	QA	QA	Standard	-	-	-	High	NA	1 year	-	x	x															
				Set up an inspection team for works standard compliance	QA	DUWSS	Standard	-	-	-	High	NA	1 month	-			x														
				Technician certification for specific works (connection, repair, extension, etc. …)	HR	HR	Standard	Metering	Distribution	Branches	Low	NA	Regular	-													x	x	x	x	Internal certification
E3	WASAC NRW management	E3.1	Customize IWA water balance to WASAC (to clear understand NRW components)	Review the existing water balance used	NRW	NRW	NRW	-	-	-	High	NA	1 month	-						x											JICA expert will help
				Approval of component of the water balance	NRW	NRW	NRW	-	-	-	High	NA	2 months	-						x	x										
		E3.2	Ensure proper NRW management in WASAC	Review WASAC NRW structure	NRW	WASAC	NRW	HRM	-	-	High	NA	1 months	-	x							x									JICA expert will propose
				Review WASAC NRW reduction target	NRW	WASAC	NRW	-	-	-	High	NA	Yearly	-	x												x	x	x	x	
				Review the NRW procedure manual	NRW	NRW	NRW	-	-	-	High	NA	1 year	-		x	x	x	x	x											
		E3.3	Mobilize Partners in NRW reduction projects	Identification of different partners intervening in NRW project	NRW	DUWSS	NRW	UP	-	-	High	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
E4	Stakeholders management	E4.1	Increase the collaboration with local authorities and other infrastructures development agencies	Organize regular meeting and workshop	WO	WO	Distribution	NRW	-	-	Middle	Staff, Logistics	Regular	15,000,000		3,000,000											3,000,000	3,000,000	3,000,000	3,000,000	Once a year
				Prepare and implement MOU with road constructor, Districts and other infrastructures agencies	WO	WO	Distribution	NRW	-	-	Middle	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Monitoring of activities	WO	WO	Distribution	NRW	-	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
		E4.2	Certification of private companies and technicians for specific works (new water works)	Identification ,selection and certification of qualified companies and technicians	WASAC	WASAC	DUWSS	-	-	-	High	NA	Continuous	-													x	x	x	x	From the second year
		E4.3	benchmarking visits in other water utilities	Identification of best practices water utilities companies	WASAC	WASAC	DUWSS	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Preparation of partnership agreement	WASAC	WASAC	DUWSS	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Exposure visits	WASAC	WASAC	DUWSS	-	-	-	Low	Staffs, Logistics	Continuous	15,000,000													7,500,000		7,500,000		Once every two years
		E4.4	Collaboration with research centers and universities	Select research center and universities involved in water sector	WASAC	WASAC	DUWSS	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Prepare and sign partnership agreement	WASAC	WASAC	DUWSS	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
E5	Training	E5.1	Ensure that WASAC have skilled and qualified staff	Assess current staff skill gap (new connection standard , GIS usage, pipe installation, pressure management , etc..)	WASAC	WASAC	HR	-	-	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	JICA experts may support
				Set up appropriate training plan	WASAC	WASAC	HR	-	-	-	High	NA	6 months	-		x	x														
				implement the training plan	WASAC	WASAC	HR	-	-	-	High	General expenses	Continuous	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Set up an internal knowledge transfers mechanism	WASAC	WASAC	HR	-	-	-	High	NA	6 months	-				x	x	x											
				Monitoring and Evaluation of the change	WASAC	WASAC	HR	-	-	-	High	NA	Continuous	-				x	x	x	x	x	x	x	x	x	x	x	x	x	
		E5.2	Benchmarking of different branches for NRW reduction to enhance NRW	Compile and analyze branch NRW report	WASAC	WASAC	NRW	-	-	-	High	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Monthly report
				Set NRW target for Each branch	WASAC	WASAC	NRW	-	-	-	High	NA	2 months	-					x	x											branches NRW targets should be align with company target

5-Year Strategic Action Plan for NRW Reduction

Gr No.	Components	Sub Gr No.	Countermeasures	Specific actions	Budget	Responsible TEAM for Specific actions					Priority	Necessary Resources	Period	Total amount (RWF)	Implementation Schedule and Estimated Budget																Comments
						Respon-sible UNIT	Action Section/Branch								2017/2018												2018/2019	2019/2020	2020/2021	2021/2022	
															1st Year												2nd Year	3rd Year	4th Year	5th Year	
															Jul	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June					
			performance	Organize regular meeting with branches	***WASAC***	***WASAC***	*NRW*	-	-	-	High	General expenses	Continuous	-						x						x	x	x	x	x	Quarterly
				Propose incentive measures for NRW reduction	***WASAC***	***WASAC***	*NRW*	-	-	-	High	NA	Continuous	-					x												
E6	Institution	E6.1	Ensure the implementation of the branch new structure	Recruitment of new staff to populate the new structure	***WASAC***	***WASAC***	*DUWSS*	*DCS*	-	-	High	General expenses	6 moths	-							x	x	x	x	x	x					
		E6.2	Reinforce the research and development	Identify area of research and set up the team	***WASAC***	***WASAC***	*DUWSS*	*DCS*	-	-	Low	NA	1 year	-							x	x	x	x	x	x					
		E6.3	Continuous improvement and innovation	Establish the innovation incentive mechanism	***WASAC***	***WASAC***	*DUWSS*	*DCS*	-	-	Low	NA	1 year	-							x	x	x	x	x	x					
E7	Logistic and quality materials	E7.1	Avail enough equipment and logistics (vehicle , motorcycle , tools, protective equipment , etc.…)	Inventory of available equipment and logistic facilities at the branch level and determines urgent need	***DSS***	***DSS***	*Admin & Logist*	*DUWSS*	*DCS*	*Branches*	High	NA	3 months	-	x	x	x														
				Procurement of equipment and logistics needed	***DSS***	***DSS***	*Admin & Logist*	*DUWSS*	*DCS*	*Branches*	High	General expenses	2year	-				x	x	x	x	x	x	x	x	x	x				

TOTAL Amount	4,615,448,581	780,740,000	921,740,000	941,330,000	972,981,250	998,657,331	
	US$5,494,582	*US$929,452*	*US$1,097,310*	*US$1,120,631*	*US$1,158,311*	*US$1,188,878*	
WASAC	15,000,000	0	7,500,000	0	7,500,000	0	15,000,000
NRW	1,056,300,000	284,430,000	99,260,000	297,100,000	287,100,000	87,100,000	1,054,990,000
WO	782,400,000	133,480,000	161,480,000	161,480,000	161,480,000	161,480,000	779,400,000
QA	9,000,000	3,000,000	0	0	3,000,000	3,000,000	9,000,000
UP	0	0	0	0	0	0	0
RM	15,720,000	5,720,000	2,500,000	2,500,000	2,500,000	2,500,000	15,720,000
CSM	2,737,028,581	329,670,000	651,000,000	480,250,000	511,401,250	744,577,331	2,716,898,581
Branch	0	0	0	0	0	0	0
HR	0	0	0	0	0	0	0
ICT	0	0	0	0	0	0	0
Ad&Lo	0	0	0	0	0	0	0
	4,615,448,581	756,300,000	921,740,000	941,330,000	972,981,250	998,657,331	4,591,008,581

<u>Responsible Department/ Unit/ Section</u>
Leak detection and pressure management Section: LD&PM
Zoning and mapping Section : GIS
Inspection and Enforcement Section: I&E
Water Production Section: Production
Water Distribution Section: Distribution
Quality Assurance Unit: QA
Utility Planning Unit: UP
Revenue Management Unit: RM
Customer Service Management Unit: CSM
Direction Support Service: DSS
Human Resource Unit: HR
Administration and Logistics Unit: Admi & Logistics

WASAC
Water & Sanitation Corporation
'Dignifying Life'

WASAC Ltd Board of Directors in their Board Meeting Session dated 27th/04/2018, Approved WASAC ltd 5 Years Strategic Plan for Non-Revenue Water Reduction.

Board Member Present

No	NAMES	POSITION	SIGNATURE
1.	Dr. MUNYANEZA Omar	Chairperson	
2.	DUSHIMIMANA Lambert	V/Chairman	
3.	DUSHIMUMUKIZA Déograthias	Member	Absent in the meeting
4.	UMUHIRE Chantal	Member	
5.	ABABO Peace	Member	maternity leave
6.	KAYITESI Marceline	Member	
7.	NDATSINZE Felix	Member	
8.	Eng. Aimé MUZOLA	CEO/Secretary	
9.	UMUHUMUZA Gisele	Deputy CEO	

5 Years Strategic Plan

For

Non-Revenue Water Reduction

Water and Sanitation Corporation

WASAC Ltd

Table of Contents

1. Introduction

1.1 Background

Rwanda has made impressive progress in extending water supply and sanitation coverage during the past few years under clear political commitment, proper institutional framework and an updated national policy and strategy. While striking results have been achieved in the recent years, considering many years of neglect and the low base from which Rwanda has emerged, water supply services still need improvement to ensure sustainability, availability and affordability to all Rwandans.

Water and Sanitation Services in Rwanda have been delivered under a bundled Energy and Water utility service. The utility has undergone a various changes in the last 15 years - from the initial bundled structure of ELECTROGAZ; to the initial attempt to unbundle the utility into RECO and RWASCO; again, bundled to EWSA; which finally gave birth to WASAC and REG.

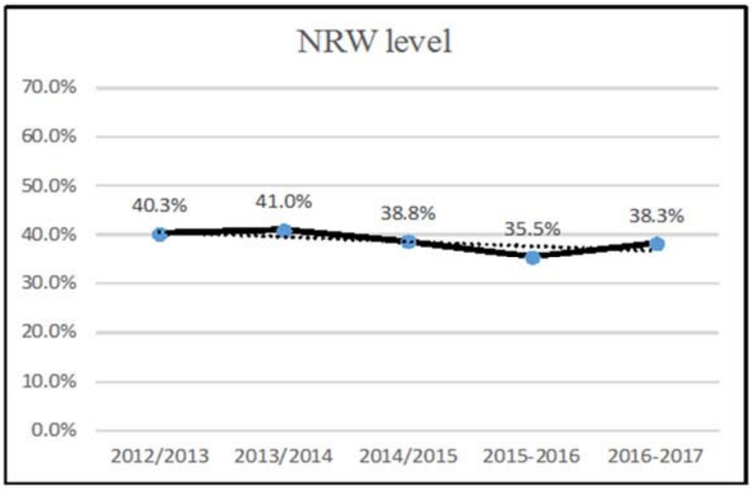
WASAC was established in 2014 as the utility to manage the water and sanitation services in Rwanda and currently focused on the provision of new infrastructure; delivery of efficient and effective services; development of strong human capacity; and meeting key national milestones. WASAC committed to provide quality, reliable and affordable water and sewerage services by establishing a sustainable and customer-oriented utility that would improve the lives of Rwandans.

As many other water utilities across the world, WASAC is still facing a massive challenge of having high ratio of Non-Revenue Water (NRW) at a rate of 35,5 % (2015-2016).NRW is defined as the difference between the volumes of water introduced into the water distribution system and the volumes of water billed. Reducing NRW is critical for financial stability, efficient resource utilization, efficient utility management, enhanced consumer satisfaction and postponement of capital-investment to increase water supply capacity.

There has been great improvement in NRW reduction from the creation of WASAC particularly from the second semester of 2015 (July to November 2015) mainly due to the creation of the NRW unit which is dedicated to monitoring and managing the NRW at the national level and implementing the performance improvement program (PIP) from October 2015.The PIP is focusing on the improvement of key strategic areas including NRW reduction where each branch has a target to achieve according to the overall NRW reduction target of WASAC.

Despite many efforts and strategies currently implemented within WASAC, the level of NRW is still increasing to the level of 38 % (2016-2017).

Therefore, there is a strong need for WASAC to have a consistent and holistic Strategic plan which indicates the clear direction to address progressive NRW.



Year	NRW level
2012/2013	40.3%
2013/2014	41.0%
2014/2015	38.8%
2015-2016	35.5%
2016-2017	38.3%

Figure 1 : NRW trend from 2013- 2017

Table 1 : 2016-2017 NRW rate per branch

ANNUARY (2016 Jul. -2017 June)					
No	Branches	Water Supplied	Water Billed	Difference	NRW
		m3	m3	m3	%
1	KIGALI City	26,902,655	16,723,474	10,085,964	37.5%
2	MUHANGA	888,627	632,579	256,048	28.8%
3	RUBAVU	2,996,017	1,636,568	1,359,606	45.4%
4	MUSANZE	2,393,538	1,594,434	799,296	33.4%
5	RUSIZI	990,791	672,363	318,428	32.1%
6	HUYE	2,074,429	1,203,245	870,816	42.0%
7	NYANZA	595,437	401,255	194,182	32.6%
8	NGOMA	463,982	346,862	117,865	25.4%
9	GICUMBI	567,590	371,376	196,214	34.6%
10	RWAMAGANA	1,977,613	966,024	1,019,754	51.6%
11	NYAMAGABE	554,102	365,764	188,632	34.0%
12	KARONGI	450,962	302,829	148,133	32.8%
13	NYAGATARE	1,812,136	954,465	857,671	47.3%
14	BUGESERA	1,220,017	828,112	391,905	32.1%
15	RUHANGO	325,230	207,646	117,478	36.1%
TOTAL		44,213,124	27,206,996	16,921,989	38.3%

This 5 Year Strategic Plan (5YSP) identifies all components to be tackled, priorities, necessary budget and timeframe in the next 5 years to improve WASAC performance and then ensure financial and commercial viability of the company.

The successful implementation of this 5YSP will require the total investment of around 4.6 Billion Rwf (excluding major CAPEX) to act mainly on Network rehabilitation, billing and metering improvement. However, the budget is not the only obstacle to overcome, the other challenges are related to human resources capacity development, institutional reform, change management, cost optimization and efficiency of the operations.

WASAC's Vision and Mission

Vision: To be the most sustainable Water and Sanitation Utility in Africa, exceeding stakeholder's expectations

Mission: Providing quality, reliable and affordable water and sewerage services through continuous innovations and detailed care to our customers' needs

1.2 5YSP for NRW Reduction guiding documents

Reaching WASAC vision and the ambitious national target (EDPRS III, VISION 2020, 7 years' government program) and the SDG6 dedicated to water and sanitation requires Rwanda to address universal and equitable access to drinking water and sanitation along with issues of quality and supply. There is an urgent need to increase the production to meet the demand and reduce the NRW for the efficient use of produced water and the financial stability of the company.

This 5YSP develops a specific, realistic and integrated strategic plan where all issues related to NRW have been diagnosed, root causes clarified, strategies and specific actions to address the identified issues proposed with estimated budget and timeline.

1.3 Non-revenue water reduction target

To ensure the sustainability of water supply in WASAC Ltd service areas, there is a need to address the current production gap and reduce the NRW at the minimum level. In accordance to the WASAC 5 Years Strategic Business Plan formulated in November 2015, the target is to reduce the NRW rate from 38% to 25% in 2019/2020.

Considering the NRW reduction achievement for the past 2 years compared to the planned target, the timeline must be extended to the year 2022/2023 as presented in the table below

Table 2: Target for NRW reduction for the coming 5 years

Financial year July to June	5 Year Strategic Business Plan	Target value of 5 Year Strategic Business Plan	Implementation Year of 5YSP	Phase of 5YSP	Actual NRW level value %	Proposed New NRW rate
2015/16	Year 1	38%			35.50%	
2016/17	Year 2	32%			38.30%	38.30%
2017/18	Year 3	28%		Preparation		38%
2018/19	Year 4	26%	Year 1	Phase 1		35%
2019/20	Year 5	25%	Year 2	Phase2		32%
2020/21			Year 3			30%
2021/22			Year 4			28%
2022/23			Year 5			25%

The NRW target rate for Kigali city will be confirmed after the implementation of identified NRW reduction activities in pilot areas (kadobogo in kacyiru branch and Runda in Nyarugenge branch) which are being implemented by the joint of WASAC and Japanese experts under the project of NRW reduction with the support of JICA.

2. Methodology and approach

2.1 Procedure for the preparation of the Plan

The Preparation of this 5YSP began in August 2016 and involved the participation of JICA technical cooperation, WASACs directorates, unit, branches and Water treatment plants through interviews, questionnaires, field visits, workshops. The NRW reduction measures currently implemented by WASAC in Kigali and upcountry branches (14 branches outside Kigali) were assessed by consulting different WASAC reports, field visits to assess the network condition, interviews with different WASAC officials, branch managers and Head of water treatment plant.

During the assessment, following steps was conducted in each branch:

1) Questionnaire to 20 Branch Offices and Head Office
2) Water network visit in 20 Branches
3) Reports and Customer Data Base analysis.

Different workshops and seminars were organized to discuss the results of above mentioned topics and propose the countermeasure for each problem identified as presented in the diagram below

Problems identification

↓

Root cause analysis

↓

Proposal of counter measures/strategy

↓

Preparation of Action Plan

2.2 5YSP work Plan

The Work Plan is divided into 2 phases in accordance with the activity content:

a) Phase1: Immediate actions with quick impact (July 2018 to June 2019)

The urgent issues to be addressed have been identified (see table N..) and will be implemented in year one of the implementation of the 5YSP to ensure quick results with available means. These actions will be implemented in parallel with the ones in pilot area of the joint NRW reduction project with JICA (Kacyiru Branch: Kadobogo, Nyarugenge Branch: Ruyenzi) to ensure that the experience gained is being applied in the large scale of WASAC network. Besides Kacyiru and Nyarugenge Branch where the pilot project will be implemented, the same NRW reduction strategies will be applied in other WASAC branches. At the end of this phase, the 5 YSP will be revised for a more concrete one considering the achievements and challenges

b) Phase 2: Routine works (from July 2019 to June 2023)

The NRW reduction routine activities will be implemented based on the experience and technologies acquired in the previous Phase and from the joint NRW reduction project with JICA.

This NRW reduction 5-year Strategic Plan will be updated yearly to a more practical plan based on result of the previous years.

3. Current Situation of NRW Reduction Activities

3.1 Problem Identification

The present conditions and problems extracted as a result of analysis of the basic information are as follows.

a) Insufficient water supply (water shortage)

Most of the WASAC branches have a serious problem of water shortage. The supply gap is mainly due to the current production which is not yet meeting the demand. There is an intermittent supply where water is supplied to areas in daily rotation or only in some hours in the daytime or nighttime. From this situation where water is not supplied continuously, air is mixed into water, hinders correct flow and customer meters measurement. Furthermore, leaks can be detected only if the distribution pipes are filled with water. In addition, When the water supply pipe is broken, sometimes sand and stones may penetrate pipes from leaking point and cause meters blocking. Continuous water supply is an essential condition for the effective implementation of NRW reduction measures.

b) Input volume meter inaccuracy

Although all WASAC water treatment plants and pumping stations are metered, there is still the challenge of ensuring the accuracy of these bulk meters. Some bulk meters are aged, have not been calibrated in so long, inappropriate installation position (close to pumps and bends) and the size of the meters sometimes not appropriate.

There is a need to asses all bulk meter’s condition and proceed for replacement or installation of new meters to ensure the accuracy of the water volume input in WASAC water network.

c) Meter reading and billing

Although 100% of WASAC customers have meters, meter reading and billing still needs improvement. Some customers are not billed on monthly basis; others are billed zero consumption while they may have consumed water. Some commercial Field officers do not note down customer indexes and sometimes speculates the consumption. The field inspection by billing inspector to ensure accurate readings is not yet sufficient;

There is not a clear procedure on replacement of customers meters. Ad hoc meter replacement has been done mainly for the blocked meters or from customer complaints.

From the last customer inventory done in Kigali, it has been observed that more than 18 % of Kigali WASAC customers' meters are more than 15 years old, which compromises their accuracy.

Customers' meters have not been tested on site. Only the metering services in Kigali has a test bench. There are a considerable number of meters blocked because of intermittent supply where the service pipe became corroded. Alternatively, sand and other solid particle from leaking pipe can enter and remain suspended in the service pipe due to poor repair work.

The importance of large customers management is recognized. However, insufficient customer consumption analysis has been conducted (only checking of abnormal consumption). Analysis of customer data is extremely required.

Customers who have subscribed to WASAC prepayment system, are billed monthly and after a certain period the adjustment with the real meter readings(consumption) is not done timely.

Some customer meter are not really accessible , sometimes its requires the Commercial Field Officer to move the whole compound or cross buildings to reach the meter . the meter location should not exceed 3m from the fence.

d) Unbilled unmetered authorized consumption

Usually, WASAC estimates the unbilled authorized consumption at 2% of the total water supply in the system (Water for flushing pipes and cleaning reservoirs). Water for firefighting (for fire hydrants which are not yet metered) is not yet included.

e) Water Thefts (Illegal Connections) and Vandalism

In the past two years, about 150 cases of illegal water usage have been confirmed. Many of them have been reported by informers and are from households. The involvement of branch staff to find illegal connections is still low. There is not yet a strong campaign organized to find illegal water users , customers are visited not because of their strange historical consumption trend but on the available information from informers. Public awareness on water theft is not yet sufficient, resulting to an unaware public.

Some WASAC water infrastructures equipment are not protected (manhole not covered) and it has been observed that some people destroy water infrastructure to fetch water or to steal water network equipment.

There is a need to involve local authorities for water infrastructure protection.

Table 3: Number of confirmed illegal connection per branch 2015 -2017

No	Branch	Nbr
1	Bugesera	3
2	Gikondo	7
3	Huye	5
4	Kacyiru	11
5	Kanonbe	8
6	Muhanga	3
7	Musanze	4
8	Ngoma	11
9	Nyagatare	14
10	Nyamirambo	1
11	Nyarugenge	12
12	Remera	14
13	Rubavu	6
14	Ruhango	3
15	Rusizi	1
16	Rwamagana	42
	Total	145

f) **Planning and Design of water network**

The current WASAC water network design condition still presents some substandard which need to be addressed. Basically, all Water distribution pipes should originate from a water distribution tank. In Kigali and other WASAC water network this is not always the case. Some areas are supplied with water directly from a pumping stations or treatment plants. This can be one of the causes of high pressures in supplied areas.

Although, the transmission pipes should be independent pipes that are used for the purpose of transmission between a treatment plant and a distribution tank; the present water network condition has no functional separation among transmission pipes (basically, constant flow rates and continuous transmission) and distribution pipes (change in distribution volumes in time). In this case the establishment of DMA (District Metered Area) and distribution management is quite difficult.

The distribution tank should also adjust differences between transmission and distribution volume. It is necessary to separate transmission and distribution pipes via distribution tanks.

The lack of design of pressure distribution blocks according to altitudes and the direct delivery of water by the pumps from the treatment plants to a distribution tank at the highest altitude cause the pumps to use excessively high transmission pressures (a waste of electric power). Therefore, high distribution pressures are used in the distribution areas with low altitudes and require high pressure resistance pipe materials and promote water leaks (Gatsata case).

Houses and buildings are sometimes built on the ground over transmission and distribution pipes, making the maintenance of those pipes difficult.

g) High Pressure in WASAC water network

High pressure in the network increases the volume of water lost due to leakages and reduce the water network infrastructure lifespan .Sometimes the pressure level exceeds the nominal pressure of installed pipes which lead to frequent pipes leakages and burst (case of Nyarurenzi network). Currently, WASAC does not control and monitor the pressure in its entire water network. Pressure zones (High and low) have not been identified, the acceptable pressure range not yet determined; Pressure measurement is not conducted according to a survey plan and in all the areas. Other challenges include pressure gauge which have not been installed in WASAC network. insufficient pressure reduction measure that have not been implemented in WASAC network and some PRVs (Pressure Reducer Valve) which have been installed with insufficient pressure survey, hydraulic calculation and specific long-term plan of installation and maintenance.

h) Frequent Leaks and burst

An average of 90 leaks per days are being reported and repaired by WASAC branches. The majority of leaks reported are from service connection pipes mainly due to poor quality of pipes fittings or installation works. Nyarugenge, Gikondo, Musanze and Rubavu branches consist of a large number of leaks reported on distribution pipes due to aged pipes.

There have been a number of infrastructure developments across the country mainly for road construction, house construction and the laying of optic fiber which are destroying water infrastructure and leading to leaks and busts. For several of the distribution tanks, the water level gauges are not operational and water level is not properly measured and monitored. On some distribution reservoirs, float valves are not working or not installed. This situation leads to frequent reservoirs overflows.

WASAC does not consist of a trained, dedicated team that monitors active leakages at branch level and leak detection equipment are not sufficient for leak detection. Mainly visible leaks (usually leaking for long periods of time) are reported and repaired. Usually, leaks are reported by the population through call center, via twitter @wasac_rwanda or direct calls to branch staff, this cannot ensure that all leaks have been reported. The response time to pipe repair is still low due to the unavailability of material and logistic issues (means of transport).

The quality of repair is sometimes compromising because of poor standard of material (fittings) and less awareness of staff.

Leak and bust recording, analysis and reporting is not carried out properly, it is still challenging to get all leaks information and details (location, diameter and material) from branches.

Leaks survey are not regularly performed, few minimum night flow measurement have been done in branches because there is a lack of sufficient equipment, number of trained staff and the design of the existing water network (difficulty in identifying a specific area).

i) Asset management

WASAC water network has been mapped but still need correction and adjustment as per build network. The procedure of network update still needs to be revised and disseminated to all GIS users. The current branch structure do not facilitate GIS data update due to lack of staff with expertise. The use of GIS data and network maps is still low due to less awareness and traditional routine habit. New customers connections, network extension and modification in the network should be regularly uploaded on GIS database.

The network maintenance and rehabilitation plan has not been fully implemented mainly due to the budget constraint , the large amount of the company budget is allocated to increase the production and access. Therefore the delay in network rehabilitation and no proper and regular preventive maintenance of water infrastructure resulting some nonfunctional and unreliable water infrastructure.

j) Standard of material and construction water works

Currently, WASAC new customers purchase their own materials for new connection (pipes, fittings and protective equipment) these materials are normally in poor condition and sometimes not compatible to the existing network condition (mixing pipes and fittings made in dissimilar materials).

Although the major part of WASAC water network is well designed , there is still some distribution pipeline which doesn’t not meeting required standard in term of size and the type of material. There are some distribution pipes installed without considering the quality of soil (cause of corrosion). There are also some substandard water works which are done by private contractors mainly due to less involvement and supervision from WASAC staff.

There are a number of trenches that do not respect the standard measurements, which then expose the pipes. Sometimes the connection is not done with proper equipment mainly for pipe cutting and drilling. These are causing water loss as indicated by the daily leakage reports.

Lastly, WASAC is yet to assign a dedicated team for water works inspection mainly for the new connections and leak repaired.

k) Stakeholders management

WASAC started public awareness campaign through local media but still general public is not yet sufficiently involved and aware on NRW which lead some time on delay of report leaks or illegal connection and the protection of the water supply infrastructure. There should be an organized strong awareness campaign on regular basis and direct contact with the population through community works (umuganda) , visit of schools, universities and churches.

There is also less coordination and collaboration with other infrastructures developers (mainly road constructors and telecommunication companies) which lead sometimes to the damage of WASAC water infrastructure and water loss.

l) Staff capacity

There is a certain level of individual capacities which should now be extended at company level. The framework of sharing and expanding knowledge is not ye strong enough. WASAC has quite number of skilled and experienced staff but which is not yet reflected in company performance. There is a need for a strong staff capacity development and knowledge sharing program.

m) Logistics issues

There is no enough material, equipment and means of transport for WASAC operations. These include, to mention but a few;

i) One vehicle for the all activities in each branch

ii) Frequent shortage of materials mainly fittings and small pipes for reparation which lead to poor reparation and delay of leak repairs.

3.2 Assessment of root causes of identified problems

After the problem identification, root causes of each problem have been identified through meetings and workshops with different units and the results are summarized in tables below (Technical, Commercial and Administrative).

Table 4: Root causes of problems

a) Technical

Nr	Problems	causes
A	Production	
1	Intermittent supply (frequent rationing)	• High demand vs production • Delay in investment of production • Rapid urbanization • Limited funds • undersized pipes • Undersized reservoirs capacity • less knowledge of network • network design • Electricity cut off
B	Leaks and Burst	
2	High pressure in the network	• Topography of the ground • Lack of pressure management skills • less knowledge of the network (maps, network information) • Insufficient protective equipment in the network (valves , PRV…) • Network design (PN pipes installed VS service pressure)
3	Time response to leaks repair still low:	• Insufficient logistic facilities (vehicle, tools, etc…) • Ownership, communication, • Insufficient material (mainly fittings for reparation) at the branch level • Few number of Technicians at the branch level • less knowledge of network • less records and analysis of leaks
4	Lack of Leakage survey	• less knowledge on leakage survey (technicians) • insufficient staff and logistics (car and equipment)
5	Lak of Leak detection activities	• less knowledge on leak detection • Insufficient Leak detection equipment • Complexity of the WASAC water network (design, pipes material, ground)
6	Inappropriate pipes installed	• No enough knowledge on pipe choice (Eg , Use of PE pipes instead of HDPE pipes; more than 200mm installed in high pressure zones) . • Not enough material in the store (sometimes pipes installed due to its availability) • Budget constraint • Less management control system for pipe installation

Nr	Problems	causes
7	Leaks and overflows on reservoir	• Insufficient protective equipment and poor maintenance • Insufficient operational and monitoring skills on water network facilities • Some old and leaking reservoirs • Poor Construction of some reservoirs • No clear management of thanks and reservoirs (Responsibility of branch or WTP)
8	Poor Maintenance	• Lack of operational and monitoring skills on water network facilities • Less awareness • Poor maintenance plan (Reactive approach • Insufficient Logistic means (vehicle, tools, ...)
9	Many Leak on service pipes	• Poor quality of materials mainly procured by customers • High pressure in the network • Poor standards for service connection • inappropriate tool for connection (pipe cutting , pipe drilling , pipe welding etc…
10	Poor quality of repairs	• lack of appropriate material, • long process of material requisition • Less knowledge and ownership of technician
11	Under estimation of water loss caused by construction works	• Low of awareness of NRW • Challenge in estimation of water leaking time
12	Many service connections connected to small distribution pipes (Eg 3/4 and 1" pipe , tertiary with tertiary)	• Insufficient distribution pipelines (extension) • Budget constraint • Less awareness of new connection standard and design • Lack of planning and implementation considering future urbanization • Complexity of existing informal settlement
13	Many leaks at cramps & saddles	• Lack of regular maintenance • Sometimes poor quality of material and work • High pressure in the network
14	Leaks from some pipes newly installed	• Poor quality of work and material • Poor Design/ implementation • Less knowledge
15	Water loss during pipe repair and pipe replacement	• Complexity of network (few sectioning valves) • High pressure in the network • Insufficient logistic and material (sometime not material not available) • Inappropriate tools for connection (pipe cutting, drilling and welding)
16	Surge effect, transient phenomenon, water hammer on pipeline caused by rationing (opening and closing valves	• Interruption of water supply and regular closing and opening valves • Insufficient and some faulty number of protective equipment in the network (air valves, anti-harmer tanks, etc.) High pressure • frequent power cut

Nr	Problems	causes
		- Poor maintenance of protective equipment Unknown and Inaccessible protective equipment (air valves, valves, etc..)
C	Design and mapping	
17	GIS data not updated	- insufficient GIS staff - less awareness of GIS importance - less knowledge of the network (Unknown pipelines) - insufficient equipment (GPS, appropriate computer, etc..)
18	Poor design of water network	- Lack of ownership - Less awareness - Low knowledge on Hydraulic calculation - New projects do not consider long term future demand
19	Different information on customer database from GIS & CMS	- GIS and CMS is still being updated
20	Pressure gauges not sufficient in number for pressure	- Lack of awareness - Less Planning of pressure management
21	high lift-pumps installed	- Less awareness - Budget constraint - Poor design - Complexity of the topography
22	Primary mains undersized	- Less awareness - Budget constraint - Poor planning and design
23	Distribution pipes and service pipes connected directly to transmission main	- Less awareness - Budget constraint - Poor planning and design - Water shortage
24	Flexible joints not installed where required	- Less awareness and knowledge - Budget constraint
D	Standards	
26	Inappropriate material during design /Implementation	- No enough knowledge - Negligence - No study of soil type - Not enough material in the store - Less inspection and control of works
27	Substandard service connection	- No standard procedure manual for new connection - Lack of ownership and induction for new staff - Insufficient distribution pipes
28	poor quality of connection material	- use of cheap material purchased by customers - less control of material purchased by customers
29	Trenching and backfilling sometimes not well done	- procedure manual of works (no formal guidelines) - insufficient Manpower - insufficient knowledge
30	Inappropriate pipe following the region and the quality of soil	- Less awareness and knowledge on soil handling - Soil handling not include procedure manual of works

Nr	Problems	causes
31	Many connections to small size (Eg ¾ as distribution pipes)	- poor planning - budget constraint - informal settlement
32	Substandard materials on local market	- low purchasing power - less control
33	Poor Quality of material(Standards)	- Substandard materials on local market - less ability for pipes testing
34	Not compliance of standard house connections	- Less awareness - Negligence - Less supervisions and inspection of new connection - No certified technicians for new connections
35	Poor quality of materials purchased by customers	- Low purchasing power of customers - Ignorance - Less control and inspection of material purchased by customer
36	Less of on-site work and material standard inspection	- No staff (team) dedicated and trained for work and material inspection
37	Straight pipe length not sufficient between valves & meters	- Less awareness and knowledge - Complexity of existing meter installation
38	Thrust force not considered properly	- Less awareness and knowledge - Negligence
39	Old Galvanized Steel Pipes installed (48.6km)	- Budget constraint
41	Inappropriate pipe fittings and accessories	- Less awareness and knowledge - Negligence - Sometimes fittings not available in stores (procurement plan)
E	Asset management	
44	Aged pipes and less protective equipment (valves, PRV, Air valves, water hammer tanks, etc)	- poor planning and implementation - Irregular maintenance, - budget constraint
45	lack of preventive maintenance plan	- Poor planning, - budget constraint
46	No plan for network Flushing	- Poor planning, - Network design
47	Insufficient valves for network management	- poor plannig , - network design
48	Air pocket caused by lack air valves or not properly installed.	- poor plannig , - network design
49	Less flush of service pipes before the new meter installation	- water shortage - ownership
50	Use of PE pipes instead of HDPE pipes	- No enough knowledge
51	Corrosion of pipes (DCI Pipes, steel pipes…)	- corrosive soil - water quality - choice of material - non internal and external protection coating

Nr	Problems	causes
52	under sized pipes	• poor design and planning, • Rapid urbanization
53	Pipe replacement planned but not fully implemented	• Poor planning • Budget constraint

b) Commercial

Nr	Problems	causes
A	Unauthorized consumption	
1	Illegal water use cases	• wrong attitude from some customers and staff, • Less investigations and enforcement • No compliance of new connection Standard that facilitate customer to remove meters • Inappropriate Meter location • Meter not protected (meter box) • Less customer awareness on water tariff
2	Illegal water use to disconnected customers (inactive connection)	• wrong Attitude, • Poor management of disconnected and inactive customers • Disconnection practices allowing easy illegal water use • Less inspection of disconnected customers
3	Less inspection of customer installation	• Less awareness • Few number of staff at the branch level • Insufficient logistic (cars , motorcycles, etc..)
B	**Billing**	
4	Some Customers not billed	• Negligence of some CFO's • Big number of customers assigned to CFO • Scattered Households in certain areas
5	Many zero consumption	• Lack of water, • Closed customer's compounds, • Blocked and unreadable meters • Illegal water usage • disconnected customers due to unpaid bills • negligence of CFO's
6	Less field inspection by billing Officer and Commercial services staff	• staff mainly focused on revenue collection (less staff involved in meter reading inspection) • less number of staff at the branch level • insufficient logistic (car, motorcycle , etc..)
C	**Data acquisition and analysis**	
7	Error in data acquisition (meter reading)	• less staff ownership, • internet network connection sometimes not available; • Unreadable meters • Human errors • Bad attitude of some staff (CFO's)

Nr	Problems	causes
8	Lack of data analysis (consumption, billing, zero consumption, etc..)	• Less staff ownership • Insufficient knowledge for Data analysis • People in charge are assigned to other tasks (front desk, recovery, etc..) • Less number of staff at the branch level
9	Under estimation of consumption	• Less awareness and knowledge • Blocked meters, unreadable and damaged meters • Negligence
10	Many inactive/abandoned /disconnection public taps and some not located on demand basis	• Increase of house connection in the area • Poor planning • Poor public tap management
11	Non-served population Information not available	• Customer inventory not yet completed for urban towns • Customer inventory not yet started for urban towns
D	**Metering**	
13	Poor implementation of meter installation and replacement policy	• No compliance of meter installation and replacement policy implementation • less knowledge • reactive approach for the replacement
14	Meter inaccuracy	• No planning for customer's meter testing and replacement • Insufficient water meter test bench (onlyKigali) • Use of inappropriate meter size • Aged meters
15	Tampered meters	• wrong attitude and vandalism • less inspection of customer's installation at branch level • meter not sealed
16	Water meter blocked by solid particles	• less flushing after repairs and new connection • Aged and corroded pipes
17	Many aged water meters	• No implementation of policy and standard for meter replacement • Unrespect of meter replacement plan • Less prioritization on meter replacement at branch level • Sometimes lack of meters
18	Customer meter accuracy test not practiced on-site	• Less awareness • No tools for meter on-site testing at branch level • Insufficient logistic (car, motorcycle)
19	Different types of meters installed in our network	• Delay of meters' replacement • Rapid technology development • Different partners bringing meters
21	Meter reading skill (awareness)	• Less commercial field officer induction for the metering
22	Long process for meter test (mainly upcountry)	• Unavailable meter test bench in upcountry branches • Less awareness and knowledge of staff on meter testing

c) Administrative

Nr	Problems	causes
A	**WASAC**	
1	Limited budget for network rehabilitation and maintenance	• limited revenue • low water tariff compare to expenditure • High NRW • Less organization focus on network rehabilitation (priority to increase production) • More attention on production and network extension than rehabilitation and upgrade
2	Less ownership by some WASAC staff	• Less awareness on NRW • Less motivation and bad attitude for some staff
3	Poor knowledge on how to asses NRW component and causes	• Less awareness • Insufficient training • New concept
4	Insufficient logistic means (cars and Motorcycles) and material to ensure quick intervention and repair	• limited budget • Long process and bureaucracy
5	Lack of enough staff at the branch level and at HQ mainly ones dedicated to NRW reduction	• limited budget • Less organization focus on NRW reduction (revenue collection and increase of production) • Insufficient number of staff for NRW reduction
6	Poor analysis and reporting system on NRW	• limited knowledge
7	No enough induction period for new staffs	• Weakness in Human Resource Development • Lack of procedures for training
8	Less supervision and inspection of contractors works	• Negligence • Overloaded staff • Less knowledge on engineering work supervision
9	Poor pipe handling and inadequate storage (no support)	• Less awareness • Less storage facilities (space) in branches
10	Standard, specification of materials and works not shared to the branches	• Less awareness • Less knowledge sharing about standard
11	Lack of appropriate staff training	• Budget constraint and awareness • Lack of implementation of capacity building planning
12	Less communication between branches, HQ	• Poor reporting system • No shared storage for public documents(maps ,procedure manual ,standard and policy)
13	Less storage facilities at Branches level	• No appropriate space for storage at branches • Store management (no dedicated staff for stocks)
B	**CUSTOMERS**	
14	Customer purchasing power	• low income that lead to the purchase of low quality material
15	Customers awareness on NRW still low	• insufficient sensitization
16	Vandalism	• bad attitude • Many customers consider water should be free • Many non-served population (house connection)

Nr	Problems	causes
C	OTHER STAKEHOLDERS	
17	Lack of stakeholder awareness on NRW	- insufficient sensitization
18	Infrastructures development partners not considering the facilities of all parties (utility, partners)	- lack of collaboration among different utilities/stakeholders - negligence
19	Lack of policy and collaboration between road administrator and utility companies	- lack of collaboration among different utilities/stakeholders
20	Very high expectations from many stakeholders	- Rapid development of the country
21	Too Ambitious target which sometimes lead to substandard works	- Rapid development of the country - Budget constraint
22	Unplanned settlement in some area	- financial incapability to implement urbans master plans quickly
23	Poor quality of work done by contractors	- Limited human capacity from contractors - poor supervision
24	Limited human capacity from contractors	- lack of qualified system of contractors - lack of professionalism
25	Pipe damaged by road construction	- No clear policy of collaboration between road administrator , road constructor and utility companies
26	Building constructed on the pipes	- No clear policy of collaboration between urban administrator, construction company and utility companies - Less knowledge of the network - Less consultation from road construction

4 Strategic Plan for NRW Reduction

4.1 Reduction measures

From the result of the root causes analysis a series of workshops with different units has been conducted to set up strategies and actions that should be implemented to address the current identified problems.

Reference is made to International Water Association (IWA) water balance table, the proposed 133 specifics actions were classified in 5 main components (water supply system inflow measurement accuracy, commercial losses, Technical losses , unbilled authorized consumption and supportive measures) and grouped in 42 strategies. An order of priority was set gradually based on quick actions with high financial impact; medium term actions which do not require huge investment and long term actions which require huge capital investment and other resources

Table 5: IWA Water Balance Table

System Input Volume	Authorized Consumption (Effective water)	Billed Authorized Consumption	Billed Water Exported	Metered	Revenue water
			Billed Metered Consumption		
			Billed Unmetered Consumption	Unmetered	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Metered	Non-Revenue water
			Unbilled Unmetered Consumption	Unmetered	
	Water Losses (Ineffective water)	Apparent Losses (Commercial losses)	Unauthorized Consumption	Metered/Unmetered	
			Customer Metering Inaccuracies and data handling error	Metered	
		Real Losses (Physical losses)	Leakage on Transmission and/or Distribution Mains	Leakage	
			Leakage and Overflows at Water Reservoir		
			Leakage on Service Connections up to point of Customer Metering		

Table 6 shows the framework of the NRW reduction 5-year Strategic Plan

Table 6: 5Year Strategic Plan for NRW Reduction (see attachment)

Table 7: Responsible Section in WASAC for the Implementation of NRW Reduction Action Plan

Component	Strategy	No*	Responsible Section of WASAC
A. Water supply system inflow measurement accuracy	A1. Volume input metering accuracy	7	WO (Production, Distribution), NRW, CSM (Metering)
	A2. Water production (prevent intermittent supply)	4	UP, WO(Production)
B. Commercial loss	B1. Meter reading and billing	18	DCS, RM(Billing), CSM(Metering), Branches, WO(GIS), DSS(ICT),
	B2. Customers meter management (normal, large and public tap)	7	RM(Billing), CSM(Metering), Branches, WO(GIS), DSS(ICT)
	B3. Illegal Connection	7	NRW (Inspec. & Enforce.), CSM(Metering), RM(Billing), Branches
C. Technical loss	C1. Pressure management	13	WO(GIS, Distribution), NRW(LD&PM), Branches
	C2. Asset Management (Rehabilitation)	10	WO(GIS, Distribution,), CSM(Metering), Branches
	C3. Leaks and burst repair	18	NRW(LD&PM), WO(GIS, Distribution,), Branches, QA(Standard),
D. Unbilled authorized consumption	D. Unbilled authorized consumption	6	RM(Billing), CSM(Metering), Branches, WO(Distribution,)
E. Supportive measures	E1. GIS and CMS database	4	WO(GIS), DSS(ICT), RM, HRM, Branches, NRW
	E2. Planning, design and implementation of works	10	UP, QA(Standard), CSM(Metering), Branches, WO(Distribution), DUWSS
	E3. WASAC NRW management	6	WASAC, DUWSS, UP,NRW, HR
	E4. Stakeholders management	9	WO(Distribution), NRW, WASAC(DUWSS)
	E5. Training	9	WASAC(HR, NRW)
	E6. Institution	3	WASAC(DUWSS,DCS)
	E7. Logistic and quality materials	2	DSS (Admini&Logist.), DUWSS, , Branches
Total		133	

No*: Number of specific actions

4.2 Implementation structure of the Strategic plan

Each specific action was assigned to the responsible departments/units or section as mentioned in the Table7. The Figure 2 shows the responsible departments /units or section.

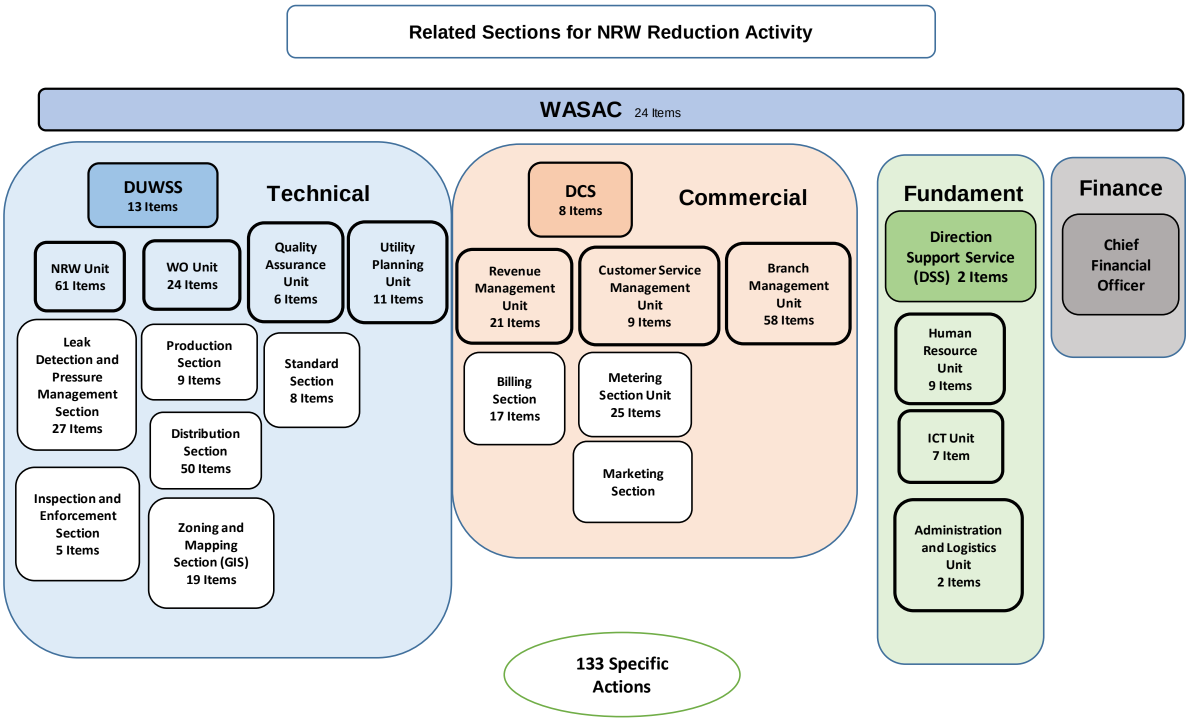


Figure 2: Responsible Department and Units of WASAC HQ

The figure 2 shows that real activities related to NRW reduction will be implemented mainly by 11 Units (NRW, WO, Quality Assurance, Utility Planning, Revenue Management, Customer Service Management, Branch Management, Finance , Human Resource, ICT, Administration and Logistics) wich belong to 4 departements (UWSS, CS, Financial, Support Service). Some unit are directly responsible of the implementation of the strategy and others are responsible of specific actions , see annex No 1. Therefore, the involvement and support of each WASAC staff is strongly recommended. The responsability of implementation of activities can be reviewed or adjusted considering the existing WASAC structure.

a) Implementation team

The DUWSS and Commercial directorates and NRW unit are key for the implementation of this 5YSP. The support services and finance directorate should ensure the full support for the implementation of this 5YSP.

The unit/section and team mentioned for specific actions are directly responsible of their implementation. The NRW unit will be the driving force for the implementation of all planned activities

b) Monitoring Team

The monitoring of the implementation of this 5YSP will be done quarterly with a team appointed by the Senior management. This team should be composed of the staff from DUWSS, DCS, Internal Audit and Branches. The monitoring team leader should be among the WASAC senior managers appointed by the CEO. The NRW unit will work closely with other unit/section to ensure that the activities are being timely implemented, compile and analyze all report to be submitted to the monitoring team. The Monitoring team will scrutinize the summarized report and select the section/ branches to be visited. The monitoring team will appoint the survey team for random on field visit to confirm realizations. At least, one monitoring team member and one staff from NRW units will be in the monitoring survey team. After the monitoring survey, the report will be presented to the Management on quarterly basis

4.3 Implementation and Monitoring Plan

As presented in the annex 1, the implementation and monitoring plan will help to track and assess the 5YSA results and achievements, it will be referred to and updated on regular basis. In addition, this implementation plan will guide the monitoring team on how to collect, analyze and dissemination data both to WASAC management and others stakeholders.

4.4 Budget for the Strategic Plan

For the successful implementation of this strategic plan, a budget of 4.6 billion Rwf has been estimated and should be considered at its approval stage by the WASAC Board of Directors. The phase one implementation has been considered in the approved budget for the Financial Year 2017/2018.

With reference to the detailed plan budget, the breakdown of the estimated budget is summarized in the bellow table

Fiscal Year	Budget (Frw)	Note
2018/2019	780,740,000	Phase one
2019/2020	921,740,000	
2020/2021	941,330,000	
2021/2022	972,981,250	
2022/2023	998,657,331	
Total	4,615,448,581	

This budget does not consider major CAPEX such as huge water network rehabilitation (which is currently under implementation through RSWSSP project) and the complete shift to remote reading metering or prepaid metering system which will be detailed later.

The Non-revenue water reduction in the 5 coming years will allow WASAC to expand and improve service, enhance financial performance and reduce energy consumption. The benefits associated with the NRW reduction from 38% to 25 % in the coming 5 years are various as the volume of water that can be billed will increase by 7.5 million m^3 and an incremental revenue of 11 billion RW on an average tariff of 500 Rwf/m^3 as presented in the table bellow

		2018/2019	**2019/2020**	**2020/2021**	**2021/2022**	**202/223**
System input volume (projection)		48,744,969	51,182,218	53,741,329	56,428,395	59,115,461
NRW ratio	Without NRW reduction	38%	38%	38%	38%	38%
	With NRW reduction	35%	32%	30%	28%	25%
	Difference	3%	6%	8%	10%	13%
Volume saved		1,462,349	3,070,933	4,299,306	5,642,840	7,685,010
Average tariff		500	500	500	500	500
Revenue increment		731,174,535	1,535,466,540	2,149,653,160	2,821,419,750	3,842,504,965

The implementation of this 5YSP involves some routine activities, other with big magnitude and completely new activities. Extra activities, which are not yet being implemented in WASAC will requires the total budget of 2.5 billion in 5 years as detailed in the table below.

Specific actions	Total amount (RWF)	2018/2019	2019/2020	2020/2021	2021/2022	2021/2022	Comments
		1st Year	2nd Year	3rd Year	4th Year	5th Year	
Installation of new meters / Replacement of faulty bulk meters / correction of meters installation based on the result of meter condition analysis	**102,500,000**	51,250,000	51,250,000				Systematic bulk meters assessment wich will required the replacement of fault or installation of new bulk meters
Procure additional Portable meter test equipment (at least 1 per branch)	**120,000,000**	120,000,000					Procurement of portable test meters for on site customer meter testing wich is the new activity within WASAC
Replace default and old meters	**848,563,947**	175,000,000	161,000,000	165,830,000	170,804,900	175,929,047	8000 additional meter replacement compared to the annual meter replacement plan within WASAC
Procure and install one water test bench per province	**100,000,000**					100,000,000	New activity plan to have at least one test bench in each province for deap customer meter test
Automatic meter reading or prepaid meters for big customers	**200,000,000**		200,000,000				New activity plan to have remote reading meters/prepaid meters on TOP wasac 200 customers
Procure and install pressure gauges in the network	**20,000,000**		10,000,000	10,000,000			New activity of installing at least 10 pressure gauges / branch
Implementation of pressure management plan* (PRV, BPT, rearrangement of pumping stations and pipeline network)	**164,400,000**	33,600,000	30,000,000	33,600,000	33,600,000	33,600,000	Installation of 12 PRV each year in addition of the existing 24 PRV installed yearly by WASAC
Implementation of the maintenance and rehabilitation plan*	**775,000,000**	155,000,000	155,000,000	155,000,000	155,000,000	155,000,000	Additional budget for water network maintenace and small rehabilitation
Procure and dispatch leak detection equipment to branches	**200,000,000**			100,000,000	100,000,000		New activity within branches . The leak detection equipment are only being done by HQ team
Exposure visits	**15,000,000**		7,500,000		7,500,000		Additional exposure visit for WASAC staff
RWF	**2,545,463,947**	534,850,000	614,750,000	464,430,000	466,904,900	464,529,047	

4.5 Funds mobilization mechanism for the implementation of 5YSP

Currently, the combination of funding sources (Tariff, Taxes) is not sufficient for the implementation of this NRW reduction strategic plan (routine activities and planned new activities). The conventional sources like funding from development partners (JICA, Vitens Evides, etc…) or NGOs through Water Sector Working Group (WSWG) could be one of the options. However, new funding mechanisms could be possible since NRW reduction is profitable for WASAC as mentioned in cost-benefit analysis. Therefore, there is needs to actively seek for new sources such as private partners and commercial banks to secure the budget necessary for the implementation of the 5YSP in timely manner.

In addition, when we consider the CAPEX, more sources will be needed. In this case, government and conventional sources are more realistic to fill the gap.

5 Important Note

As observed above, a specific, realistic and integrated 5YSP for NRW reduction has been developed. it means WASAC is now on the starting point toward the proper NRW management. From this point, WASAC has to take all actions mentioned in the 5YSP which requires 4.6 Billion RWF for coming 5 years. However, WASAC should note that more investment will be needed for NRW reduction, because this amount is not including CAPEX and general expenses.

To ensure the implementation of the 5YSP, yearly PDCA cycle (Plan: Preparation of annual plan, Do: Implementation of each action mentioned in annual plan, Check: Monitoring of the progress, and Act: Update the 5YSP in accordance with the progress and outcome) is quite important. WASAC is required to be always aware of this PDCA cycle and take a steady step forward.

NRW reduction is not the goal for WASAC. It is one of the tools to supply safe drinking water to all continuously. However, without proper NRW management, the goal will not be achieved.

ANNEXES

Annex 1: 5YSP Implementation and Monitoring Plan

Annex 2: Questionare submitted to WASAC branches

1. Problems related to the need for WASAC to take action against the unbilled water consumption

1.1 Problems of water serving activities

Please explain the issues in terms of the management of the water service WASAC through concrete enumerations, according to the examples listed below.

- Inadequate water service volumes in specific regions (Please provide documentation on forecasts of supply and demand, if they exist.)
- Increase in operating costs, management and maintenance of water treatment plants
- Improved low incomes (increase in commercial losses, inadequate service volumes) and management of WASAC

1.2 Issues relating to specific regions and installations

Please summarize in a table the branch offices, service areas and specific facilities under the supervision of WASAC particularly with problems and requiring priority action against the water consumed is not billed (name of branch management, name office, retail facilities, problem areas and content of current activities and measures). Also puting the location site maps, maps of service areas, distribution network maps as well as all the works plans. These maps and plans will serve us to select candidate sites for our study site.

For example, the 4 branch offices below have documented low coverage rate and priority measures against the water consumed is not billed are necessary. Please indicate whether there are specific areas of these branch offices.

Name of management	Office Name	Service rate attested (%)	Name of the region	Details of installations	problematic points	Measures

1.3 Issues related to the implementation of measures against WASAC water unbilled consumption

No		Order	Items	Content problem
1			Details of water service installations : supply, transfer and distribution	
2			Form of the distribution network, the relief of the region	
3			Control of information on existing lines, such as plans of the distribution network	
4			Control of distribution volumes and water supply pressure	
5			Plans and execution studies leaks	
6			Execution of leak repairs	
7			Data management and maintenance of the pipeline network, historic leaks, repairs and renovations	
8			Supply of materials for the repair and renovation of distribution pipes and service pipes, etc.	
9			Check the operation of installations water treatment plants, pumping stations and distribution tanks	
10			Check the operation of installations water treatment plants, pumping stations and distribution tanks	
11			Quality and standard of water meters specifications	
12			Management and maintenance of existing water meters, supply and meters of installations	
13			Installations, equipments and materials for inspection work meters	
14			Verification of consumption and preparation to meters the consumption data	
14			Volumes of water consumed and billed preparation bills	
15			Customer data management, analysis of the volumes used, etc.	
16			Water Assessment unbilled consumption, distribution volumes analysis	
18			Elaboration of annual plans of activities and measures against water not billed consumption	
18			Quality control work for the execution of activities and measures against water not billed consumption	

19			Organizational structure and execution of WASAC system to implement, globally or individually, activities and measures against water not billed consumption	
20			Execution capabilities of agents and implementation capacity of the entire organization WASAC	
21			Budget for the implementation of measures against water not billed consumption	
22			Various	

1.4 Considered problems by WASAC in terms of the implementation of measures against water not billed consumption

Based on the table above, what are the main reasons for the problem of water consumed is not billed for WASAC ? Please enter them in the order in the table in paragraph 1.3. If there is no section for some reason in the table, please register as a supplement.

Please also indicate the items considered necessary to solve and improve the effective implementation of measures against unbilled water consumed by WASAC in the future.

2. Plan of measures against water not billed consumption

2.1 Implementation Plan and request support

Please indicate the concrete implementation plan, strategic plan, medium and long term plans, the annual plan and the financing plan for the measures against non-revenue water consumed of WASAC, developed to address the problems mentioned -above. Please also indicate the related plans as well as the higher level plans considered necessary by WASAC as measures against water consumed is not billed.

Entitled of the execution plan of WASAC	Content of the plan	Situation of execution

Entitled of related plans and higher level plans	Content of the plan	Situation of execution

Please also indicate if support activities are performed by international organizations or by reference to bilateral agreements, or in case of future plans are being formulated, the details of the cooperation and the concrete situation of such activities .

Organization concerned by the request	Items of the request	Situation of activities

3. Flowchart of WASAC, controlled areas and court activities

Please provide the organizational charts of the Directorate General and bracnhes of WASAC, the number of agents, the list of each of the branches offices, their addresses and maps of controlled areas. Please also summarize the desactivités content and the number of officers in each division of the branches and each division of the Department of Production and Operations of the branches. Please mention the divisions responsible for activities relating to measures against unbilled water consumed in the document in Annex 2 of this questionnaire "Divisions WASAC affected by the measures against water consumed unbilled".

4. Situation on budget

Please give us the financial statements (for all years from 2010 to 2015) and Tables of water tariffs.
Does WASAC has developed a financial plan for the implementation of water reduction activities consumed unbilled?
Please show us the documents of the annual financial plan. What problems financially for the implementation of water reduction activities consumed unbilled?

B. Questionnaire submited to WASAC NRW unit

1. Situation of enforcement of measures against water not billed consumption

Please respond concretely to the following questions concerning the activities of measures against non-revenue water consumed currently performed by WASAC.
Please also give us documents such as statements of work and database examples. We would also receive the location site maps, the map of the water distribution area, plans of all structures

and plans of the water distribution network, etc., relating to the area 'observation.

1.1 General items

No	Divers questions	YES / No	concrete content
a	Have plans for medium and long term and annual plans of activities were formulated for measures against NRW ? Was a budget he has planned ?		
b	Is there a division responsible measures against the unbilled water consumed and the agents responsible were they appointed ? Composition of this division.		
c	What are the indicators to measure the water consumed is not billed (eg water consumption rate unbilled) ? What concrete targets for these indicators ?		
d	The annual reports of statistics do not indicate a definition of water consumption rate not charged. The evaluation seems to be made from the volumes of water consumed but how rates are determined unbilled water volumes attested ?		
e	The activities of the measures against non-revenue water consumed are they subject to evaluation (for example, financial assessment of the cost-effectiveness) ?		
f	For activities measures against water consumed unbilled, directions of work, procedures, specifications and methods they are raised and standardized of analysis for all divisions and branch offices ? Please indicate which kept manuals and guidelines (list specific title, content).		
g	Content of the work entrusted to subcontractors (eg, inspection and repairs of leaks pose feeder and distribution pipes, installation and replacement of meters, meter verification, investigation of the theft of water, meter readings, distribution of invoices), subcontracting business capacity.		

1.2 Measures against actual losses (physical)

No	Divers questions	yes / No	explanations
a	The division into districts for leakage control or a division into blocks of the area they are controlling the pressure determined in the area of the distribution network ? Is a block subdivision also performed ? If so, what are the criteria for determining the area (area, number of subscribers, etc.) ? Map of the block division of the distribution network.		
b	How is the control of water pressure made within blocks of division of water supply?		

c	Monitor the flow and pressure is it made to the distribution network (purpose, location, frequency) ?		
d	The volume of existing leaks is it measured (night minimum flow) in the block division distribution ?		
e	Are underground leak detection work ? (Periodically / only in case of problems / no)		
f	What methods of surveys, ranking and analysis of the history of leaks repairs ? Please indicate the number of cases of discovering leaks and present the history data leak repairs.		
g	Leakage of water distribution systems seem to be many and what are the measures taken to treat with them?		

1.3 Measures against the apparent (commercial) losses

No	Divers questions	Yes/ No	Explanations
a	What are the principal causes of the apparent losses (water theft, error meters, absence of meter, data processing, etc.)?		
b	Numbers and content of reported thefts. Please provide the data.		
c	Number of flights and illegal modifications meters. Please provide the data.		
d	Orientations for the increased establishment of meter rates.		
e	What are the meter replacement criteria (number of years of use, number of meters, breakdowns, etc.)?		
f	Whether or not meters testers, retail devices, methods and verification criteria		
g	Method of determining the water billed volume in the absence of meter		
h	Treatment method of aggregation of billed water volumes. Please provide data on the volume of water billed (by division of use, division of calculating charged volumes).		
i	Customer data management mode. Please provide an example of a subscriber database.		
j	Methods of managing and monitoring large users customers.		

1.4 Basic information and others

No	Divers questions	Yes / No	Explanations
a	mapping information and treatment method		
b	Treatment of water data unbilled consumption		
c	Plan Renewal Program (Please provide data on this renewal). - Data on the pipes (years of installation, type of pipe, diameter, repair history, etc.) are they		

	treated? - Are the evaluated dilapidated pipes and formulated a plan for renewal? - - Does he really Renewal place?		
d	An analysis of the effects on the management of measures against unbilled water consumed done? By what method?		
e	Outreach activities of the inhabitants in relation to non-revenue water consumed are they implemented? Please indicate their content.		

2. Measures already implemented and their effectiveness

Please list below the concrete steps already taken to reduce the volume of water consumed and not billed indicate their effectiveness (effects).

Content of measures	Effects	Problematic points

2. Detection equipment water leakage in each branch office

Please submit a list of the types and the number of leak detection equipment in each branch office and branch offices as well as their condition.

1) Equipment for measuring flow rate and pressure (ultrasonic flow meters, magnetic flow meters, pressure gauges, data loggers, etc.)

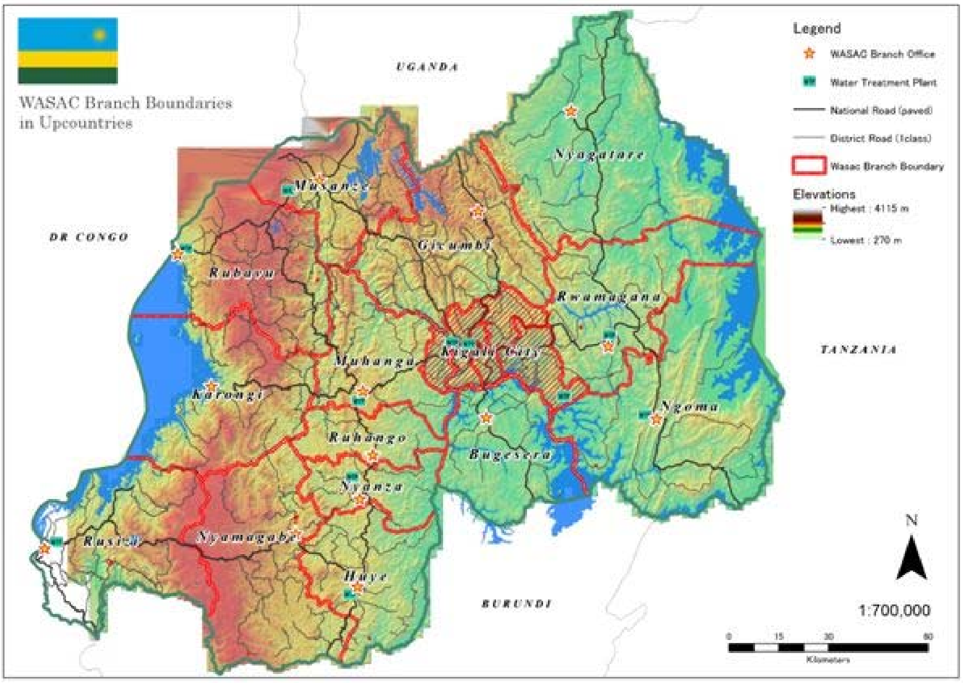
2) leak detection devices (leak detectors, buried pipes sensors, acoustic sensors, etc.)

3) Vehicles for work, others

Device designation	Number	Operating state

Annex 3: Summary of Result from branch questionnaire

Questionnaire survey has conducted for 20 Branch Offices in September 2016 and the answers to the questionnaire are summarized in October 2016. The result was explained for NRW team and discussed it on November 8, 2016.



1. Map

- The pipeline network maps are not prepared and not equipped at most of all branch offices.
- The branch offices do not possess the software of pipeline network maps. They are waiting support of the ESRI project after finish Kigali city.

2. Staffs (Organization)

- About the persons who inspect and manage the NRW reduction in branch, no particular person has not appointed. Among 20 branches, 12 branches answered that WDO and technicians.
- As for the commercial field officer, it is appointed as one in 1,000 customers.
- How is the number of Technician/ Plumber decided at each Branch Offices? Is the present number sufficient for dairy inspection work, installation work of new service connection work, leakage repair work, so on? Is the supporting member for technician such as technical activity, cleanings sufficient?
- At all branch offices, formation of the leakage detection teams is desired.

3. Shortage of water distribution volume

- All three branches visited face to shortage of amounts of distribution water due to shortage of water resource. Therefore, branch offices are supplying water to the water distribution area according to the rotational schedule or taking shifting supply in day and night.

4. Pressure Control

- Geographically, although it is rolling, there is no big vertical interval like Kigali, and there is installation of some pressure reducing valve so that a maximum water pressure is 60 m or less in general, and there are few high pressure parts.
- Generally, branch office is not conscious of lack of his fundamental knowledge on pressure management.
- Construction of DMAs is requested by Branch office in order to conduct pressure management.

5. Commercial Aspect

- About the commercial loss, although the installation rate of customer meter is 100% including public taps, there is no regulation about replacement of meters. Therefore, only stoppage/blocked meters are made replacement. It is not managed about the useful life of meter.
- In Rwamagana branch, 30% of water meters are more than 10 years used without replacement. Only unfunctional meters found by customers or blocked meters by deposits of sand in the meters after repair leaks.
- Supervision on water use situation of big consumer is recognized. In Rwamagana the customers have average consumption per month over 100 m3 during six months are classified as big consumer.
- Data analysis on water use condition of the customers is required.
- Although the numbers of public tap constitute about 3% of the numbers of whole customers, there is much as 13% including livestock combination in Nyagatare.

6. Leakage (Physical Loss)

- Although it is coped with only visible leakage of water on the physical loss, it doesn’t correspond to the invisible underground leakage of water.

- Periodical and premeditated leakage investigation using a set of leakage detection devices and a formation of the trained leakage detection teams are desired.

- The almost case of leakage parts are on water distribution pipe with small diameter and the service connection pipe.

- A regards leakage in different diameters of laid pipes, many leaks are observed in pipes of small sections (DN 63 DN 50 DN 40, DN32, DN25).
- Ruwamagana: 115 leaks per month are many and they are frequently remarkable in the distribution pipes, and several are caused by the damage made by inhabitant's activities and by the variation in pressure between the time missed and resend water.
- The leaks information is reported by customers (17 answers), meter reader: commercial field officers (17 answers) and patrol of staff (9 answers). Dose the reporting by habitant used call centre? What is the concrete content, frequency and the person in charge of the patrol? Has the function of call center at each Branch Office been set up?
- Management of water level and overflow of the reservoir is not sufficient.
- Quick leak repair after the leak discovery is required.

7. Replacement of Aged pipe

- Replacement of the aged pipes and the frequent occurrence pipe of the leakage is required.

8. Service Connection

- Installation of a service connection pipe is performed based on application of new connection, but management of service connection materials and work performance are insufficient so that technical standards are needed.

9. Vandalism

- There are few numbers exposed although there is much vandalism such as an illegal use and water theft. Although a radio, a newspaper are performing the educational campaign about water use, the educational activity in the school is not yet performed.

10. Cooperation with the Authorities Concerned

- It is necessary to perform enough discussion and adjustment with local governments.

Annex 4: Summary report of WASAC branches Visits

In September, 2016 and February and March, 2017, site visit survey was conducted with the members of NRW team to confirm the situation of the WASAC district Branch.

- Site visit survey for three Branch Offices, Ruwamagana, Nagatare and Ngoma, was conducted in September 2016 to confirm existing activities of WASAC branch offices, the situations of facilities, and evaluate it.

- The site visit survey for remaining 11 Branch offices (Musanze, Ruvavu, Gicumbi, Ruhango, Nyanza, Huye, Nyamagabe, Karongi, Rusizi, Bugesera, Muhango) was conducted from the middle of February until the beginning of March.

No.	Province	Branch Office	Day Visit
1	South	NYANZA	2017/2/21
2		HUYE	2017/2/22
3		NYAMAGABE	2017/2/23
4		RUHANGO	2017/2/20
5		MUHANGA	2017/3/8
6	West	KARONGI	2017/2/27
7		RUBAVU	2017/2/15
8		RUSIZI	2017/3/1
9	North	MUSANZE	2017/2/13
10		GICUMBI	2017/2/16
11	East	RWAMAGANA	2016/9/20
12		NYAGATARE	2016/9/21
13		NGOMA	2016/9/22
14		BUGESERA	2017/3/6

No	Province	Kigali City	Day Visit
1	Kigali City	Kacyiru	2016/8/23
2		Gikondo	2016/8/24
3		Nyarugenge	2016/8/30
4		Nyamirambo	2016/8/23
5		Remera	2016/8/23
6		Kanombe	2016/8/23

A. Current Status of the Branches

1. Southern Province

1.1 Nyanza Branch

- The diameter of the distribution pipes is small for the number of customers (quantity of water supplied), so a replacement plan has been prepared.
- The estimate for the replacement plan shows only the pipe diameter, material, and total length, and there no drawings showing where and how the replacement will be carried out (this is the same for all branches).
- It is necessary for WASAC as a whole to review its design, construction, and supervision system.
- Large customers (prisons, universities, schools, hotels) consume about 50% of the quantity of water.
- The existing meters are more than 20 years old.

1.2 Huye Branch

- Most of the distribution pipes and meters are more than 30 years old, and their replacement is necessary.
- Replacement of old pipes with new ones is being carried out, with replacement of the highest priority 1 km being complete. However the plan for replacement of 5 km has been submitted to headquarters, but the budget is not forthcoming.

1.3 Nyamagabe Branch

- Most of the distribution pipes and meters are more than 30 years old, and their replacement is necessary, the same as in Huye Branch.
- Distribution pipes were installed in 1982, so more than 30 years has passed.
- In the past pipes imported from Europe were used so the quality was good, but at present they are being manufactured in China, Uganda, Kenya, Rwanda, etc., and the quality is not very good.
- There are many leaks from PVC, PE, and GIPservice pipes.
- The water gauge in the distribution reservoir is broken, and manned surveillance is being carried out.

1.4 Ruhango Branch

- The PVC transmission pipes have longitudinal cracks, so it is considered that there is a problem with the material. Also water leaks occur at the rate of about 1 per 3 months, so re-installation is urgently required.
- The quantity of water billed varies greatly even though the quantity of water supplied does not vary very much, so there is a great variation in the quantity of non-revenue water.
- In some locations low density polyethylene pipes and galvanized steel distribution pipes are being used.
- There is a large increase in new customers but the distribution pipes cannot be renewed, so in many cases connections are made from narrow distribution pipes.

1.5 Muhanga Branch

- The distribution pipe network is not suitable in terms of diameter, so it is not possible to distribute the design flow rate of the water treatment plant.
- About 300 customers are connected to a 25 mm diameter pipe.
- Generally speaking, the pipe size of the water distribution network is small and there is a plan for replacement. However the budget is not available, so the plan cannot be implemented.
- The oldest meter is 20 years old.
- Many customers do not pay the water charges and 815 of them have been disconnected, but of those about 500 customers do not intend to pay.
- Customers purchase the pipe material, but they purchase the cheapest material, so the quality is poor.
- None of the water distribution reservoirs have flow rate meters to measure the incoming flow rate.

2. Western Province

2.1 Karongi Branch

- The network is more than 50 years old, and it is necessary to implement areplacement plan.
- There are no replacement plan diagrams written on the piping drawings. (This is the same for all branches).
- There is much rock and excavation is difficult, so the transmission pipes are exposed in places.

2.2 Rubavu Branch

- The soil is volcanic soil with high water permeability, so water leaks do not appear on the surface. It is necessary to carry out underground water leak detection using a water leak detector in priority.
- The water distribution pipes were installed a long time ago.
- Water is distributed to an excessive number of customers from small diameter distribution pipes.
- Faulty individual water meters have been replaced, but old meters remain not replaced.
- The quantity of water leak repair materials stored is insufficient. In particular, materials for small diameter pipe joints are procured every time they are needed.
- There are no flow meters for measuring the inflow rate to distribution reservoirs.
- There are no floating valves in the distribution reservoirs, and manned surveillance is being carried out. The water gauges are unusable because of the accumulation of dirt.

2.3 Rusizi Branch

- PVC that is 30-40 years old is in use.
- Also, water is supplied to 300 households from 25 mm diameter water distribution pipes, etc., so it is necessary to prepare a replacement plan based on hydraulic calculations.

3. Northern Province

3.1 Musanze Branch

- The soil is volcanic soil with high water permeability, so water leaks do not appear on the surface. It is necessary to carry out underground water leak detection using a water leak detector in priority.
- Excavation is difficult, so in places pipes are exposed.
- The size of water distribution pipes is small for the quantity of water supplied, with 20 households being supplied from a ¾ inch pipe.
- Low density polyethylene pipes are being used, so the pressure resistance strength is insufficient. It is necessary to replace these low density pipes with high density polyethylene pipes.
- It is considered that there are many leaks in places where there is no change in the daytime and night

time flow rates. Therefore the inflow valves to these areas should be closed, to reduce the quantity of non-revenue water.

- There are GIS maps, but they have not been updated for a long time.
- Air becomes trapped in the pipelines, but the air valves are not automatic, so the air has to be manually vented.
- There are no floating valves in the distribution reservoirs, so valves are operated with manned surveillance.
- There are no flow meters for measuring the incoming flow rates to the distribution reservoirs.

3.2 Gicumbi Branch

- Small diameter distribution pipes using low-density polyethylene (PE32) and galvanized steel needs to be replaced.
- High-lift pumps (40 bar specification) are being used, but this is excessive pressure.
- There are problems with planning, design, construction, and supervision, so the WASAC checking and supervision system is not properly formed.
- The pipe bending prevention for transmission pipes is being carried out on a very smallscale not corresponding to the water pressure. The size specified for flanged ends of gate valves, etc., is too small for the actual pressure.
- Water leaks are caused by road construction. The burial depth is shallow, and the backfill is inappropriate, so it is considered that damage is caused by vehicle loads.

4. Eastern Province

4.1 Rwamagana Branch

- The Branch staff wish to form a non-revenue water reduction team in order to implement measures against non-revenue water.
- Development of the distribution pipe networks commenced in 1986, and almost all is PVC.
- Even though water is supplied 24 hours a day, because the demand is high, during the daytime the water does not reach the most distant parts, although many areas can be supplied with water for 24 hours.
- The branch does not possess piping drawings covering all the areas of the city.
- The locations of water leaks are almost all on smalldiameter water supply connection pipes. No countermeasures are taken against water leaks that cannot be seen.
- Records of water leak repairs are written up in notes.
- Water leaks are notified by meter reading officers(Commercial Field Officers) or the residents.
- Several hours are required between reportsof a water leak and repair. Also, the quantity of water leakage during that time is estimated.

- Most of the materials used for repairs are in storage. Materials and equipment are provided by WASAC Headquarters. If there is no stock at the branch then a procurement request is sent to Headquarters.
- Block Meter refers to a meter with defective operation. A cut in water supply causes water to be drained and air to be accumulated in the raised part of a service pipe, and the pipe dries. In that case, the meter dries and suspended matter within the meter hardens, so it becomes difficult for the meter to rotate.
- When a meter cannot be used, billing is carried out based on the actual amount of usage in the past.
- The diameters of the customer meters are 20 mm, or 25 mm. The rate of installation of meters is 100%.
- For customers with large usage, after reading the meter, inspection is carried out one more time.
- Meters that have exceeded their service life are not well managed. It is necessary to produce standards.
- It is considered that the commercial loss due to non-revenue water is large. It is thought that there are many illegal connections and water is stolen, but only about 5 illegal connections per year are found. Even after discovery it is not possible to strictly enforce the regulations with a legal dispute.

4.2 Nyagatare Branch

- It is not possible to supply water for 24 hours a day.
- There are many leaks in the small diameter pipes.
- There are many acts of vandalism (acts causing damage), in which air valves, drain valves, and manholes are destroyed. It is necessary that there be cooperation with the Local Authority regarding vandalism. Illegal connections (illegal use) are few. The vandalism is reported when it is detected by meter readers, customers, and technicians. It is necessary to raise the awareness of the residents, and cooperation with the local government organizations is also necessary. Use of local media (radio, newspapers, etc.), and discussions with the relevant organizations is required. Awareness activities at schools is carried out by the Sanitary Department, but they have not yet started activities regarding use of water supply.
- Water hammer is caused by insufficient air valves.
- The branch wants to have water leak detectors. It is necessary to newly form a water leak detection team.
- The maximum pressure within the distribution pipe network is 6 bar. There are water leaks within toilets in houses caused by the high pressure.
- There is a problem of turbidity during the rainy season. Customer meters are replaced at 140 locations annually.
- Pipe repair materials are provided by Headquarters upon request from branches. There is no budget at branch level.
- It is considered that commercial losses are greater than technical losses.
- Distribution tank floating valve replacement has been carried out at 8 locations, as part of an annual action plan.
- Normally, drawings cannot be managed at the branch. There are not even prints of the water distribution

area drawings. There is little awareness of active use of water distribution pipe network drawings.

4.3 Ngoma Branch

- The water supply source quantity is always insufficient, so priorities for supply are determined, and rotation of water supply is carried out by operation of valves within the pipe network. Water is stored in tanks in each household, and used in a few days. Water can be supplied to the whole area for 2 days per week.
- Valves are installed on the water distribution pipe network at 25 locations (60 mm to 200 mm), and these are opened and closed every day in order to rotate the water supply. There are no problems with this operation.
- The pipes in which leaks occur are mainly small diameter pipes of 32 mm and less, and service pipes. There are about 18 leaks per month. Leaks occur in large diameter pipes about 2 to 3 times per month. They are detected by meter readers or customers who report them. Causes include (1) heavy traffic vehicles (road construction), (2) high pressure problems, (3) material quality (house connection pipe), the procurement of low-cost materials in the market, and (4) operational problems, so at present contractors are not used, but repairs are carried out directly by WASAC staff. There are no inspections in particular of house connections. There are no standards for inspections.
- The branch does not possess any water leak detectors. At present the branch does not have a water leak detection team, but there are plans to form one. Records of water leak repairs are written up in notes, and some of the repair equipment for leaks is owned by the branch.
- Meters are installed at all supply destinations. Meter replacement is only carried out for faulty meters. The cause of blocked meters is blockage with sand or soil that has entered at the location where a leaking pipe is repaired. The frequency of meter replacements is low, at about 10 to 20 times per month.
- The consumption by large customers is analyzed and checked every month.
- It is considered that there is illegal use, but they have not been found. Information is obtained from meter reading officers (Commercial Field Officers) and residents, but detection is difficult. When detected the supply is cut off, but this causes a dispute.
- Measures for reduction in NRW (Non-Revenue Water) are being tried, and periodic inspection, replacement of old meters, replacement of old pipes, and repair of leaks are carried out at appropriate times.
- Awareness activities for customers are being carried out (in order to recommend use of good quality materials for service pipes), and discussions with the relevant administrative organizations are held.
- Galvanized steel pipes corrode easily, so 3 years ago it was decided to replace them all, and replacement is still in progress. At present about only 5% remain.
- Water flow meters on the outlet side of water distribution tanks are installed only at 2 locations.

- WASAC supplies the meters for water supply connections. The branch pipes are purchased by residents. The diameter of PVC pipes is 25 mm, and meters 20 mm. The pipe connection work is carried out by WASAC. The operation of making a hole for water supply connections at branch saddles is not carried out using a drill, but the hole is formed using a heated reinforcement bar. Pressure tests are not carried out.

4.4 Bugesera（Nyamata) Branch

- It is an urgent task to expand the quantity of water treatment.
- Meters were installed from 2010 onwards, so they are new.
- It is necessary to prepare a water distribution piping plan in accordance with development plans for the International Airport and industrial estate, based on demand forecasting and hydraulic calculations.
- The water supply materials of new customers are evaluated, and if there is a problem with quality the connection is not permitted.
- The Rwanda Standard Board has jurisdiction over the standards for pipes, and imported pipes that comply with the standards are imported. It is also a testing organization, and they carry out witness inspections at factories within the country. This is also carried out by staff from WASAC.
- There are no flow meters for measuring the inflow rate to distribution reservoirs.

5. Kigali

5.1 Kacyiru Branch

- Water is supplied from two directions: water supplied from the Ntora water distribution tank which receives water from Nzove water treatment plant, and water supplied from the Kimisagara water treatment plant. Therefore the water supply status is good, and water can be supplied 24 hours a day, 7 days a week continuously.

5.2 Gikondo Branch

- The sources of water include the Nzove water distribution tank, the Kimisagara water treatment plant, and some groundwater, but it passes through the areas under jurisdiction of Kacyiru Branch and Nyarugenge Branch, for distribution within Gikondo. Therefore the quantity of water within Gikondo is always insufficient, and the water supply status is poor.
- It is expected that the water supply situation will be improved with the new water treatment plant (Kagarama), construction of which is scheduled to be completed in 2017 in the south of Kigali City in a project by Metito. Also, there is a plan for supply of water resulting from the expansion of the Nzove water treatment plant. It is expected that the water supply and distribution status will be improved with the completion of these projects.

- The water supply status is 2 to 3 days a week × 24 hours a day.
- It is said that there is significant theft of water, but detections of illegal connections are about one every 2 to 3 months. There is a system of reward money for detection of illegal connections.
- There are many water leaks. The causes of water leaks are old pipes, and damage to pipes due to road construction or house construction. In most cases, low cost poor quality pipe materials are used for new connections to houses newly constructed or for replacements.
- Water meters remainnot replaced for a long time.

5.3 Nyarugenge Branch

- The sources of water supply are Kimisagara water treatment plant and Nzove water treatment plant. The water treatment plants are close in distance, so the supply conditions are good, and water is supplied 24 hours a day 7 days a week.
- There are many water leaks even though pipe replacement is ongoing. In some cases buried pipes are damaged during road construction or repairs. In some cases houses are constructed above the pipes, so maintenance of the pipelines is difficult.
- There are many water leaks, and in 1 day leaks are repaired at about 20 locations. Also, water leaks sometimes occur at the water distribution tanks at 18 locations. The water leaks are not just from the old network, but there are also leaks from the new areas.
- There are also many leaks in newly connected service pipes. The water leaks can easily occur due to the cheap materials and the construction method carried out by the contractor, because the cost of the water supply connection materials and equipment and construction are borne by the contractor.
- There are also problems with the materials used in the networks delegated from the Local District.

5.4 Nyamirambo Branch

- The sources of the water supply are Kimisagara and Nzove water treatment plants.
- The water supply status has been improved with the completion of Nzove II Plant. At present the water supply status is good, with water being supplied 24 hours a day 7 days a week, except in a part of the area (water supply 2-3 days per week).
- As a result of improvement in the water supply status, there are problems of water leaks caused by high water distribution pressure. The water pressure during the day is 11 to 14 bar, and 7 to 10 water leaks occur per day.Most of the leaks occur in service pipes.
- The pipeline network was installed in the 1960s. The material of the old pipes was galvanized steel, and the material of the new pipes is PVC, but the quality of the new pipes is poor and there are many leaks.
- Almost all the water leaks occur in service pipes.
- There is little theft of water and few illegal connections. There are fines if detected, and, because it is

mainly a residential area there is no major advantage to theft of water, as in commercial or industrial areas.

5.5 Kanombe Branch

- The source of the water supply is Karenge water treatment plant. The status of water supply is poor, with supply 3 days per week × 24 hours per day.

6. Items Common to All Branches

- There are no maps (drawings) indicating the water pressure status of areas within the pipe network that require water pressure management. None of the branches have distribution pipe network map (not even a handwritten one), so there is an extremely poor awareness of the use of drawings.
- There are no drawings showing the pipe materials, diameters, year installed, etc., which is necessary for formulation of plans for replacement of aged pipes and improvement in the pipe network.
- The quantity of water distributed is insufficient due to insufficient supply from the water source in many cases, so water is rotated among areas on a daily basis, and water distribution is carried out separately day and night time.
- Data which is necessary for analysis of the causes of water leaks, such as information on leaks from what location on pipes (bends, joints, the main pipe), and how the leak occurred (splits, holes, separation of joints, corrosion), etc., is not recorded in the water leak repair records. Also, this information is not written onto the piping drawings.
- Regarding physical damage, action is taken only in connection with visible water leaks (detected naturally), but no action is taken in connection with water leaks that cannot be seen that occur underground. It is desirable to form water leak detection teams that carry out water leak surveys using water leak detectors.
- The location of almost all the water leaks is on small diameter water distribution pipes, and water supply connection pipes.
- Water supply pipe connections are carried out when there is an application for a new connection, but there is insufficient control of the materials and construction, and technical standards are necessary.
- There are problems with planning, design, construction, and supervision, and implementation and supervision are being carried out only by a consultant or contractors, so the system of supervision by WASAC has not been established.
- In connection with commercial losses, customer meters have been installed at 100% of subscribers including public water taps, however regulations regarding replacement of meters have not been developed, and only meters that have stopped working are replaced. Meters are not managed based on their service life.

- In the case of customers with large usage, in most cases surveillance is carried out in a thoughtful manner.
- It is said that there are many cases of vandalism such as illegal connections and water thefts, but few are exposed. There are cases where radio and newspapers, etc., are used for awareness activities in connection with use of the water supply, but educational activities at schools are not being carried out yet.
- There are no employees or teams dedicated to activities to reduce non-revenue water.
- There are no vehicles that can be used for dedicated activities to reduce non-revenue water.
- Even where DMAs had been created (and there are branches that have not created a DMA), they are not being operated.
- There are no mechanisms for sharing improvement initiatives between branches. Information is not being exchanged.
- When a pipeline replacement plan is submitted to Headquarters, drawings that form the basis of the plan are not attached. Even when plans are formulated, in most cases, they are not implemented due to budget problems.
- Flow meters for measuring the inflow rate into distribution reservoirs have not been installed, so it is not possible to check the water leaks that occur in service pipes.
- There is no equipment such as water leak detectors, water pressure meters (manometers), etc.

5-Year Strategic Action Plan for NRW Reduction

Gr No.	Components	Sub Gr No.	Countermeasures	Specific actions	Budget	Responsible TEAM for Specific actions					Priority	Necessary Resources	Period	Total amount (RWF)	Implementation Schedule and Estimated Budget																Comments
						Respon-sible UNIT	Action Section/Branch								2017/2018												2018/2019	2019/2020	2020/2021	2021/2022	
															1st Year												2nd Year	3rd Year	4th Year	5th Year	
															Jul	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June					
A. System Input Volume																															
A1	Volume input metering accuracy	A1.1	Establish the framework to ensure the system volume input accuracy	Inventory of bulk meters (GIS, Esri, Survey)	***NRW***	***NRW***	*Production*	*Distribution*	-	-	High	NA	already available	-	x																
				Set up a dedicated and experienced team to visit, analyze and report all bulk meters condition (meter age, size, installation, etc..)	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High	NA	1 month	-	x																
				Visit, analyze and detailed report of all bulk meters condition	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High	Consultant, Staff, Logistics	3 months	2,880,000		960,000	960,000	960,000													JICA expert will be required
				Installation of new meters / Replacement of faulty bulk meters / correcting of meters installation based on the result of meter condition analysis	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High	Staff, Bulk meters, Fittings, Logistics	5 months	204,000,000					41,000,000	41,000,000	41,000,000	41,000,000	40,000,000								This amount has been budgeted for the FY2017-2018
				Prepare a plan for bulk meter regular check up for the future.	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High	Staff	1 month	-				x													
				Implementation of the plan for bulk meter regular check up for the future.	***NRW***	***NRW***	*NRW*	*Metering*	*Production*	*Distribution*	High		Regular	-					x	x	x	x	x	x	x	x	x	x	x	x	bulk meter check up will be yearly
				Bulk meter reading and analysis	***NRW***	***NRW***	*NRW*	*Production*	*Distribution*		High		Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	bulk meter readings should be monthly
A2	Water production (prevent intermittent supply)	A2.1	Increase water production to ensure Continuous supply for proper flow and pressure management	Assessment of water supply gap	***UP***	***UP***	*UP*	-	-	-	High	General expenses	already available	-	x																Increase of the production is very key for NRW reduction activities but this task is currently being implemented using development budget
				Identify project to address the current gap and future demand	***UP***	***UP***	*UP*	-	-	-	High	General expenses	already available	-	x																
				Implement of the identified project (Construction of new WTP, upgrade existing WTP, forwarding infrastructures and the Network)	***WO***	***WO***	*Production*	-	-	-	High	Development budget	on going	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Install backup generators at critical WTP and pumping station (Long term)	***WO***	***WO***	*Production*	-	-	-	Medium	Development budget	2 years	-															x	x	
B. Commercial Losses																															
B1	Meter reading and billing	B.1.1	Ensure correct and 100% customers meter reading	Sensitization of CFO's about the importance of accurate readings through workshops	***RM***	***RM***	*Billing*	*Branches*	-	-	High	Staff, Logistics	Regular	15,000,000				2,500,000						2,500,000			2,500,000	2,500,000	2,500,000	2,500,000	Twice a year
				Train CFO how to use map in meter reading	***RM***	***RM***	*Billing*	*Branches*	-	-	High	Staff, Logistics	3 months	720,000					240,000	240,000	240,000										
				Enforce billing supervision at branch level by recruiting billing and revenue collection supervisors	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	2 months	-						x	x										
				Regular Random re-reading of customer meters (by the branch management and also the senior management)	***RM***	***RM***	*Billing*	*Branches*	-	-	High	NA	Continuous	-						x	x	x	x	x	x	x	x	x	x	x	Activity in progress
				Make the business case for outsource meter reading	***RM***	***RM***	*Billing*	*Branches*	-	-	High	NA	2 months	-						x	x										
		B.1.2	Ensure Customer meter accuracy	Make a plan for Regular meter accuracy test.	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High		1 month	-						x											
				Implement of the plan for Regular meter accuracy test.	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High	Staff, Equipment, Logistic	Regular	4,800,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	85,000	1,000,000	1,000,000	1,000,000	1,000,000	Meter test by test bench & portable test meter
				Procure additional Portable meter test equipment (at least 1 per branch)	***CSM***	***CSM***	*Metering*	-	-	-	High	Meter test equipment	6 months	120,000,000		x	120,000,000														Procurement of portable test meters budgeted for FY2017-2018
				Replace default and old meters	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High	Meters, Staffs, Logistics	continuous	2,108,228,581	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	15,000,000	450,000,000	479,250,000	510,401,250	543,577,331	15000 meters /year
				Procure and install one water test bench per province	***CSM***	***CSM***	*Metering*	-	-	-	Low	Meter test bench	1 year	200,000,000																200,000,000	Estimated 50 Million for 1 meter test bench
		B.1.3	Improve technology and equipment for meter reading and billing	Procure portable bills printers	***CSM***	***DCS***	*Metering*	*ICT*	-	-	High	Printers and accessories	6 months	92,000,000		x	x	92,000,000													Budgeted for FY2017-2018
				Exposure visit for success stories and adapt if necessary	***CSM***	***DCS***	*Metering*	*ICT*	-	-	High	Staff, Logistics	1 months	8,000,000							8,000,000										The exposure visit can be organize in the region or other African countries
				Automatic meter reading or prepaid meters for big customers	***CSM***	***DCS***	*Metering*	*ICT*	-	-	High	Meters, Staffs, Logistics	1 years	200,000,000													200,000,000				
		B.1.4	Monitoring of customer consumption trends	Analysis of customer consumption Database	***RM***	***RM***	*Billing*	*Branches*	-	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	monthly analysis should be done
				Plan and visit customer with irregular consumption	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Analysis of estimated/constant bills	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Weekly meter reading for big customers (at least 200 big customers)	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x					Routine activity
				Regular follow up of big customers	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	Regular	-													x	x	x	x	After installation of prepaid meters
B2	Customers meter management (normal, larges and public tap)	B2.1	Continue customer mapping and inventory	Complete customer inventory and mapping in Upcountry Branches	***RM***	***RM***	*Billing*	*Branches*	*GIS*	*ICT*	High	Consultant, GIS staff, logistic	6 moths	-	x																On going activity
				Set up and implement a clear customer database update procedures in GIS and CMS	***RM***	***RM***	*Billing*	*Branches*	*GIS*	*ICT*	High	GIS staff	2 moths	-		x	x														
		B2.2	Ensure the quality of meter installation and replacement	Update meter installation and replacement policy	***CSM***	***CSM***	*Metering*	-	-	-	High	NA	2 months	-		x	x														2 months for policy set up and Continuous implementation
				Implement meter replacement according to the replacement policy	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High		Regular	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	Routine activity
				Supervision and inspection of meter installation for new connection works	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High	General expenses	Continuous	-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Routine activity
		B2.3	Reinforce public tap management	Public tap inventory and assessment of their condition (meter ,location ,etc..)	***RM***	***RM***	*Metering*	*Branches*	*GIS*	-	High	General expenses	2 months	-		x	x														
				Review the existing public tap management procedures	***RM***	***RM***	*Metering*	*Branches*	-	-	High	NA	1 month	-				x													
B3	Illegal Connection (illegal water use)	B3.1	Prevention of illegal water usage	Raise staff and community awareness through workshops, media show	***NRW***	***NRW***	*Inspe. & Enforce.*	-	-	-	High	Staff, Logistics	Regular	25,000,000						2,500,000						2,500,000	5,000,000	5,000,000	5,000,000	5,000,000	Twice an year workshop/tv show should be organized
				Enhance Incentive for informers (including staff)	***NRW***	***NRW***	*Inspe. & Enforce.*	-	-	-	High	Informers incentives	Continuous	5,800,000	50,000	50,000	50,000	50,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	1,200,000	1,200,000	1,200,000	1,200,000	Assume 2 reported illegal cases per months
				Inspection of suspected customer's and large consumer's connections based on customer data analysis	***NRW***	***NRW***	*Inspe. & Enforce.*	*Branches*	-	-	High	Staff, Logistics	Regular	13,300,000	125,000	125,000	125,000	125,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	2,700,000	2,700,000	2,700,000	2,700,000	
				Installation of meter protection boxes for suspected customers	***CSM***	***CSM***	*Metering*	*Branches*	-	-	High	Staff, Logistics	Regular	4,000,000			400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000					
				Complete disconnection of confirmed inactive customers	***RM***	***RM***	*Billing*	*Branches*	-	-	High	General expenses	continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
		B3.2	Charge fines for confirmed illegal	Disconnection of confirmed illegal cases	***RM***	***RM***	*Billing*	*Inspe. & Enforce.*	*Branches*	-	High	Staff, Logistics	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	

			water usage customers	Monitoring of fines payment	**NRW**	**NRW**	Inspe. & Enforce.	Branches	-	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
C. Physical Losses																															
C1	Pressure management	C1.1	Determination of high pressure zones	Review, analysis and regular update of existing map of water network, pumping station ,WTP installations, etc..	**WO**	**WO**	GIS	-	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	There should be hard copy showing the situation before and after changes
				Hydraulic calculation and modeling	**WO**	**WO**	GIS	-	-	-	High	General expenses	Regular	-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Identification, mapping and dissemination of higher pressure zones	**WO**	**WO**	GIS	-	-	-	High	GIS staff	1 year	-			x	x	x	x	x	x	x	x	x	x					
		C1.2	Determine the acceptable pressure range in the network and customer tap	Make a survey on the existing pressure in the network and on customer taps	**NRW**	**NRW**	LD&PM	-	-	-	High	Staff, Logistics	2 months	3,360,000				1,680,000	1,680,000												
				Propose the acceptable pressure range considering our local conditions	**NRW**	**NRW**	LD&PM	Distribution	-	-	High	Staff	3 months	-						x	x	x									
		C1.3	High pressure zones survey (from hydraulic analysis)	Identification of place to install pressure gauges ,dataloggers	**NRW**	**NRW**	LD&PM	Distribution	Branches	GIS	High	Staff, Logistics	3 months	-									x	x	x	x	x				
				Procure and install pressure gauges in the network	**NRW**	**NRW**	LD&PM	Distribution	Branches	GIS	High	Staff, Pressure gauges, Logistics	2 years	20,000,000													10,000,000	10,000,000			at least 10 gauges / branch
				Follow-up and Analysis of pressure measurement results	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	Staff, Logistics	Continuous	-						x	x	x	x	x	x	x	x	x	x	x	
		C1.4	Proper pressure management	Inventory of existing PRVs, Break Pressure Tanks (BPT)	**WO**	**WO**	Distribution	LD&PM	GIS	-	High		2 months	-	x	x															
				Identification and prioritization of actions to address pressure issues	**NRW**	**NRW**	LD&PM	Distribution	-	-	High	Staff	3 months	-		x	x	x													
				Set up a plan for pressure management	**NRW**	**NRW**	LD&PM	Distribution	-	-	High	Staff	3 months	-		x	x	x													
				Implementation of pressure management plan (PRV, BPT, rearrangement of pumping stations and pipeline network)	**NRW**	**NRW**	LD&PM	Distribution	-	-	High	Staff, Pressure reducer equipment, Logistics	Regular	324,800,000			5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	67,200,000	67,200,000	67,200,000	67,200,000	24 PRV will be installed in year one as planned in the 2017-2018 action plan
				Continuous pressure control	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	Staff, Logistics	Continuous	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	
C2	Asset Management (Rehabilitation)	C2.1	Asset data management by GIS	Inventory, drawing and mapping of water facilities	**WO**	**WO**	GIS	-	-	-	High	Consultant, GIS staff, Logistic	1 year	-	x	x	x	x	x	x	x	x	x	x	x	x					On going activity (Esri project)
				Regular update of GIS data	**WO**	**WO**	GIS	-	-	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
		C2.2	Network maintenance and rehabilitation	Inventory of infrastructures to be rehabilitated	**WO**	**WO**	Distribution		-	-	High		3 months	-	x	x	x														
				Analysis for optimal use of water infrastructure	**WO**	**WO**	Distribution	-	-	-	High	GIS staff, Logistics, GIS software	2 moths	-	x	x															Eg. pipe replacement ,
				Prioritization of areas for rehabilitation	**WO**	**WO**	Distribution	-	-	-	High	Staff	Yearly	-		x	x										x	x	x	x	
				Preparation of maintenance and rehabilitation plan	**WO**	**WO**	Distribution	-	-	-	High	Staff	Yearly	-		x	x										x	x	x	x	
				Implementation of the maintenance and rehabilitation plan	**WO**	**WO**	Distribution	-	-	-	High	Staff, Material, Logistics	Continuous	750,000,000			13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	155,000,000	155,000,000	155,000,000	155,000,000	we referred to the rehabilitation budget allocated to the FY2017-2018
				Monitor and evaluation of the implementation of the maintenance plan	**WO**	**WO**	Distribution	-	-	-	High	Staff, Logistics	Continuous	2,400,000						240,000						240,000	480,000	480,000	480,000	480,000	twice a year
		C2.3	Infrastructure protection	Installation of protective facilities (manhole covers , fences …)	**WO**	**WO**	Distribution	Branches	-	-	Low	Staff, Protective equipment, Logistics	Continuous	15,000,000						1,500,000						1,500,000	3,000,000	3,000,000	3,000,000	3,000,000	mainly installation of air valves
				organize public awareness for infrastructure protection against vandalism	**WO**	**WO**	Distribution	Metering	Branches	-	Low	General expenses	Regular	-							x						x	x	x	x	Once a year
C3	Leaks and burst repair	C3.1	Quick and good quality repairs	Sensitization for leak reporting (meeting , TV show , rewarding informers , etc..)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	Regular	10,000,000							2,000,000						2,000,000	2,000,000	2,000,000	2,000,000	Once a year
				Daily monitoring of leaks reported and repair (wtsp, LIS)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Avail minimum stock at the branch level	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	1 year	-		x	x	x	x	x	x	x	x	x	x	x					availability of material is Continuous process
				Regular inspection of leaks repaired	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Dissemination of standard for leak repair	**QA**	**QA**	Standard	NRW	-	-	High	NA	Continuous	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Train staff for leak repair	**NRW**	**NRW**	LD&PM	Branches	-	-	High	Staff, Logistics	Continuous	15,000,000			3,000,000										3,000,000	3,000,000	3,000,000	3,000,000	once a year
		C3.2	Active leakage control	Make historical analysis of leakages (location, diameter, material etc..)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Prepare an yearly plan of visible leakage and invisible survey (including reservoir)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	Regular	-	x												x	x	x	x	
				Implement the yearly plan of visible leakage survey (including reservoir)	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	2160000
				Train staff for leakage survey and leak detection	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	Staff, Logistics, Equipment	Regular	15,000,000			3,000,000										3,000,000	3,000,000	3,000,000	3,000,000	JICA NRW Project
				Procure and dispatch leak detection equipment to branches	**NRW**	**NRW**	LD&PM	Branches	-	-	High	Leak detection equipment	2 years	400,000,000														200,000,000	200,000,000		Leak detection for branches
				Select critical areas to detect invisible leaks	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	NA	Continuous		x												x	x	x	x	Analysis and survey are required.
				Conduct leak detection activities in all branches and make estimation of water lost through leakages	**NRW**	**NRW**	LD&PM	Distribution	Branches	-	High	Staff, Logistics, Equipment	Continuous	2,160,000	x	x	x	x	x	x							2,160,000	x	x	x	year 1 HQ staff to be trained by JICA . For next years HQ staff will train branches staff
		C3.3	Establish water supply monitoring system (DMA, SCADA ,etc..)	Complete the isolation of Kigali branches	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	Middle	Staff, Equipment	1 year	-	x	x	x	x	x	x	x	x	x	x	x	x	x				Ongoing activity (JICA NRW Project)
				Creation and management of DMA within branches	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	Middle	Development budget	Continuous								x	x	x	x	x	x	x	x	x	x	Can be financed by the development budget
				Establish a network monitoring system including reservoirs	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	Middle	Development budget	5 years	-													x	x	x	x	Can be financed by the development budget
		C3.4	Reporting and recording of leakages	Review and harmonize leaks reporting and repairs format	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	High	NA	3 months	-	x																
				Daily report of leakages with Location, diameter , materials and so on	**NRW**	**NRW**	LD&PM	GIS	Distribution	Branches	High	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Routine activity
D. Unbilled Authorized Consumption																															
D1	Unbilled metered authorized consumption	D1.1	Ensure proper fire hydrant management	General inventory of all fire hydrants and confirmed if metered and billed	**RM**	**RM**	Billing	Metering	Distribution	Branches	High	General expenses	2 months	-	x	x															
				policy establishment for fire hydrants installation and management	**RM**	**RM**	Billing	Metering	Distribution	Branches	High	NA	1 month	-			x														
				calculation and analysis of water used by fire hydrants	**RM**	**RM**	Billing	Metering	Distribution	Branches	High	NA	Regular	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	
D2	Unbilled unmetered authorized consumption	D2.1	Have a plan for network and reservoirs flushing	Preparation of network flushing plan	**WO**	**WO**	Distribution	Branches	-	-	Low	NA	Regular	-	x												x	x	x	x	Every year
				Implementation of the network flushing plan	**WO**	**WO**	Distribution	Branches	-	-	Low	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Estimation of water uses in network flushing , reservoir cleaning	**WO**	**WO**	Distribution	Branches	-	-	Low	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Monthly report
E. Fundamental Measures																															
E1	GIS and CMS database	E1.1	link GIS and Customer Management System (CMS)	Harmonize customer data in GIS and CMS	**WO**	**WO**	GIS	ICT	RM	-	High	NA	1 year	-	x	x	x	x	x	x	x	x	x	x	x	x					
				Regular updates of both Systems (GIS, CMS) simultaneously	**WO**	**WO**	GIS	ICT	RM	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
		E1.2	Avail GIS staff up to branch level	Recruit and affect GIS staff in branches	**HR**	**HR**	HRM	-	-	-	Low	General expenses	1 year	-														x			
				Train branch GIS staff	**NRW**	**NRW**	GIS	Branches	-	-	Low	Staff, Logistics	Continuous	15,000,000						1,500,000						1,500,000	3,000,000	3,000,000	3,000,000	3,000,000	
		E2.1	Develop long term master plan of water network	Prepare a study of WASAC water network master plan	**UP**	**UP**	UP	-	-	-	High	Development budget	2 years	-	x	x	x	x	x	x	x	x	x	x	x	x	x				The preparation and elaboration of Kigali water supply and sanitation master
				Elaboration of WASAC water network master plan	**UP**	**UP**	UP	-	-	-	High	Development budget	2years	-													x				
				Implementation of the water network master plan	**UP**	**UP**	UP	-	-	-	High	Development budget	Continuous	-													x	x	x	x	

E2	Planning, design and implementation of quality works	E2.2	Disseminate existing standard of design and installation of water works	Inventory of all standards and design available	***QA***	***QA***	*Standard*	-	-	-	High	NA	1 month	-		x															
				Procure missing needed standards	***QA***	***QA***	*Standard*	-	-	-	High	General expenses	2 months	-			x	x													
				training and workshop for Dissemination of standards of design and installation	***QA***	***QA***	*Standard*	-	-	-	High	Staff and logistics	1 months	9,000,000					3,000,000										3,000,000	3,000,000	
		E2.3	Ensure the quality of designs and water works	Establish and maintain material specification (meter, pipes, fittings, etc..)	***QA***	***QA***	*Standard*	*Metering*	*Distribution*	*Branches*	High	NA	2 months	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Establish design validation procedures	***QA***	***QA***	*Standard*	-	-	-	High	NA	1 year	-	x	x															
				Set up an inspection team for works standard compliance	***QA***	***DUWSS***	*Standard*	-	-	-	High	NA	1 month	-			x														
				Technician certification for specific works (connection, repair, extension, etc. …)	***HR***	***HR***	*Standard*	*Metering*	*Distribution*	*Branches*	Low	NA	Regular	-													x	x	x	x	Internal certification
E3	WASAC NRW management	E3.1	Customize IWA water balance to WASAC (to clear understand NRW components)	Review the existing water balance used	***NRW***	***NRW***	*NRW*	-	-	-	High	NA	1 month	-						x											JICA expert will help
				Approval of component of the water balance	***NRW***	***NRW***	*NRW*	-	-	-	High	NA	2 months	-						x	x										
		E3.2	Ensure proper NRW management in WASAC	Review WASAC NRW structure	***NRW***	***WASAC***	*NRW*	*HRM*	-	-	High	NA	1 months	-	x							x									JICA expert will propose
				Review WASAC NRW reduction target	***NRW***	***WASAC***	*NRW*	-	-	-	High	NA	Yearly	-	x												x	x	x	x	
				Review the NRW procedure manual	***NRW***	***NRW***	*NRW*	-	-	-	High	NA	1 year	-		x	x	x	x	x											
		E3.3	Mobilize Partners in NRW reduction projects	Identification of different partners intervening in NRW project	***NRW***	***DUWSS***	*NRW*	*UP*	-	-	High	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
E4	Stakeholders management	E4.1	Increase the collaboration with local authorities and other infrastructures development agencies	Organize regular meeting and workshop	***WO***	***WO***	*Distribution*	*NRW*	-	-	Middle	Staff, Logistics	Regular	15,000,000		3,000,000											3,000,000	3,000,000	3,000,000	3,000,000	Once a year
				Prepare and implement MOU with road constructor, Districts and other infrastructures agencies	***WO***	***WO***	*Distribution*	*NRW*	-	-	Middle	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Monitoring of activities	***WO***	***WO***	*Distribution*	*NRW*	-	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
		E4.2	Certification of private companies and technicians for specific works (new water works)	Identification ,selection and certification of qualified companies and technicians	***WASAC***	***WASAC***	*DUWSS*	-	-	-	High	NA	Continuous	-													x	x	x	x	From the second year
		E4.3	benchmarking visits in other water utilities	Identification of best practices water utilities companies	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Preparation of partnership agreement	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Exposure visits	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	Staffs, Logistics	Continuous	15,000,000													7,500,000		7,500,000		Once every two years
		E4.4	Collaboration with research centers and universities	Select research center and universities involved in water sector	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Prepare and sign partnership agreement	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
E5	Training	E5.1	Ensure that WASAC have skilled and qualified staff	Assess current staff skill gap (new connection standard , GIS usage, pipe installation, pressure management , etc..)	***WASAC***	***WASAC***	*HR*	-	-	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	JICA experts may support
				Set up appropriate training plan	***WASAC***	***WASAC***	*HR*	-	-	-	High	NA	6 months	-		x	x														
				implement the training plan	***WASAC***	***WASAC***	*HR*	-	-	-	High	General expenses	Continuous	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	
				Set up an internal knowledge transfers mechanism	***WASAC***	***WASAC***	*HR*	-	-	-	High	NA	6 months	-				x	x	x											
				Monitoring and Evaluation of the change	***WASAC***	***WASAC***	*HR*	-	-	-	High	NA	Continuous	-				x	x	x	x	x	x	x	x	x	x	x	x	x	
		E5.2	Benchmarking of different branches for NRW reduction to enhance NRW performance	Compile and analyze branch NRW report	***WASAC***	***WASAC***	*NRW*	-	-	-	High	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Monthly report
				Set NRW target for Each branch	***WASAC***	***WASAC***	*NRW*	-	-	-	High	NA	2 months	-					x	x											branches NRW targets should be align with company target
				Organize regular meeting with branches	***WASAC***	***WASAC***	*NRW*	-	-	-	High	General expenses	Continuous	-						x						x	x	x	x	x	Quarterly
				Propose incentive measures for NRW reduction	***WASAC***	***WASAC***	*NRW*	-	-	-	High	NA	Continuous	-					x												
E6	Institution	E6.1	Ensure the implementation of the branch new structure	Recruitment of new staff to populate the new structure	***WASAC***	***WASAC***	*DUWSS*	*DCS*	-	-	High	General expenses	6 moths	-							x	x	x	x	x	x					
		E6.2	Reinforce the research and development	Identify area of research and set up the team	***WASAC***	***WASAC***	*DUWSS*	*DCS*	-	-	Low	NA	1 year	-							x	x	x	x	x	x					
		E6.3	Continuous improvement and innovation	Establish the innovation incentive mechanism	***WASAC***	***WASAC***	*DUWSS*	*DCS*	-	-	Low	NA	1 year	-							x	x	x	x	x	x					
E7	Logistic and quality materials	E7.1	Avail enough equipment and logistics (vehicle , motorcycle , tools, protective equipment , etc.…)	Inventory of available equipment and logistic facilities at the branch level and determines urgent need	***DSS***	***DSS***	*Admin & Logist*	*DUWSS*	*DCS*	*Branches*	High	NA	3 months	-	x	x	x														
				Procurement of equipment and logistics needed	***DSS***	***DSS***	*Admin & Logist*	*DUWSS*	*DCS*	*Branches*	High	General expenses	2year	-				x	x	x	x	x	x	x	x	x	x				

TOTAL Amount	4,615,448,581	780,740,000	921,740,000	941,330,000	972,981,250	998,657,331	
	US$5,494,582	*US$929,452*	*US$1,097,310*	*US$1,120,631*	*US$1,158,311*	*US$1,188,878*	
WASAC	15,000,000	0	7,500,000	0	7,500,000	0	15,000,000
NRW	1,056,300,000	284,430,000	99,260,000	297,100,000	287,100,000	87,100,000	1,054,990,000
WO	782,400,000	133,480,000	161,480,000	161,480,000	161,480,000	161,480,000	779,400,000
QA	9,000,000	3,000,000	0	0	3,000,000	3,000,000	9,000,000
UP	0	0	0	0	0	0	0
RM	15,720,000	5,720,000	2,500,000	2,500,000	2,500,000	2,500,000	15,720,000
CSM	2,737,028,581	329,670,000	651,000,000	480,250,000	511,401,250	744,577,331	2,716,898,581
Branch	0	0	0	0	0	0	0
HR	0	0	0	0	0	0	0
ICT	0	0	0	0	0	0	0
Ad&Lo	0	0	0	0	0	0	0
	4,615,448,581	756,300,000	921,740,000	941,330,000	972,981,250	998,657,331	4,591,008,581

Responsible Department/ Unit/ Section
Leak detection and pressure management Section: LD&PM
Zoning and mapping Section : GIS
Inspection and Enforcement Section: I&E
Water Production Section: Production
Water Distribution Section: Distribution
Quality Assurance Unit: QA
Utility Planning Unit: UP
Revenue Management Unit: RM
Customer Service Management Unit: CSM
Direction Support Service: DSS
Human Resource Unit: HR
Administration and Logistics Unit: Admi & Logistics

Implementation & Monitoring Plan for NRW Reduction 2017/2018

Gr No.	Components	Sub Gr No.	Countermeasures	Specific actions	Budget	Responsible TEAM for Specific actions					Priority	Necessary Resources	Period	Total amount (RWF)	Implementation Schedule and Estimated Budget																Implementation tips	Monitoring		Comments
						Respon-sible UNIT	Action Section/Branch								2017/2018 1st Year												2018/2019 2nd Year	2019/2020 3rd Year	2020/2021 4th Year	2021/2022 5th Year		Monitoring Indicators	Means of verification	
															Jul	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June								
A. System Input Volume																																		
A1	Volume input metering accuracy	A1.1	Establish the framework to ensure the system volume input accuracy	Inventory of bulk meters (GIS, Esri, Survey)	NRW	NRW	Production	Distribution	-	-	High	NA	already available	-	x																Establish the list of all bulk meters which indicate spec. and current condition	The list of all bulk meters is prepared and shared with DUWSS	List checked	This list should contain all details of bulk meters (diameter , age , condition , etc..) as per agreed format
				Set up a dedicated and experienced team to visit, analyze and report all bulk meters condition (meter age, size, installation, etc..)	NRW	NRW	NRW	Metering	Production	Distribution	High	NA	1 month	-	x																-	Team constitution	Nomination letters from DUWSS	The team will be composed by experienced people on metering
				Visit, analyze and detailed report of all bulk meters condition	NRW	NRW	NRW	Metering	Production	Distribution	High	Consultant, Staff, Logistics	3 months	1,920,000		960,000	960,000	960,000													-	Report is prepared for each bulk meter by the team	Report available	
				Installation of new meters / Replacement of faulty bulk meters / correcting of meters installation based on the result of meter condition analysis	NRW	NRW	NRW	Metering	Production	Distribution	High	Staff, Bulk meters, Fittings, Logistics	5 months	204,000,000					41,000,000	41,000,000	41,000,000	41,000,000	40,000,000								Replacement of fault meters and installation of new meter where necessary	Number of replaced / installed new meters	Report available	
				Prepare a plan for bulk meter regular check up for the future.	NRW	NRW	NRW	Metering	Production	Distribution	High	Staff	1 month	-				x													-	Plan prepared	Plan available	
				Implementation of the plan for bulk meter regular check up for the future.	NRW	NRW	NRW	Metering	Production	Distribution	High		Regular	-					x	x	x	x	x	x	x	x	x	x	x	x	-	Progress of the plan	Report of the check up	
				Bulk meter reading and analysis	NRW	NRW	NRW	Production	Distribution		High		Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	Bulk meters readings is recorded on daily basis	Monthly report of bulk meter reading and analysis	the new readings should show the gain from the replacement
A2	Water production (prevent intermittent supply)	A2.1	Increase water production to ensure Continuous supply for proper flow and pressure management	Assessment of water supply gap	UP	UP	UP	-	-	-	High	General expenses	already available	-	x																			
				Identify project to address the current gap and future demand	UP	UP	UP	-	-	-	High	General expenses	already available	-	x																			
				Implement of the identified project (Construction of new WTP, upgrade existing WTP, forwarding infrastructures and the Network)	WO	WO	Production	-	-	-	High	Development budget	on going	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
				Install backup generators at critical WTP and pumping station (Long term)	WO	WO	Production	-	-	-	Medium	Development budget	2 years	-															x	x				
B. Commercial Losses																																		
B1	Meter reading and billing	B.1.1	Ensure correct and 100% customers meter reading	Sensitization of CFO's about the importance of accurate readings through workshops	RM	RM	Billing	Branches	-	-	High	Staff, Logistics	Regular	15,000,000				2,500,000						2,500,000			2,500,000	2,500,000	2,500,000	2,500,000	Organize workshop at least twice a year	Number of workshop and attendances	Report of workshop	
				Train CFO how to use map in meter reading	RM	RM	Billing	Branches	-	-	High	Staff, Logistics	3 months	720,000					240,000	240,000	240,000										Organize trainings for meter reading	Number of trainings and attendances	Report of trainings	
				Enforce billing supervision at branch level by recruiting billing and revenue collection supervisors	RM	RM	Billing	Branches	-	-	High	General expenses	2 months	-						x	x										Recruitment of billing supervisors	1 billing supervisor / 4000 customers	Number of billing supervisor	
				Regular Random re-reading of customer meters (by the branch management and also the senior management)	RM	RM	Billing	Branches	-	-	High	NA	Continuous	-						x	x	x	x	x	x	x	x	x	x	x	Random customers meters re-reading to check indexes provided by CFOs	Frequency of re-reading (monthly by the branch management and once every quarter by the senior management)	Re- reading reports	Senior management should make unannounced visit to branch
				Make the business case for outsource meter reading	RM	RM	Billing	Branches	-	-	High	NA	2 months	-						x	x										Collecting information about meter reading outsourcing and make the business case	Business case prepared	Business case report	The business case should indicates the cost benefit analysis and the success story within the region/ Africa
		B.1.2	Ensure Customer meter accuracy	Make a plan for Regular meter accuracy test.	CSM	CSM	Metering	Branches	-	-	High		1 month	-						x											Plan preparation showing the frequency, number of meters, equipment to be used for meter testing	Meter test plan available	Approved annual plan for meter on-site testing	The plan should describe the way this activity will be done
				Implement of the plan for Regular meter accuracy test.	CSM	CSM	Metering	Branches	-	-	High	Staff, Equipment, Logistic	Regular	4,670,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000	85,000	1,000,000	1,000,000	1,000,000	1,000,000	On-site meter testing	Number of meters tested on-site	Monthly reports on-site meter testing from branches	
				Procure additional Portable meter test equipment (at least 1 per branch)	CSM	CSM	Metering	-	-	-	High	Meter test equipment	6 months	120,000,000		x	120,000,000														-	Number of portable meter test equipment procured	Procurement documents	
				Meter replacement	CSM	CSM	Metering	Branches	-	-	High	Meters, Staffs, Logistics	continuous	2,088,228,581	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	15,000,000	450,000,000	479,250,000	510,401,250	543,577,331	Replacement of fault /aged meter based on on-site meter testing and other meter situation report available (Esri , CFO monthly report ,etc..)	Number of fault/aged meter replaced	Monthly meter replacement report from branches (hard and soft copy)	
				Procure and install one water test bench per province	CSM	CSM	Metering	-	-	-	Low	Meter test bench	1 year	200,000,000																200,000,000	procurement of meter test bench based on agreed technical specifications	Number of meter test bench installed per province	Monthly report of meter testing using meter test bench	One meter test bench per province
		B.1.3	Improve technology and equipment for meter reading and billing	Procure portable bills printers	CSM	DCS	Metering	ICT	-	-	High	Printers and accessories	6 months	92,000,000		x	x	92,000,000													-	On-site bills printing available	Random on-site verification	there should be a mechanism to ensure that the bill have been printed out and submit to the customers
				Exposure visit for success stories and adapt if necessary	CSM	DCS	Metering	ICT	-	-	High	Staff, Logistics	1 months	8,000,000							8,000,000										Collect information about the best performers water utilities , visit and prepare the action plan for the implementation of best practices	Number of exposure visit and action plan prepared	Report from exposure visit and the action plan to implement best practices from visited companies	The exposure visit can be organize in the region or other African countries
				Automatic meter reading or prepaid meters for big customers	CSM	DCS	Metering	ICT	-	-	High	Meters, Staffs, Logistics	1 years	200,000,000													200,000,000				Procurement and installation of automatic /prepaid meters to big customers	Number of automatic/ prepaid meters installed	Report of automatic /prepaid meters installed	
		B.1.4	Monitoring of customer consumption trends	Analysis of customer consumption Database	RM	RM	Billing	Branches	-	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Monthly / yearly customer consumption analysis , extraction of irregular consumption trend	Number of customer suspected by consumption trend analysis	Monthly report of irregular consumption trends	
				Plan and visit customer with irregular consumption	RM	RM	Billing	Branches	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	Number of cases visited	Monthly report of customers with irregular consumption visited	
				Analysis of estimated/constant bills	RM	RM	Billing	Branches	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Extract from the system all customers with constant consumption and visit them	Number of customers with constant consumption visited	Monthly report of customers with constant consumption visited	
				Weekly meter reading for big customers (at least 200 big customers)	RM	RM	Billing	Branches	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x					Select 200 big customers for all WASAC and visit them each week	Number of big customer visited weekly (200 per week)	weekly report of meter reading	these 200 big customers will be billed once a month
				Regular follow up of big customers	RM	RM	Billing	Branches	-	-	High	General expenses	Regular	-													x	x	x	x	After the installation of prepaid meters , there should be regular visit of meter installation and condition	Visit at least once a quarter	Quarterly report of prepaid meter verification	after the installation of prepaid meters
B2	Customers meter management (normal, larges and public tap)	B2.1	Continue customer mapping and inventory	Complete customer inventory and mapping in Upcountry Branches	RM	RM	Billing	Branches	GIS	ICT	High	Consultant, GIS staff, logistic	6 moths	-	x																Customer mapped and recorded in GIS with all their details (POC, Meter , Location , etc..)	All customers and their details in GIS	Monthly GIS data checking	
				Set up and implement a clear customer database update procedures in GIS and CMS	RM	RM	Billing	Branches	GIS	ICT	High	GIS staff	2 moths	-		x	x														Avail and disseminate GIS and CMS update procedure	GIS and CMS update procedure manual available and disseminated	Check if updates are following procedures	
		B2.2	Ensure the quality of meter installation and replacement	Update meter installation and replacement policy	CSM	CSM	Metering	-	-	-	High	NA	2 months	-		x	x														Review the existing meter replacement process , prepare and disseminate the revised meter replacement policy	Meter replacement policy available and disseminated	Approved meter replacement policy being used	meter replacement policy should be approved by WASAC senior management
				Implement meter replacement according to the replacement policy	CSM	CSM	Metering	Branches	-	-	High		Regular	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	Number of meter replaced following revised policy	check if on-site meter replacement follows the revised policy	
				Supervision and inspection of meter installation for new connection works	CSM	CSM	Metering	Branches	-	-	High	General expenses	Continuous	-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Set up the inspection team	Number of water works inspected by the team	Inspection team recommendations to be implemented	this team may also inspect all water work within WASAC
		B2.3	Reinforce public tap management	Public tap inventory and assessment of their condition (meter ,location ,etc..)	RM	RM	Metering	Branches	GIS	-	High	General expenses	2 months	-		x	x														Inventory of all public taps , their condition (disconnected or not) , etc….	List available	On-site cross checking	
				Review the existing public tap management procedures	RM	RM	Metering	Branches	-	-	High	NA	1 month	-				x													Review the existing public tap management , prepare and disseminate the revised public tap management procedure	Public tap management procedure available and disseminated at banch level	Check if the revised public tap management procedure is being used	
B3	Illegal Connection (illegal water use)	B3.1	Prevention of illegal water usage	Raise staff and community awareness through workshops, media show	NRW	NRW	Inspe. & Enforce.	-	-	-	High	Staff, Logistics	Regular	25,000,000						2,500,000						2,500,000	5,000,000	5,000,000	5,000,000	5,000,000	Organize community NRW awareness campaign (meeting radio/tv show , posters etc..)	Number of events and participants /targeted population	Reports of events	
				Enhance Incentive for informers (including staff)	NRW	NRW	Inspe. & Enforce.	-	-	-	High	Informers incentives	Continuous	5,700,000	50,000	50,000	50,000	50,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	1,200,000	1,200,000	1,200,000	1,200,000	Prepare internal policy for staff incentive on illegal case reporting and enhance quick and confidential payment to informers	Increase of number of reported illegal connection	Monthly report of reported illegal connection	
				Inspection of suspected customer's and large consumer's connections based on customer data analysis	NRW	NRW	Inspe. & Enforce.	Branches	-	-	High	Staff, Logistics	Regular	13,050,000	125,000	125,000	125,000	125,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	2,700,000	2,700,000	2,700,000	2,700,000	-	Number of large customers visited	Monthly inspection report	
				Installation of meter protection boxes for suspected customers	CSM	CSM	Metering	Branches	-	-	High	Staff, Logistics	Regular	4,000,000			400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000					Inventory of all suspected connection and install a meter box	Number of water meter box installed	Report of water box meters installed	After the installation of meter boxes there should be a regular check (at least once a quarter)
				Complete disconnection of confirmed inactive customers	RM	RM	Billing	Branches	-	-	High	General expenses	continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Irreversible disconnection that will not allow the customer to re-connect by themselves	Number of inactive customers totally disconnected	Report of inactive customers totally disconnected	A customer disconnected for more than … months should be remove from the main pipe
		B3.2	Charge fines for confirmed illegal water usage customers	Disconnection of confirmed illegal cases	RM	RM	Billing	Inspe. & Enforce.	Branches	-	High	Staff, Logistics	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	Number of illegal cases disconnected	Report of confirmed illegal cases	
				Monitoring of fines payment	NRW	NRW	Inspe. & Enforce.	Branches	-	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Recovery of fines from customers with illegal cases	Ratio of amount due and amount paid	Report of fines payment	
C. Physical Losses																																		
C1	Pressure management	C1.1	Determination of high pressure zones	Review, analysis and regular update of existing map of water network, pumping station ,WTP installations, etc..	WO	WO	GIS	-	-	-	High	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Update all changes in the network in daily work	Updating procedure established	Hard copy showing the situation before and after changes	
				Hydraulic calculation and modeling	WO	WO	GIS	-	-	-	High	General expenses	Regular	-		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Establish the hydraulic calculation model for each water network	Hydraulic calculation available for network extension	All extension work are checked if hydraulic calculation was done before implementation.	
				Identification, mapping and dissemination of higher pressure zones	WO	WO	GIS	-	-	-	High	GIS staff	1 year	-			x	x	x	x	x	x	x	x	x	x					Identify the high pressure zone by using GIS software and hydraulic modeling	Pressure zones mapped in GIS and informed to branches	GIS data about location of the high pressure zone	
		C1.2	Determine the acceptable pressure range in the network and customer tap	Make a survey on the existing pressure in the network and on customer taps	NRW	NRW	LD&PM	-	-	-	High	Staff, Logistics	2 months	3,360,000				1,680,000	1,680,000												Pressure measurement in the network	Number of points which pressure was measured in the network	Pressure survey report	
				Propose the acceptable pressure range considering our local conditions	NRW	NRW	LD&PM	Distribution	-	-	High	Staff	3 months	-						x	x	x									Analysis of the survey report and propose acceptable range	Acceptable pressure acknowledged	Acceptable pressure range included in DUWSS procedure manual	
		C1.3	High pressure zones survey (from hydraulic analysis)	Identification of place to install pressure gauges ,dataloggers	NRW	NRW	LD&PM	Distribution	Branches	GIS	High	Staff, Logistics	3 months	-									x	x	x	x	x				From the pressure survey zones , indicate the place to install pressure gauges	Number of identified places	Map of identified place to install pressure gauges	
				Procure and install pressure gauges in the network	NRW	NRW	LD&PM	Distribution	Branches	GIS	High	Staff, Pressure gauges, Logistics	2 years	20,000,000													10,000,000	10,000,000			-	Number of pressure gauge installed in appropriate areas	On-site checking of pressure gauges installed	
				Follow-up and Analysis of pressure measurement results	NRW	NRW	LD&PM	Distribution	Branches	-	High	Staff, Logistics	Continuous	-						x	x	x	x	x	x	x	x	x	x	x	-	Frequency of pressure measurement analysis	Report of pressure measurement analysis	Pressure measurement should be done at least once week and data analysis once a month
				Inventory of existing PRVs, Break Pressure Tanks (BPT)	WO	WO	Distribution	LD&PM	GIS	-	High		2 months	-	x	x															Inventory of all protective equipment and assess their current working condition	List available	Report of protective equipment assessment and random on site checking	protectives equipment are PRVs. Break pressure tanks , Air valves , etc….)

Implementation & Monitoring Plan for NRW Reduction 2017/2018

Gr No.	Components	Sub Gr No.	Countermeasures	Specific actions	Budget	Responsible TEAM for Specific actions					Priority	Necessary Resources	Period	Total amount (RWF)	Implementation Schedule and Estimated Budget																Implementation tips	Monitoring		Comments
						Respon-sible UNIT	Action Section/Branch								2017/2018 1st Year												2018/2019 2nd Year	2019/2020 3rd Year	2020/2021 4th Year	2021/2022 5th Year		Monitoring Indicators	Means of verification	
															Jul	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June								
		C1.4	Proper pressure management	Identification and prioritization of actions to address pressure issues	NRW	NRW	LD&PM	Distribution	-	-	High	Staff	3 months	-		x	x	x													After assessment, make a list of urgent actions to address high pressure issues	List of action by their priorities available	Report of urgent actions to address high pressure issues	
				Set up a plan for pressure management	NRW	NRW	LD&PM	Distribution	-	-	High	Staff	3 months	-		x	x	x													Prepare an plan for pressure management based on high priority actions identified	Plan available	Maps and plan checking	
				Implementation of pressure management plan (PRV, BPT, rearrangement of pumping stations and pipeline network)	NRW	NRW	LD&PM	Distribution	-	-	High	Staff, Pressure reducer equipment, Logistics	Regular	324,800,000			5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	5,600,000	67,200,000	67,200,000	67,200,000	67,200,000	Procurement and installation of PRVs, BTP and other related equipment based on the plan	Number of equipment installed	On-site checking of equipment installed and the map	
				Continuous pressure control	NRW	NRW	LD&PM	Distribution	Branches	-	High	Staff, Logistics	Continuous	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	Ensure that pressure is maintained at acceptable range	Pressure level maintained at acceptable level	Monthly pressure measurement report	
C2	Asset Management (Rehabilitation)	C2.1	Asset data management by GIS	Inventory, drawing and mapping of water facilities	WO	WO	GIS	-	-	-	High	Consultant, GIS staff, Logistic	1 year	-	x	x	x	x	x	x	x	x	x	x	x	x					-	All water infrastructure attributes recorded in GIS	Random checking on-site and in GIS	
				Regular update of GIS data	WO	WO	GIS	-	-	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Update all changes in the network in daily work	Changes recorded in GIS	Hard copy showing the situation before and after changes from GIS	
		C2.2	Network maintenance and rehabilitation	Inventory of infrastructures to be rehabilitated	WO	WO	Distribution		-	-	High		3 months	-	x	x	x														Make the list and maps of area to be rehabilitated	List and maps available	Check the list of areas to be rehabilitated	
				Analysis for optimal use of water infrastructure	WO	WO	Distribution	-	-	-	High	GIS staff, Logistics, GIS software	2 moths	-	x	x															Set up criteria to select the pipe material for urgent rehabilitation	Criteria available	Report of pipes to be rehabilitated urgently	
				Prioritization of areas for rehabilitation	WO	WO	Distribution	-	-	-	High	Staff	Yearly	-		x	x										x	x	x	x	Make a list , BOQ and Maps of areas to be rehabilitated urgently	List , BOQ and maps available	check the selected area and compare to the ground situation(randomly)	
				Preparation of maintenance and rehabilitation plan	WO	WO	Distribution	-	-	-	High	Staff	Yearly	-		x	x										x	x	x	x	-	Approved maintenance and rehabilitation plan available	Check the approved maintenance and rehabilitation plan	the maintenance plan will be done at branch level and monitored by HQ team
				Implementation of the maintenance and rehabilitation plan	WO	WO	Distribution	-	-	-	High	Staff, Material, Logistics	Continuous	750,000,000			13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	13,000,000	155,000,000	155,000,000	155,000,000	155,000,000	Implementation of planned activities for maintenance and rehabilitation	Activities implemented as planned	Check if the maintenance and rehabilitation plan is being used following standards	
				Monitor and evaluation of the implementation of the maintenance plan	WO	WO	Distribution	-	-	-	High	Staff, Logistics	Continuous	2,400,000						240,000						240,000	480,000	480,000	480,000	480,000	Monitor the progress of network maintenance and rehabilitation plan	Progress of maintenance and rehabilitation activities	Monthly progress reports	
		C2.3	Infrastructure protection	Installation of protective facilities (manhole covers , fences …)	WO	WO	Distribution	Branches	-	-	Low	Staff, Protective equipment, Logistics	Continuous	15,000,000						1,500,000						1,500,000	3,000,000	3,000,000	3,000,000	3,000,000	Inventory of equipment not protected and install protective facilities	Number of installed protective facilities	On-site checking of installed protective equipment facilities (randomly)	
				organize public awareness for infrastructure protection against vandalism	WO	WO	Distribution	Metering	Branches	-	Low	General expenses	Regular	-							x						x	x	x	x	-	Number of awareness campaign	Report of awareness campaign	
C3	Leaks and burst repair	C3.1	Quick and good quality repairs	Sensitization for leak reporting (meeting , TV show , rewarding informers , etc..)	NRW	NRW	LD&PM	Distribution	Branches	-	High	NA	Regular	10,000,000							2,000,000						2,000,000	2,000,000	2,000,000	2,000,000	Organize events for community sensitization for leak reporting	Number of events (meeting , TV show, etc..)	Events reports	
				Daily monitoring of leaks reported and repair (wtsp, LIS)	NRW	NRW	LD&PM	Distribution	Branches	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Record and analyze all leak reported and repaired	Total number of leak reported and repaired	Leak Information System (LIS) records and on site checking (randomly)	
				Avail minimum stock at the branch level	NRW	NRW	LD&PM	Distribution	Branches	-	High	NA	1 year	-		x	x	x	x	x	x	x	x	x	x	x					Prepare the list of minimum and necessary stock required based on leaks reports	Minimum stock level available at the branch	Branch stock records report (monthly)	minimum stock is here refeed to the stock for 3 months for leaks reparation and network maintenance
				Regular inspection of leaks repaired	NRW	NRW	LD&PM	Distribution	Branches	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	On-site leak repaired verification complying with standards	Number of inspected leak repaired	Leak repaired inspection report	
				Dissemination of standard for leak repair	QA	QA	Standard	NRW	-	-	High	NA	Continuous	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	Dissemination of leak reparation standard through training and workshop	Reduction of number of leak repaired not complying with the standard	Leak repaired inspection report	
				Train staff for leak repair	NRW	NRW	LD&PM	Branches	-	-	High	Staff, Logistics	Continuous	15,000,000			3,000,000										3,000,000	3,000,000	3,000,000	3,000,000	-	Number of technician trained	Training report	
		C3.2	Active leakage control	Make historical analysis of leakages (location, diameter, material etc..)	NRW	NRW	LD&PM	Distribution	Branches	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Collect and analyze all leaks information available	Number of analysis methods (location, diameter, material etc.)	Leaks analysis reports	
				Prepare an yearly plan of visible leakage and invisible survey (including reservoir)	NRW	NRW	LD&PM	Distribution	Branches	-	High	NA	Regular	-	x												x	x	x	x	-	Approved plan available	Check the plan	
				Implement the yearly plan of visible leakage survey (including reservoir)	NRW	NRW	LD&PM	Distribution	Branches	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	On ground visible leak survey	Number of leaks identified	Check if the plan is being implemented	
				Train staff for leakage survey and leak detection	NRW	NRW	LD&PM	Distribution	Branches	-	High	Staff, Logistics, Equipment	Regular	15,000,000			3,000,000										3,000,000	3,000,000	3,000,000	3,000,000	Organize training for leak detection using appropriate equipment	Number of staff trained	Training report	
				Procure and dispatch leak detection equipment to branches	NRW	NRW	LD&PM	Branches	-	-	High	Leak detection equipment	2 years	400,000,000														200,000,000	200,000,000		Tender document preparation and procurement of leak detection equipment	Leak detection equipment available	Leak detection equipment being used by branches staff	
				Select critical areas to detect invisible leaks	NRW	NRW	LD&PM	Distribution	Branches	-	High	NA	Continuous		x												x	x	x	x	Critical area selection to start leak detection activities within the branch using historical analysis	Selected areas available	Analysis report of critical areas	At least one critical in each branch
				Conduct leak detection activities in all branches and make estimation of water lost through leakages	NRW	NRW	LD&PM	Distribution	Branches	-	High	Staff, Logistics, Equipment	Continuous	2,160,000	x	x	x	x	x	x							2,160,000	x	x	x	-	Number of leak detected and estimated volume of water saved	Monthly leak detection reports	
		C3.3	Establish water supply monitoring system (DMA, SCADA ,etc..)	Complete the isolation of Kigali branches	NRW	NRW	LD&PM	GIS	Distribution	Branches	Middle	Staff, Equipment	1 year	-	x	x	x	x	x	x	x	x	x	x	x	x	x				Demarcation , manholes construction , meter installation and NRW control	NRW ratio known for Kigali branches	Monthly NRW reports	
				Creation and management of DMA within branches	NRW	NRW	LD&PM	GIS	Distribution	Branches	Middle	Development budget	Continuous								x	x	x	x	x	x	x	x	x	x	Demarcation , Bulk meter installation and NRW control	Number of DMA created and well managed	Branch NRW report	at least one well managed DMA per branch
				Establish a network monitoring system including reservoirs	NRW	NRW	LD&PM	GIS	Distribution	Branches	Middle	Development budget	5 years	-													x	x	x	x	Design and implementation of SCADA system	SCADA system functioning	Recorded data by SCADA	
		C3.4	Reporting and recording of leakages	Review and harmonize leaks reporting and repairs format	NRW	NRW	LD&PM	GIS	Distribution	Branches	High	NA	3 months	-	x																Review existing report format and propose a standard format	New leak report format available	New format being used by branches on daily basis	
				Daily report of leakages with Location, diameter , materials and so on	NRW	NRW	LD&PM	GIS	Distribution	Branches	High	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Daily record and report of leaks in the new format	Leaks daily report available	Data from daily report	
D. Unbilled Authorized Consumption																																		
D1	Unbilled metered authorized consumption	D1.1	Ensure proper fire hydrant management	General inventory of all fire hydrants and confirmed if metered and billed	DUWSS	NRW	Billing	Metering	Distribution	Branches	High	General expenses	2 months	-	x	x															-	List available	On-site verification (randomly)	Immediate action
				policy establishment for fire hydrants installation and management	DUWSS	NRW	Billing	Metering	Distribution	Branches	High	NA	1 month	-			x														Review the existing fire hydrant installation policy and proposed the new one	Policy available	Check if the policy is being recognized	
				calculation and analysis of water used by fire hydrants	RM	RM	Billing	Metering	Distribution	Branches	High	NA	Regular	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	Extract the list of non -metered fire hydrant and estimate their consumption	Estimated consumption available	Calculation analysis report	
D2	Unbilled unmetered authorized consumption	D.2.1	Have a plan for network and reservoirs flushing	Preparation of network flushing plan	WO	WO	Distribution	Branches	-	-	Low	NA	Regular	-	x												x	x	x	x	Produce network flushing plan for each branch	Network flushing plan available	Compiled branch network flushing plans	
				Implementation of the network flushing plan	WO	WO	Distribution	Branches	-	-	Low	General expenses	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	Frequency of network flushing	Network flushing report	
				Estimation of water uses in network flushing , reservoir cleaning	WO	WO	Distribution	Branches	-	-	Low	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Make the estimation of water used in network using agreed formula	Estimated volume available	Network flushing report	
E. Fundamental Measures																																		
E1	GIS and CMS database	E1.1	link GIS and Customer Management System (CMS)	Harmonize customer data in GIS and CMS	WO	WO	GIS	ICT	RM	-	High	NA	1 year	-	x	x	x	x	x	x	x	x	x	x	x	x					Complete customer mapping , clean up CMS data , harmonize the 2 systems	GIS and CMS completely harmonized	GIS and CMS data	
				Regular updates of both Systems (GIS, CMS) simultaneously	WO	WO	GIS	ICT	RM	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Record all changes on daily basis and update the system	Changes are considered	Compare data before and after changes	
		E1.2	Avail GIS staff up to branch level	Recruit and affect GIS staff in branches	HR	HR	HRM	-	-	-	Low	General expenses	1 year	-														x			-	Number of GIS staff per branch	Branch structure	
				Train branch GIS staff	NRW	NRW	GIS	Branches	-	-	Low	Staff, Logistics	Continuous	15,000,000						1,500,000						1,500,000	3,000,000	3,000,000	3,000,000	3,000,000	-	Number of staff trained	Training report	
E2	Planning, design and implementation of quality works	E2.1	Develop long term master plan of water network	Prepare a study of WASAC water network master plan	UP	UP	UP	-	-	-	High	Development budget	2 years	-	x	x	x	x	x	x	x	x	x	x	x	x	x							
				Elaboration of WASAC water network master plan	UP	UP	UP	-	-	-	High	Development budget	2years	-													x							
				Implementation of the water network master plan	UP	UP	UP	-	-	-	High	Development budget	Continuous	-													x	x	x	x				
		E2.2	Disseminate existing standard of design and installation of water works	Inventory of all standards and design available	QA	QA	Standard	-	-	-	High	NA	1 month	-		x															-	List available	Report of the inventory	
				Procure missing needed standards	QA	QA	Standard	-	-	-	High	General expenses	2 months	-			x	x													-	Number of standard and design procured	New available standards procured	
				training and workshop for Dissemination of standards of design and installation	QA	QA	Standard	-	-	-	High	Staff and logistics	1 months	9,000,000					3,000,000										3,000,000	3,000,000	-	Number of training, workshop and participants	Training /workshop report	
		E2.3	Ensure the quality of designs and water works	Establish and maintain material specification (meter, pipes, fittings, etc..)	QA	QA	Standard	Metering	Distribution	Branches	High	NA	2 months	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Review existing material specifications standard and propose modifications if necessary	Material specifications available	Material specifications disseminated to all department via booklet /internet	The material specification can be revised yearly based on lesson learn from previous works/tenders
				Establish design validation procedures	QA	QA	Standard	-	-	-	High	NA	1 year	-	x	x															Establish the designs validation procedures and approved	Approved design validation procedure included in DUWSS procedure manual	DUWSS procedure manual	All water works should have designs prepared by project engineer and approved by the project manager
				Set up an inspection team for works standard compliance	QA	DUWSS	Standard	-	-	-	High	NA	1 month	-			x														-	Number of water works monitored by the team	Report of monitoring team	This team should be a permanent team
				Technician certification for specific works (connection, repair, extension, etc. …)	HR	HR	Standard	Metering	Distribution	Branches	Low	NA	Regular	-													x	x	x	x	Measure staff capacity to do specific works and certify them	Number of staff certified	Report of staff capacity measurement	
E3	WASAC NRW management	E3.1	Customize IWA water balance to WASAC (to clear understand NRW components)	Review the existing water balance used	NRW	NRW	NRW	-	-	-	High	NA	1 month	-						x											-	Issues identified	Reviewed water balance	the water balance will referred to IWA standard water balance
				Approval of component of the water balance	NRW	NRW	NRW	-	-	-	High	NA	2 months	-						x	x										WASAC approval of water balance component and methodology to calculated/estimate/ assumption	Methodology approved	2017-2018 water balance approved	
		E3.2	Ensure proper NRW management in WASAC	Review WASAC NRW structure	NRW	WASAC	NRW	HRM	-	-	High	NA	1 months	-	x							x									Review the current NRW unit position in WASAC structure to ensure that the unit is focusing advisory, strategies setting , monitoring	WASAC NRW unit structure improved	WASAC revised structure	
				Review WASAC NRW reduction target	NRW	WASAC	NRW	-	-	-	High	NA	Yearly	-	x												x	x	x	x	Review the NRW target as mentioned in WASAC Business plan , propose a new target considering the current achievement	New NRW target approved	Revised WASAC business plan	the new target has been already proposed in this 5YASP and will be approved together with the document
				Review the NRW procedure manual	NRW	NRW	NRW	-	-	-	High	NA	1 year	-		x	x	x	x	x											Consult the DUWSS and DCS procedure manual and extract NRW activities for the establishment of NRW procedure manual	Approved NRW procedure manual available	NRW procedure manual being used by all directorates	
		E3.3	Mobilize Partners in NRW reduction projects	Identification of different partners intervening in NRW project	NRW	DUWSS	NRW	UP	-	-	High	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Organize workshop and invite different organizations working in water sector ,present the 5YSAP and request their support	Number of workshop/meeting organized	Report of workshop/meeting	
		E4.1	Increase the collaboration with local authorities and other infrastructures development agencies	Organize regular meeting and workshop	WO	WO	Distribution	NRW	-	-	Middle	Staff, Logistics	Regular	12,000,000		3,000,000											3,000,000	3,000,000	3,000,000	3,000,000	Organize workshop and meetings with stakeholders to exchange information about on-going and planned projects	Number of workshop and meeting organized	Report of workshop and meeting	
				Prepare and implement MOU with road constructor, Districts and other infrastructures agencies	WO	WO	Distribution	NRW	-	-	Middle	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	MOU preparation for each specific project to clarify the responsibility of each agency	Number of Signed MOU	Signed MOU being implemented	
				Monitoring of activities	WO	WO	Distribution	NRW	-	-	High	NA	Regular	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Set up the monitoring team that will monitor the implementation of MOUs	Number of monitoring activities conducted	Monitoring team reports	

Implementation & Monitoring Plan for NRW Reduction 2017/2018

Gr No.	Components	Sub Gr No.	Countermeasures	Specific actions	Budget	Responsible TEAM for Specific actions					Priority	Necessary Resources	Period	Total amount (RWF)	Implementation Schedule and Estimated Budget																Implementation tips	Monitoring		Comments
						Respon-sible UNIT	Action Section/Branch								2017/2018												2018/2019	2019/2020	2020/2021	2021/2022		Monitoring Indicators	Means of verification	
															1st Year												2nd Year	3rd Year	4th Year	5th Year				
															Jul	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June								
E4	Stakeholders management	E4.2	Certification of private companies and technicians for specific works (new water works)	Identification ,selection and certification of qualified companies and technicians	***WASAC***	***WASAC***	*DUWSS*	-	-	-	High	NA	Continuous	-													x	x	x	x	Identified and classified companies/technician working in water sector . Asses their expertise in specific assignment and certified them	Number of company/technician certified	Report from the assessment	The assessment should be done based on the reports of previous work done for WASAC , their financial situation , etc..)
		E4.3	benchmarking visits in other water utilities	Identification of best practices water utilities companies	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Review water utilities performance in the past 3 years , select the best performers	Best water utility identified	Report of water utility performance assessment	
				Preparation of partnership agreement	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Prepare and organize partnership agreement meetings	Partnership agreement signed	Partnership agreement being implemented	
				Exposure visits	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	Staffs, Logistics	Continuous	15,000,000													7,500,000		7,500,000		Organize exposure visit in selected best water utilities	Number of benchmarking visit organized	Report of the visit	the benchmarking visit can also start by water companies that have already partnership agreement with WASAC . Eg Lilongwe water board
		E4.4	Collaboration with research centers and universities	Select research center and universities involved in water sector	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Select research center and universities to cooperate with	Research centers and universities selected	Report of the selection	
				Prepare and sign partnership agreement	***WASAC***	***WASAC***	*DUWSS*	-	-	-	Low	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Prepare and organize partnership agreement meetings	Partnership agreement signed	Partnership agreement being implemented	
E5	Training	E5.1	Ensure that WASAC have skilled and qualified staff	Assess current staff skill gap (new connection standard , GIS usage, pipe installation, pressure management , etc..)	***WASAC***	***WASAC***	*HR*	-	-	-	High	General expenses	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Conduct staff skills gap assessment	Skill gap identified	Report of skill gap assessment	
				Set up appropriate training plan	***WASAC***	***WASAC***	*HR*	-	-	-	High	NA	6 months	-		x	x														-	Approved training plan available	Training plan being implemented	the NRW training plan should be incorporated the general WASAC training plan
				implement the training plan	***WASAC***	***WASAC***	*HR*	-	-	-	High	General expenses	Continuous	-			x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	Number of training done vs planned	Report of trainings	
				Set up an internal knowledge transfers mechanism	***WASAC***	***WASAC***	*HR*	-	-	-	High	NA	6 months	-				x	x	x											-	Approved knowledge transfer mechanism	Knowledge transfer mechanism available and incorporated in HR policy	HR policy that incorporate knowledge transfer mechanism
				Monitoring and Evaluation of the change	***WASAC***	***WASAC***	*HR*	-	-	-	High	NA	Continuous	-				x	x	x	x	x	x	x	x	x	x	x	x	x	Checking work improvement regularly	Performance improvement	Monitoring report	
		E5.2	Benchmarking of different branches for NRW reduction to enhance NRW performance	Compile and analyze branch NRW report	***WASAC***	***WASAC***	*NRW*	-	-	-	High	NA	Continuous	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Branches Monthly NRW compilation and analysis	Branches NRW reports available	NRW monthly reports	
				Set NRW target for Each branch	***WASAC***	***WASAC***	*NRW*	-	-	-	High	NA	2 months	-					x	x											-	Branches NRW targets available	NRW reports	
				Organize regular meeting with branches	***WASAC***	***WASAC***	*NRW*	-	-	-	High	General expenses	Continuous	-						x						x	x	x	x	x	Conduct meeting for NRW reduction achievement monitoring	Number of meeting and participants	Meeting report	
				Propose incentive measures for NRW reduction	***WASAC***	***WASAC***	*NRW*	-	-	-	High	NA	Continuous	-					x												Assess possible NRW reduction incentive approach	NRW incentive mechanism in place	Motivation mesurement of each branch	
E6	Institution	E6.1	Ensure the implementation of the branch new structure	Recruitment of new staff to populate the new structure	***WASAC***	***WASAC***	*DUWSS*	*DCS*	-	-	High	General expenses	6 moths	-							x	x	x	x	x	x					Assess branches staffing gap and recruit	Number of newly recruited staff	Branch structure	
		E6.2	Reinforce the research and development	Identify area of research and set up the team	***WASAC***	***WASAC***	*DUWSS*	*DCS*	-	-	Low	NA	1 year	-							x	x	x	x	x	x					Identifying research areas , put in place a team and conduct research	Team for specific research areas available	Research results publications	
		E6.3	Continuous improvement and innovation	Establish the innovation incentive mechanism	***WASAC***	***WASAC***	*DUWSS*	*DCS*	-	-	Low	NA	1 year	-							x	x	x	x	x	x					Put in place and implement innovation incentive policy	Innovation incentive policy available	Innovations rewarded	
E7	Logistic and quality materials	E7.1	Avail enough equipment and logistics (vehicle , motorcycle , tools, protective equipment , etc.…)	Inventory of available equipment and logistic facilities at the branch level and determines urgent need	***DSS***	***DSS***	*Admin & Logist*	*DUWSS*	*DCS*	*Branches*	High	NA	3 months	-	x	x	x														Make the general assessment of logistics needs at branches level and logistics available	Logistics need assessment available	List of equipment needed (urgently and for long term)	
				Procurement of equipment and logistics needed	***DSS***	***DSS***	*Admin & Logist*	*DUWSS*	*DCS*	*Branches*	High	General expenses	2year	-				x	x	x	x	x	x	x	x	x	x				Procurement of needed logistics	Number of equipment and logistics available	Procurement and assignment documents	

TOTAL Amount		4,591,008,581	780,740,000	921,740,000	941,330,000	972,981,250	998,657,331
		US$5,465,486	*US$929,452*	*US$1,097,310*	*US$1,120,631*	*US$1,158,311*	*US$1,188,878*
WASAC		15,000,000	0	7,500,000	0	7,500,000	0
NRW		1,054,990,000	284,430,000	99,260,000	297,100,000	287,100,000	87,100,000
WO		779,400,000	133,480,000	161,480,000	161,480,000	161,480,000	161,480,000
QA		9,000,000	3,000,000	0	0	3,000,000	3,000,000
UP		0	0	0	0	0	0
RM		15,720,000	5,720,000	2,500,000	2,500,000	2,500,000	2,500,000
CSM		2,716,898,581	329,670,000	651,000,000	480,250,000	511,401,250	744,577,331
Branch		0	0	0	0	0	0
HR		0	0	0	0	0	0
ICT		0	0	0	0	0	0
Ad&Lo		0	0	0	0	0	0
		4,591,008,581	756,300,000	921,740,000	941,330,000	972,981,250	998,657,331

Responsible Department/ Unit/ Section

Leak detection and pressure management Section: LD&PM
Zoning and mapping Section : GIS
Inspection and Enforcement Section: I&E
Water Production Section: Production
Water Distribution Section: Distribution
Quality Assurance Unit: QA
Utility Planning Unit: UP
Revenue Management Unit: RM
Customer Service Management Unit: CSM
Direction Support Service: DSS
Human Resource Unit: HR
Administration and Logistics Unit: Admi & Logistics

NRW Monthly Report

for

April / 2018

KACYIRU Branch

Version.0

Supported by

Customers Inspection Report

S1

Branch KACYIRU

Period April 2018

[Monthly Plan (customer with irregularly consumption & random re-reading]

		No. of Customers	No. of Customers to be visited (Plan)	Achievement
a	Number of customers with consumption increased more than 30%	100	8	2
b	Number of customers with consumption decreased more than 30%			
c	Number of zero consumption customers			
d	Number of constant consumption customers			
e	Number of Random re-reading of customer meters		10	1

**Monthly plan will be prepared based on customer data analysis*

[Detailed Report of Inspection]

N	Date of inspection	Customer Identification	Customer meter			Suspect reason for inspection	Observation	
		POC	S/N	Previous Index	Current Index		Findings	Action taken
1	2018/1/4							
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

[Detailed Report of Inspection]

N	Date of inspection	Customer Identification	Customer meter			Suspect reason for inspection	Observation	
		POC	S/N	Previous Index	Current Index		Findings	Action taken
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								

Prepared by ______________________ (Commercial Service Officer)

Approved by ______________________ (Branch Manager)

Illegal Cases Management Report

S2

Branch KACYIRU

Period April 2018

N	Customer Identification	Type of illegal	Estimated period of	Estimated volume of	Decision	Disconnection				Penality charged(A)		Penality paid before(B)		Penality paid this month(C)		Balance(A)-(B)-(C)		number of installment remained	Re-connection	
	POC/ Name					Type	Coordinate		Date of Disconnection	Fine	Regularization	Fine	Regularization	Fine	Regularization	Fine	Regularization		Date	Meter Index
							X	Y												

Prepared by ____________________ (Commercial Service Officer)

Approved by ____________________ (Branch Manager)

On-site Meter Testing Report

S3

Branch KACYIRU

Period April 2018

No.	Date	POC	Test Meter	Customer Meter				Meter Error (%)	Observation	Action taken
			S/N	Brand	S/N	Years of manufacturing	Index			

Prepared by ______________________ (Commercial Service Officer)

Approved by ______________________ (Branch Manager)

Replacement of customer meters

S4

Branch KACYIRU

Period April 2018

No	Date	POC	Old meters specifications				Reason of replacement	New meters specifications				Pressure (bar)	Observation&work done	Reference No.
			brand	serial number	size	index		brand	serial number	size	index			

Replacement of customer meters

S4

Branch KACYIRU

Period April 2018

No	Date	POC	Old meters specifications				Reason of replacement	New meters specifications				Pressure (bar)	Observation&work done	Reference No.
			brand	serial number	size	index		brand	serial number	size	index			

Replacement of customer meters

S4

Branch KACYIRU

Period April 2018

No	Date	POC	Old meters specifications				Reason of replacement	New meters specifications				Pressure (bar)	Observation&work done	Reference No.
			brand	serial number	size	index		brand	serial number	size	index			

Replacement of customer meters

S4

Branch KACYIRU

Period April 2018

No	Date	POC	Old meters specifications				Reason of replacement	New meters specifications				Pressure (bar)	Observation&work done	Reference No.
			brand	serial number	size	index		brand	serial number	size	index			

Replacement of customer meters

S4

Branch KACYIRU

Period April 2018

No	Date	POC	Old meters specifications				Reason of replacement	New meters specifications				Pressure (bar)	Observation&work done	Reference No.
			brand	serial number	size	index		brand	serial number	size	index			

Prepared by (Commercial Service Officer)

Approved by (Branch Manager)

Follow up of big customers report

S5

Branch KACYIRU

Period April 2018

No	Date	POC	Customer Category	meters specifications				Consumption						observation
				brand	serial number	size	Conditions	previous index		current index		Average daily consumption	Daily consumption from CMS	
								Date	reading	Date	reading			

Prepared by ______________ (Commercial Service Officer)

Approved by ______________ (Branch Manager)

Inspection of the installation of New connection

S6

Branch KACYIRU

Period April 2018

No	Date	POC	Distribution Pipe information			Type of Branch	Presence of Valves	Service Pipe information			New meters specifications				No. of houses served	Installation date	Quality of trench and backfilling	Quality of materials	Quality of works	Pressure	Observation
			size	material	Nominal Pressure (Bar)		at branch and before meter	size	material	Nominal Pressure (Bar)	brand	serial number	size	index						(Bar)	

Prepared by ______________________ (Commercial Service Officer)

Approved by ______________________ (Branch Manager)

Leakage Information System

S7

Branch KACYIRU

Period April 2018

No.	Date	DN(mm)/Inch	Pipe Material	Pipe category	Leakage point	Cause of the leak	Location (geographic coordinates)		Location Admin.	Reported time		Closing time		Duration of leakage		Reopening time		Response time	Lost water		Material used	Repaired by	Comment if any
							X	Y	(Cell and Village)	H	M	H	M	H	M	H	M		Volume(m3)	Way used			

WASAC
Water & Sanitation Corporation
'Dignifying Life'

Leakage Information System

S7

Branch KACYIRU

Period April 2018

No.	Date	DN(mm)/Inch	Pipe Material	Pipe category	Leakage point	Cause of the leak	Location (geographic coordinates)		Location Admin.	Reported time		Closing time		Duration of leakage		Reopening time		Response time	Lost water		Material used	Repaired by	Comment if any
							X	Y	(Cell and Village)	H	M	H	M	H	M	H	M		Volume(m3)	Way used			

Leakage Information System

S7

Branch KACYIRU

Period April 2018

No.	Date	DN(mm)/Inch	Pipe Material	Pipe category	Leakage point	Cause of the leak	Location (geographic coordinates)		Location Admin.	Reported time		Closing time		Duration of leakage		Reopening time		Response time	Lost water		Material used	Repaired by	Comment if any
							X	Y	(Cell and Village)	H	M	H	M	H	M	H	M		Volume(m3)	Way used			

Prepared by ____________________ (Water Distribution Officer)

Approved by ____________________ (Branch Manager)

Inspection of leak repair

S8

Branch KACYIRU

Period April 2018

No.	Date	Coordinates (X,Y)	Pipe information		Reported date	Repaired date	Quality of repair	Quality of materials	Quality of works	Observation	Reference No.
			size	material							

Prepared by ____________________ (Water Distribution Officer)

Approved by ____________________ (Branch Manager)

Progress report of Network Rehabilitation Plan

S9

Branch KACYIRU

Period April 2018

	Plan							Implementation			
N	Place/Location/Area	Age of the network to be replaced	Types of pipes to be replaced	Length(m)	Nominal Diameter of pipes(mm) to be replaced	Nominal Presure of pipes(BAR) to be replaced	Budget (RWF)	Trench (%)	Material (%)	Installation (%)	Observation
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											

Prepared by ______________________ (Water Distribution Officer)

Approved by ______________________ (Branch Manager)

Progress report of Reservoir Rehabilitation Plan

S10

Branch KACYIRU

Period April 2018

	Plan						Implementation	
N	Place/Location of the reservoir	Capacity of the reservoir	Material	Requested Work (Reservoir itself, Maintenance of floater valve/Replacement of floater valve/Repair of pipe, …)	Size of the floater valve	Budget (Rwf)	Status (%)	Observation
1								
2								
3								
4								
5								
6								
7								
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10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

Prepared by ____________________ (Water Distribution Officer)

Approved by ____________________ (Branch Manager)

Progress report of Protective Equipment Installation/ Rehabilitation Plan

S11

Branch KACYIRU

Period April 2018

	Plan								Implementation	
N	Equipment to be rehabilitated	DN of the equipement (mm)	Place/Location	State of the equipement to protected	Work requested (New installation /Replacement / Maintenance)	Coordinates (X,Y)		Budget (Rwf)	Status (%)	Observation
	[Sectionning valve]									
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
	[PRV]									
1										
2										
3										
4										
5										
6										
7										
8										
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14										
15										
16										
17										
18										
19										
20										
	[Air Valve]									
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										

Prepared by ______________________ (Water Distribution Officer)

Approved by ______________________ (Branch Manager)

Ver. 2020/2021

Revised

5 Years Strategic Plan

For

Non-Revenue Water Reduction

Water and Sanitation Corporation

WASAC Ltd

Table of Contents

1. Introduction

1.1 Background of revision of 5YSP

In July 2018, WASAC started the implementation of the 5 Years Strategic Plan for NRW reduction as a tool to monitor the implementation of NRW activities considering the targeted NRW rate of 25 % in 2023.

The Preparation of this 5YSP began in August 2016 in the framework of JICA technical cooperation to strengthen the capacity of NRW control in WASAC, this exercise involved WASACs directorates, unit, branches and Water treatment plants through interviews, questionnaires, field visits and workshops. The NRW reduction measures implemented in WASAC were assessed by consulting different WASAC reports, field visits to assess the network condition, interviews with different WASAC officials, branch managers and Head of water treatment plant.

After 3 years of its implementation, this revision is considered to adjust and incorporate the activities from the findings through the implementation of the 5YSP, pilot project result and recommendations from Kigali water supply Master plan recently developed by Japanese experts.

1.2 Non-revenue water reduction target

From the initial version of July 2018, the target was to achieve 25% NRW rate in the year 2022/2023. Considering the NRW rate achievement for the last past 3 years (above 40% %) it seems to be not practicable to achieve the set target (25%) in the remaining 2 years. It is in this regard that the target to achieve for the year 2022/2023 is revised to 38%

Table 2: Target for NRW reduction for the coming 2 years

Financial year July to June	5 Year Strategic Business Plan	Target value of 5 Year Strategic Business Plan	Actual NRW level value %	Proposed New NRW rate
2018/19	Year 1	35%	38.8 %	
2019/20	Year 2	32%	41.9%	
2020/21	Year 3	30%	43,3%	
2021/22	Year 4	28%		40%
2022/23	Year 5	25%		38 %

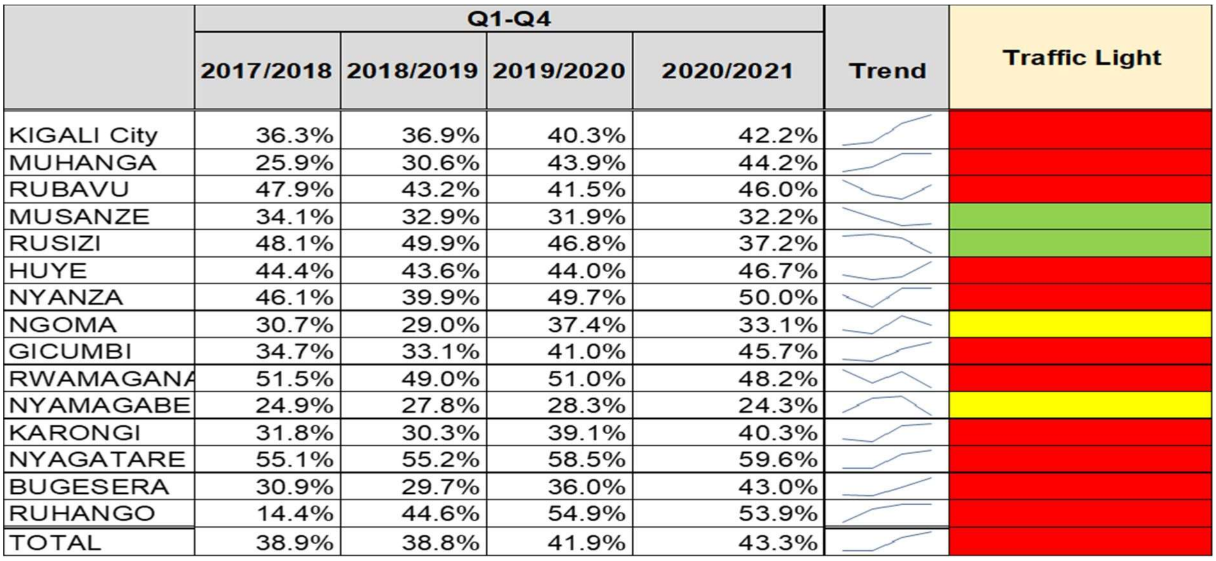
2. Achievement from the implementation of 5YSP

2.1 NRW key performance indicators trend

a) NRW ratio (percentage)

There is not yet a decrease of NRW (water loss) as expected at the beginning of the implementation of the 5YSP, the NRW rate still high and increasing compare to the set target. The two last years were more challenging mainly due the stoppage of activities to prevent the spread of Covid19 and the increase of production (mid feb2021) which brings pressure variation in the network and causes leakages in different part of the network in Kigali and satellite cities

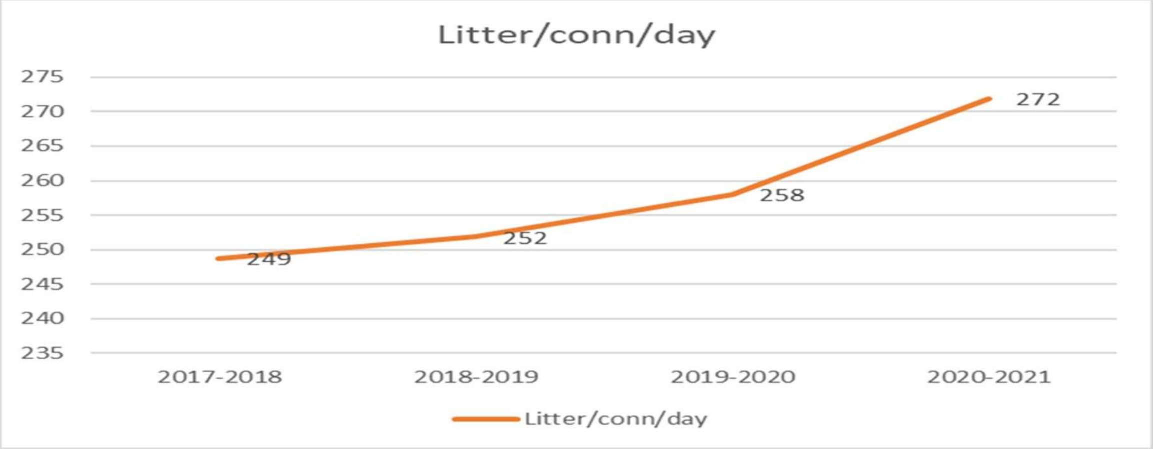
WASAC branches 4 years NRW Trend is also increasing mainly for the 2 last years



	Q1-Q4				Trend	Traffic Light
	2017/2018	2018/2019	2019/2020	2020/2021		
KIGALI City	36.3%	36.9%	40.3%	42.2%		🟥
MUHANGA	25.9%	30.6%	43.9%	44.2%		🟥
RUBAVU	47.9%	43.2%	41.5%	46.0%		🟥
MUSANZE	34.1%	32.9%	31.9%	32.2%		🟩
RUSIZI	48.1%	49.9%	46.8%	37.2%		🟩
HUYE	44.4%	43.6%	44.0%	46.7%		🟥
NYANZA	46.1%	39.9%	49.7%	50.0%		🟥
NGOMA	30.7%	29.0%	37.4%	33.1%		🟨
GICUMBI	34.7%	33.1%	41.0%	45.7%		🟥
RWAMAGANA	51.5%	49.0%	51.0%	48.2%		🟥
NYAMAGABE	24.9%	27.8%	28.3%	24.3%		🟨
KARONGI	31.8%	30.3%	39.1%	40.3%		🟥
NYAGATARE	55.1%	55.2%	58.5%	59.6%		🟥
BUGESERA	30.9%	29.7%	36.0%	43.0%		🟥
RUHANGO	14.4%	44.6%	54.9%	53.9%		🟥
TOTAL	38.9%	38.8%	41.9%	43.3%		🟥

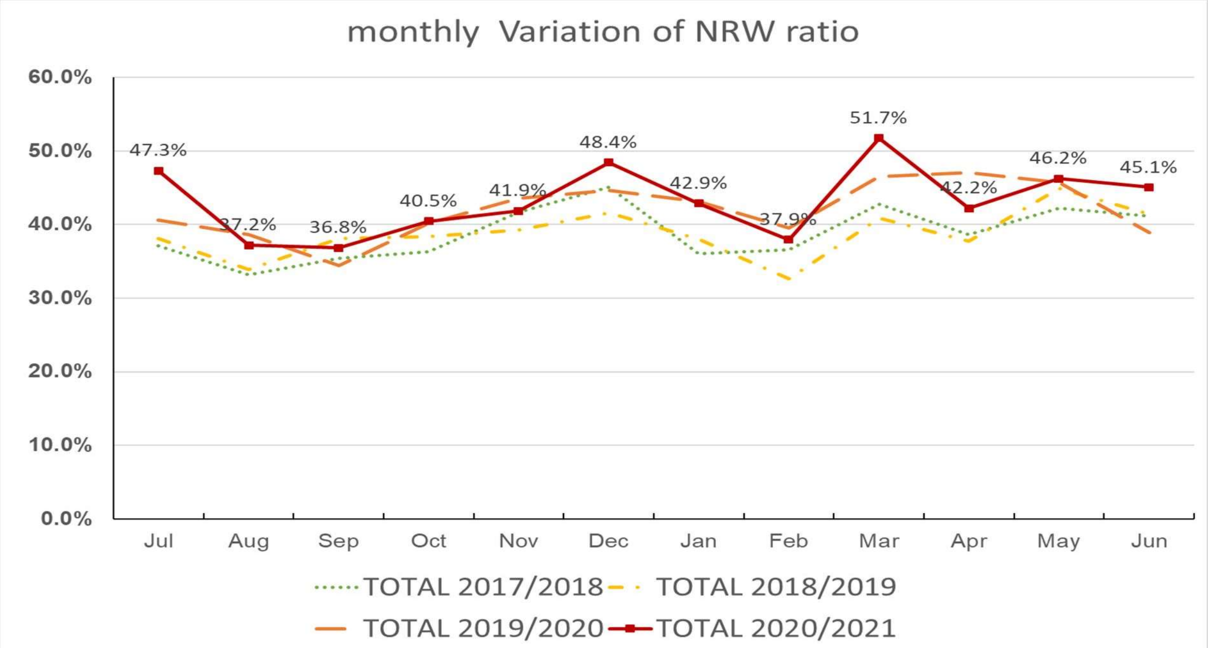
b) Water Loss per connection / Day (liters/conn/day)

Water loss per connection on daily basis also is increasing as it is shown in the chart below:

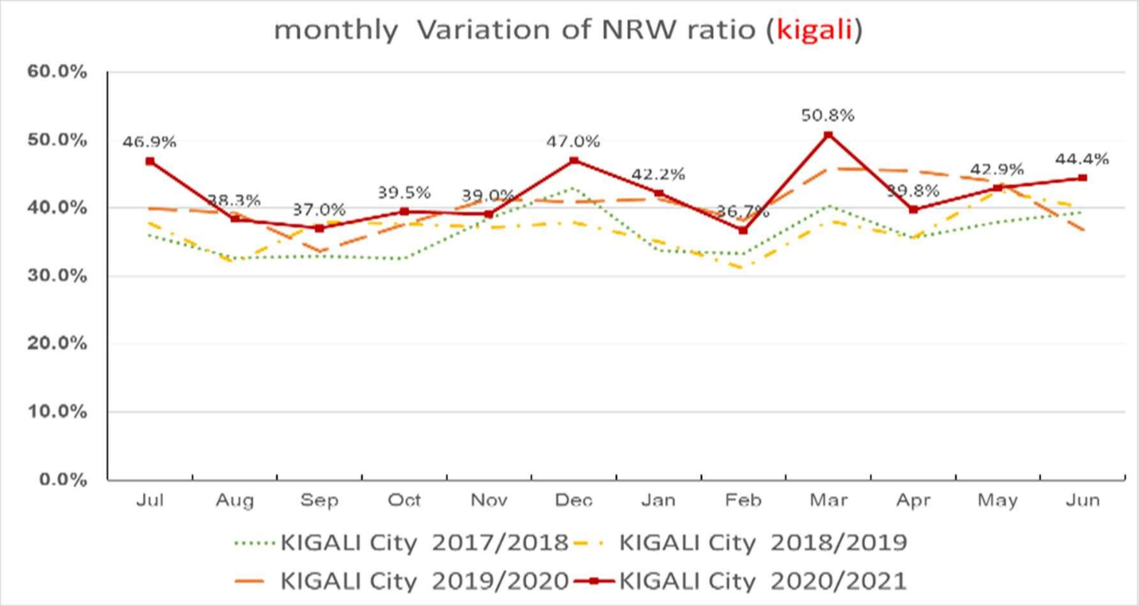


2.2 Monthly variation of NRW

The NRW trend for last 3 years is almost the same except the year 2020-2021 witch has a big increase for the month of March 2021 mainly due to the filling of new pipelines and reservoirs constructed in Kigali (Afdb project). Covid- 19 prevention measures also slowed down activities during the year 2019/2020 and 2020/2021

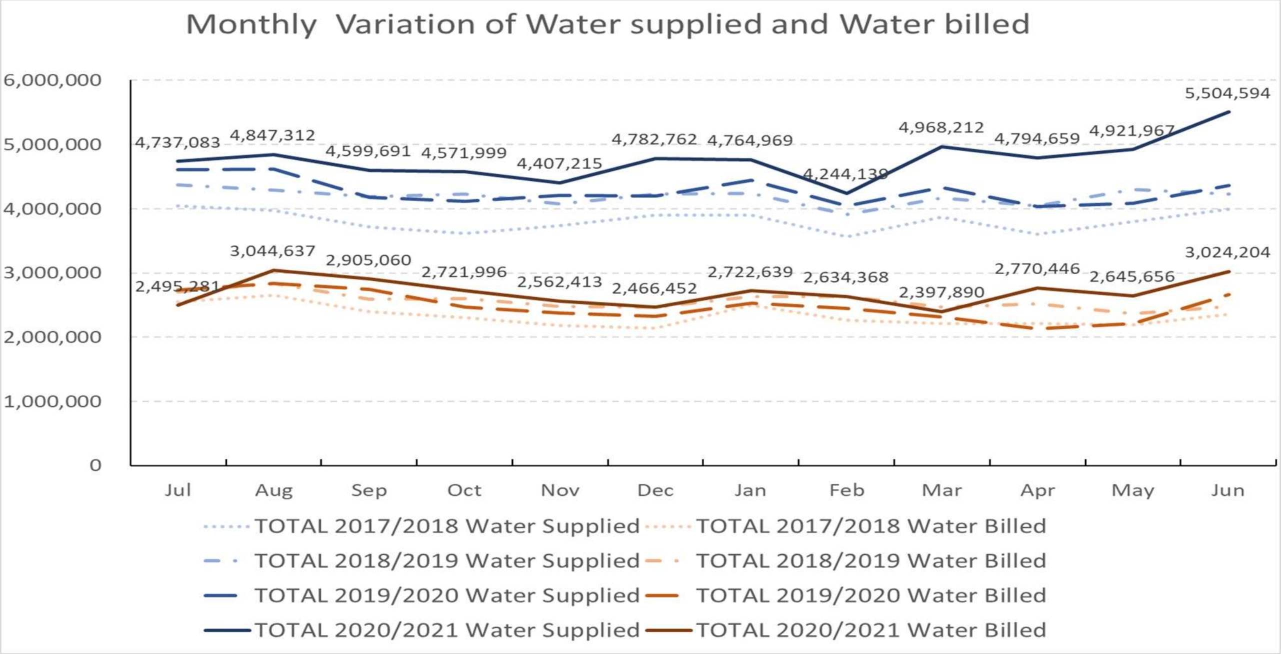


The NRW trend for kigali is similar to the national trend due to the fact that kigali contrubute by more than 60 of water supplied in the entire WASAC water network



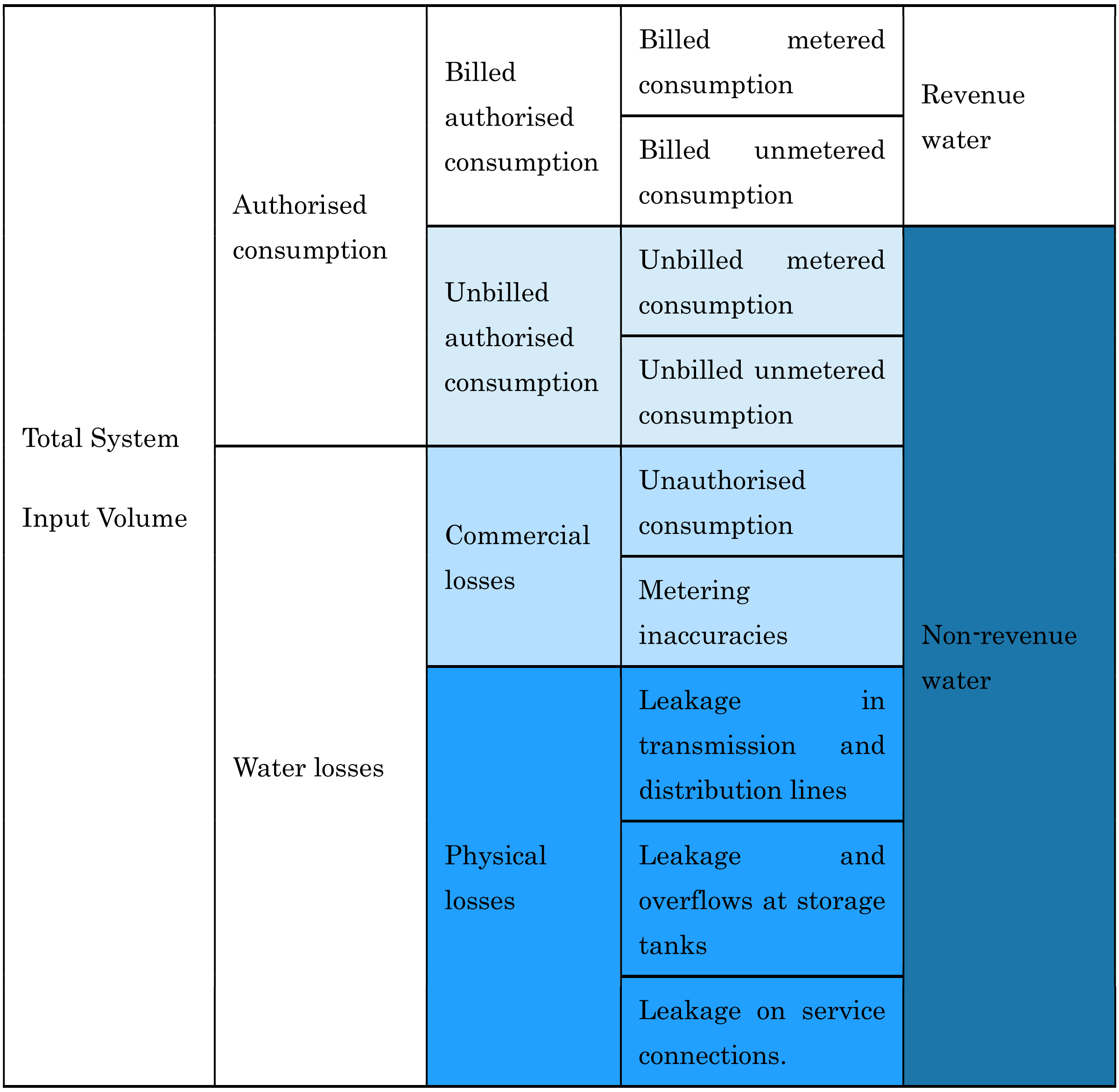
2.3 Monthly variation of water supplied and Water billed

Both for the Total and Kigali, the trend of water supplied is increasing with a pick on the last quarter of the year 2020/2021 mainly due to the adding of new production unit (kanzenze WTP) from mid- February.



2.4 Water balance 2020-2021

The International Water Association (IWA) water balance (see figure 1) was used to assess the non-revenue water components. The physical and commercial losses were assessed using top down approach methodology witch consist of assess commercial losses and estimate the volume of physical losses



Total System Input Volume	Authorised consumption	Billed authorised consumption	Billed metered consumption	Revenue water
			Billed unmetered consumption	
		Unbilled authorised consumption	Unbilled metered consumption	Non-revenue water
			Unbilled unmetered consumption	
	Water losses	Commercial losses	Unauthorised consumption	
			Metering inaccuracies	
		Physical losses	Leakage in transmission and distribution lines	
			Leakage and overflows at storage tanks	
			Leakage on service connections.	

Figure 1 International Water Association (IWA) Water balance

Currently, there is not yet much historical data to performed (detailed) non-revenue water assessment but the available ones give an estimated proportion between physical and commercial water losses.

a) WASAC water balance component definition

The figure below defines Water balance component, way of getting data: some data have been directly measured, other estimated based on historical data available and other based on assumptions.

Nr	Components of WB	Way to get data : Measurement /Estimation/Assumption
1	Volume input	Total water produced-backwash
2	Billed Metered Consumption	Total billing from CMS + billed bulk water + regularization bills
3	Billed Unmetered Consumption	
4	Unbilled Metered Consumption	N/A: In WASAC all metered consumption are billed.
5	Unbilled Unmetered Consumption	Network flushing , reservoir cleaning
6	Metering inaccuracies	Estimation of water meter margin errors basing on test done in pilot project .
7	Error in estimation of unmetered consumption (CMC)	Estimation based on probable errors on estimated bills
8	Unauthorized consumption	Estimation based on confirmed illegal cases of water usage.
9	Errors linked to the data acquisition processes	Estimation following adjusted bills

10	Leakages on Transmission and Distribution Mains pipes	Estimation based on the number of reported leaks in WASAC's transmission and distribution network.
11	Leakages and Overflows at Storage Tanks	Estimation of the volume lost through leaks and overflow of storage reservoirs.
12	Leakages on Service Connections up to point of Customer Meter	Estimation based on the number of reported leaks in WASAC's service connections.

Total system input

The total volume input was calculated as follow=

Total water produced – (Total volume used for backwashing + Water service at WTP)

Total Water produced is measured with bulk (mechanical/electromagnetics) meters at WTP; backwashing water is clean water that is used to clean filters in the treatment process; Water service is internal use at WTP for chemical preparation, offices , etc..

Billed metered water

Billed metered water is measured using all customer's consumptions. These data are computed and extracted in WASAC billing system (CMS)

Billed Unmetered Consumption

Billed unmetered consumption consist mainly of water tankers who fetch water at different points (kimisagara) , bills to road constructors who damage pipes, estimation bill for regularization in case of water theft

Unbilled metered consumption

N/A for WASAC case, all metered consumption are billed including fire hydrant

Authorised unbilled unmetered consumption

Authorized unbilled unmetered consumption is the volume of water mainly used for network flushing after repairs, pipe laying, new connection and all reservoirs cleaning. Considering huge number of repairs (80 a day), cleaning of storage reservoir (twice a year) and round 20k new connection done annually, *unbilled unmetered consumption was estimated at 2% of the total water system input volume*.

Metering inaccuracies

From the sample of meters aged more than 15 years tested, 93 % had an error of more than 23 %. Currently, about 52k (20%) of WASAC customer's meters have more than 15 years. In pilot project done in kacyiru and Remera branches in the support of JICA, 20% of customer meters tested were confirmed inaccurate (more than ±5%) and 7,4% blocked *Based on the above findings, we estimate 10% of volume supplied lost because of meter inaccuracy*

Unauthorized consumption (water theft)

An average of 56 cases on a total of 1200 customers visited yearly was confirmed as illegal , which is (4.6%) of customer visited , Most of confirmed illegal cases are coming from informers.

It is still challenging to find all illegal water usage and

We estimate 3 % of the volume of water supply lost through illegal cases (confirmed and not yet confirmed).

Leakage in transmission and distribution lines

An average of 75 visible leaks are being reported and recorded on daily basis. Most of leakages are coming from distribution and connection pipes. Leakages from transmission pipes are not frequent but when they happen, there is a loss a huge volume of water.

There are a lot of road constructions across the country which also causes pipe damages and water loss. In heavy rain seasons we also observed huge damage of water infrastructures which cause water loss.

From the assessment done on water lost through leakages we come up with the summarised table:

	% of water supply
Volume Lost because of leakages on Transmission and distribution pipes	16.6%
Volume Lost because of leakages on Service pipes	9.3%
Volume lost because of leakages and overflow on reservoirs	1%
Total	26.9%

From the assessment above, we can summarize WASAC 2020-2021 water balance as follow

Volume input: 100 %	- **Revenue Water** : 32,447,875 m3 (**55,6%)** - **Authorized unbilled consumption: Estimated to 2% (1,167,315 m3)**
	- **Non Revenue Water (water loss)**: **42.4%** ○ **Commercial losses : 15.5%**

	○ **Technical losses : 26.9%**

Total volume input 100%	Authorized Consumption 56.7%	Billed Authorized Consumption	Billed Metered Consumption	55.6%	Revenue Water 55,6%
			Billed Unmetered Consumption		
		Unbilled Authorized Consumption	Unbilled Metered Consumption	0%	Non Revenue Water 44.4%
			Unbilled Unmetered Consumption	2%	
	Water loss 42.4%	Apparent losses 15.5%	Metering inaccuracies	10%	
			Error in estimation of unmetered consumption	2%	
			Unauthorized consumption	3%	
			Errors linked to the data acquisition processes	0.5%	
		Real losses 26.9%	Leakages on Transmission and Distribution Mains	16,6%	
			Leakages and Overflows at reservoirs	1%	
			Leakages on Service Connections	9.3%	

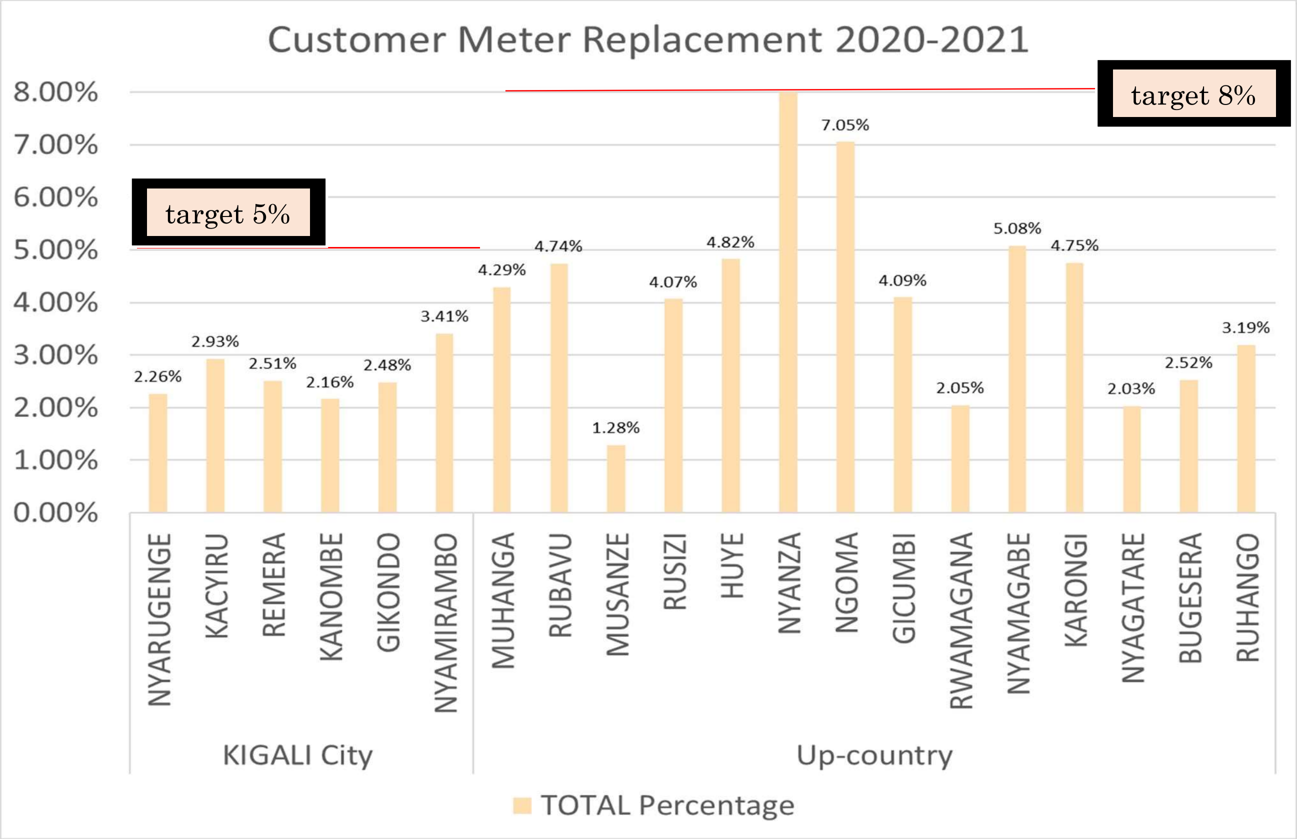
Figure 2 WASA-Water balance 2020-2021

3. Progress of key activities for commercial loss reduction

3.1 Customer aged and fault meter replacement

The purpose of this activity is to replace aged (more than 15 years) and default meter. The annual target for this activity was to replace 5 % of customer meter (for branches having more than 15k customers) and 8% for branches with less than 15k customers.

The replacement of aged and faulty meters still low and depends mainly on the availability of water meters in stores. From the target of replacing 15,000/ year, for the last three year the achievement was: 4142 (2018/2019) , 4995 (2019/20) and 72929(2020-2021)



The table above shows that all branches are below the target for the FY(2020-2021)

3.2 Meter testing (Bulk meter and customer meter)

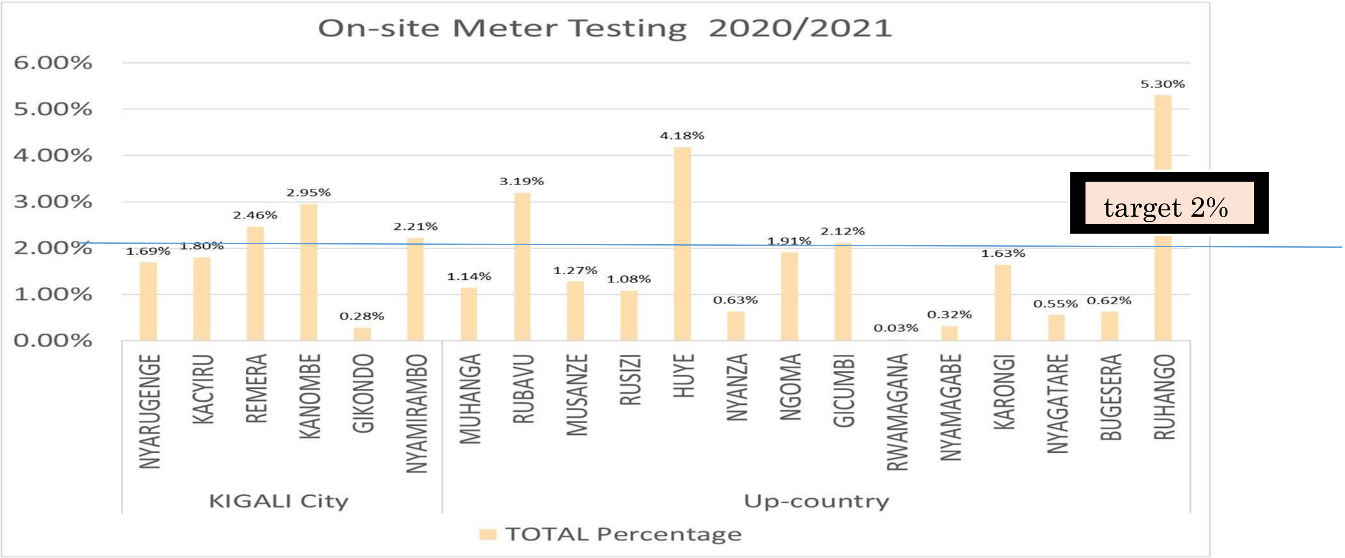
This activity aims to test meters (bulk and customer meters) to ensure their accuracy

a) Customer meter testing

On-site meter testing which is useful to check meter accuracy and facilitate the replacement of customer meter which has unacceptable error (±5%) using apropriate meter testing equipement.

The implementation of this activity it is still low but increasing in the last 3 years.

The target of testing 2% of the total meter park was almost achieved (1.7%) for the FY(2020-2021) but many of those meter tested was already confirm unfoctional (blocked , unreadable , ..). For the next year the focus should be done for the aged ,working meters and big customers



From the above chat it is clear that 6 branches reached the target of testing 2 % of their customer meters. It was also observed that many of this testing was performed basing on customer's complaints instead of branch initiative.

b) Bulk meters at (WTP) assessment and replacement

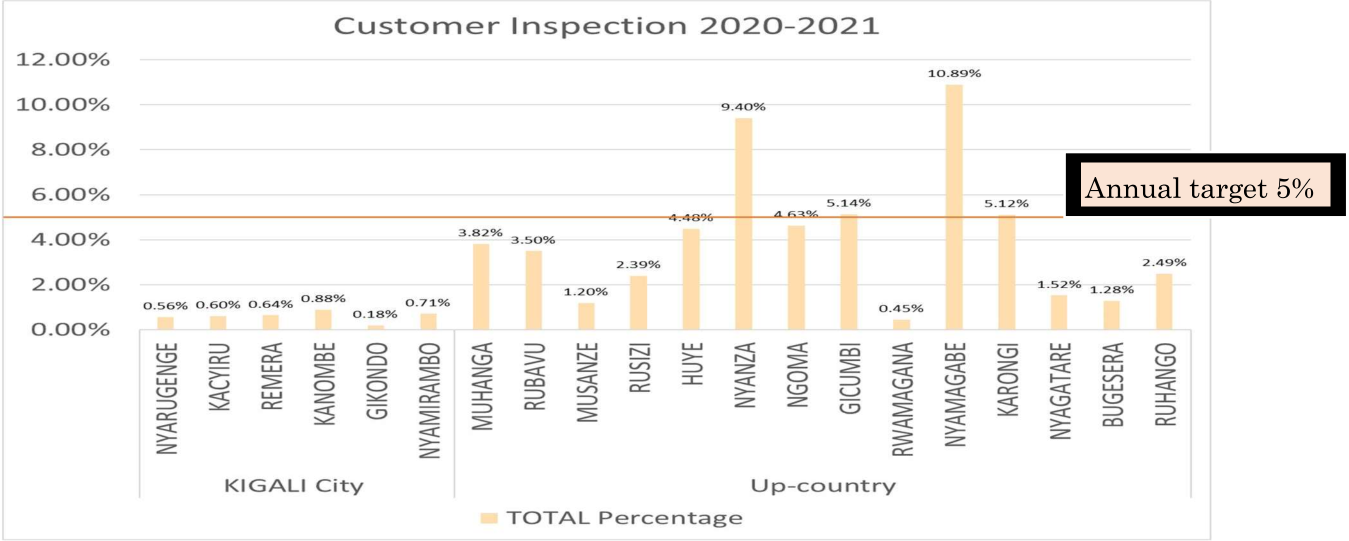
To ensure the accuracy of data (water supply in the network) in the computation of the NRW rate, 91 bulk meter were assessed in different occasions, 18 were confirmed not working and as per September 2021 not yet replaced but planned to be replaced in this fiscal year (2021-2022).

WTPS	METER	ERROR (%)	COMMENTS
KIMISAGARA	Supplied water DN 400	19.30%	Replaced
NYAGATARE	Cyondo (to town)	18.27%	Not yet replaced
	cyondo (to rural)	-10%	Not yet replaced
	Gihengeri DN 280	11.36	Not yet replaced
	Gihengeri DN 200	14.87	Not yet replaced
MUHAZI	supplied TO Rwamagana town DN300	-8%	Not yet replaced
	Cyatokwe DN100	11.65%	Not yet replaced
	TO Mukarange DN 300	7.50%	Not yet replaced
GISUMA	Supplied water DN 300	8.50%	Not yet replaced
GIHUMA	Outlet reservoir to Nyamagabe city DN 150	5.89%	Not yet replaced
	Out let Gisuma to Kigeme DN100	6.99%	Not yet replaced
	Inlet of Nyamagabe city reservoir	7.50%	Not yet replaced
RWASABURO	Bunono PS DN 100	11.60%	Not yet replaced
KANYABUSAGE	Supplied water	-15.88%	Not yet replaced
NYAMABUYE	Supplied to Kibali DN 100	22.90%	Not yet replaced
SHYOGWE-MAYAGA	Supplied water DN 200	35.60%	Not yet replaced
	Raw water	10.75%	Not yet replaced
LITIRO	Supplied water DN	-46.46%	replaced

3.3 Customer installation inspection

a) Abnormal consumption inspection

This activity aims to inspect customer with abnormal consumptions (zero consumption, constant consumption, big increase or decrease, etc...) after the monthly billing analysis. The annual target for this exercise is to visit 5% of the total number of customer.



From the table above it's obvious that many of branches did not reach the target of 5%

b) Illegal connection inspection

This activity aims to reduce illegal consumption through proactive, effective and comprehensive identification & investigation of illegal water consumers and maximize collection of fines that has been charged on the identified illegal consumers.

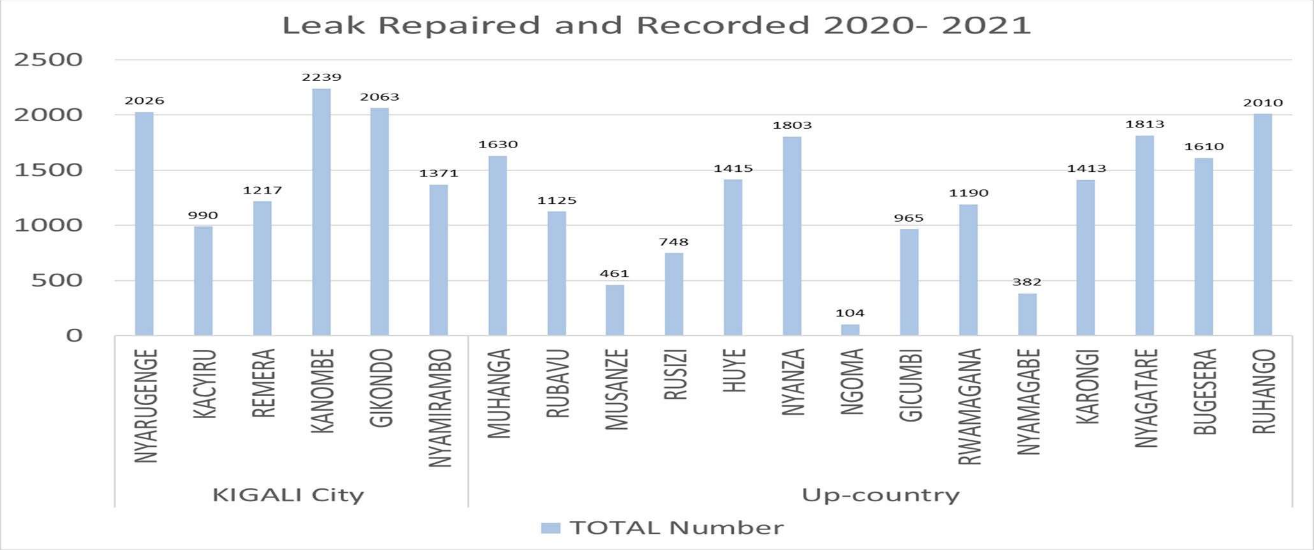
In the last 6 years, the total number of 338 customers have been confirmed illegal cases where an amount of 499 Million fined and the payment so far is about 203 Million Rfw

Fiscal Year	Number of confirmed Illegal cases	Amount charged (Rwf)	Amount paid (Rwf)
2015-2016	88	72,703,717	31,436,690
2016-2017	67	80,921,261	15,323,311
2017-2018	45	77,380,139	44,152,308
2018-2019	53	91,397,469	66,256,421
2019-2020	38	102,363,759	60,151,827
2020-2021	47	74,444,765	35,047,903
TOTAL	**338**	**499,211,110**	**252,368,460**

4. Progress of key activities for Physical loss reduction

4.1 Visible leaks repairs and records

An average of 75 visible leaks are being reported and recorded on daily basis. Most of leakages are coming from small pipes (HDPE) mainly due to poor quality of pipes or connection. There is need for a deep assessment of connection pipes condition and massive connection pipe replacement.



There is some improvement to speed up intervention (stop leakage and repairs) but we can still observe some challenges such as: less number of staff dedicated to this exercise, the frequent unavailability of spare parts in WASAC store.

4.2 Invisible leakages detection and repairs

Leak detection have been performed mainly on transmission pipes due to less number of staff trained for this exercise and its complexity due to the existing water network condition.

4.3 Reservoir assessment and floater valves replacement

From the assement done in WASAC water network , 49 reservoirs was found with not working floaters valves , 29 floater valves were replaced to prevent any possible reservoir overflow. In the this on-going fiscal year, remaining 20 not working floater valves are planned to replaced.

Figure 3 . floater valve installed in the reservoir

4.4 Network maintenance & rehabilitation

Network maintenance is still at low stage mainly caused by the magnitude of other urgent task such as leakages repairs, relocation of water infrastructures (mainly road construction). The culture of preventive maintenance not yet sustained.

For the network rehabilitation, a part for the massive network rehabilitation being done in Kigali and 6 satellite cities (afdb project) there are about 400km distribution pipes and huge number of connection pipes (mostly HDPE pipes) that have been identified in Kigali for urgent rehabilitation. Budget constraint still challenging .

4.5 Pressure control

a) Creation and Monitoring of DMA

20 DMA will be created mainly in Rwamagana and Nyagatare in the framework of SCALE project that WASAC is implementing together with VEI from the Netherlands. Other DMA which are already created will be updated and monitored closely

b) PRV installation

After identification of high pressure zones in different part of WASAC water network, an average of 20 PRVs are being installed to control the pressure.

From the experience of 3 years , it was concluded that PRV installation can be consider as short term solution because of its operation and maintenance complicity.

5. Findings from pilot project

5.1 Outline of the pilot activities

Two sites were selected as pilot areas and within was conducted NRW reduction activities to confirm which activities are effective and efficient to reduce NRW considering the existing condition. The selection criteria mentioned below (Table) were used in the selection.

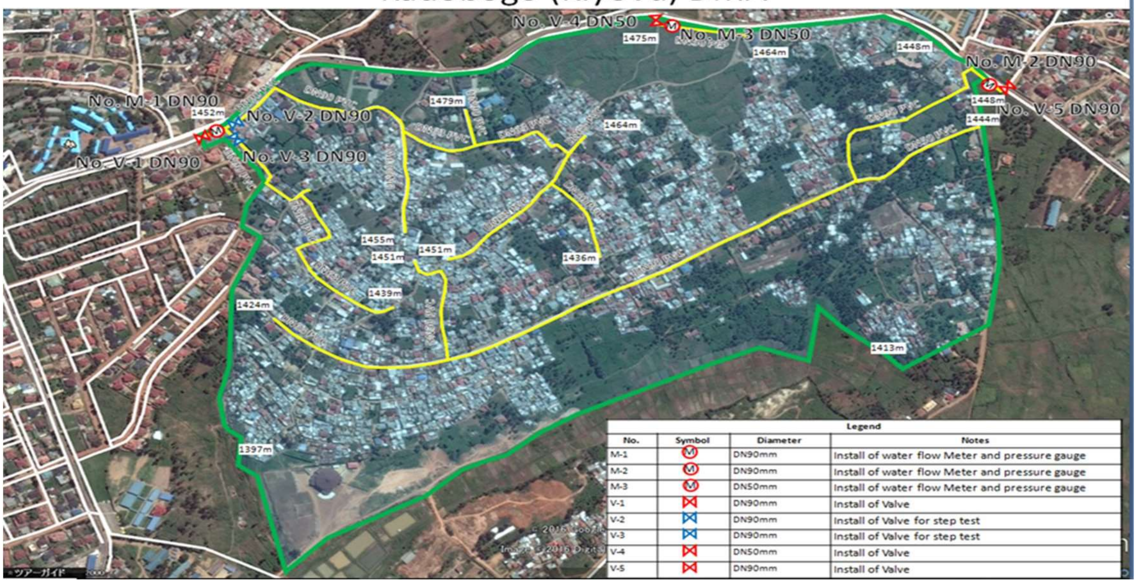
Table 1c: criteria of selection of pilot area

No.	Criterion	Grading
1	Possibility of isolation and Also number of households in the pilot plant less than 500	Legend of evaluation Good: 2 points Average: 1 point Bad: 0 point.
2	24 hours and 7 days water supply	
3	Distribution map accuracy	
4	Install water meter at every households	
5	Leakage occur situation	
6	Possibility of leak detection	

The distribution network drawings and customer information were obtained, field surveys were carried out and the boundaries of the areas were determined, and, the points of inflow into the area were determined. The table below shows the major indicators obtained in the project.

Pilot Area	Area1 Kadobogo	Area 2 Ruyenzi
	January, 2017	January, 2018
WASAC Branch	KACYIRU	NEW NYARGENGE
Area	100.4ha	648.2ha
Population	16,096	35,794
Served Population (=Number of connections x 5)	8,510	10,665
Service Coverage Rate (%)	53	30
Number of Connections	1,202	1,483
Domestic, commercial, industry, and government	1,192	1,470
Public taps	10	13
Monthly Water Consumption (m3/month)	14,113	21,634
Average Consumption per Capita (L/day)	53	65

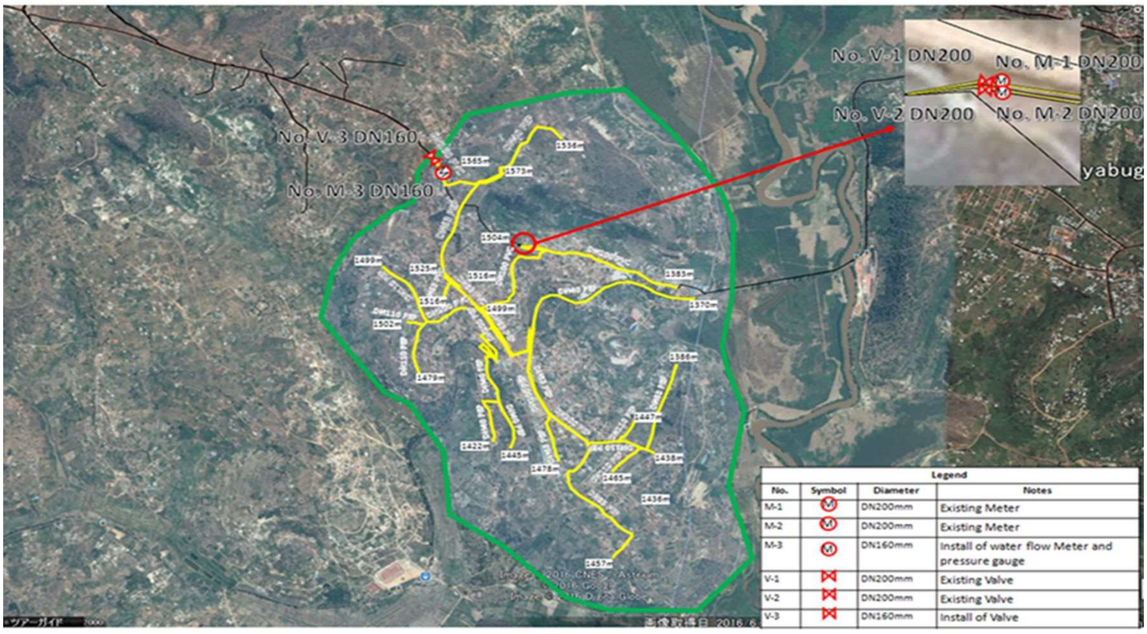
Kadobogo (Kiyovu) DMA



Legend

No.	Symbol	Diameter	Notes
M-1	Ⓜ	DN90mm	Install of water flow Meter and pressure gauge
M-2	Ⓜ	DN90mm	Install of water flow Meter and pressure gauge
M-3	Ⓜ	DN50mm	Install of water flow Meter and pressure gauge
V-1	⋈	DN90mm	Install of Valve
V-2	⋈	DN90mm	Install of Valve for step test
V-3	⋈	DN90mm	Install of Valve for step test
V-4	⋈	DN50mm	Install of Valve
V-5	⋈	DN90mm	Install of Valve

Ruyenzi (Runda) DMA



5.2 Activities done in pilot area

The following activities were done.

Category	Activities	Remarks
Reduction of Apparent Losses	Customer Survey (Meter accuracy test and meter replacement)	All customer meter
	Disconnected Customers Survey	78 Household
	Non-Customer Survey	40 Household
	Billing Analysis	
Reduction of Real Losses	Leakage survey at Water Taps	All customer meter
	Leak Survey	Using UFM, Leak detection equipment
	Water Pressure Reduction	Installation of PRVs
	Replacement of Distribution and Service Pipes	HDPE→PPR (660m)

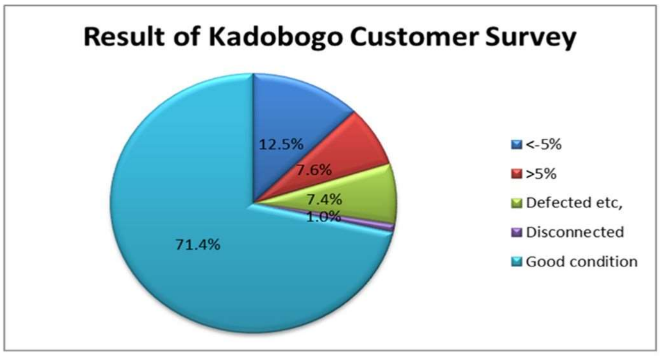
Result of pilot activities

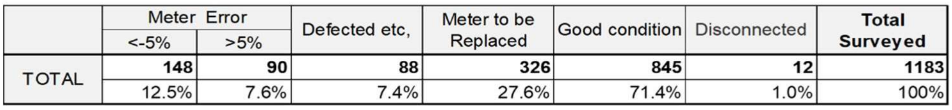
Item		NRW Ratio
Baseline		37%
Target value		20%
Achievement value	The end of Mar. 2019	14.2%
	The end of Apr. 2019	19.5%

5.3 Lesson Learned from pilot project

Lesson learned from the two pilot projects are quite similar and will be focus on for the adjustment of the revised version of the 5YSP

a) Customer meter management





	Meter Error		Defected etc,	Meter to be Replaced	Good condition	Disconnected	Total Surveyed
	<-5%	>5%					
TOTAL	148	90	88	326	845	12	1183
	12.5%	7.6%	7.4%	27.6%	71.4%	1.0%	100%

The result from the meter tested shows that more than 25% of the customer meters are not in the acceptable range (+/-5%). However, there was no big impact of the water consumption after replacement of those meters. This is because there are both + and – error and the consumption is estimated even if meter is not working

Therefore, the following lessons were learned.

Faulty meter should be replaced quickly for proper customer meter management.

On-site meter accuracy test for all customer meters is not necessary.

We should select the meters to be tested, based on the result of customer billing analysis which help find abnormal consumption.

b) Estimated consumption

We found that there were a certain number of customers whose consumption are estimated, not calculated by meter reading. The several reasons of estimated consumption are presumable as follows: CFOs can't read the customer meter due to some reason such as locked gate, locked meter box and unreadable meter; The customer meter is not functioning; The inappropriate practice by CFOs. It was also observed that those estimated customers can be found by customer billing analysis to check the constant consumption including zero consumption.

Number of customers billed for the same amount of water consumption

for three consecutive months (January to March 2019) in Kadobogo

	PM1	PM2	PM3	Total
Total	62	6	53	121 (9.0%)
Non-zero constant consumption	17	0	10	27
Zero consumption	45	5	43	93

Therefore, the following activities are recommended to reduce the estimated consumption which causes a part of NRW. Customer billing analysis should be done frequently to find the estimated consumption. Upgrade CMS to easily identified customers that have been billed based on the estimation and raison of zero consumption (door closed, no water , etc..) Activities to reduce the estimated consumption like the sensitization of customer, CFOs training and quick replacement of faulty meters should be encouraged.

c) Pressure control

The effectiveness of pressure control can be analyzed by measuring Minimum Night Flow (Qmnf). PRVs installation in Kadobogo were so effective to reduce NRW as follows.

Effectiveness of Pressure control by PRV installation

Item	Date	PM2		PM3	
		Qmnf	Pressure	Qmnf	Pressure
Before PRV installation	5/Oct.	0.74m3/h	7.0bar	9.44m3/h	7.5bar
After PRV installation	24/Oct.	0.31m3/h	2.5bar	5.8m3/h	2.0bar
Difference		0.43m3/h (58.1%)	4.5bar	3.64m3/h (38.6%)	5.5bar

However, without proper operation and maintenance, PRVs become malfunctioning easily. Therefore, the following lessons were learned.

Pressure control works very well to reduce NRW (real loss). PRVs are useful, but proper operation and maintenance is needed. We should consider PRVs installation as a temporary/ second solution and consider the network rearrangement to control pressure as a permanent/ prime solution.

d) Leak detection and repair

Leak detection is quite effective to reduce water leakage. By using Ultrasonic Flow Meter (UFM), Leak Detector and Acoustic Bar, we found 4 invisible leaks in the pilot area and reduced a big amount of NRW.

Through the leak detection activities, the following lessons are learned.

Given the following issues, focusing on the leak detection is too early for WASAC and not efficient.

There are still many visible leaks in WASAC network. The accuracy of pipe location in GIS is still not sufficient. Non-metal pipes like HDPE, PVC which is difficult to identify the leak sounds are installed commonly in the network.

The number of valves and fire hydrants which can be used to detect the leak sounds are not enough in our network.

The surface of the underground pipes is not paved normally, which makes leak sound detection more difficult. Without proper pressure control, the leaks happen again even after repair works. The quality of the service pipes in our network are questionable.

e) Pipe replacement

Because we found most of the leaks in the pilot area come from HDPE pipes, HDPE pipe replacement in the small area (Subzone1-3 and Subzone1-4) of pilot area was conducted to find the effectiveness of pipe replacement.

As a result, the pipe replacement reduced Qmnf in Subzone 1-3 from 1.14 m3/h to 0.70 m3/h and that in Subzone 1-4 from 4.24 m3/h to 2.40 m3/h. The total reduction of 2.28 m3/h, or around 40 % reduction, confirmed large effect of the replacement of water on leakage reduction.

	Qmnf before pipe replacement	Qmnf after pipe replacement	Qmnf reduction	Reduction (%)
Subzone 1-3	1.14 m3/h	0.70 m3/h	0.44m3/h	39%
Subzone 1-4	4.24 m3/h	2.40 m3/h.	1.84m3/h	43%

Through this activity, the following lessons were learned.

The pipe replacement for substandard pipe is effective to reduce NRW. Some HDPE pipes has a quality issue.

The leak repair data should be collected in all WASAC network to identify the causes of leaks. The leak repair data should be analyzed, and the result should be used to make a pipe replacement plan.

f) Water Balance

Based on all activities in Kadobogo pilot area, we estimated the water balance in Kadobogo as follows.

Item	Apparent losses (7.5%)				Real losses (29.8 %)		Total losses
Cause of losses	Instrumental error	Error at meter replacement	Illegal consumption	Zero consumption, Estimation of billed water consumption	Surface leakage	Underground leakage	
Breakdown of NRW rate (%)	0.5	1.2	0.5	5.3	11.9	17.9	37.3

This means that the real losses consisted 80% of total NRW in Kadobogo.

Lesson learned from the estimation of the water balance are as follow

The estimation of water balance is not an easy task and requires a lot of historical data such as leakage point, cause, materials, pressure etc.

6. NRW consideration in Kigali Water Supply Master Plan

6.1 Outline of Kigali water supply Master Plan

The objective of the Kigali Water Supply Masterplan is to provide a blueprint of the future water supply system by 2050 and steps to be taken by the Rwandan government for achieving the same. Based on the Master plan, feasibility studies on the priority projects will be conducted for the improvement of the existing water supply facilities and new facilities in order to meet the rapid increase of water demand in the Greater Kigali as well as for the sake of ensuring quality water supply service effectively and efficiently over a long period of time.

It was developed through JICA technical cooperation project in 2020 and will be approved by the Board of Directors in 2021.

6.2 Existing Challenges

As mentioned by the Greater Kigali master plan team, in Kigali the existing facilities were developed incrementally to catch up with the social demand. However, this development without a comprehensive water supply plan and design criteria; therefore, a comprehensive plan is awaited for a long time duly considering various aspects including:

- The fact that the current distribution system, which lacks proper zoning arrangement according to the difference of elevation, forces WASAC to face difficulties while managing water distribution pressure adequately.
- The operation of some water reservoirs is unstable, and water cannot reach certain areas within the Greater Kigali.
- The current water supply facilities have too complicated networks that cause difficulty in operation and maintenance.

- There is also a concern that the Greater Kigali may face a lack of water source due to the rapid increase in water demand in the near future.

The following issues related to NRW are also mentioned in Master Plan as existing challenges.

- Inappropriate distribution system
- Large elevation difference
- Aged pipes, and faulty arrangement of pipelines and valves
- Lack of pressure management
- Low quality of service connection material & works

6.3 Necessary activities mentioned in Master Plan to reduce NRW

a) Reconstruction of Distribution systems

In Master Plan, it is mentioned that NRW reduction through reconstruction of distribution systems is the top priority issue to be tackled within the early stage of the Masterplan implementation. Master Plan suggests the following target area and phase.

ACTIVITIES	Timeline	Budget (Rfw B)	Expected reduction	Observation
Ntora- Remera (Gisozi,kinyinya , nyarutarama) network re-configuration, transmission and pipe connection replacement .	2022-2024	24.2	10%	200km service pipe replacement , 90km secondary , 20km distribution , 3.5km transmission, 13 service reservoirs
NRW/Pipelines (Phase 2) Kanombe/Masaka	2022-2025	34.1		
NRW/Pipelines (Phase 2) Runda	2023-2026	24.4		

Rugarika				
RW/Pipelines (Phase 3) Kacyiru/Remera (South)	2025-2028	16.4	10%	Kacyiru, Remera, Kimironko and Kimihurura
NRW/Pipelines (Phase 3) Gikondo	2025-2028	26.8		
NRW/Pipelines (Phase 4) Nyamirambo, Ndera-Rusororo, Nyarugenge CBD	2025-2028	64		

b) Service connection

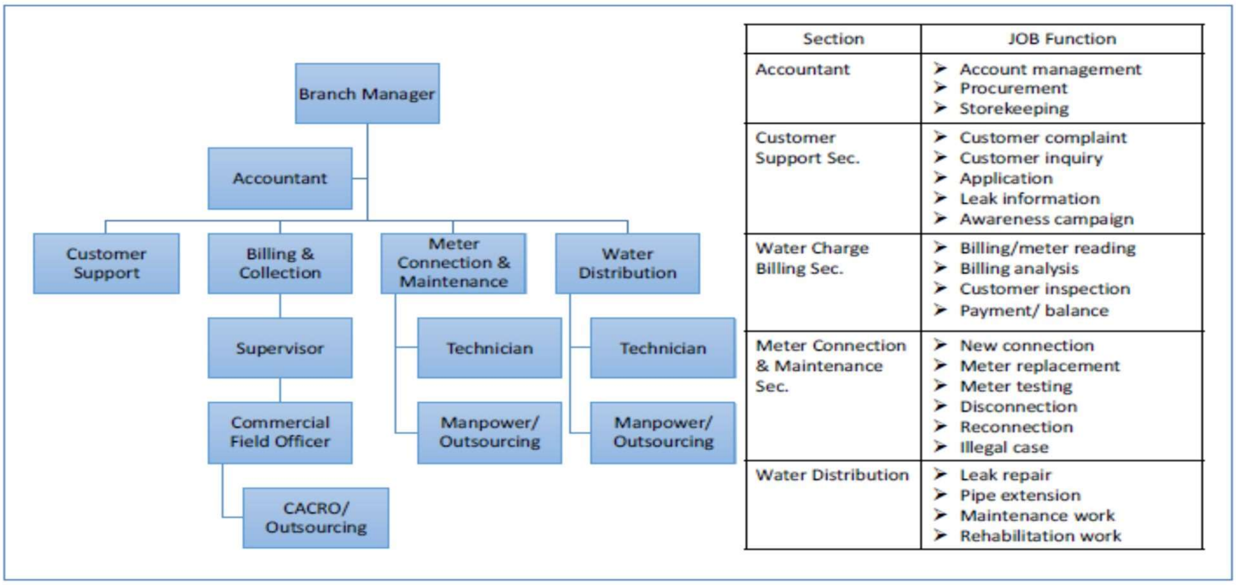
Master Plan recommends to develop private sectors for service connection as the number of connections are planned to increase dramatically in the future.

Especially, it recommends to introduce a system of designated contractor for service connection to avoid outsourcing the works to unreliable private sector,

Master Plan says that it will be easier to control leakage caused by poor quality of material and installation, by adapting this designated contractors system.

c) Branch restructuring

Master Plan points out that the customer meter management in branch is not well functioning as the responsible section to manage the customer meters in branch is vague under the current branch structures.



Section	JOB Function
Accountant	➢ Account management ➢ Procurement ➢ Storekeeping
Customer Support Sec.	➢ Customer complaint ➢ Customer inquiry ➢ Application ➢ Leak information ➢ Awareness campaign
Water Charge Billing Sec.	➢ Billing/meter reading ➢ Billing analysis ➢ Customer inspection ➢ Payment/ balance
Meter Connection & Maintenance Sec.	➢ New connection ➢ Meter replacement ➢ Meter testing ➢ Disconnection ➢ Reconnection ➢ Illegal case
Water Distribution	➢ Leak repair ➢ Pipe extension ➢ Maintenance work ➢ Rehabilitation work

Therefore, the new organizational structure of the branch is proposed as below.

d) Countinuous activities

Master plan says that the dissemination of the experience and continuous implementation of NRW reduction activities are the keys to the NRW reduction under the current conditions.

7. Summary of prioritized Activities for the revised 5YSP

The revision of the 5YSP will consider mostly the lesson learn from the 3 years implementation, the result of pilot project and recommendation from Kigali water supply master plan team as summarized bellow

Type of activity	Activities	Budget (Rfw)		Observation
		2021-2022	2022-2023	
Routine	Quick and quality repairs	100M	100M	Recruitment of additional staff in Kigali branch (1 eng + 2 tech)
	On-site meter testing	NA	NA	No extra cost. Will be done by branch staff
	Billing analysis and customer inspection	NA	NA	
	Bulk meter assessment and replacement	204M	102M	Priority for those 18 already confirmed inaccurate
	Pressure management and reservoir management	189M	189M	Installation of PRVS and floater valves
	Leak detection activities	176M	176M	Recruitment of staffs to populate the NRW unit structure
	Inspection and enforcement of water theft	146M	146M	Recruitment of staffs to populate the NRW unit structure (2 officers and 3 operators)
Investment	Upgrade of CMS	TD	TD	To easy meter reading and billing analysis

	Aged and old meter replacement	600M	1.8M	Replacement of 52k aged meters (15k year 1 and 37k year 2)
	Distribution water Network rehabilitation (15km in 21/22 and 30km in 22/23	635M	1.5 B	400km have been identified in Kigali as requesting urgent rehabilitation but bcs of budget constrain less than 50km will be replaced in 2 years
	Connection Pipe replacement	0	500M	Replacement of 5 customers pipe connection
	Water Network reconfiguration (kacyiru – remera)	TB (JICA grant)		Replacement of 200km service pipe , rehabilitation/upgrade of 90km secondary pipes , 20km distribution , 3.5km transmission pipes and construction of 13 service reservoirs
	Introduction of SCADA system	2.5B		Kigali transmission network
Policy review	New connection	N/A		WASAC should not allow customers to procure connection material to ensure good quality
	Store management	N/A		WASAC should ensure water material available in the store all the time
	Company structure			There is a need to review WASAC structure to speed operations and be more responsive

7.1 Routine activity

a) Quick and quality repairs

In order to respond quickly to the high number (around 75/ day) of visible leaks reported to WASAC from different channel of communications (call center, WhatsApp , etc..), there is a need to add more technician staff in branches (stating by 1 engineer and 2 technical staff in 6 kigali braches) who will be mostly dedicated to NRW reduction. There is also need to ensure that the repairs material are available in WASAC stores

b) On- site meter testing

The attention will be given to meters from customers with abnormal consumption from the monthly billing analysis instead of waiting the customer complain which is in most of the case. This activity will continue to be done by branches staff at no extra cost.

c) Billing analysis and customer inspection

The target of visiting 5% of the total number of customers yearly was not achieved for the last 3 years. For these remaining 2 years the target will be adjusted at 3% but the quality of the task (visit mainly big customers, zero and constant consumption) will be emphasized

d) Bulk meter assessment and replacement

The bulk meters' assessment will continue to ensure the accuracy of bulk meters for the accurate measure and computation of NRW. the priority will be given for 18 bulk meters that are already confirmed as not accurate

e) Pressure management and reservoir management

This activity will consist mainly to the identification of high pressure zones and install Pressure Reducers Valves (PRVs). Priority will be given to the 20 places that was already identified and the replacement of 91 floater valves wich are not functioning

f) Leak detection activities

Considering the fact that leak detection activity requires well trained staff and adequate equipment, in this section we will concentrate more to the recruitment and training of 5 staff (2 engineers and 3 operators) to fill the NRW unit structure

7.2 Investment

a) Upgrade of CMS

It is still challenging to ensure the accuracy of the meter reading, there is need for some improvement both for the billing system (CMS) and GIS to easy the monitoring of the meter reading and the billing analysis. Temporary uploading of pictures of reading is recommendable for the monitoring of meter reading by billing supervisor. From the billing list it should be easy to detect billing from estimated consumption. Geo-referenced meter reading as being performed by some water utility in the region can be also considered

b) Aged and old meter replacement

This activity consists of the replacement of aged (more than 15 years) and default meter with special attention on meter that have been confirmed default from on-site meter test. Currently, around 52,000 water meter are aged more than 15 years and need to be replaced urgently. Because of the budget constraint the replacement of all those aged meter will be done in 2 fiscal years (15k in year 21/22 and 37k in 22/23)

Table : WASAC meter age

Number of meters	Kigali	Upcountry	TOTAL
Age : Less than 5 years	29,873	30,209	60,082
Age : 5 to 10 years	38,259	45,656	83,915
Age : 11 to 15 years	34,653	27,636	62,289
Above 15 years	31,379	19,979	51,358
TOTAL	134,164	123,480	257,644

c) Distribution water Network rehabilitation

In addition to the network rehabilitation that are being done in Kigali and 6 satellite cities from the Afdb loan witch is mostly related to the transmission lines , there have been identified in Kigali 400km mostly distribution pipes that need to be upgraded or rehabilitated.

Table 2 Estimated Cost for Upgrading of Kigali water Network in Frw

Diameter	Length in meters	Cost/Km (Rwf)	Total Cost (Rwf)
63 (2 '')	64,455.53	10,000,000	644,555,287.59
90 (3 '')	76,284.12	20,000,000	1,525,682,449.62

110 (4 '')	29,652.08	20,000,000	593,041,621.96
160	60,404.87	30,000,000	1,812,146,104.62
200	(767.02)	50,000,000	(38,351,078.80)
250	4,735.69	50,000,000	236,784,532.60
300	11,722.84	100,000,000	1,172,284,064.20
400	24,748.36	100,000,000	2,474,836,359.00
500	8,003.48	100,000,000	800,347,537.00
600	1,513.19	100,000,000	151,318,514.10
Total	280,753.14		9,372,645,391.89

Table 3 Estimated Cost for Rehabilitation of Kigali water Network in Frw

Diameter	Length in meters	Cost/Km (Rwf)	Total Cost (Rwf)
63	56,435.28	10,000,000	564,352,811.51
90	24,908.12	20,000,000	498,162,365.26

100	994.40	20,000,000	19,887,913.76
110	2,487.93	20,000,000	49,758,697.34
110	16,572.68	20,000,000	331,453,698.24
125	707.07	30,000,000	21,212,005.44
150	83.33	30,000,000	2,499,916.59
160	5,432.67	30,000,000	162,980,145.81
200	4,556.40	50,000,000	227,819,913.50
250	1,587.15	50,000,000	79,357,293.80
300	1,569.26	100,000,000	156,925,561.20
Total	115,334.28		2,114,410,322.45

8. Implementation structure of the revised Strategic plan

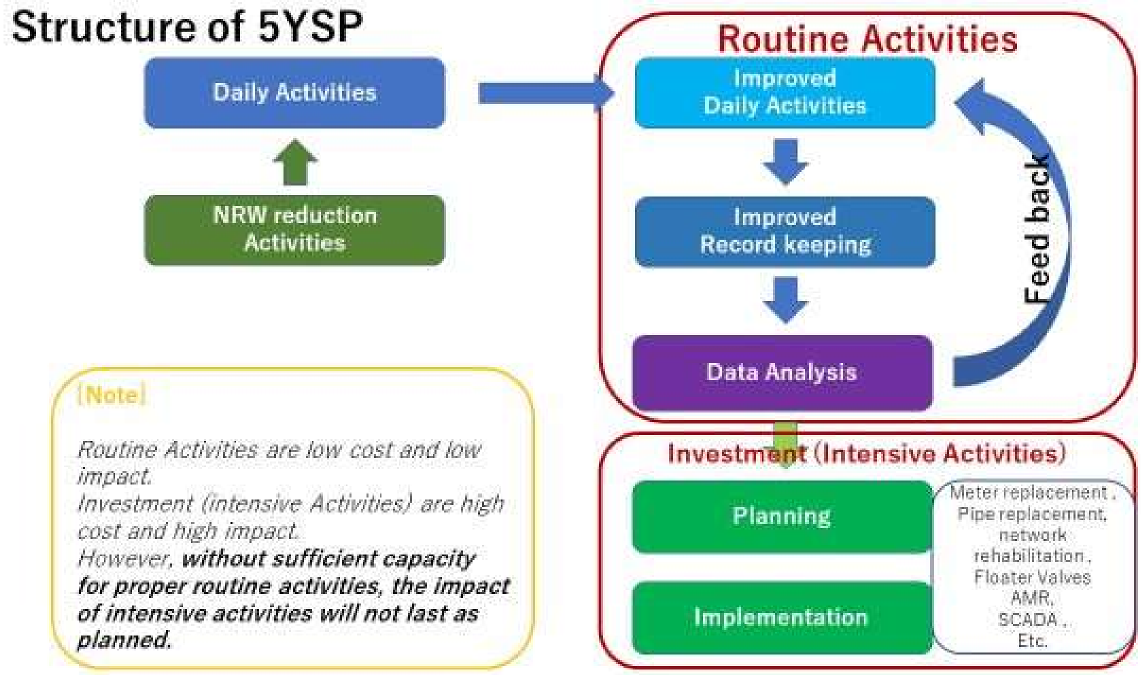
Each specific activity was assigned to the responsible departments/units or section as mentioned in the Table bellow

Type of activity	Activities	Directorate/unit responsible
Routine	Quick and quality repairs	Branches + DUWSS
	On-site meter testing	Branches and Metering section
	Billing analysis and customer inspection	Branches
	Bulk meter assessment and replacement	Metering section
	Pressure management and reservoir management	DUWSS/NRW unit
	Leak detection activities	DUWSS/ NRW unit
	Inspection and enforcement of water theft	DUWSS/NRW
Investment	Upgrade of CMS	UP/IT/DCS
	Aged and old meter replacement	UP/ DCS/branches
	Distribution water Network rehabilitation (15km in 21/22 and 30km in 22/23	DUWSS /WOS
	Connection Pipe replacement	DUWSS/Branches
	Water Network reconfiguration (kacyiru –remera)	UP/ DUWSS
	Introduction of SCADA system	SPUI/DUWSS/IT
Policy review	New connection policy revision	CSM/ DCS/SMM
	Store management	DSS/SMM
	Company structure	DSS/SMM

NRW reduction activities will be implemented mainly by 8 Units (NRW, WO, Utility Planning, Revenue Man, Customer Service Management, Branch Management, Finance , Human Resource, ICT, Administration and Logistics) wich belong to 4 departements (UWSS, CS, Financial, Support Service). Some unit are directly responsible of the implementation of the strategy and others are responsible of specific actions .

Therefore, the involvement and support of each WASAC staff is strongly recommended. The responsability of implementation of activities can be reviewed or adjusted considering the existing WASAC structure.

Effort will be concentrate both to improve routine activities (quick repairs, meter reading , leak detection , customer inspection , etc..) and the heavy investment that are needed to improve the billing , rehabilitate the network and automate operations (SCADA , smart meters ,).Without sufficient capacity for proper routine (everyday) activity , it will be very complex to implement and sustain big investment


Structure of 5YSP

Routine Activities are low cost and low impact.
Investment (intensive Activities) are high cost and high impact.
However, ***without sufficient capacity for proper routine activities, the impact of intensive activities will not last as planned.***

8.1 Implementation team

The DUWSS and Commercial directorates and NRW unit are key for the implementation of this 5YSP. The support services and finance directorate should ensure the full support for the implementation of this 5YSP.

The unit/section and team mentioned for specific actions are directly responsible of their implementation. The NRW unit will remain the driving force for the implementation of all planned activities

8.2 Monitoring Team

The monitoring of the implementation of this 5YSP will continue to be done quarterly by a team appointed by WASAC chief Executive Officer. This team is composed by 5 senior managers (Director of Urban Water and Sewerage Services, Director of Commercial Services, Director of Rural Water Services, Director of Development services, Manager of Utility Planning)

The NRW unit will continue to work closely with other unit/section to ensure that the activities are being timely implemented, compile and analyze all report to be submitted to the monitoring team. The Monitoring team will scrutinize the summarized report and select the section/ branches to be visited. The monitoring team will appoint the survey team for random on field visit to confirm realizations. At least, one monitoring team member and one staff from NRW units will be in the monitoring survey team. After the monitoring survey, the report will be presented to the Management on quarterly basis

8.3 Implementation and Monitoring Plan

As presented in the annex 1, the implementation and monitoring plan will help to track and assess the 5YSP results and achievements, it will be referred to and updated on regular basis. In addition, this implementation plan will guide the monitoring team on how to collect, analyze and dissemination data both to WASAC management and others stakeholders.

8.4 Budget for the revised Strategic Plan

For the successful implementation of this revised strategic plan, a budget of 8.9 billion Rwf has been estimated and should be considered at its approval stage by WASAC management .

With reference to the detailed plan budget, the breakdown of the estimated budget is summarized in the bellow table

Fiscal Year	Budget (Frw)	Note
2020/2021	4.4 B	
2021/2022	4.5 B	
Total	8.9B	

This budget does not consider major CAPEX such as huge water network rehabilitation which is currently under implementation through RSWSSP project and the complete shift to remote reading metering or prepaid metering system which will be detailed later.

The Non-revenue water reduction in the 2 coming years will allow WASAC to expand and improve service, enhance financial performance and reduce energy consumption.

The benefits associated with the NRW reduction from 43.3% % to 37% % in the coming 2 years are various as the volume of water that can be billed will increase by 6.5 million m^3 and an incremental revenue of 4.7billion RW on an average tariff of 730 Rwf/m^3 as presented in the table bellow

		2021/2022	2022/223
System input volume (projection)		68,060,384	74,866,422
NRW ratio	Without NRW reduction	43.30%	43.30%
	With NRW reduction	40%	37%
	Difference	3.30%	6.30%
Volume saved		2,245,993	4,716,585
Average tariff		730	730
Revenue increment		1,639,574,651	3,443,106,748

The implementation of this 5YSP involves some routine activities, other with big magnitude and completely new activities.

9. Funds mobilization mechanism for the implementation of 5YSP

Currently, the combination of funding sources (Tariff, Taxes) is not sufficient for the implementation of this revised NRW reduction strategic plan (routine activities and needed investment. The conventional sources like funding from development partners (JICA, Vitens Evides, etc…) or NGOs through Water Sector Working Group (WSWG) could be one of the options.

However, new funding mechanisms could be possible since NRW reduction is profitable for WASAC as mentioned in cost-benefit analysis. Therefore, there is needs to actively seek for new sources such as private partners and commercial banks to secure the budget necessary for the implementation of the 5YSP in timely manner.

In addition, when we consider the CAPEX, more sources will be needed. In this case, government and conventional sources are more realistic to fill the gap.

Attachment 11: Pilot Project 1･2 Completion Report

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

WATER AND SANITATION CORPORATION (WASAC)

PROJECT FOR STRENGTHENING NON-REVENUE WATER CONTROL IN KIGALI CITY WATER NETWORK

Completion report of the Pilot Project 1
Kadobogo Area

OCTOBER 2019

KYOWA ENGINEERING CONSULTANTS CO., LTD.

YOKOHAMA WATER CO., LTD.

KOKUSAI KOGYO CO., LTD.

Contents

Chapter 1. Outline of Pilot Project

1.1 Purposes of Pilot Project

The purposes of the Pilot Project are 1) to implement various activities for the reduction of non-revenue water (NRW) and verify their effectiveness and 2) to identify the most effective NRW reduction method that produces immediate effects while implementing the activities and include it in the Five-year Strategic Plan for Non-revenue Water Reduction.

1.2 Activities Implemented in Pilot Project

It is stipulated in PDM of the Project for Strengthening Non-revenue Water Control in Kigali City Water Network that a pilot project is to be implemented in two areas. The activities in Area 1 began in June 2017 after a preparatory period and completed in September 2019. Based on the knowledge and lessons learned from the activities, those that were not included in the original PDM, *i.e.*, high pressure control and replacement of distribution and service pipes, were included in the pilot project. In Area 2 with a higher achievement target, the pilot project activities are being implemented with the use of pressure control in the night and water rationing taken into consideration.

Because the target for the reduction in NRW rate (20 %) was achieved from January to March 2019 in Pilot Project 1 (in Kadobogo), the cost-benefit analysis of the project was conducted in April 2019 to elucidate its effectiveness. The project activities in the area (including those in the maintenance period) completed in September 2019. This report summarises the achievement of the activities in Pilot Project 1.

1.3 Outcome of Pilot Project

The lessons learned and recommendations derived from the Pilot Project on NRW reduction activities are described in Chapter 3, as outcome of the project.

The method that enables NRW reduction in a short time is summarised below. It was revealed that water leakage from distribution and service pipe was the major cause of NRW because it accounted for approx. 80 % of NRW. It was also revealed that the leaks were caused by the high pressure used for water distribution and poor quality of pipe materials. Therefore, the prioritized implementation of the activities mentioned below, as activities for NRW reduction, is recommended.

1. **Activities to reduce water leakage**
    - A. Water pressure control (reduction of the high pressure)

      Identify areas where water pressure is high and take corrective measures against the high pressure. Where it is not possible to take a measure that permanently reduces high pressure, including rehabilitation of a water distribution system, the installation of PRVs is the quickest and effective temporary measure. Installed PRVs must be maintained in good condition.

B. Installation of new pipes that comply with the standards

Use pipe materials that comply with the quality standards of WASAC and install them appropriately when installing new pipes.

2. Measures against existing water leaks

A. Replacement of leaky pipes and old and dilapidated pipes

Identify leaky pipes, those that leak even after repair and old and dilapidated pipes and replace them with pipes that comply with the standards.

B. Water leak survey and repair

Repair a pipe at a place where a water leak has been reported quickly as part of the regular work. Conduct a systematic leak survey in an area in which many water leaks have been detected to locate leaking points. Create as many DMAs as possible and monitor volume and rate of NRW in each of them. In an area where water leaks occur frequently, it is possible to locate leaking points by plotting points of leaks in the past on a map. Measure minimum night flow in such an area and estimate the frequency and scales of leaks from the measurements. Conduct the water leak detection survey in areas where NRW volume is large.

3. Accurate measurement of water consumption to be billed

A. Maintenance of customer meters

Repair/replace defective meters (including malfunctioning ones) found in the meter reading immediately to ensure the impartiality of customer meter measurement. Conduct the accuracy test of a meter when the cost-benefit analysis of the billed water consumption has revealed abnormality in meter readings and replace a meter that has a measurement error outside the allowable range.

B. Accurate measurement of water consumption to be billed

Read customer meters accurately. When a meter reader fails to read a meter of a customer (because of such reasons as the absence of the customer or breakdown of a meter), charge such a customer for water consumption estimated in accordance with the rule of WASAC with consent of the customer. When a meter has been replaced, add the water consumption measured by the replaced meter to that measured by the new meter and use their sum in the billing.

Identify a cause of no billed water consumption, whether water has not been used (disconnection, not in use, not main, shifted) or water consumption has not been measured (a meter blocked, closed, stolen or vandalised) and correct the cause in the case where water consumption has not been measured.

Chapter 2. Contents and Outcome of Pilot Project Activities

2.1 Formation of Action Team

The Action Team for the implementation of the Pilot Project was formed in August 2016. New team members were appointed as replacements in September 2017. The Action Team composed of 31 members was headed by Mr NTAMUTURANO Desire, the Head of Leak Detection and Pressure Management. The members included staff members of the NRW, GIS and Meter Units of WASAC Head Offices. The rest were the Directors, Water Distribution Officers, Customer Service Officers and Billing Officers of the six branch offices in Kigali (Nyarugenge, Nyamirambo, Gikondo, Kacyiru, Kanombe and Remera). (See Appendix 2.1.)

2.2 Selection and Outline of Project Areas

(1) Selection of pilot project areas

The pilot areas were selected from 11 candidate sites (1) Gatsata, 2) Kimisagara Maeket, 3) Ruyenzi, 4) Rwezameyo, 5) Rwarutabura, 6) Rwampala, 7) Niboye, 8) Baatsinda, 9) Kadobogo, 10) Gaposho and 11) Kamutwa） in the service areas of four branch office of WASAC in Kigali (Nyarugenge, Nyamirambo, Gikondo and Kacyiru) recommended by WASAC. The selection criteria mentioned below (Table 2.2.1) were used in the selection. A field reconnaissance and a study of available documents were conducted in August 2016 and two pilot areas (Area 1: Kadobogo, Kacyiru Branch and Area 2: Ruyenzi, Nyarugenge Branch) were selected in September 2016 in the discussion between the Project Team and WASAC based on the results of the reconnaissance and study. (See Appendix 2.2.)

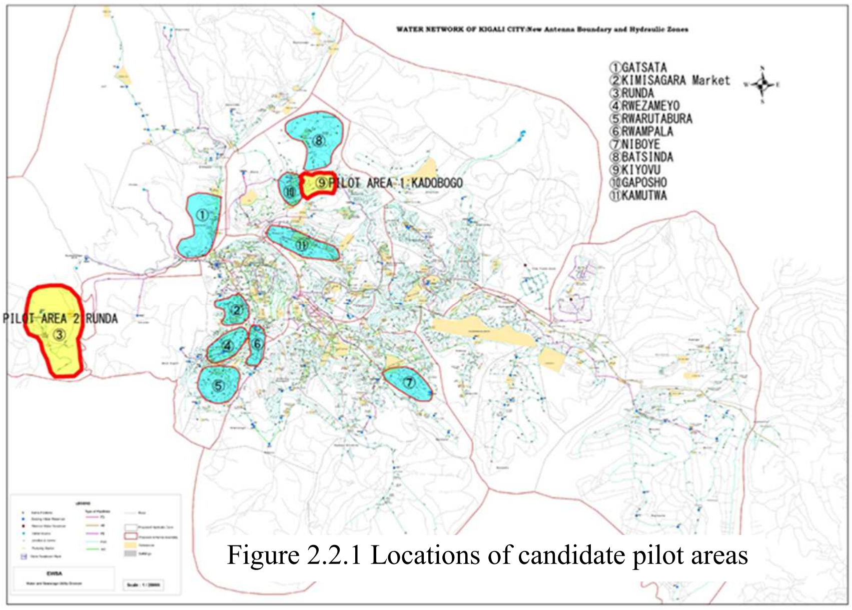


Figure 2.2.1 Locations of candidate pilot areas

Table 2.2.1 Selection criteria

No.	Criterion	Grading
1	Possibility of isolation and Also number of households in the pilot plant less than 500	Legend of evaluation Good: 2 points Average: 1 point Bad: 0 point.
2	24 hours and 7 days water supply	
3	Distribution map accuracy	
4	Install water meter at every households	
5	Leakage occur situation	
6	Possibility of leak detection	

Table 2.2.2 Selected pilot areas

Pilot Area	Cell	Sector	District	WASAC Branch	Order of implementation
Area 1	Kadobogo	Kinyinya	Gasabo	Kacyiru	First
Area 2	Ruyenzi	Runda	Kamonyi	Nyarugenge	Second

(2) Notes on selection of pilot project areas

Because water outage made it very difficult to conduct various surveys, including flow measurement, pressure measurement and meter calibration, 24 hours/7days water supply was selected as a selection criterion. However, all the four branches rationed water supply by day of the week because of the shortage of water supply and suspended water supply constantly and frequently for leakage repair. The water supply in the service area of Gikondo Branch among the four was particularly bad.

Roads branching off from main streets and entering project sites are unpaved, meandering and uneven. Their widths vary. All of them are sloping and none of them is flat. Therefore, it is not possible to locate where water pipelines are installed. Some of them run through premises of private houses. The earth covering over them is not constant: Pipelines are partially exposed at some places and buried very deep in the ground at others. Resin pipes are mostly used for the water distribution. The number of gate valves installed at the branching points of distribution pipes is extremely small. The number of valves to control water flow and that of the places at which sensors of leakage survey instruments can be installed are also small. For these reasons, the difficulty in the leakage detection was expected at all the sites.

(3) Collection of basic information

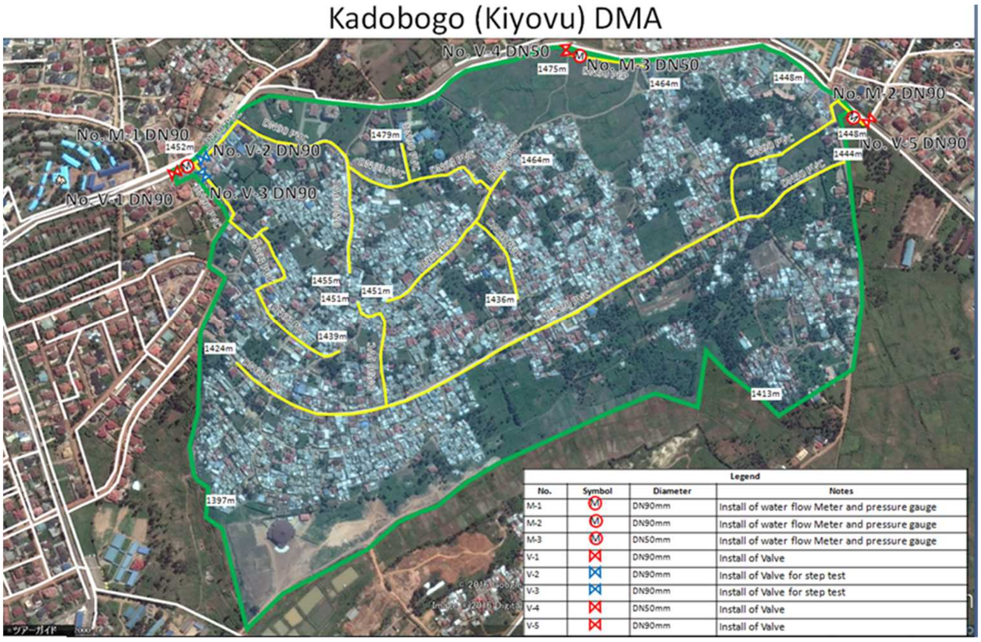
distribution network drawings and customer information were obtained, field surveys were carried out and the boundaries of the areas were determined, and, the points of inflow into the area were determined. The table below (Table 2.2.3) shows the major indicators obtained in the project.

Table 2.2.3 Major indicators of pilot areas (at the time of start)

Pilot Area	Area1 Kadobogo	Area 2 Ruyenzi
	January, 2017	January, 2018
WASAC Branch	KACYIRU	NEW NYARGENGE
Area	100.4ha	648.2ha
Population	16,096	35,794
Served Population (=Number of connections x 5)	8,510	10,665
Service Coverage Rate (%)	53	30
Number of Connections	1,202	1,483
Domestic, commercial, industry, and government	1,192	1,470
Public taps	10	13
Monthly Water Consumption (m3/month)	14,113	21,634
Average Consumption per Capita (L/day)	53	65

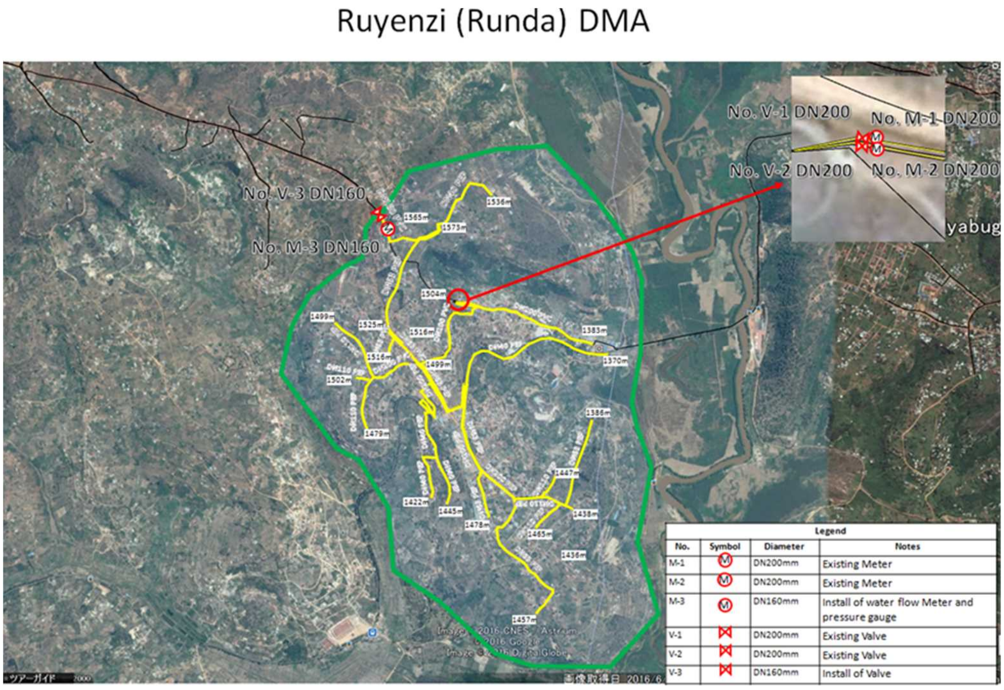
Area 1 (Kadobogo) was divided into three subzones (PM1, PM2 and PM3), each of which could be hydraulically isolated from the others. It was decided to divide Area 2 (Ruyenzi) into three subzones (RY1, RY2 ad RY3) after defining their boundaries with the method used in the division of Area 1. A map of points of connections (POCs), which was required for the meter accuracy survey, was created.

In the survey for preparation of the customer list in the Pilot Area, it was necessary to check the POC numbers. However, the POC numbers were not necessarily displayed in the positions that were prescribed in advance, including gates, but were displayed on various other locations, such as gateposts, window frames, doors, electricity meters, water meters, etc. Moreover, in some cases they were handwritten using a marker, and the number was lost due to the effects of rain, etc. Therefore, the on-site operation of checking the customer location corresponding to the POC number was extremely difficult, and took a lot of time. The POC list and POC location maps are important information and are essential for the day-to-day work carried out by WASAC, such as meter reading, meter surveys, surveys of water leaks, etc., and accurate information is necessary. A plan to affix a POC sticker to a gate of each connected house was proposed. However, the plan was not adopted because of the lack of budget and time.



Legend			
No.	Symbol	Diameter	Notes
M-1	Ⓜ	DN90mm	Install of water flow Meter and pressure gauge
M-2	Ⓜ	DN90mm	Install of water flow Meter and pressure gauge
M-3	Ⓜ	DN50mm	Install of water flow Meter and pressure gauge
V-1	⋈	DN90mm	Install of Valve
V-2	⋈	DN90mm	Install of Valve for step test
V-3	⋈	DN90mm	Install of Valve for step test
V-4	⋈	DN50mm	Install of Valve
V-5	⋈	DN90mm	Install of Valve

Figure 2.2.2 Routes of main pipelines and location of installation of water flow meters and gate valves in Pilot Area 1 (Kadobogo)



Legend			
No.	Symbol	Diameter	Notes
M-1	Ⓜ	DN200mm	Existing Meter
M-2	Ⓜ	DN200mm	Existing Meter
M-3	Ⓜ	DN160mm	Install of water flow Meter and pressure gauge
V-1	⋈	DN200mm	Existing Valve
V-2	⋈	DN200mm	Existing Valve
V-3	⋈	DN160mm	Install of Valve

Figure 2.2.3 Routes of main pipelines and locations of installation of water flow meters and gate valves in Pilot Area 2 (Ruyenzi)

(4) Notes on information required for implementation of pilot project activities

1) Creation and updating of POC location map

WASAC conducted a field survey on customer POC numbers to obtain positional coordinate data of POCs with a portable GPS device and created a POC location map by plotting POCs on a GIS-based pipeline diagram created by overlaying the routes of pipelines on the Google Map. However, the field work, *i.e.*, the customer survey and meter accuracy survey, revealed that some of the POCs shown on the POC map or described in the POC list did not exist and that some existing connections were not shown on the map or included in the list.

While the boundaries of the hydraulic division were being confirmed on the POC map, the POC map and list were corrected repeatedly. This correction necessitated the correction of the data on billed water consumption required for the calculation of NRW rates. The information on POCs must be accurate not only because it is required for the house-to-house survey of meters and water leakage, but because it is used as basic data in the calculation of the NRW rate.

Since Esri completed the addition of the positional information of customers to the GIS data, it has been possible to display a location of a POC on a tablet terminal. Staff member of the branch offices have been using the tablets provided to each branch office in September 2018 in the work in the field. GIS Unit has been updating the GIS data based on the information on new customers provided by the branch offices every month. However, the GIS data of customers has not been integrated into the Customer Management System

(CMS) of WASAC.

2) Calculation of total water consumption measured by meters (billed water consumption)

It was revealed that the water consumption measured by an old meter had not been included in the billed water consumption in a month of meter replacement. Therefore, the billed water consumption of the month was reduced and the volume of NRW of the month increased by the water consumption measured by the old meter. It was revealed that this problem was caused because it was not possible to enter the sum of the measurements by old and new meters in CMS. WASAC has begun a study for the improvement of CMS to correct this and other defects.

As the current system only allows calculation of total billed water consumption in the entire service area of a branch office, total billed water consumption in a subdivision of the service area, such as a DMA (district metering area) in the pilot project areas, has to be calculated manually with Microsoft Excel. WASAC is spending a lot of time and labour on the manual calculation. To reduce the time and labour required for the calculation of total billed water consumption in DMAs, WASAC was requested to improve CMS. The improved system shall allow addition of a DMA code to the information of each customer and automatic calculation of total billed water consumption in each subdivision. To make this system functional, staff of branch office must visit every location of a newly applied connection, give a DMA code to the connection and enter the code in CMS. However, ICT Unit has not been consulted on the improvement. The improvement of CMS is essential for the extension of DMA creation in future. (See Appendix 2.2.)

2.3 Plan and Schedule of Project Implementation

(1) Planned work schedule

A work plan for NRW reduction was created and implementation plan and schedule for the activities in Pilot Areas 1 and 2 were prepared in November 2016. The implementation schedule was revised based on the results of the discussions in the third and fourth SC meetings (held on 28 August 2018 and 22 May 2019, respectively).

Table 2.3.1 Implementation schedule of Pilot Project (original and revised plans)

No.	Output 3		1st Year												2nd Year												3rd Year											
			2016						2017												2018												2019					
			JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
1	Preparation to organize Action team and to construct Pilot Area	Original Plan		▨																																		
		Revised Plan		🟩																																		
2	Construction of Pilot Area 1 (KADOBOGO) and Pilot Area2 (RUYENZI)	Original Plan						Pilot Area 1	▨	▨	▨	▨	▨	▨	▨	▨	▨	Pilot Area 2	▨	▨	▨	▨	▨	▨	▨	▨												
		Revised Plan					Pilot Area 1, 2	🟩	🟩	🟩	🟩	🟩	🟩																									
3	Measuring NRW and implementation of NRW																																					
	Establishes the baseline NRW rate	Original Plan															▨		▨		▨		▨															
		Revised Plan												🟩	🟩	🟩					🟩		🟩		🟩													
	Conducting measures for reducing "Apparent Losses"	Original Plan																▨	▨																			
		Revised Plan															🟩	🟩	🟩	🟩	🟩																	
	Conducting measures for reducing surface leakage	Original Plan																		▨	▨																	
		Revised Plan																				🟩	🟩															
	Conducting measures for reducing underground leakage	Original Plan																				▨	▨															
		Revised Plan																						🟩	🟩													
4	Analysis, Preparing and holding the workshop and seminar	Original Plan																						▨	▨	▨												
		Revised Plan																							🟩	🟩												
5	Measuring NRW and implementation of NRW reduction activities on the **Pilot Area 2**	Original Plan																									▨	▨	▨	▨	▨	▨	▨	▨	▨			
		Revised Plan																						🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩			
6	Preparing and holding the workshop and seminar	Original Plan																																▨	▨			
		Revised Plan																																🟩	🟩			

The activities in Kadobogo were to be implemented between 1 September 2017, after setting a baseline NRW rate, and 30 May 2018 (in a nine-month period). The concrete work plan of the Pilot Project was explained to the Action Team on 11 August 2016. (See Appendix 2.3.)

Explanation to Action Team

Explanation of a device to be use in Pilot Project

Fig. 2.3.1 shows the workflow of the Pilot Project.

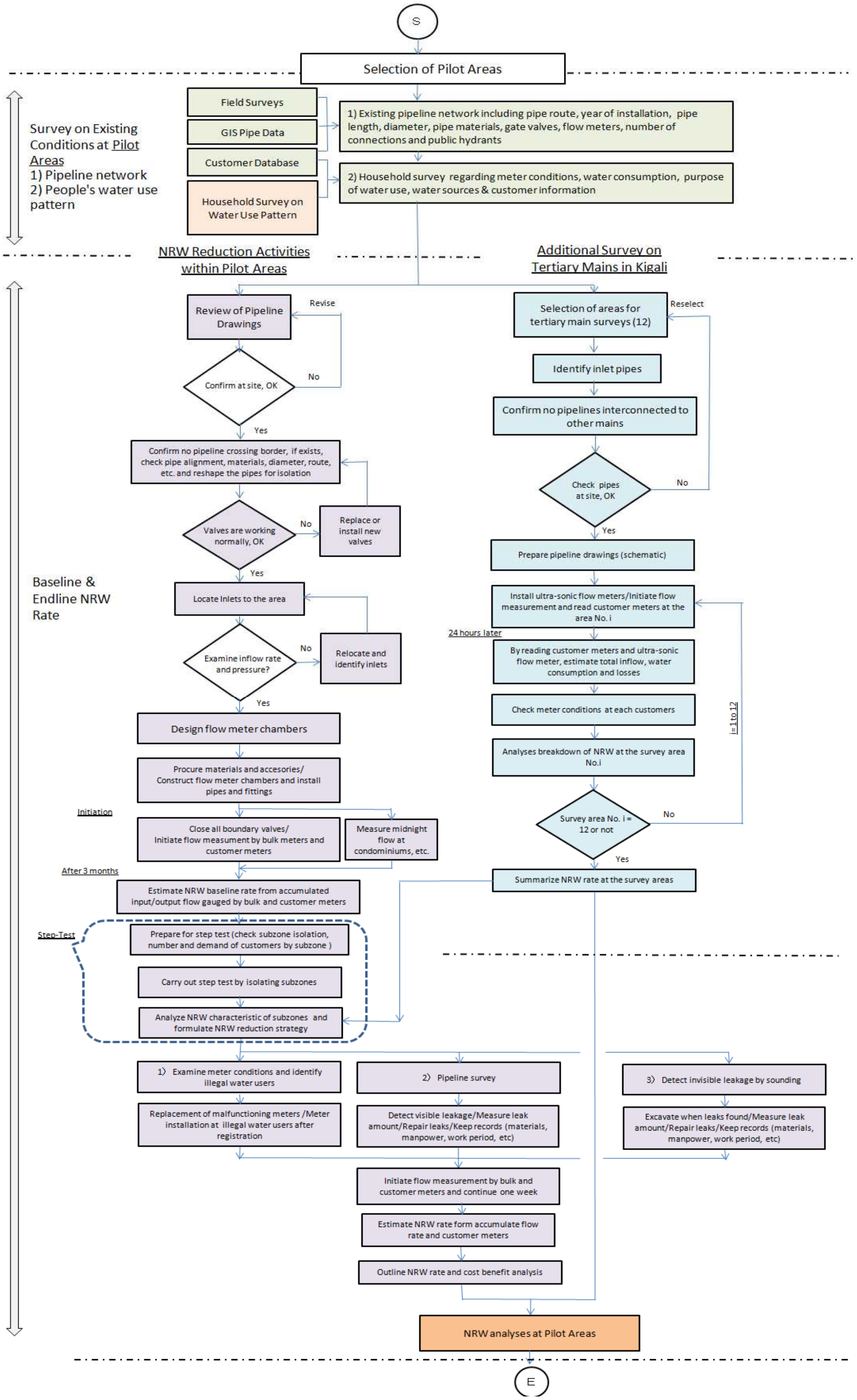


Figure 2.3.1 Flow of work (step test and measures to be taken on small-diameter distribution and service pipes and against apparent losses and above-ground and underground water leaks) in pilot project

（2）Outcome of implementation of Work Plan

Tables 2.3.2 and 2.3.3 show the implementation status of the activities in the schedule. The following activities are being implemented: 1) review of the meter accuracy survey, 2) replacement of defective meters found in the survey, 3) reconfirmation of the boundaries of the pilot areas, 4) questionnaire survey of disconnected former users and unconnected potential users, 5) preliminary and full-scale surveys for the implementation of the step test in the subzones in Area 1 (PM1, PM2 and PM3), 6) water pressure monitoring survey in PM1, PM2 and PM3, 7) survey on water consumption by typical households in the area and 8) detection of above-ground and underground water leaks.

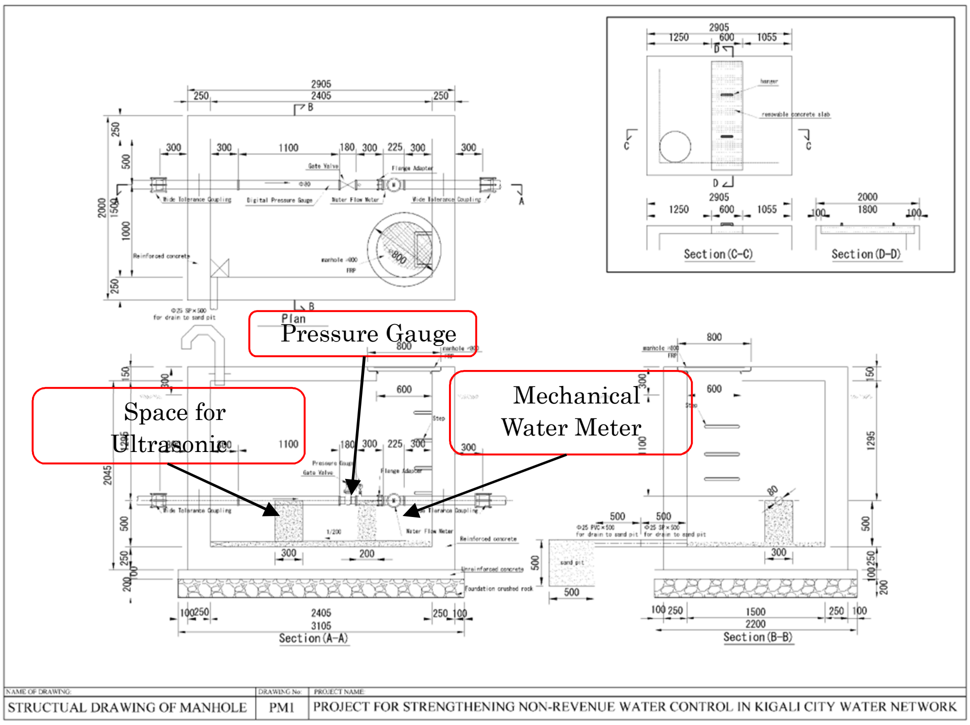
A study was conducted on hinderances to the NRW reduction based on the monthly changes in the NRW rate resulting from the implementation of the Pilot Project. Based on the results of the study, a measure against high water pressure (installation of PRVs) and replacement of the existing distribution pipes, which were not included in the original plan, were included in the Pilot Project.

To evaluate the effectiveness of each measure with the NRW rate as a reference, two or more measures were not implemented simultaneously. For a one-month period after the completion of each measure, no other measure directly contributing to the NRW reduction was implemented to allow effects of the implemented measure to emerge and to evaluate the effects.

2.4 Hydraulic Isolation of Pilot Areas and Installation of Water Flow Meters and Pressure Gauges

1) Installation of water meter chambers

Water flow meters and pressure gauges were installed at the inlets of the three subzones (PM1, PM2 and PM3) in Kadobogo and a subzone (PM4) in Ruyenzi. Test excavation was conducted in October 2016 to examine the condition of the existing pipes at the inlets and to decide the locations of meter installation. The meter installation was completed in May 2017. (See Appendix 2.4.)



No.	Items	Quantity (set)
For Pilot Project 1 (Kadobogo)		
1	Water Meter (DN50mm, PN16, Mechanical Type)	1
2	Water Meter (DN80mm, PN16, Mechanical Type)	2
3	Pressure Gauge (DN25mm, IP65 protection, Range 0 to 20,000psi)	3
4	Sectional Valve (DN90mm, PN16)	2
5	Sectional Valve (DN150mm, PN16)	1
For Pilot Project 2 (Ruyenzi)		
1	Water Meter (DN150mm, PN16, Mechanical Type)	1
2	Pressure Gauge (DN25mm, IP65 protection, Range 0 to 20,000psi)	1

Figure 2.4.1 Drawing of water meter chamber

Water meter chamber and valve chamber

Inside of water meter chamber

2) Hydraulic isolation of pilot area

A field survey of pipelines based on the GIS-based pipeline diagram was conducted in November and December 2016 for the hydraulic isolation in Kadobogo and Activities 3), 4) and 6) were implemented in late December. Gate valves required for the step test were installed at two locations on tertiary mains in February 2017.

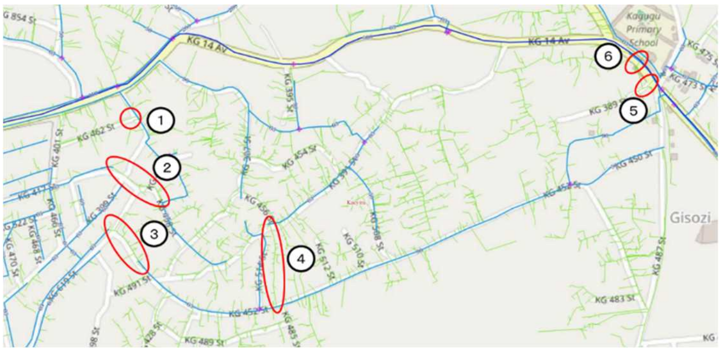


Figure 2.4.2 Hydraulic isolation of pilot area

1: There is a boundary between old and new residential areas which are not connected with a water pipeline.

2: An erroneous GIS data - This pipeline does not exist.

3: Although the GIS data indicated the existence of a pipeline in this area, the existence of three pipelines was confirmed in the test excavation.

4: As a location of a pipeline was identified, install a valve on the pipeline and close the valve during the measurement of NRW.

5: An erroneous GIS data – This pipeline branches off not from a DN500mm pipeline but from a DN900mm pipeline.

6: An underground 3/4” pipeline was installed across a road. The part traversing the road was plugged to make it a pipeline branching off from a φ90mm pipeline.

Test excavation at sites

Three teams (of three workers each) conducted new hydraulic isolation at the boundaries of the pilot area and those between the subzones of the area (PM1, PM2 and PM3) and corrected the locations of the boundaries on the drawing.

In the hydraulic isolation, the following work was implemented: 1) confirmation of the boundaries on the distribution network drawing, 2) acquisition of the list of POC numbers and POC map, 3) confirmation of the functional state of the gate valves in the network, 4) creation of a map of the subzone boundaries based on the Google Map, 5) closure of the gate valves at the boundaries, 6) confirmation of the availability of water at household water taps (whether water flows from the taps or not) near the boundaries and 7) sorting of customers on the list by subzone.

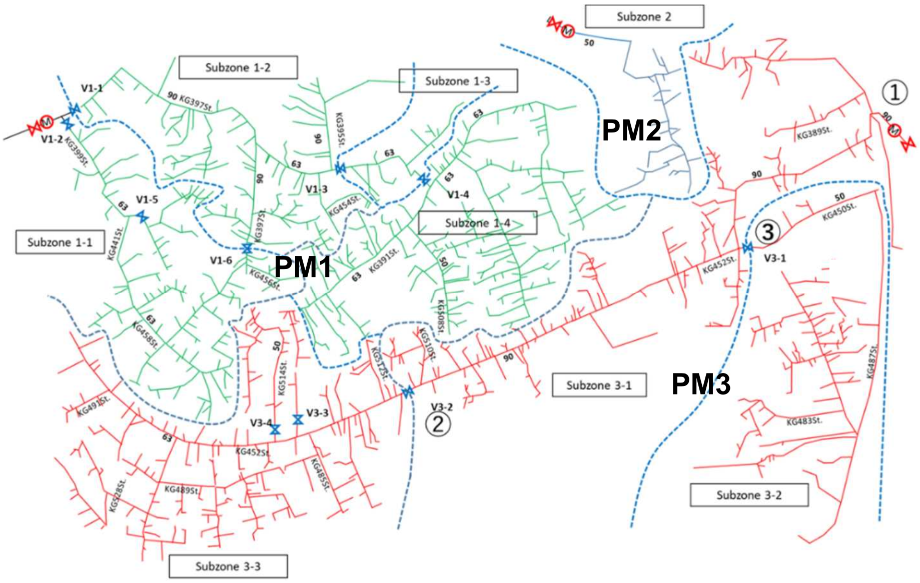
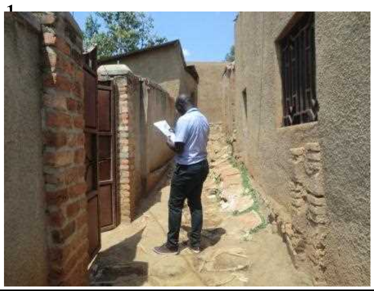


Fig. 2.4.3 Outline of pilot area 1 (Kadobogo)

		
Confirmation of valve closure	Confirmation that water does not flows from a tap	Confirmation of a POC number

2.5 Baseline NRW rate setting

The measurement of flow rates into Pilot Area 1 commenced in June 2017 and the monthly NRW rate in each subzone is continuously calculated by dividing the billed water consumption in each subzone by the volume of water distributed to the subzone.

The average of the NRW rates in June and July 2017, 37.3 %, was used as the baseline NRW rate in Area 1 and the NRW reduction target in the project was set at 20 %.

Table 2.5.1 Base line of Pilot Project 1

Items	Unit	June, 2017	July, 2017	Average
Connection	Number	1,240	1,244	1,242
Input Discharge	m3	19,054	20,389	1,972
Billed water	m3	11,345	13,412	12,379
NRW	m3	7,709	6,977	7,343
NRW Rate	%	40.5%	34.2%	37.3%

2.6 Activities for Reducing Apparent Losses

Apparent losses usually include illegal water consumption through unlawful connections, small water flow that cannot be detected by water meters, instrumental errors of the meters, errors in meter reading and errors in the estimation of water consumption. To estimate the proportion of each of these components in the apparent losses, the customer water meters were inspected for their operating conditions and reading accuracy on site and a questionnaire survey of disconnected customers and non-customers were conducted.

All 1,242 customer water meters in Kadobogo were examined for their accuracy (see 2.6.1). The questionnaire survey was conducted with 99 disconnected customers and 40 non-customers (see 2.6.2).

The results of these surveys and the data of monthly billed water consumption were used for the estimation of water losses resulting from instrumental errors of the meters, illegal water consumption and errors in the estimation of billed water consumption (See 2.6.2). Measures such as the replacement of defective meters, installation of water meters at illegal connections and training of meter readers on the meter reading were taken.

The reference materials are shown in Appendix 2.6.

2.6.1 Accuracy Test of Customer Meters

(1) Usage of Portable Test Meter

Training on how to use a portable test meter was provided to staff of Kacyiru Branch and the preparation for the on-site accuracy test of customer meters in the pilot area began in August 2017.

Explanation at Kacyiru Branch

On-site training on measurement of meter accuracy

The test was conducted by two teams, each of which consisted of four members, one from the NRW Team, two from the branch office and one from JICA Expert Team. The allowable meter measurement error was set at ±5 % in accordance with the standard of WASAC (WASAC, Ltd. Commercial Policy and Procedure Manual). It was decided that Kacyiru Branch would replace meters that did not satisfy the allowable range with the meters procured by JICA for this project. Each team measured meter errors at around 10 sites in a day.

Photo 9 Measurement of meter accuracy

Measurement flow rate

In the beginning, a flow rate to be used in the test was set at 1,000 L/h, as described in the instructions of the measuring instrument. However, because this rate was too high compared with the water consumption of customers in the project area, the flow rate setting was changed. The test was conducted for one minute at a high flow rate of 800 – 1,000 L/h and for three minutes at a low flow rate of 100 – 300 L/h. The final decision on the meter replacement was supposed to be made based on the result of the accuracy test on the test bench in the laboratory of the Meter Unit of WASAC. However, as this laboratory test was found to be time-consuming, the decision on the replacement was to be made based only on the readings of a portable test meter on site, in the end.

However, it took a very long time to test a meter of each customer in the test conducted in Kadobogo and the test inconvenienced customers because a lot of water was wasted in the test. To conduct the test efficiently without inconveniencing customers in Pilot Area 2 (Ruyenzi), the measurement method described below was adopted in April 2018.

① Use 600 L/h, the average water consumption of the customers, as the flow rate for the test. (The average water consumption was obtained from the on-site measurements of water consumption of customers at three locations.)

② The duration of the measurement shall be two minutes to reduce the cost of water consumption of customers and to ensure the accuracy of the measurements.

③ The measurement results shall not be corrected for instrumental error of a test meter.

④ The allowable range of the instrumental error shall be ±5 %.

⑤ Conduct the accuracy test at large-scale customers.

⑥ Conduct the surveys of water meters and service pipes of all customers prior to the accuracy test to identify defective meters and confirm the scale of water leakage with a detector and operating conditions of water pipes.

(2) Meter accuracy test and meter replacement

In the PDM of the project, activities to reduce real loss are to be implemented after those to reduce apparent loss have been completed. However, as a water leak must be repaired immediately when it has been detected, the meter replacement and repair of leaks were carried out in parallel. The meter test results are shown in Attachment 2.6.

The Customer Survey List (POC List) of Kadobogo Area was created in September 2017. There were 1,242 POCs in the area. An on-site meter survey was planned to be carried out at these 1,242 points between September and December 2018. The survey could not be carried out at 35 points because the meters were not accessible or residents were not at home. Therefore, the number of points where the meter survey was implemented was 1,207 (or 97 % of POCs).

The errors of water meters were measured on site with portable test meter when the meters were inspected visually. The water supply was disconnected due to non-payment of bills at 35 points (3% of the survey points) and defective meters were found at 88 points (7% of the survey points). Therefore, the error measurement was carried out at 1,084 points. The meters with errors out of ±5 % (allowable range) were found at 239 points (above the upper limit at 90 points and below the lower limit at 149 points) and the errors of the meters were within the allowable range at 845 points.

Table 2.6.1 Result of meter accuracy measurement

Meter error	-5 % or below	Between -5 % and +5%	+5 % or above	Measurement points	Defective meter	Total
PM1	82	467	52	601	49	650
PM2	5	39	5	49	1	50
PM3	62	339	33	434	38	472
Total	149	845	90	1,084	88	1,172
Percentage	14%	78%	8%	100%		

The total number of points where meter replacement was necessary was 327 (28 % of the number of the measured meters, 1172), 239 (20 %) due to error out of allowable range (±5 %) and 88 (8%) due to defects. Twelve percent of the inaccurate meters had errors below the lower limit and 8 % of them had errors above the upper limit, or the number of the former was 50 % more than that of the latter. The inaccurate meters were replaced with new ones between October 2017 and December 2018. The meter replacement was implemented at a total of 323 points, including 29 points at which meters were replaced without being tested by WASAC, between July 2017 and December 2018, as shown in the table below.

Table 2.6.2 Numbers of replaced meters

Monthly Replacement Number of Meter

Year	Month	Number
2017	Jul	0
	Aug	1
	Sep	0
	Oct	21
	Nov	13
	Dec	44
2018	Jan	42
	Feb	92
	Mar	56
	Apr	24
	May	1
	Jun	8
	Jul	7
	Aug	2
	Sep	2
	Oct	1
	Nov	6
	Dec	3
Total		323

(3) Problems found in and lessons learned from meter test

It took four months, much longer than planned, to complete the meter accuracy test which commenced in the end of August 2017. The points mentioned below were found to be the causes of the delay that were to be rectified for the accurate on-site meter reading by WASAC. Among them, the problems concerning POC numbers were particularly serious.

An accurate map of the location of POC must be available when the on-site meter test is conducted. If there is an error or omission on this map, it may take long for a test team to reach a target customer. There was a case in which a test team spent an hour to find a customer in the test conducted in Kadobogo. To prevent such a case, GIS data and customer data in CSM must be updated and matched.

- The test team had to spend a long time to reach target POCs because there was no accurate POC map, the POC number stickers were not affixed to the designated place of customers' houses or the numbers were written by hand at places other than the designated place.

- Some customers locked the gates of their houses when no one is at home. Therefore, the test teams had to visit such houses repeatedly.
- It took time for the teams to have a meter box that had been locked by a lessor unlocked to conduct the test. In some cases, the meter accuracy could not be measured because the boxes could not be unlocked.
- Flow rate could not be measured with a test meter because the water pressure in a service pipe was low.
- Suspension of water supply for leakage repairs and by the rationing occurred frequently while the test was being conducted. It was not possible to examine the performance of a meter or to measure water pressure with a manometer during such water outage.

(4) Evaluation of effectiveness of meter replacement

1) Evaluation based on changes in NRW rates

The meter replacement was carried out at 293 points (91 % of the 323 points) by April 2018. However, the NRW rates in April and May were 39.5 % and 40.0 %, respectively, which were larger than the baseline value of 37.3 %. A slight reduction in the NRW rate was observed later, as the rates in June and July were 31.7 % and 33.6 %, respectively. The WASAC branch office repairs water leaks at an average of 10 points per month in the area. As both the replacement and the repair contribute to the reduction of NRW, it is impossible to tell the effectiveness of the meter replacement on NRW reduction. Therefore, it is not reasonable to evaluate the effectiveness of the replacement of customer meters with monthly NRW rates.

2) Evaluation based on estimated average errors per meter before and after the replacement of inaccurate meters

The effectiveness of the meter replacement was evaluated by comparing the estimated average errors per meter before and after the replacement of 239 meter that were required to be replaced.

The total errors of the 1,084 meters on which the on-site meter test was carried out was -1,508.21 % and the average error per meter was -1.39 %. The total error after replacing the 239 meters with errors out of ±5 %, on the ideal assumption that the errors of all the replacement meters are zero, is -749.54 %, or the error per meter is -0.69%. The improvement realized by the meter replacement is estimated at 0.7 %, the difference between the two errors per meter. This improvement is extremely small. (Note that water consumption of each customer was assumed to be same before and after the replacement.)

Table 2.6.3 Evaluation of effectiveness of meter replacement

Item	Result of survey	Estimation after replacement	
		Errors of meters: 0%	Errors of meters: ±5 %
Number of points used in the estimation	1084	1084	1084
among which the number of points where pumps were replaced	-	239	239
Total meter error (%)	-1,508.21	-749.54	-1,044.54
Average error (%)	-1.39	-0.69	-0.96

As shown in the table below, the calculation of NRW based on the actual data of May 2018 when the replacement of the meters was in progress shows that a 0.7 % increase of billed water consumption by the meter replacement decreases the NRW rate by only 0.4 %. The time required for repaying the cost of the meter replacement with the increment in the sale of water realized by the replacement is calculated at 12 years. This calculation result shows that the meter replacement will not produce financial benefit to WASAC. If a large number of meters have positive errors, the replacement may bring adverse financial effect to WASAC.

Table 2.6.4 Evaluation of effectiveness of meter replacement based on data of May 2018

Item	Result of survey	Estimation after replacement	Effectiveness
Rate of meter accuracy improvement		0.7%	0.7%
Billed water consumption (m3)	12,822	12,912	90
Distributed water (m3)	21,373	21,373	-
RW rate (%)	60.0%	60.4%	0.4%
NRW rate (%)	40.0%	39.6%	-0.4%

Table 2.6.5 Effectiveness of investment in meter replacement

Item	Unit price (Frw)	Quantity	Cost (Frw)
Average water bill	565	90 m3	50,850
Price of meter	30,000	239 units	7,170,000
Repayment period (months)	-	-	141
Repayment period (years)	-	-	12

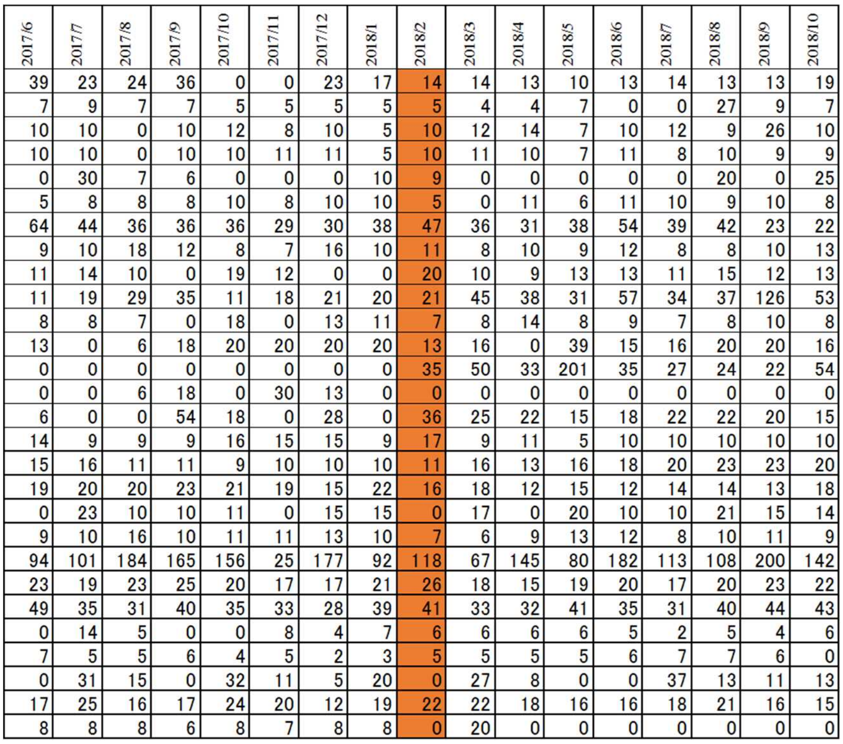
3) Comparison of water consumption before and after meter replacement

The effectiveness of the meter replacement was evaluated with the comparison of total billed water consumption before and after the replacement.

The data of billed water consumption in six months before and after a reference month, the month in which water meters were replaced, were available at 305 points among the points where the meters were replaced. The comparison of the data revealed a 0.6 % increase after the replacement. It is difficult to conclude that this slight increase was caused by the meter replacement because the data of only six months before and after the replacement were used in the comparison and monthly water consumption changes from month to month. In conclusion, the direct effect of the meter replacement to the entire area is considered minute.

Table 2.6.6 Estimated effectiveness of meter replacement

Item	Before replacement	After replacement	Ratio
Average monthly billed water consumption: m3	3,314	3,334	1.006



2017/6	2017/7	2017/8	2017/9	2017/10	2017/11	2017/12	2018/1	2018/2	2018/3	2018/4	2018/5	2018/6	2018/7	2018/8	2018/9	2018/10
39	23	24	36	0	0	23	17	14	14	13	10	13	14	13	13	19
7	9	7	7	5	5	5	5	5	4	4	7	0	0	27	9	7
10	10	0	10	12	8	10	5	10	12	14	7	10	12	9	26	10
10	10	0	10	10	11	11	5	10	11	10	7	11	8	10	9	9
0	30	7	6	0	0	0	10	9	0	0	0	0	0	20	0	25
5	8	8	8	10	8	10	10	5	0	11	6	11	10	9	10	8
64	44	36	36	36	29	30	38	47	36	31	38	54	39	42	23	22
9	10	18	12	8	7	16	10	11	8	10	9	12	8	8	10	13
11	14	10	0	19	12	0	0	20	10	9	13	13	11	15	12	13
11	19	29	35	11	18	21	20	21	45	38	31	57	34	37	126	53
8	8	7	0	18	0	13	11	7	8	14	8	9	7	8	10	8
13	0	6	18	20	20	20	20	13	16	0	39	15	16	20	20	16
0	0	0	0	0	0	0	0	35	50	33	201	35	27	24	22	54
0	0	6	18	0	30	13	0	0	0	0	0	0	0	0	0	0
6	0	0	54	18	0	28	0	36	25	22	15	18	22	22	20	15
14	9	9	9	16	15	15	9	17	9	11	5	10	10	10	10	10
15	16	11	11	9	10	10	10	11	16	13	16	18	20	23	23	20
19	20	20	23	21	19	15	22	16	18	12	15	12	14	14	13	18
0	23	10	10	11	0	15	15	0	17	0	20	10	10	21	15	14
9	10	16	10	11	11	13	10	7	6	9	13	12	8	10	11	9
94	101	184	165	156	25	177	92	118	67	145	80	182	113	108	200	142
23	19	23	25	20	17	17	21	26	18	15	19	20	17	20	23	22
49	35	31	40	35	33	28	39	41	33	32	41	35	31	40	44	43
0	14	5	0	0	8	4	7	6	6	6	6	5	2	5	4	6
7	5	5	6	4	5	2	3	5	5	5	5	6	7	7	6	0
0	31	15	0	32	11	5	20	0	27	8	0	0	37	13	11	13
17	25	16	17	24	20	12	19	22	22	18	16	16	18	21	16	15
8	8	8	6	8	7	8	8	0	20	0	0	0	0	0	0	0

Note) Data at some of the 305 points are shown.

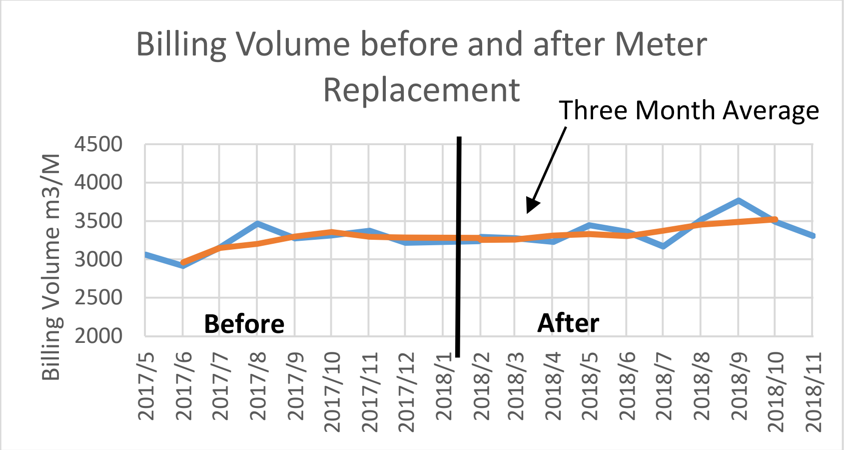


Fig. 2.6.1 Comparison of billed water consumption before and after meter replacement

(5) Strategies for meter replacement

The above-mentioned meter survey revealed the following;

- WASAC has installed water meters at a large proportion (nearly 100 %) of POCs.
- While it takes time and labour to calibrate and replace water meters, the benefit of the meter replacement is small.
- The replacement may have negative effect because some meters have positive errors.

The above-mentioned findings suggest the appropriateness of the following meter management strategies.

- The purpose of the ordinary meter replacement is to guarantee the fairness and reliability of billing to customers.
- The following meters should be replaced or repaired immediately:
  Defective meters (to be identified during the meter reading)
  Blocked meters (to be identified during the meter reading)
- The meter accuracy test should be carried out in the cases mentioned below. If a meter has an error below -5 % or above +5%, it should be replaced.
  When the analysis of billed water consumption has revealed abnormally large or small billed water consumption,
  When an abnormality in the movement of the point of a meter or an abnormal change in billed water consumption from that of the previous reading is found during the meter reading, or
  When a customer makes a complaint about the billing.
- Meters shall be replaced at regular intervals of approx. 10 years to maintain their accuracy.
- The possibility of installing a smart meter at a place where it is difficult to carry out meter reading will be studied.

2.6.2 Survey on Water Consumption of Disconnected Customers and Non-customers

(1) Survey purpose and subjects

There are many disconnected customers and non-customers in the pilot area. A questionnaire survey of those who could not use public water supply was conducted to elucidate 1) water sources they relied on, 2) how much they spent on water, 3) whether they were using water supplied through illegal connections and 4) their requests to WASAC.

In this survey, 99 disconnected customers in the pilot area were interviewed. They were customers with no billed water consumption for the three months, from June to August 2017, to whom Kacyiru Branch had suspended water supply. The branch office classified the reasons of the disconnection into six categories; Disconnected (90), Closed (4), Stolen (2), Not in use (1), Not mine (1) and Shifted (1). A study was conducted on the details of the reasons for the disconnection, the measure taken against customers who have not paid water bills.

A total of 40 non-customers, selected from each subzone in proportion to its area, were interviewed in the survey.

The survey team consisted of three members; one staff member of Kacyiru Branch and two members of JICA Team (one Japanese expert and one local staff member). As the branch office assigned different staff members to the survey team on different days because they were busy performing their regular duties, JICA Team practically conducted the survey. Portable water quality test equipment (conductivity meter and residual chlorine analyser) were used in the analysis of water quality at the sources. Major analysis results are described below. The questionnaire form used in the survey is shown in Attachment 2.6.

(2) Results of survey of disconnected customers

a. Characteristics of disconnected customers

Around 40 % of the disconnected customers were lessees. These customer household consists of 9.5 members on average. The fact that this figure is much larger than the national average strongly suggests the possibility that multiple families live together in a customer's house.

	Lessee	Homeowner	Total
Sample Number	31	47	78
Percentage	39.7 %	60.3 %	100.0 %

b. Main water sources

The main water sources of the disconnected former customers are public taps (53.8 %), springs (37.2 %) and rainwater (28.2 %) (see table below). The public taps, in particular, are the alternative water sources of more than half of the disconnected households. Therefore, residents are expected to express strong opposition to the closure of public taps only for a reason of delay in payment. In the on-site survey, residents criticised the action taken by WASAC on sudden closure of public taps. Such sentiment of the residents is backed by the evidence of illegal water use found near public taps.

Although not shown in the table below, 20.5 % of households (16 households) depend only on insanitary water sources, such as spring water and rainwater. It should be noted that this percentage is higher than 16.4 %, the percentage of households relying on insanitary water sources, rainwater and spring water in urban areas described in the RDHS Report, 2014-15.

	Public tap	Water seller	Neighbour	Deep well	Shallow well	Spring water	Rain-water	Total
Sample Number	42	11	6	1	0	29	22	78
Percentage	53.8 %	14.1 %	7.7 %	1.3 %	0.0 %	37.2 %	28.2 %	100.0 %

c. Request to WASAC

All the disconnected former customers requested the reduction in water charges and arrears. As it is difficult even for ordinary households to pay a large sum of arrears in one instalment, it is necessary to consider this issue concerning the water charges and arrears.

	Affordable water charges	Measures to reduce payment amount	Total
Sample Number	2	80	80
Percentage	2.5 %	100.0 %	100.0 %

(3) Result of survey of non-customers

a. Family composition and employment status

A non-customer household consists of an average of 4.8 members, which is slightly larger than the national average, 4.3 persons/household. Among the 40 households surveyed, 35 % (or 14) of them did not have a permanent job. This unemployment rate is much higher than the national average of 15 %. This high unemployment rate is also inferred from the fact that many households in Kadobogo are those of immigrants who have come to live in the area looking for temporary or permanent employment.

b. Main water sources

Half of the non-customers rely on water from public taps and springs. They use water purchased from neighbours and rainwater as supplemental water sources. While the role of public taps is very significant for non-customers, spring water is also important for them. Sanitary management and use of spring water are required for Rwanda to achieve its goal of drinking water for all by 2022. The number of households depending on spring water and rainwater is large.

	Public tap	Water seller	Neighbour	Deep well	Shallow well	Spring water	Rain-water	Total
Sample Number	19	5	12	2	0	19	13	40
Percentage	47.5 %	12.5 %	30.0 %	5.0 %	0.0.%	47.5 %	32.5 %	100.0 %

c. Cost of water consumption

Non-customers spend 100 – 150 RWF per day, or 3,000 – 4,500 RWF per month, on water. As this amount is comparable to the water charges that ordinary customers pay to WASAC, the rapid extension of the water service of WASAC is awaited.

d. Request to WASAC

Around 90 % of non-customers request reduction of water charges. It must be noted that there are some who are critical of action taken by WASAC staff. WASAC needs to improve its regular customer services.

	Continuous water supply	Affordable water charges	Improvement of staff's attitude	Measures to reduce payment amount
Sample Number	1	36	5	1
Percentage	2.5 %	90.0 %	12.5 %	2.5 %

(4) Issues to be addressed

Relationships between lessees and owners:

Most of the residents in Kadobogo are immigrants from other areas in Rwanda and 70 % of them live in rented houses. It is prescribed in an ordinary contract that a lessor shall pay water bill of a lessee. Therefore, there have been many cases in which a lessor has to pay a large sum of water bill because of the indifference of a lessee to water consumption. In some of these cases, a dispute arises between a lessor and a lessee concerning the payment of water bills, water supply to the house concerned is suspended because of the delay in the payment, a lessor closes the stop valves and locks the meter box so that a lessee cannot use water freely and a current lessee cannot use piped water because the water supply to the house was suspended (compulsory disconnection) when the former lessee lived in it.

Illegal water users:

Four or five suspected cases of illegal water consumption of disconnected former customers were found in the survey. They removed a plug or meter in such cases. More disconnected former customers than non-customers consume water illegally. Frequent suspension of water supply for minor reasons is reported to have created a hotbed of water theft. This survey revealed the importance of having dialogue with customers, providing as much convenience as possible to them and obtaining their consent on the suspension when water supply to them are to be suspended

Sales price:

Most of the non-customers want to use drinking water supplied through water taps in their houses. However, many of them must rely on insanitary spring water and rainwater because of the high cost of piped water. Even if a non-customer lives in an area where piped water is available, such a non-customer may have to purchase it at a public tap or from neighbours at a high price. This interview survey revealed that, although the ordinary sales price of water was 20 RWF/ jerry can (20 L), the price varied among districts and water cost 50 RWF/jerry can in many districts. The irony is that poor people are buying water at a price several times higher than piped water charge.

2.6.3 Water losses derived from illegal consumption and estimation errors

The major causes of the apparent water losses in the water supply service in Kigali City include 1) illegal consumption, 2) water losses derived from the errors in the estimation of billed water consumption and 3) mishandling of meter readings at the time of meter replacement, in addition to the above-mentioned instrumental errors. The existence of many customers with no billed water consumption in the pilot areas suggests that the meter reading has not been conducted in accordance with the rules and this poor meter reading has led to the large water losses derived from errors in the estimation of billed water consumption.

(1) Illegal consumption

No clear evidence of illegal use of piped water through illegal connections was discovered in Kadobogo. However, four to five cases of illegal consumption with unauthorized opening of disconnected water taps and intentional removal of meters were uncovered in Kadobogo. As the numbers of these cases are very small compared with the total numbers of customers, the losses caused by the illegal consumption were estimated at less than 0.5 % of the total amount of water distributed in the area. As measures against these uncovered illegal consumers have already been taken in the pilot area, the illegal consumption is believed to be almost zero at present.

(2) Estimation errors where it is impossible to read meters

WASAC is supposed to read the meters at all customers every month. However, there are cases where meters cannot be read because of the inaccessibility due to such reasons as the absence of customers, steep topography and heavy rainfall. In such cases, billed water consumption is estimated.

Inaccurate meter reading is suspected because of the existence of customers that have been billed for the same amount of water consumption continuously. The tables below show the number of the customers billed for the same amount of water consumption for three consecutive months in each subzone of Kadobogo. The numbers of such customers accounted for 10.6 % of customers (142 out of 1,342 customers) in Kadobogo (in June to August 2017) and 12.9 % of customers (214 out of 1,655 customers) in Ruyenzi (in May to July 2018). The staff members in charge of billing at the branches informed that they estimated the water consumption of approx. 10 % of customers.

Table 2.6.7 Number of customers billed for the same amount of water consumption for three consecutive months (June to August 2017) in Kadobogo

Kadobogo	PM1	PM2	PM3	Total
Non-zero billed water consumption	15	0	18	33
Zero billed water consumption	51	5	53	109
Total	66	5	71	142

The table below (Table 2.6.8) shows the numbers of customers with the same billed water consumption for the three consecutive months (January to March 2019) obtained for the analysis of the improvement in the meter reading. The number of such customers decreased from 142 in the previous count to 121. Although this decrease suggests some improvement in the meter reading, the latest count shows that the meter reading was not conducted correctly and billed water consumption of around 9 % of the customers was still estimated.

Table 2.6.8 Number of customers billed for the same amount of water consumption for three consecutive months (January to March 2019) in Kadobogo

Kadobogo	PM1	PM2	PM3	Total
Total	62	6	53	121 (9.0%)
Non-zero billed water consumption	17	0	10	27
Zero billed water consumption	45	5	43	93

Water consumption of the customers in the pilot area who had a month of no billed water consumption in a year period between May 2018 and April 2019 was analysed to estimate the maximum increase in NRW rate that could be caused by zero billed water consumption. In this analysis, such a customer was assumed to have consumed water in a volume equivalent to the average monthly consumption in the other billed months in the unbilled month and the actual total billed water consumption and the total water consumption that should have been billed were compared to estimate the volume of NRW caused by zero billed water consumption. Even if a customer actually did not consume water in the unbilled month, the customer was assumed to have consumed the said volume of water in the estimation. The following are the possible causes of no billed water consumption.

- A customer did not consume water in a particular month because the customer was away from home. The customer consumed water in the other months. (Not in use)
- Water supply was forcibly suspended. (Disconnection)
- Even though a customer consumed water, water consumption was not measured because of meter failure. (Block)
- Water is stolen. (Stolen, Vandalism)
- Water consumption of a customer is not measured and, therefore, a customer is not billed. (Close, Zooming)

- Although water consumption is measured, the customer is not billed. (Negligence)
- Cancellation of service contract, a customer outside the pilot area, relocation of a meter (Cancel, Not main, Shifted)

Table 2.6.9 Estimated NRW rate caused by zero billed water consumption

Item	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	Average
Zero Consumption POC	217	196	218	170	208	184	195	185	209	226	214	195	201
Consumption of other month in comparison of Zero Consumption (m3)	943	1,102	1,042	1,285	1,459	1,199	1,011	1,065	961	899	694	0	1,060
	893	1,024	1,171	1,638	1,438	1,350	1,147	1,227	1,096	947	0	1,446	1,216
	891	957	1,066	1,282	1,761	1,103	985	1,041	1,031	0	1,558	908	1,144
	753	953	880	1,035	992	927	718	668	0	1,392	878	799	909
	747	864	819	969	979	773	583	0	982	836	686	633	806
	787	853	780	968	1,199	1,030	0	1,267	960	934	853	746	943
	626	793	681	765	671	0	867	1,074	788	775	658	697	763
	948	947	1,019	1,027	0	1,736	948	1,039	1,067	1,149	1,023	1,165	1,097
	587	677	570	0	1,297	1,137	594	725	890	800	797	697	797
	775	872	0	1,713	1,160	1,195	955	1,177	1,211	1,141	972	1,125	1,118
	567	0	1,289	1,185	1,025	1,263	876	1,237	1,139	1,079	1,029	1,131	1,075
	0	1,247	1,122	1,360	1,298	1,336	1,064	1,319	1,296	1,406	1,226	1,284	1,269
NRW Volume caused by Zero Consumption (m3)	1,269	1,075	1,118	797	1,097	763	943	806	909	1,144	1,216	1,060	1,016
Input Distribution (m3)	21,373	22,445	22,862	23,138	20,913	21,358	18,991	18,000	18,800	16,408	16,120	16,077	19,707
NRW Rate caused by Zero Consumption(%)	5.9%	4.8%	4.9%	3.4%	5.2%	3.6%	5.0%	4.5%	4.8%	7.0%	7.5%	6.6%	5.3%
Volume/Number (m3/POC)	5.8	5.5	5.1	4.7	5.3	4.1	4.8	4.4	4.3	5.1	5.7	5.4	5.0

(3) Water losses associated with meter reading at meter replacement

It was revealed during the meter replacement in Kadobogo that the meter replacement had not been recorded accurately and the readings of the replaced meters had not been recorded. Therefore, the water consumption measured by the replaced meter was disregarded in the billing for a month of the meter replacement. As the average number of meters replaced in a month in this project was 46, this inaccurate recording is estimated to have increased the NRW rate by 1.2 % (63 % x 46 meters/1242 meters x 0.5 month).

2.7 Activities for Real Loss (Water Leakage) Reduction

2.7.1 Preparation

Training on the estimation of a volume of water leakage from the minimum night flow (Qmnf) measured with a portable ultrasonic flow meter (UFM) was provided before the installation of flow meter chambers at the inlets of the subzones in the pilot area in May 2017.

		
Measurement in PM1	Measurement in PM2	Measurement in PM3

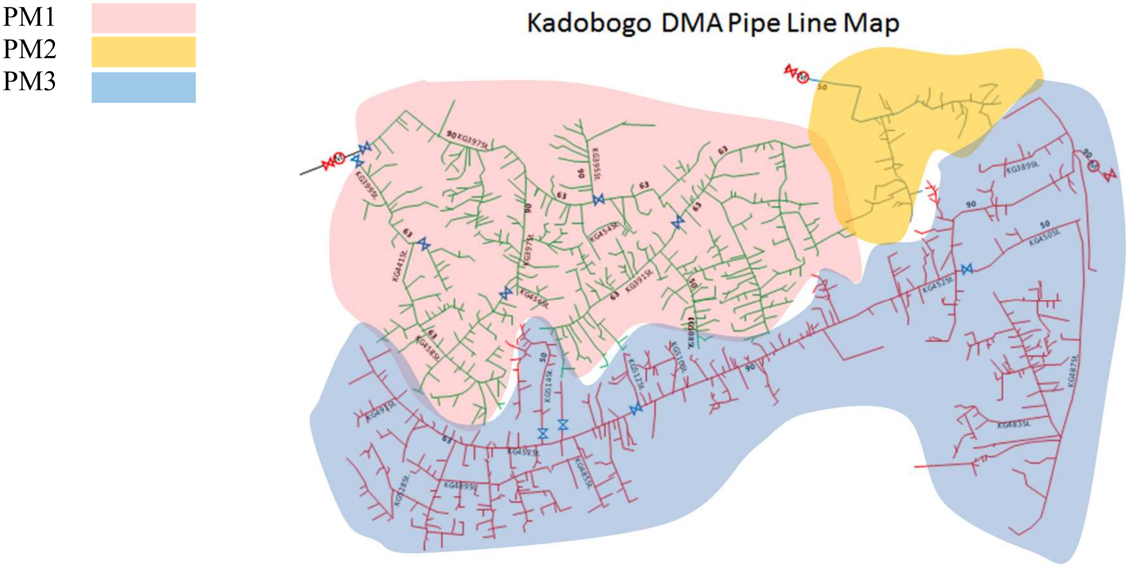


Table 2.7.1 Measurement of Minimum Night Flow (Qmnf)

PM	Number of water taps (visual confirmation)	Water distribution per day (m^3/d) (25-26/May)	Minimum night flow (Qmnf) (m^3/h) (1 am to 3 am on 26/May)	Water leakage (m^3/d) (assumed at 80 % of Qmnf)	Water consumption (L/connection/day)	NRW rate (%)
PM1	500	329	5.71	4.57×24h＝109.68	438	33.3
PM2	50	NA	n.a.	n.a.	n.a.	
PM3	420	305	6.49	5.19×24h＝124.56	429	40.8

Qmnf is generally used as an approximate volume of water leakage. However, the volume of water leakage was estimated at 80 % of Qmnf in this project with the large number of water tanks installed and possibility of water leakage in premises of customers taken into consideration.

2.7.2 Leakage survey at Water Taps

On-site training on the leak detection methods was provided in March 2017. An earphone leak detector and an electronic acoustic leak detection device were used in the training. As water leaking from different types of pipes (distribution mains, service pipes, metal pipes and non-metal pipes) makes different leak noises, ample technical experience is required to recognize the different types of leak noise.

A functional test of customer meters and leak detection were carried out at all water taps in the pilot area from August to December 2017. As meters that had not been recorded in the GIS data were found in the survey, the importance of updating GIS data was recognized.

Training on the method to detect leak noise and its transmission using a customer meter as a contact point

Table 2.7.2 Survey sheet for leak detection at water taps

Leakage Survey				Another Data			
No Leak Sound	Leak Sound	Visible	Invisible	Meter Position	Current Read Data		Destruction
☐	☐	☐	☐	☐ Road ☐ Inside			☐
Installation status of Meter							
Visible	Invisible	Glass Broken	Lid damage	Water leak	Vertical	Horizontal	Meter Box
☐ Readable ☐ Unreadable	☐ Readable ☐ Unreadable	☐	☐	☐	☐	☐	☐

Surmmary of inventry survey on Pilot Area 1 (KADOBOGO)

			PM1	PM2	PM3	Total
TOTAL Customer No.			587	27	490	1,104
Leakage Survey	Leak Sound		3	2	5	10
	Visible		4	8	6	18
	Invisible		0	0	1	1
Another Data	Meter Position	Road	30	0	15	45
		Inside	475	22	425	922
	Destruction		1	0	2	3
Installation status of Meter	Visible	Readable	481	21	423	925
		Unreadable	5	0	4	9
	Invisible	Readable	4	0	6	10
		Unreadable	0	0	0	0
	Glass Broken		6	0	3	9
	Lid damage		120	7	111	238
	Water leak		0	0	0	0
	Vertical		1	0	0	1
	Horizontal		493	23	442	958
	Meter Box		197	13	201	411

The acoustic survey revealed 19 leaks and 10 suspected leaks on service pipes. A detailed survey of the 10 suspected leaks revealed that none of them was a leak. At a place where service pipes were installed close to each other, water consumption through one of them generates a noise similar to leak noise on other pipes.

		1 
Discovery a leak from a 50 mm pipe	Detection of leak noise with listening stick	Leak detection with leak detector

		
Water meter with PRV	Surface leakage	Exposed service pipe

Comments

- The survey was conducted at 967 POCs out of the planned 1,104 POCs. As only 5 % of the meters are installed outside premises of customers, meter readers do not have free access to most of meters that are installed in the premises enclosed by a fence.
- Almost all the meters are installed horizontally.
- The indices of almost all meters (935 (99%) of the 944 surveyed meters) are readable, as is deduced from the figures in the cells of "Readable Visible/Invisible" meters in the table above.
- Around 43 % of the meters are installed in meter chambers. There is no standard meter installation method in use. Some lessors lock the meter chambers. The locked meter chambers sometimes hinder the meter reading.

2.7.3 Survey of leakage from distribution and service pipes

(1) Record of Qmnf measurement

The leakage survey began in December 2017 after the completion of the survey of customer meters. Surface leakage is discovered daily during various on-site surveys (including the meter accuracy surveys, questionnaire surveys and hydraulic isolation) and WASAC's on-site operations. The repair of surface leaks is part of the regular maintenance work of the branch office and water leaks in the pilot areas are repaired immediately after they have been discovered.

The measurement of minimum night flow (Qmnf) was conducted to measure a volume of existing water leakage and, then, the step test was conducted to narrow down an area where the volume was large. The step test was carried out from March to August 2018. Water leaks were discovered at 21 points in the survey and these leaks were repaired. Large-scale invisible water leaks (with an estimated total water leakage of 10.3 m3/h) were found at four of the 21 points. The water-leak prone (HDPE, PN50, 200 m-long) distribution pipes in PM2 were replaced with PVC pipes in the end of June.

The purposes of the Qmnf measurement are:

① To quantify water leakage to identify leakage points (implement leakage step test),

② To compare the quantities of water leakage before and after the implementation of leakage reduction activities to measure their effectiveness, and

③ To monitor the quantity of water leakage regularly.

The table below shows the result of the Qmnf measurement. The result of the Qmnf measurement is shown in Attachment 2.7.

Table 2.7.3 Qmnf Measurement History (Kadobogo)

Kadobogo

Date	Time		PM1		PM2		PM 3	
			Qmnf (m3/h)	P (bar)	Qmnf (m3/h)	P2 (bar)	Qmnf (m3/h)	P2 (bar)
May 25-26, 2017			**5.71**	**-**			**6.49**	**-**
Jun. 7-8, 2017					**0.21**	**-**		
Nov. 9-10, 2017					**1.40**	**-**	**6.00**	**-**
Nov. 22-23, 2017				**6.5-10.5**				
Nov.30-Dec7, 2017						**0.0-8.0**		**0.5-9.0**
Dec. 20-21, 2017			**7.80**	**-**	**3.30**	**2.0**	**10.80**	**9.6**
Jan. 11, 2018			**5.50**	**10.5**			**12.50**	
Jan. 24- Feb. 8, 2018				**6.0 - 10.5**		**0.0- 8.3**		**4.0 - 9.3**
Jan. 24-25, 2018					**3.27**			
Feb.22-23, 2018							**13.50**	**7.8**
May 23-24, 2018					**2.90**		**Leakage Repair3/22**	
May.31, 2018					**PRV Re-setting 5/31**	**4.0**		**Leakage Repair 4/13, 24**
Jun. 12-14, 2018					**2.31**	**4.0**		
Jun. 21, 2018					**2.81**			
Jun 25-27, 2018					**0.09**	**Leakage Repair 6/24**		
Jul. 19-20, 2018			**9.23**		**0.20**	**Pipe Replacement 6/28**	**9.30**	
Sept. 18, 2018							PRV Setting 9/18	**3.5**
Oct. 5, 2018	PRVBaseline, Stage Test				**0.74**	**7.0**	**9.44**	**7.5**
Oct. 23-24, 2018	PRVEffect Measurement		**7.70**	**10.0**	**0.31**	**Pressure Adjustment** **2.5**	**5.80**	**Pressure Adjustment** **5.5**
Nov. 26-27, 2018	PRVEffect Measurement		**10.22**	**10.0**	**0.31**	**2.5**	**3.32**	**2.5**
Dec. 20, 2018							**2.91**	**(12/31) 2.5**
Jan. 22-23, 2019							-	
Jan. 28-29, 2019							**4.71**	
Feb. 5-6, 2019			**(5.38)**	(PM1-3, 4)			**3.53**	
Feb.4-28, 2019	PM1Pipe Replacement							
Mar.26-27, 2019			**5.80 (3.1)**	(PM1-3, 4) 6.5				**(3/22) 7.22**
								(4/5) 3.5

(2) Leakage survey in PM3

Although there was large discrepancy between the locations of the inlet pipe and gate valve installation in Subzone 3-2 on the GIS map and those confirmed on site, it was revealed that the subzone could be divided in two. Therefore, test measurement of flow rates was conducted in the daytime of 19 January and measurement of flow rates in the subdivisions was conducted in the night of 25 January. Then, the leakage detection was conducted from 30 January in the upstream part of PM3 where a volume of water leakage was large and the existence of a large-scale water leak from a 25 mm service pipe that supplied water to around 15 houses (the area within the dash-dotted line in the figure on the right) was confirmed..

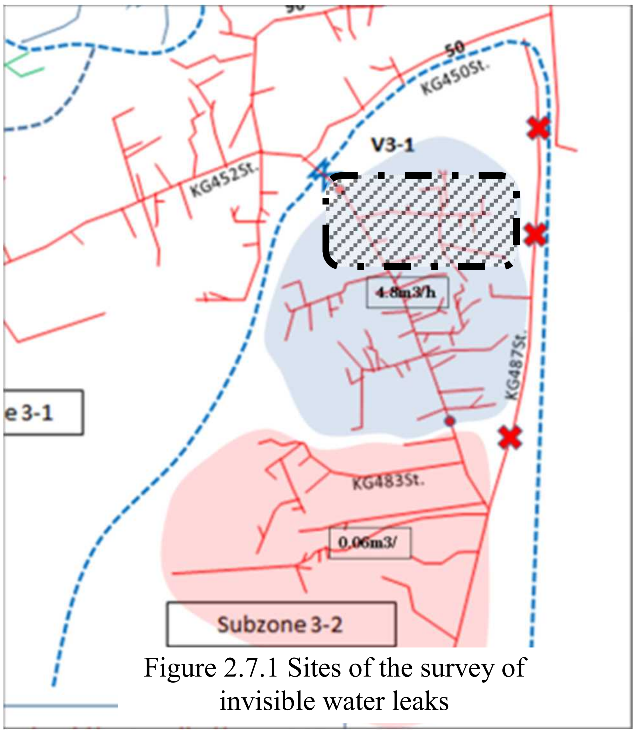


Figure 2.7.1 Sites of the survey of invisible water leaks

The figure below shows the volume of water leakage measured with a UFM in the daytime of 2 February. To measure the volume of the leakage directly, all the customers downstream of the measuring point were requested not to use water during the measurement of flow rate. Even though the measurement was taken in the daytime, the existence of 2,200 L/h of water leakage was confirmed.

		
Test measurement	Test measurement	Measurement in the night

The activities implemented in the step test and the locations of the flow rate measurement are described below (step test: a method to locate a part with large water leakage in a distribution network by installing portable UFMs upstream and downstream of an inlet pipe to a survey area and measuring the flow rate while valves on the branch pipes in the section between the two UMFs are opened and closed in turns)

<u>Implemented activities</u>

① The flow rate in the distribution main was estimated from the POC location map, pipe distribution drawing and data on billed water consumption of customers and the pipes with high flow rates were identified.

② The routes, types and diameters of pipes and locations of gate valves and customer meters, etc. confirmed on site were compared with those on the POC location map and pipe distribution drawing. The discrepancies found on the map and drawing were corrected.

③ The distribution pipe at the inlet and the upstream side of a branch pipes downstream of the inlet were excavated and UFMs were installed on the excavated pipes.

④ The flow rate measurement began after the installation of the UFMs. The measurement interval was set at around five minutes to allow the change in flow rate caused by the gate valve operation to disappear. The difference between the flow rates measured at the two measuring points was used to confirm existence/non-existence of water leakage.

⑤ As no water leakage was detected, a branch pipe that was estimated to have the second highest flow rate was selected for new flow rate measurement.

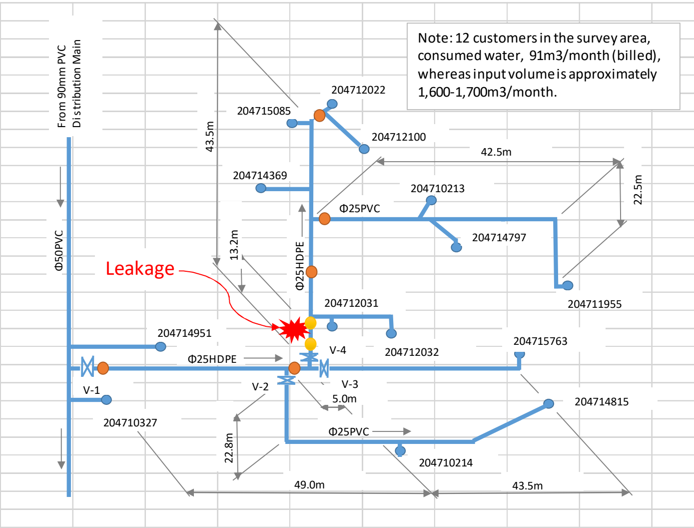
⑥ Activities iv) and v) were repeated to narrow down a section in which the measured flow rate was larger than water consumption. A 13.2 m section indicated in the drawing below was identified as a section of a large leak.

⑦ A likely site of the suggested underground water leak was identified based on the surface vegetation and ground moisture. An underground water leak was discovered in the excavation of the identified site.

⑧ The volume of water leakage was calculated from the difference between the flow rates measured with UFMs installed on the upstream and downstream sides of the leaking point.

⑨ The leak was recorded in photographs and video image.

⑩ The branch office was informed of the leak and a request for its repair was submitted to its Pipeline Repair Team.



Note: 12 customers in the survey area, consumed water, 91m3/month (billed), whereas input volume is approximately 1,600-1,700m3/month.

Figure 2.7.2 Schematic diagram of step test (locations of measurement with UFM)

Figure 2.7.3 Pipe routes on GIS map (green) and those confirmed on site (red)

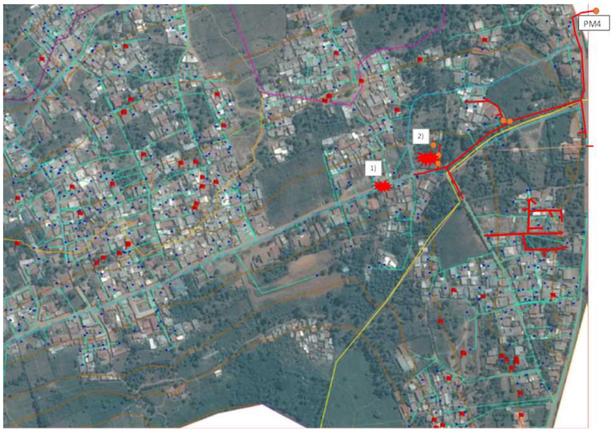
A survey of underground water leaks began in January 2018. The measurement of minimum night flow (Qmnf) and the step test were implemented to elucidate the volume of water leakage and to narrow down a section with a large volume of water leakage, respectively. The implementation of the measurement and test led to the discovery of a series of underground leaking points from the latter half of March, as shown in the table below (Table 2.7.4). The leakage repair conducted in a month period between 22 March and 24 April 2018 eliminated a total of 28,460 L/h of water leakage, of which 7,800 L/h were underground leakage, or water continuously flows out from a pipe and into the ground. This figure corresponded to 67 % of the volume of NRW in the same period, 11,590 L/h (corresponding to the average leakage of March and April (7,860+8,829)/2=8,345m^3/m)

Table 2.7.4 List of sites at which water leaks were detected and repaired in the survey

No.	Date	Subdivision	Inner diameter (mm)	Pipe material	Cause of leak	Surface/underground leak	Leakage （L/h）
1	22-Mar	PM3-2	25	HDPE tertiary pipe	High water pressure, low quality pipe material	Underground	1,500
2	25-Mar	PM3-2	25	HDPE service pipe	High water pressure, low quality pipe material	Surface	2,000
3	25-Mar	PM3-2	25	HDPE service pipe	High water pressure, low quality pipe material	Surface	50
4	27-Mar	PM3-2	25	HDPE tertiary pipe	High water pressure, low quality pipe material	Surface	60
5	2-Apr	PM3-2	25	HDPE tertiary pipe	High water pressure, low quality pipe material	Surface	50
6	4-Apr	PM1	150	PVC secondary pipe	High water pressure, uneven subsidence	Surface	10,000
7	5-Apr	PM2	50	HDPE secondary pipe	High water pressure, low quality pipe material	Surface	7,000
8	13-Apr	PM3-3	25	HDPE service pipe	High water pressure, low quality pipe material	Underground	1,800
9	23-Apr	PM3-1	90	PVC secondary pipe	High water pressure, load	Surface	1,500
10	24-Apr	PM3-1	25	HDPE service pipe	High water pressure, low quality pipe material	Underground	4,500
Total						Total (of which underground leakage)	28,460L/h 7,800L/h

Kacyiru Branch repaired underground leaks at points other than the above-mentioned leaking points every month. The branch office was in a vicious cycle in which a leak repair at a site was followed by new leaks at other sites. Table 2.7.5 describes the sites of such leaking points discovered by the Work Team in PM3-1, -2 and -3. The table reveals the particularly frequent occurrence of water leaks in PM3-2, causes of which were pressure build-up in pipes and the use of low-quality pipes.

Table 2.7.5 Discovered leaking points

PM	Leaking points	Comments
PM3-1		1) Leak detection from 21 to 24 April 2) The leak on the left was a surface leak that on the right was an underground leak. A method to narrow down leakage sections with the installation of UFMs was used for the identification of leakage points. 3) The UFMs were installed six times to narrow down leakage sections. 4) Leak noise and conditions of ground surface and vegetation were used for identifying the likely leaking points. 5) The excavation at a likely point revealed an underground water leak (of 4,500 L/h) from a HDPE 25 mm service pipe. 6) It was confirmed that a large volume of leaked water infiltrated into the ground without emerging on the ground surface.
PM3-2		1) Leak detection from 21March to 2 April 2) Narrowing down of leakage sections with UFM measurement 3) A large-scale underground water leak (of 1,500 L/h) was discovered and repaired on 22 March. 4) A new surface leak (of 2,000 L/h) was discovered on 24 March. 5) 60 L/h and 40 L/h leaks were discovered on 25 March. 6) A 50 L/h water leak was discovered on 28 March. 7) It was confirmed that leakage repair led to creation of new leaks.
PM3-3		8) Leak detection from 10 to 15 April 9) Identification of leaking pipes with UFM measurement 10) UFMs were installed four times at seven sites for the narrowing-down. 11) Large water flow was observed at the end of pipelines. 12) Although the location of the 20 m long section of the pipe at its end was identified, the location of the rest was not known. Therefore, it took long to excavate the pipe. 13) In the end, a 25 mm HDPE pipe buried 2.1 m below the ground level was discovered. It took two days to excavate the pipe. 14) An underground water leak of 1,800 L/h was discovered and repaired

(3) Leakage survey in PM2

The results of the measurement of the NRW rate and minimum night flow (Qmnf) in the subzone in the end of May 2018 suggested the possibility of large water leakage in PM2. To confirm this possibility, the step test was conducted from 20 June. The test identified a pipe from which a large quantity of water leaked. The leaking point was located in the acoustic leak survey with an earphone leak detector on 22 June (See the figure below (Fig. 2.7.6)). The leak was repaired on the same day. The average Qmnf of two days after the repair was 0.091 m3/h (Fig. 2.7.7) and that before the repair was 2.31 m3/h (Fig. 2.8.2). Therefore, the repair reduced water leakage by 2.22 m3/h.

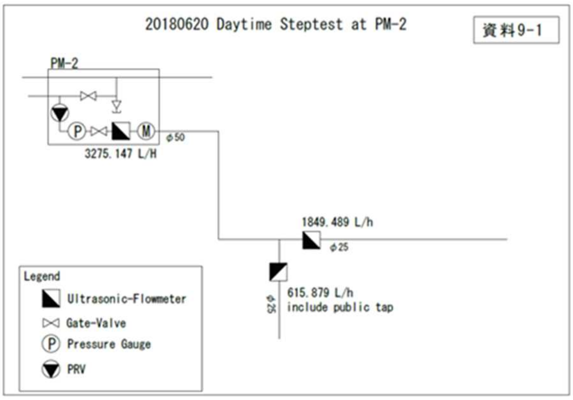


Figure 2.7.4 Step test in PM2

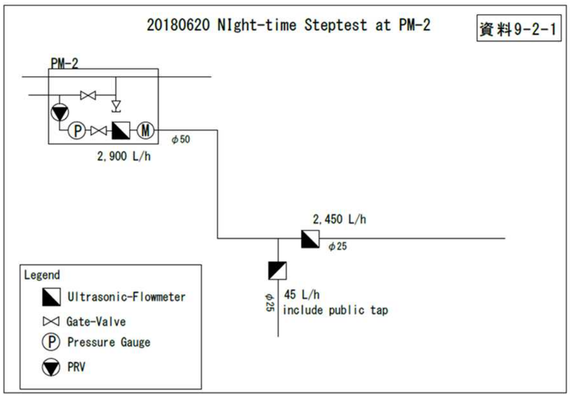


Figure 2.7.5 Step test in the night in PM2

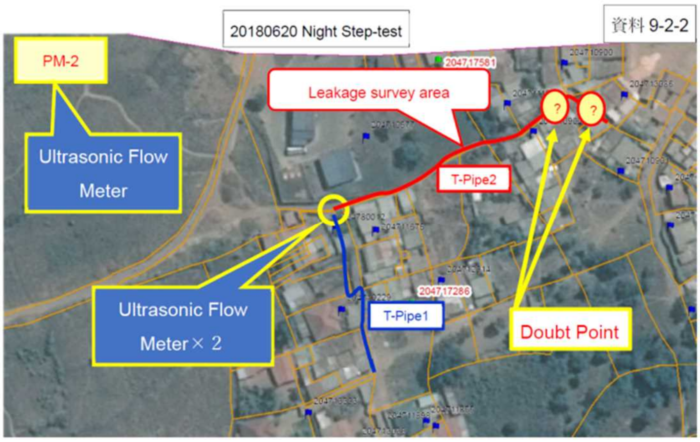


Figure 2.7.6 Leaking points

Photo 2 A water leak

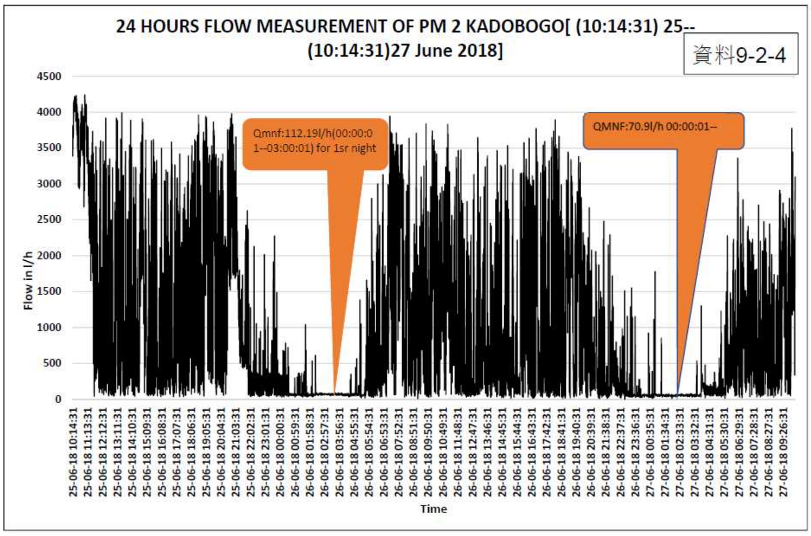


Figure 2.7.7 Qmnf after the leakage repair

(4) Continuation of leakage survey

To monitor water leakage in a leakage-prone area, the Qmnf step test was conducted on 19 and 20 July. The results of the test were compared with those of the same test conducted by June. The figure below (Fig. 2.7.8) shows the results of the comparison.

Qmnf in PM1, which used to have a lower NRW rate than the other subzones, increased from 5.5 m3/h to 9.23 m3/h. The rates in Subzones 1-2 and 1-4 increased greatly. Meanwhile, Qmnf decreased drastically from 2.8 m3/h to 0.2 m3/h and water leaks have not re-emerged in PM2. For these reasons, the PRV in PM2 is considered to have exerted its effect on the reduction of water leakage.

While Qmnf in the entire PM3 did not change much, the leakage repair in April reduced the Qmnf in Subzone 3-3 drastically from 4.5 m3/h to 0.5 m3/h. Meanwhile, in Subzone 3-2, where the leakage repair was conducted at five sites in March, Qmnf decreased momentarily from 4.8 m3/h and increased again to 3.9 m3/h later because of the recurrence of water leaks. In Subzone 3-1, water leakage increased as Qmnf increased from 3.8 m3/h to 4.9 m3/h. These findings indicate a need for new measures in areas where water leaks recurred after a leak have been repaired.

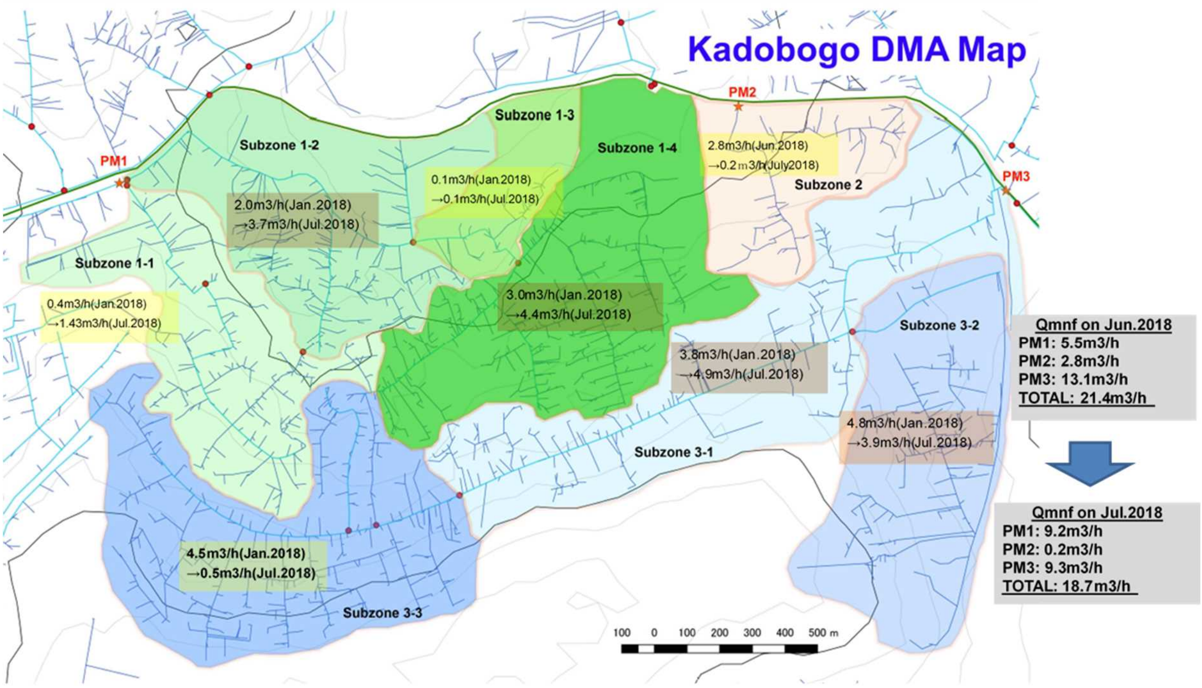


Figure 2.7.8 Results of Qmnf step test in subzones

A leakage survey was conducted in the areas with large water leakage mentioned above. The survey conducted from 10 to 20 August led to the discovery of nine and two surface leaks in PM1 and PM3, respectively. Figure 2.7.9 shows the sites where leaks were repaired. Large water leakage was found in Subzones 1-2, 1-4, 3-1 and 3-2.

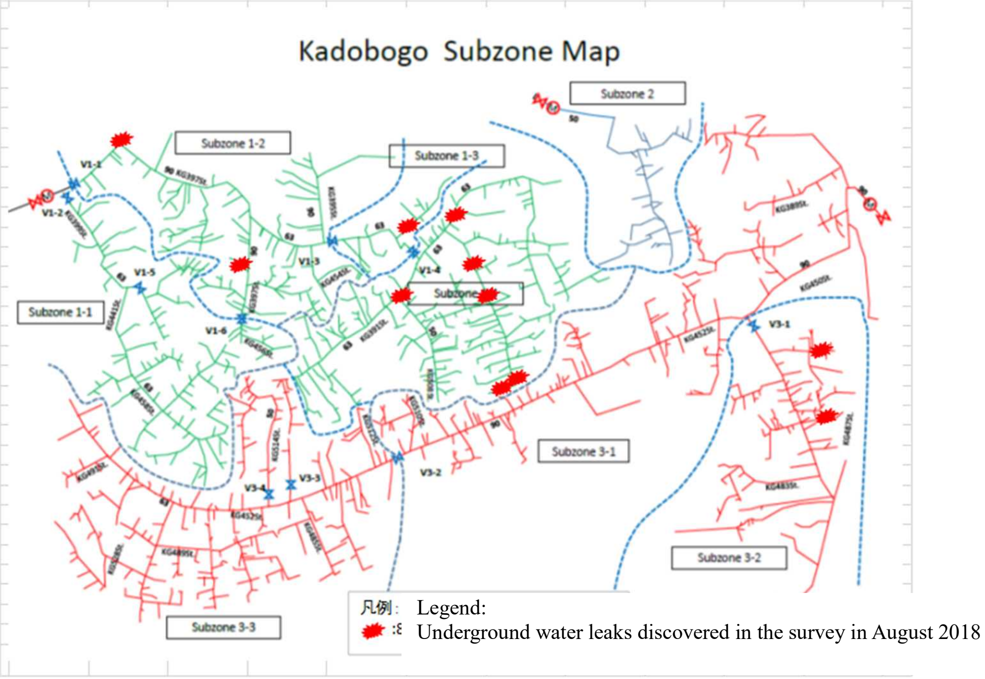


Figure 2.7.9 Sites of leakage repair (in August 2018)

	
Flow rate measurement near a leaking point	Water leak from a HDPE pipe

The water leakage detection was suspended in August 2018 and the monthly monitoring of NRW rate is continued. As it had been revealed that a water leak would recur continuously and frequently on a repaired pipe on which a measure to prevent pressure build-up was not taken, pressure reducing valves (PRVs) were installed on the distribution pipes in PM2 and PM3 by September 2018 as devices to prevent the pressure build-up. The effectiveness of the PRV installation on pressure reduction was evaluated in October and November. The volume of existing water leakage in each subzone was estimated from the Qmnf measurement, as described in Table 2.7.6. As the water pressure at the inlet in PM1, 10 bars, was high, it was decided to install a PRV also in PM1.

Table 2.7.6 Estimated volume of water leakage in subzones

Measurement date	PM1	PM2	PM3
23 – 24 Oct.	7.70m3/h	0.31m3/h	5.80m3/h
26 – 27 Nov.	10.22m3/h	0.31m3/h	3.32m3/h
Pressure	10bar	1-2bar	2.5-3.0bar
Measures to be taken	Installation of PRV1 Replacement of distribution and service pipes	Maintenance of the current state	Leakage survey and repair
Reference	Figs. 2.7.10,11	Fig. 2.7.12	Fig. 2.7.13

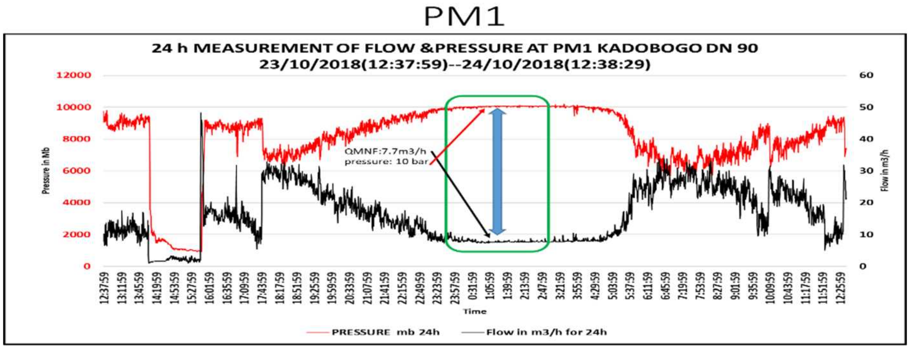


Figure 2.7.10 Qmnf measurement in PM1

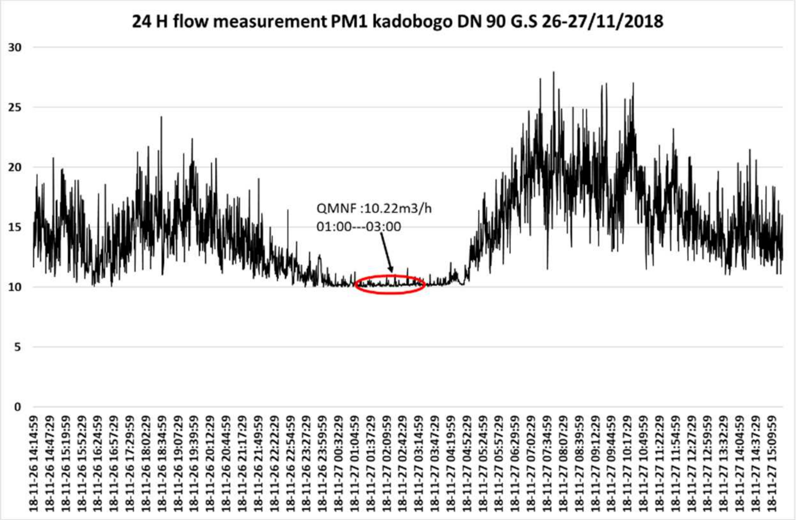


Figure 2.7.11 Qmnf measurement in PM1

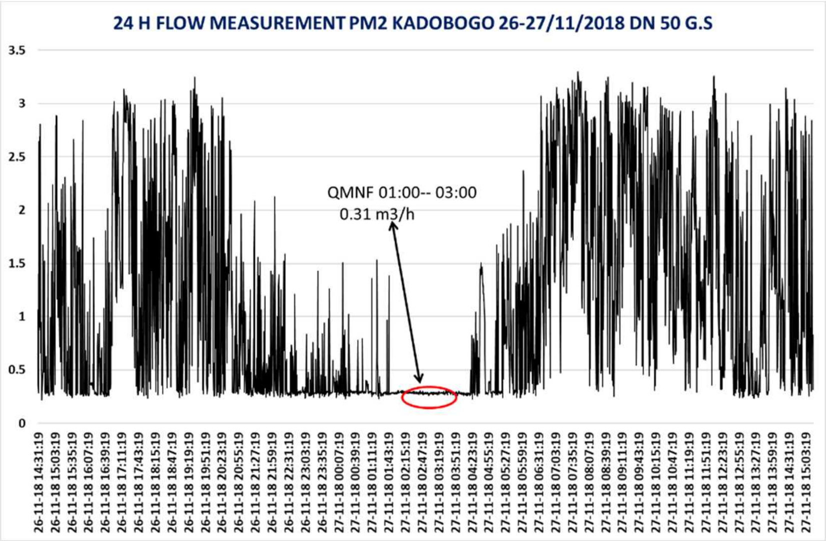


Figure 2.7.12 Qmnf measurement in PM2

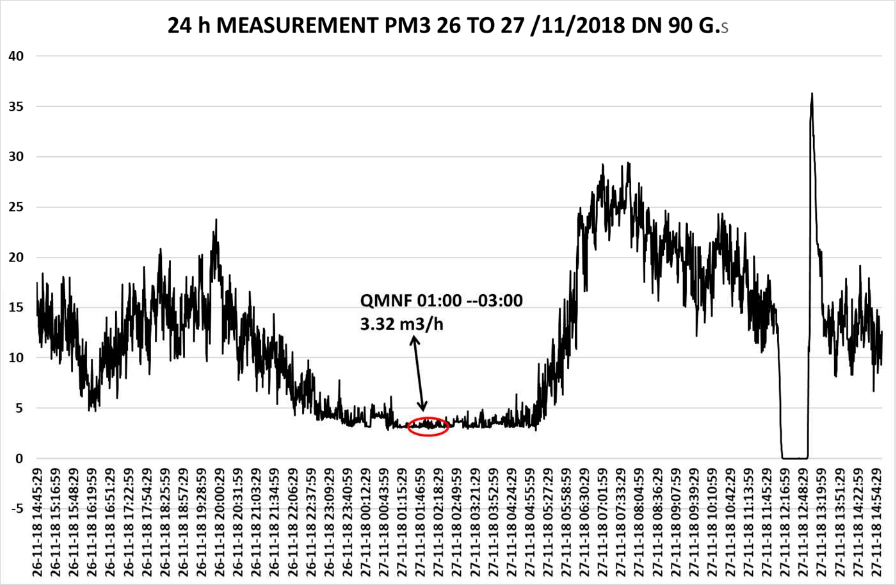


Figure 2.7.13 Qmnf measurement in PM3

The step test was conducted in PM3, where the volume of water leakage remained large, in the night of 20 December. Although the test was suspended because of a water leak from the valve at the boundary of the subzone, the measurement of Qmnf in Subzone 3-2 was completed before the suspension. While Qmnf in PM3 was 2.91 m3/h, that in Subzone 3-2 was 1.71 m3/h, which revealed that there was large water leakage in Subzone 3-2.

After the replacement of the leaking valve at the subzone boundary, Qmnf in PM3 were measured again on 5 - 6 February 2019. The Qmnf measurement decreased after the installation of the valves (after the water pressure control began) from 9.3 m3/h measured before the installation of PRVs (in July 2018). Qmnf measurements in November, December 2018, January and February 2019 were 3.23 m3/h, 2.91 m3/h, 4.71 m3/h, and 3.53 m3/h, respectively. Although these Qmnf values indicate that water leakage continued in the subzone in these four months, the fact that Qmnf changed little suggested that water leaks did not recurred in the four months. In addition, the NRW rate in the subzone has been on the decrease since November 2018. For these reasons, it was decided to terminate the time-consuming and labour-intensive leakage survey in Kadobogo and to implement the survey in Pilot Area 2 (Ruyenzi) in which the Pilot Project had to be implemented quickly.

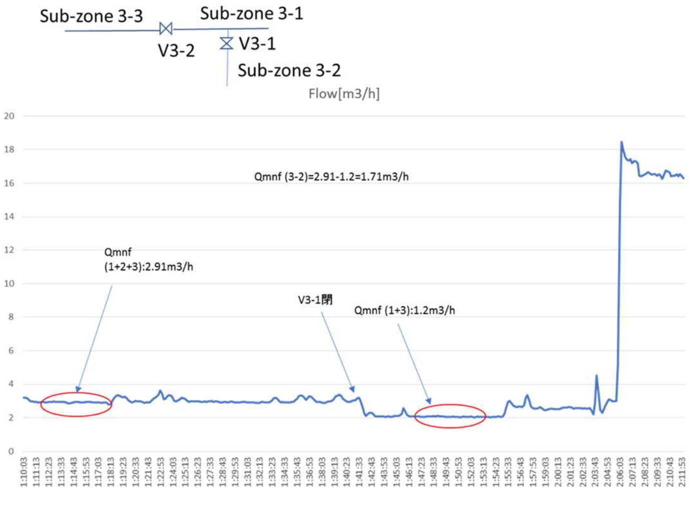


Figure 2.7.14 Step test in PM3

Minor water leak from a tertiary pipe

2.8 Activities to Reduce Water Pressure

(1) Installation of pressure reducing valves (PRVs)

The measures against the apparent losses, surface leaks and underground leaks were implemented until August 2018. Among them, the measures against underground leaks, in particular, has contributed greatly to NRW rate reduction with the identification of large leaks. However, there was a need to eliminate root causes of water leakage in order to realise drastic reduction in NRW rate that exceeded 30 %.

A cause of the high NRW rate was pressure build-up (8 bars to 10 bars and more) in the distribution pipes at the inlets in the subzones. Water was distributed to all the subzones not through the distribution reservoir located adjacent to the pilot area but through pipelines that directly branched off from the transmission pipeline from Ntora Reservoir (and that bypassed the reservoir). This pipeline configuration was a cause of the pressure build-up.

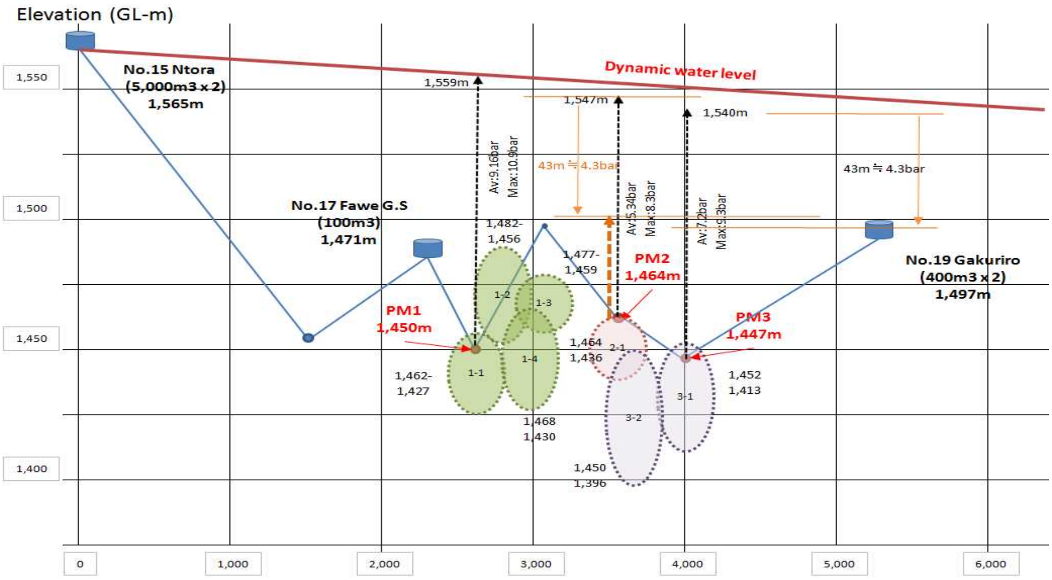


Figure 2.8.1 Relationship between elevation of and inlet water pressure in water service area in subzones in Kadobogo

A survey of the reservoir adjacent to the pilot area was conducted in May 2018 to evaluate the possibility of distributing water from it, instead of through the bypass pipeline. However, the survey revealed that the bypass pipeline was used for distributing water not only to Kadobogo but to other areas. Therefore, it was decided to install PRVs at the inlets of PM2 and PM3 to distribute water at reduced pressure in the subzones. The Steering Committee discussed the pressure reduction activities at the meeting in August 2018 and decided to revise the PDM to include such activities in the project.

Because the NRW rate in PM1 is lower that the rates in other subzones, it was decided to install PRVs in PM2 and PM3 first and in PM1 afterwards. The installation of a PRV in each subzone is explained in the following.

【PM2】

Although a PRV had already been installed in PM2, it had broken down and had not been functioning. Therefore, WASAC replaced the valve. However, as the installed PRV closed after the water pressure on the secondary side was adjusted, a study was conducted on the cause of this closing. The study revealed that the valve was installed in the wrong orientation. Therefore, the valve was reinstalled in the correct orientation on 31 May 2018. To evaluate the operating condition of the reinstalled valve, water pressure and flow rate at the valve were measured in June 2018. Fig. 2.8.2 shows the result of the measurement, which shows that the PRV was operating normally as the water pressure on the secondary side was stable at around 4 bars.

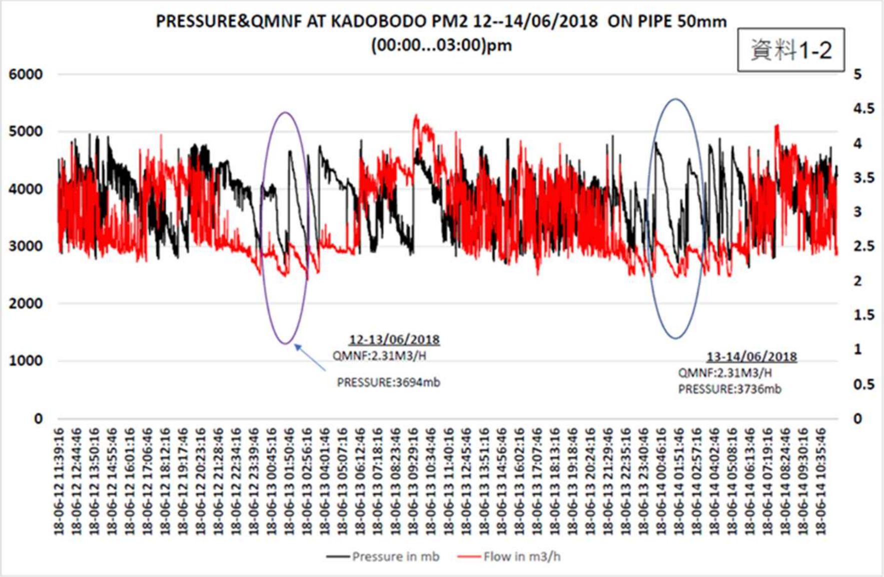


Figure 2.8.2 Relationship between water pressure and flow rate in PM2 (12 – 14 June)

【PM3】

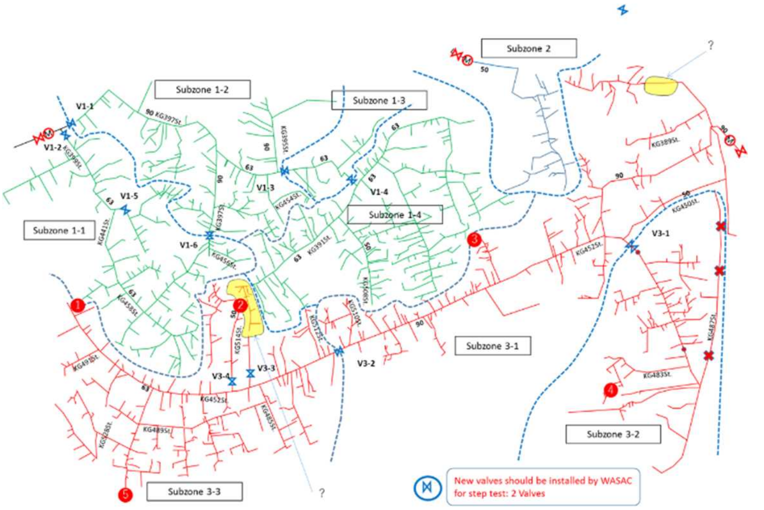
a) Measurement of flow rate and water pressure (at the inlet and five customers)

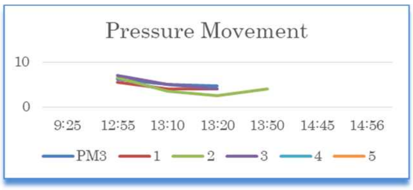
The measurement of water pressure and the volume of water leakage in PM3 was conducted on 21 – 23 February 2018. The water pressure and flow rate in the daytime were measured while the water pressure was controlled with the operation of the valve at the inlet. When the water pressure at the inlet in PM3 was reduced by 1.2 bars, from 6.2 bars to 5.0 bars, at 13:00, during the lunch time when water consumption is large, the water pressure in the distribution pipe at the end was 2.5 bars.

This survey result suggested that the water pressure could be reduced by around 2.5 bars at the inlet and the minimum required water pressure at the inlet was 4.0 bars (6.2 – 2.5 = 3.7 bars). The water pressure at the inlet in the night was high (7.8 bars) and the minimum flow rate of 13.5 m3/h indicated the existence of many water leaks. Therefore, a large reduction in water leakage was expected from the installation of a PRV and the pressure setting at the inlet at 4.0 bars with the PRV.

Table 2.8.1 Results of water pressure measurement (21 February 2018)

Pressure Movement						
	Altitude	12:55	13:10	13:20	14:45	Remarks
PM3	1435	6.2	5.0	4.7	5.0	Turn of valve: 17/17→13/17
High Area						
1	1462	5.5	4.0	4.0		
2	1438	6.5	3.5	2.5→4.0		2.5→4.0(13:50)
3	1435	7.0	5.0	4.0		
Low Area						
		9:25			14:56	Before and After survey
4	1402	2.5			5.2	
5	1387	8.5			8.5	Church





b) Flow rate and water pressure measured for 24 hours (at the inlet)

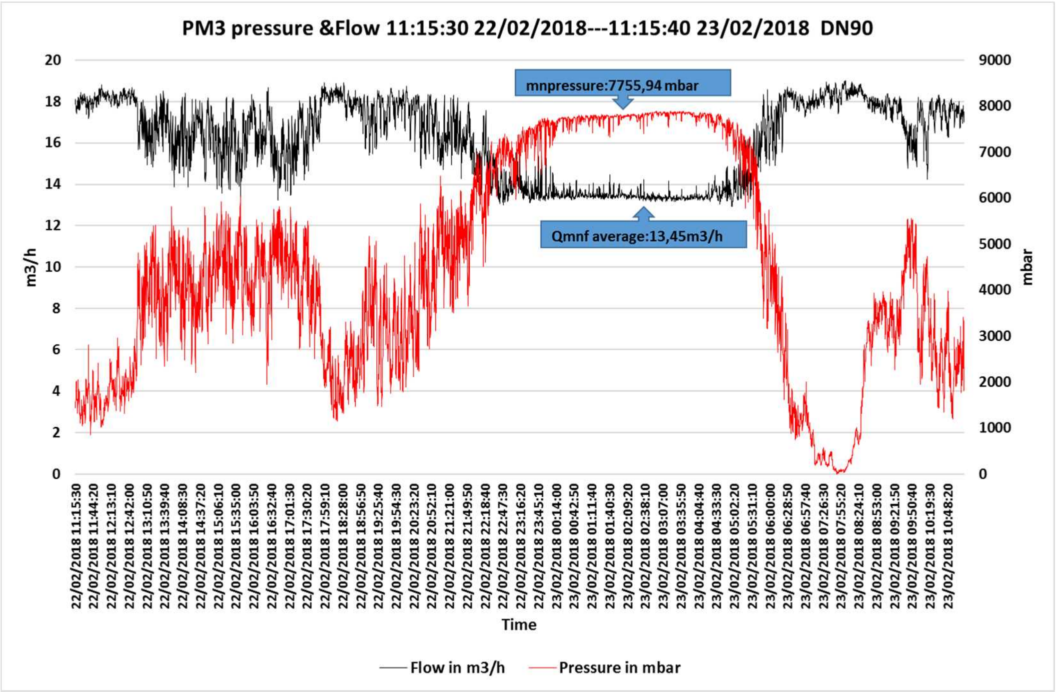


Figure 2.8.3 Relationship between water pressure and flow rate in PM3 (22 to 23 February)

While WASAC was to install a PRV it owned in PM3, JICA experts were to install pipe connectors and construct manholes. It is advisable to install a pipe that bypasses a PRVs shown in the figure below (Fig.2.8.4) not to disrupt water supply during the maintenance of the valve. However, the bypass was not installed because of the lack of fund. After the completion of the PRV installation in PM3 on 18 September, the PRV was used for reducing high pressure on the primary side to 4.0 bars on the secondary (output) side (P2) and the water distribution in PM3 with the reduced pressure began. The P2 pressure was reduced to 2.5 bars by adjusting the PRV pressure setting on 24 October.

Standard installation and composition of PRV of WASAC

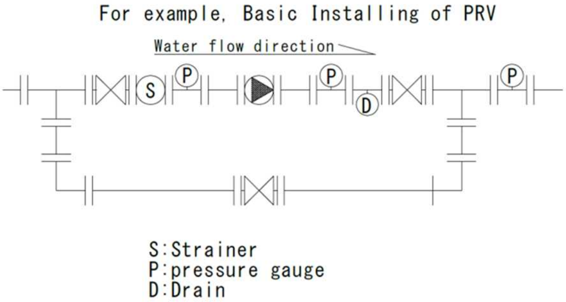


Figure 2.8.4 Typical PRV design

The replacement of a pilot pipe was urgently required because of a water leak from it discovered in October 2018 (flow rate measured on 6 February: 0.3 m3/h). WASAC replaced the pipe using its stock of PRVs in the warehouse on 14 February 2019. However, as it was revealed in March that the pressure setting on the secondary side was set at full open, the pressure setting was adjusted. However, the full opening of the PRV had occurred repeatedly whenever the pressure setting was readjusted since then. It remained unclear whether this episode was caused by deliberate valve operation by staff of WASAC or a defect of the equipment. NRW rate has increased rapidly since June 2019 because of the lack of water pressure control. While the cause of the episode was still being investigated as of August 2019, it has led to the recognition of the importance of the maintenance of PRVs after installation. It is important to examine the pressure setting of PRVs regularly.

【PM1】

Water from Ntora is distributed to PM1 an PM2 through a pipe that bypasses the Fawe Reservoir located upstream of PM1. Therefore, the water distribution pressure at the inlet in PM1, which should be adjusted to approx. 5.5 bars, is 10 bars because the water pressure generated in the Ntora Reservoir is directly working in the inlet pipe. This high water pressure has been a cause of water leakage in PM1.

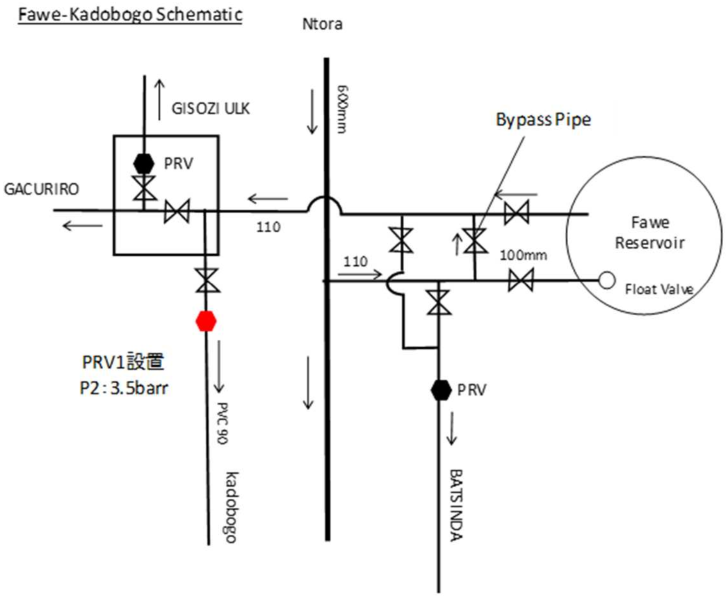


Figure 2.8.5 Water flow through and around the Fawe Reservoir

There was little difference in the water pressure measured in the daytime and the night. Qmnf and water pressure measured from 1:00 to 2:50 on 24 October were 7.7 m3/h and 10 bars, respectively, while the water pressure measured at 15:12 on the same day was 9.7 bars.

A study was conducted in November 2018 to examine whether it was possible to distribute water to PM1 through the Fawe Reservoir with the natural pressure. The study confirmed that the bypass pipe had to be used for water distribution to PM1, as practiced currently, because of the small elevation difference between the reservoir and PM1. A new field confirmation survey was conducted in January 2019. It was decided to install a PRV in the existing manhole immediately downstream of the reservoir. The PRV installation was delayed because of reasons attributable to WASAC and the installation was completed in mid-September. Figure 2.8.6 shows the water pressure after the PRV installation measured at various points in the pipe distribution network.

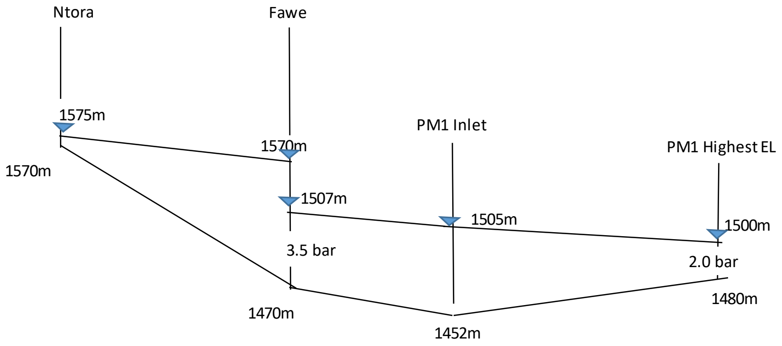


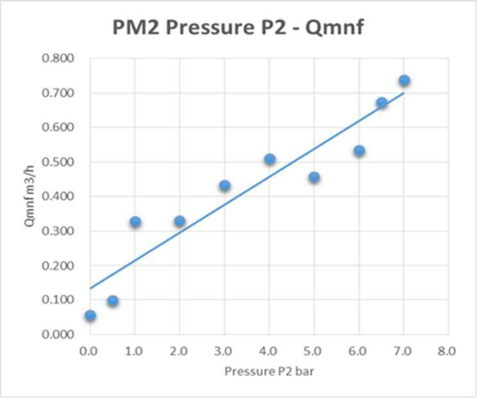
Figure 2.8.6 Diagram of water levels in the Ntora and Fawe Reservoirs and PM1 (after the installation of PRV)

(2) Effect of PRVs on the NRW reduction

The effect of the PRVs on the NRW reduction was evaluated by measuring Qmnf while water pressure was reduced in stages. A staged measurement of the water pressure on the secondary side of the PRV (P2) and Qmnf was conducted on 5 October 2018 in PM2 and PM3 in Pilot Area 1. In the measurement, the P2 was reduced by steps of 1.0 bar from the condition that the PRV was fully open. As shown in the figures below (Figs. 2.8.7 and 8), a correlation was found between P2 and Qmnf: Every time P2 was lowered by a PRV, Qmnf decreased.

Kadobogo
Pressre-Qmnf Measurement
Oct. 5, 2018 2:57-3:25
PM2
Measurement Record

No	Time	P1	P2	Qmnf
		bar	bar	m3/h
1	2:57		7.0	0.739
2	3:00		6.5	0.674
3	3:04		6.0	0.534
4	3:07		5.0	0.459
5	3:10		4.0	0.510
6	3:13		3.0	0.434
7	3:17		2.0	0.332
8	3:19		1.0	0.330
9	3:24		0.5	0.099
10	3:25		0.0	0.056



Kadobogo
Pressre-Qmnf Measurement
Oct. 5, 2018 1:18-2:03
PM3
Measurement Record

No	Time	P1	P2	Qmnf
		bar	bar	m3/h
1	1:18		7.5	9.44
2	1:21		7.0	9.19
3	1:25		6.5	8.48
4	1:28		6.0	7.98
5	1:31		5.5	8.01
6	1:35		5.0	6.43
7	1:37		4.5	7.19
8	1:41		4.0	5.95
9	1:43		3.5	6.54
10	1:46		3.0	6.08
11	1:49		2.5	5.70
12	1:52		2.0	5.25
13	1:55		1.5	3.85
14	1:58		1.0	4.36
15	2:01		0.5	3.57
16	2:03		0.0	2.16

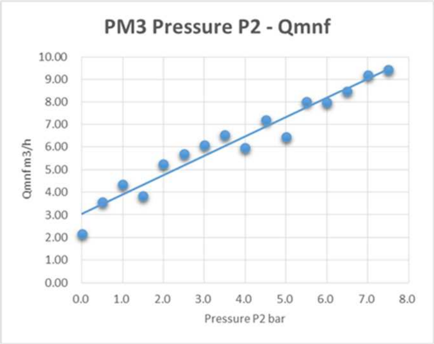


Fig.2.8.7 Results of PRVs effect measurement (Step measurement of P2-Qmnf) Kadobogo

Table 2.8.2 Results of the PRVs effect measurement Unit: Qmnf (m3/h)

Item	Date of measurement	PM2	PM3
1. Baseline measurement	5/Oct.	0.74m3/h (7.0bar)	9.44m3/h (7.5bar)
2. Effect measurement	23 – 24/Oct.	0.31m3/h(2.5bar)	5.8m3/h(2.0bar)
3. Effect volume		0.43m3/h	3.64m3/h

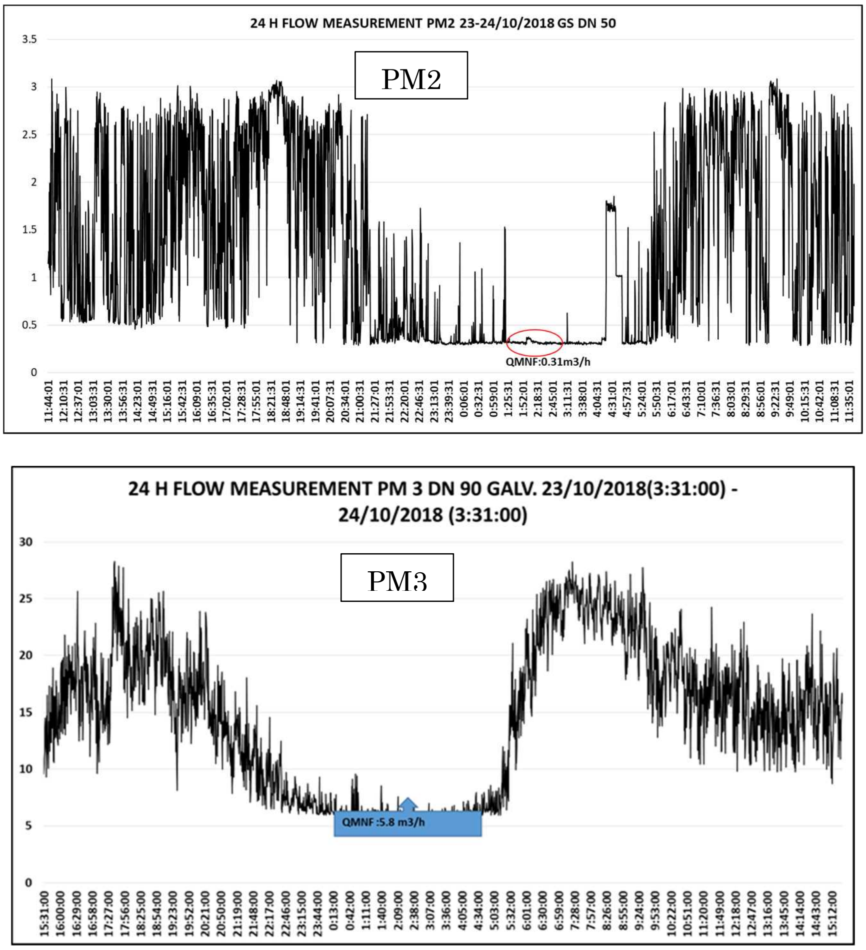


Fig. 2.8.8 Results of PRVs effect measurement (PM2, PM3)

(3) Pressure measurement at inlets

Table 2.8.3 shows the water pressure at the inlets of PM2 and PM3 measured in the daytime in October. P2 in PM2 was adjusted at 2.5 bars on 24th and that in PM3 was adjusted at 2.0 bars on 31st. Water leaked from the connecting part between a main and PRV in PM3. When P2 was set at around 5.5 bars, water leaked at a rate of 0.04 – 0.07 m3/h and when P2 was set at around 2.0 bars, there was very small leakage.

Table 2.8.3 Pressure measurements (inlet in PM1, PM2 and PM3)

PRV Survey

Date 24th October, 2018

PM1:PM2:PM3

Pressure Reading (bar)

PM	Day	Time	P1	P2	Differential	Note	
			bar	bar	bar		
PM1	Oct. 24	15:12	9.7	–	–	through Fawe Reservoir	
PM2	Oct. 24	15:18	8.5	2.5	6.0		調整圧設定値
PM3	Oct. 24	15:35	7.5	5.5	2.0	Leak0.070m3/h	
PM3	Oct.26	13:43	4.0	3.3	0.7	Leak0.000m3/h	
PM3	Oct.26	13:43	4.0				
PM3	Oct.31	14:45	8.0	5.5	2.5	Leak0.036m3/h	
PM3	Oct.31	15:10	6.7	2.0	4.7	Replaced Pressure Gauge	調整圧設定値

2.9 Activities for Replacement of Distribution and Service Pipes

(1) Preparation

Reducing the pressure in water pipes with a PRV leads to the reduction in the NRW rate in the pilot area because the high water pressure is a major cause of the water leaks. The poor quality of distribution and service pipes has also been considered another major cause of the water leaks. Replacement of such pipes in the pilot areas to demonstrate its effectiveness was proposed in the SC meeting in August 2018 and JICA approved the addition of the replacement to the NRW reduction activities.

After the meeting, the NRW Unit had discussions on the replacement with the offices involved in the project (including Kacyiru Branch, GIS Unit and JICA Team) on 14 and 17 September and selected Subzones 1-3 and -4 in Kadobogo as the areas for the replacement based on the record of water leaks, pipe distribution, etc. A team led by the person in charge of the project of NRW Unit and Water Distribution Officer (WDO) implemented a field survey to decide specifics of the replacement work. The team identified the locations of HDPE pipes to be replaced, measured the lengths of such pipes and confirmed the locations of POCs in the survey. Then, the team prepared BOQ and a piping drawing and estimated the cost for the replacement. (See Attachment 2.9.)

In the late night between 5 and 6 February 2019, Qmnf was measured in PM1-3 and -4 to obtain the baseline Qmnf before the replacement of distribution and service pipes and to compare it with Qmnf in PM3 (Fig. 2.9.1). Qmnf in PM1-3 and -4 was 5.38 m3/h, while that in PM3 was 3.53 m3/h. This observation and the map on which the locations of past repairs were plotted clearly show that the volume of water leakage in PM1-3 and -4 was large and proved the benefit of the replacement.

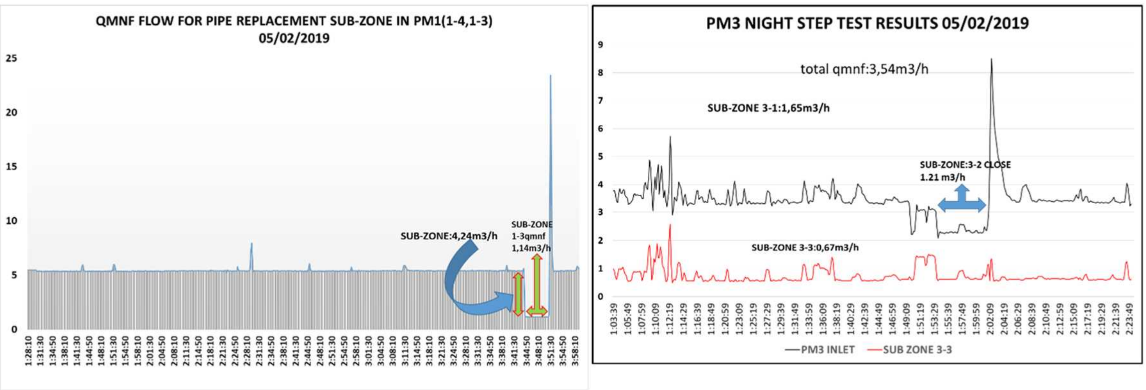


Figure 2.9.1 Results of Qmnf measurement

(2) Replacement of distribution and service pipes

JICA completed the procurement of equipment and materials required for the replacement and handed them over to Kacyiru Branch in December 2018. The branch prepared a work plan for the replacement, commenced the replacement on 4 February 2019, and completed it by the end of February 2019. The replacement was carried out in accordance with the management standards of WASAC, “Requirements for Water Distribution and House Connection.” The technicians of the branch were instructed to strictly follow the dimensions of the cross-section of excavation and the required earth covering over pipes in the standards and to use only quality earth without stones, gravel or consolidated coarse earth clods for the backfilling. Three 1 cm-mesh sieves were manufactured and used for the preparation of the backfilling material on and around pipe foundation. In addition, as-built drawings (including the plan views, extension, pipe information and x-y coordinates) were prepared and the quantities of the used materials were tallied after the completion of the replacement.

(3) Effect of replacement of distribution and service pipes

A Qmnf survey was conducted in the night between 26 and 27 March to verify the effect of the replacement of distribution and service pipes. The survey revealed that the replacement reduced Qmnf in Subzone 1-3 from 1.14 m3/h to 0.70 m3/h and that in Subzone 1-4 from 4.24 m3/h to 2.40 m3/h. The total reduction of 2.28 m3/h, or around 40 % reduction, verified large effect of the replacement of water on leakage reduction.

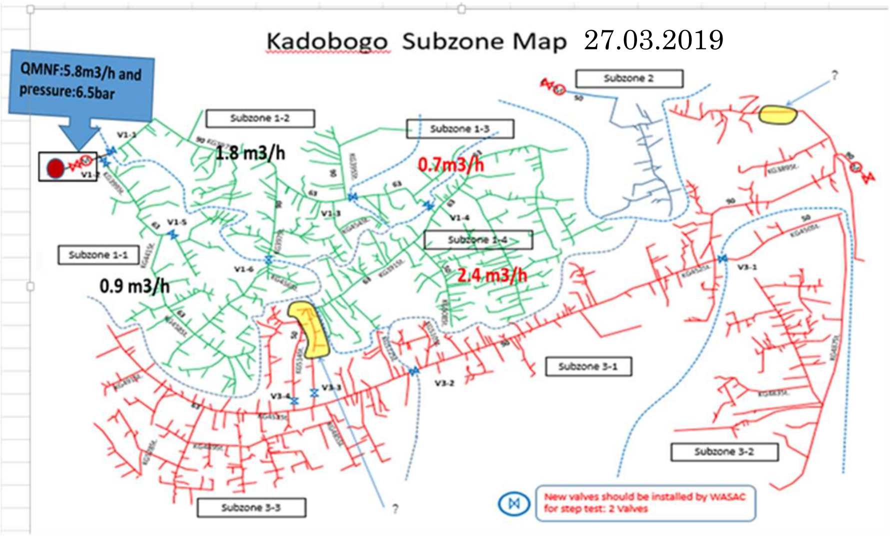


Figure 2.9.2 Result of Qmnf survey in PM1

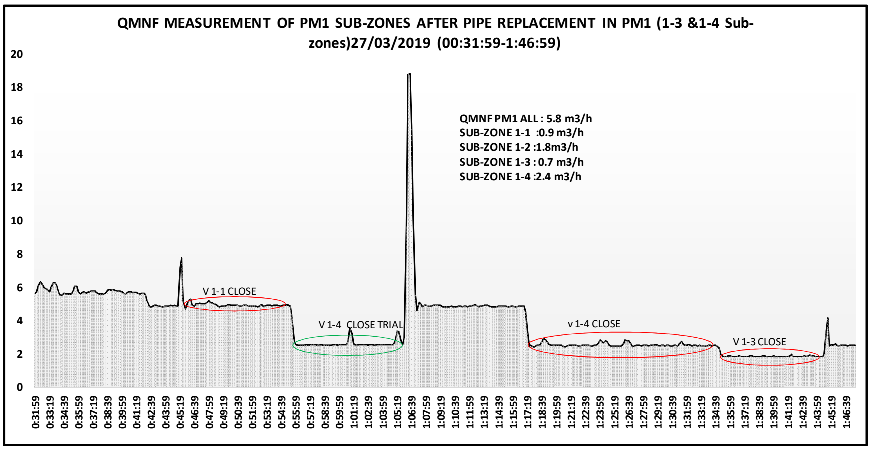
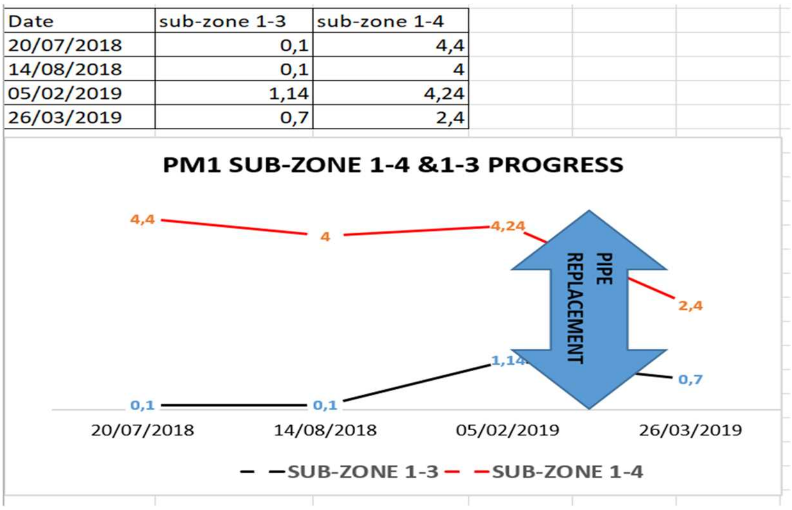


Figure 2.9.3 Result of Qmnf measurement in PM1



Date	sub-zone 1-3	sub-zone 1-4
20/07/2018	0,1	4,4
14/08/2018	0,1	4
05/02/2019	1,14	4,24
26/03/2019	0,7	2,4

Figure 2.9.4 Time-series change in Qmnf measurements in PM1

Table 2.9.1 Qmnf reduction effect of distribution and service pipe replacement

Kadobogo PM1 (Feb. 2019)

Measurement	Flow Rate	Note
1. Baseline	5.38 m3/h	before replacement
2. Effect Measurement	3.10 m3/h	after replacement
3. Reduction Volume	2.28 m3/h	
4. Reduction Rate	42%	

2.10 Measurement of NRW rate and verification of effect of Pilot Project activities

The whole effect of all the activities in the pilot project and the effects of individual activities on the NRW reduction were evaluated with the following four indicators (See Attachment 2.10, "Effect of the Pilot Project Activities.").

① Change in NRW rate

② Change in the number of the repair
③ Change in Qmnf
④ Cost-benefit analysis

2.10.1 Measurement of NRW rates

(1) Change in NRW Rate

Table 2.10.1 Achievement value of NRW Rate

Item		Kadobogo	Ruyenzi
Baseline		37%	68%
Target value		20%	25%
Achievement value	The end of March 2019	14.2%	53.4%
Achievement value	The end of April 2019	19.5%	55.0%

The calculation of the monthly NRW volume in the three subzones (PM1, PM2 and PM3) began in June 2017. The monthly NRW volume has been calculated as the difference between the total water consumption billed to customers based on the meter reading data and the volumes of water input measured with flow meters installed in the meter chambers at the inlets in the subzones. The monthly NRW rates in the three subzones have been monitored continuously since June 2017. The monthly NRW rates in June and July 2017 were used for the calculation of the baseline rate. The table used for the calculation of monthly NRW rates is shown in Attachment 2.10.

Table 2.10.3 shows the results of the calculation of monthly NRW rates between June 2017, when the calculation of NRW rate began, and April 2019. Fig. 2.1.10 shows the changes in NRW volume/rate in the entire Kadobogo. Figs. 2.10.2 to 5 show the changes in NRW volume/rate in the subzones.

A problem found in the beginning was the inconsistency between the POC numbers in the billing list and those on site. This problem made it impossible to calculate total billed water consumption in each subzone, which is required for the calculation of NRW rate, accurately. The on-site customer meter accuracy test had revealed 110 POCs in the list not found on site and 50 existing POCs not found in the list by the end of November 2017. Therefore, the hydraulic isolation was re-examined in December to define the exact locations of the subzone boundaries and the re-defined boundaries and the results of the customer meter accuracy test were used for the correction of the list of POC numbers. The NRW rates in the past were re-calculated based on the corrected list.

As the monthly meter reading was completed by around 20th of every month, the water input between 15th of the previous month and 15th of the current month was used as a reference input in the calculation of the NRW rate of the current month (see attachment 2.10).

After the revision of water charges in February 2019, the customer classification of the billing data was also revised. The billed water consumption of customers in each category (Item) in Table 2.10.2 has been used in the calculation of NRW rates.

Table 2.10.2 Numbers of customers in each item (Data of March 2019)

Item	Kadobogo	Ruyenzi	WASAC Total
Residential	1,286	1,644	186,453
Non-Residential	55	78	14,573
Industries	0	0	214
Public Tap	3	12	4178
Total	1,344	1,734	205,418

Table 2.10.3 Calculation of NRW rates in Kadobogo

Input Volume 15 to 15	2017							2018												2019				
PM Number	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Input Volume (m3/M)	19,054	19,722	21,279	19,466	16,350	17,366	18,609	22,694	21,677	19,439	22,328	21,373	22,445	22,862	23,138	20,913	21,358	18,991	18,000	18,800	16,408	16,120	16,059	15,712
IVave.		20,018	20,156	19,032	17,727	17,442	19,556	20,993	21,270	21,148	21,047	22,049	22,227	22,815	22,304	21,803	20,421	19,450	18,597	17,736	17,109	16,196	15,964	
PM1	9,634	9,741	10,309	9,631	8,412	8,537	8,791	9,577	8,391	7,179	8,995	9,134	10,134	11,272	11,607	10,204	9,417	9,410	9,509	9,509	7,676	8,199	8,568	8,521
		9,895	9,894	9,451	8,860	8,580	8,968	8,920	8,382	8,188	8,436	9,421	10,180	11,004	11,028	10,409	9,677	9,445	9,476	8,898	8,461	8,148	8,429	
PM2	1,049	1,239	1,758	1,730	1,105	1,108	1,489	2,061	1,519	1,243	1,659	2,030	1,978	872	789	965	1,108	892	910	899	834	701	644	570
		1,349	1,576	1,531	1,314	1,234	1,553	1,690	1,608	1,474	1,644	1,889	1,627	1,213	875	954	988	970	900	881	811	726	638	
PM3	8,371	8,742	9,212	8,105	6,833	7,721	8,329	11,056	11,767	11,017	11,674	10,209	10,333	10,718	10,742	9,744	10,833	8,689	7,581	8,392	7,898	7,220	6,847	6,621
		8,775	8,686	8,050	7,553	7,628	9,035	10,384	11,280	11,486	10,967	10,739	10,420	10,598	10,401	10,440	9,755	9,034	8,221	7,957	7,837	7,322	6,896	
Billed Water (m3/M)	11,404	13,500	17,374	14,246	13,397	12,959	13,908	14,765	13,351	11,579	13,499	12,822	15,340	15,175	16,541	16,595	15,496	14,792	14,000	16,816	14,367	13,834	12,939	12,986
BWave.		14,093	15,040	15,006	13,534	13,421	13,877	14,008	13,232	12,810	12,633	13,887	14,446	15,685	16,104	16,211	15,628	14,763	15,203	15,061	15,006	13,713	13,253	
PM1	6,088	6,947	9,089	7,286	6,882	6,766	7,122	7,710	6,602	5,808	6,790	6,684	8,182	7,930	8,708	8,326	7,384	7,609	7,011	8,314	6,843	7,308	6,686	7,135
		7,375	7,774	7,752	6,978	6,923	7,199	7,145	6,707	6,400	6,427	7,219	7,599	8,273	8,321	8,139	7,773	7,335	7,645	7,389	7,488	6,946	7,043	
PM2	381	506	839	666	668	692	768	531	664	503	557	322	742	547	668	849	908	718	863	869	742	701	534	494
		575	670	724	675	709	664	654	566	575	461	540	537	652	688	808	825	830	817	825	771	659	576	
PM3	4,935	6,047	7,446	6,294	5,847	5,501	6,018	6,524	6,085	5,268	6,152	5,816	6,416	6,698	7,165	7,420	7,204	6,465	6,126	7,633	6,782	5,825	5,719	5,357
		6,143	6,596	6,529	5,881	5,789	6,014	6,209	5,959	5,835	5,745	6,128	6,310	6,760	7,094	7,263	7,030	6,598	6,741	6,847	6,747	6,109	5,634	
NRW(m3/M)	7,650	6,222	3,905	5,220	2,953	4,407	4,701	7,929	8,326	7,860	8,829	8,551	7,105	7,687	6,597	4,318	5,862	4,199	4,000	1,984	2,041	2,286	3,120	2,726
NRWave.		5,926	5,116	4,026	4,193	4,020	5,679	6,985	8,038	8,338	8,413	8,162	7,781	7,130	6,201	5,592	4,793	4,687	3,394	2,675	2,104	2,482	2,711	
PM1	3,546	2,794	1,220	2,345	1,530	1,771	1,669	1,867	1,789	1,371	2,205	2,450	1,952	3,342	2,899	1,878	2,033	1,801	2,498	1,195	833	891	1,882	1,386
		2,520	2,120	1,698	1,882	1,657	1,769	1,775	1,676	1,788	2,009	2,202	2,581	2,731	2,706	2,270	1,904	2,111	1,831	1,509	973	1,202	1,386	
PM2	668	733	919	1,064	437	416	721	1,530	855	740	1,102	1,708	1,236	325	121	116	200	174	47	30	92	0	110	76
		773	905	807	639	525	889	1,035	1,042	899	1,183	1,349	1,090	561	187	146	163	140	84	56	41	67	62	
PM3	3,436	2,695	1,766	1,811	986	2,220	2,311	4,532	5,682	5,749	5,522	4,393	3,917	4,020	3,577	2,324	3,629	2,224	1,455	759	1,116	1,395	1,128	1,264
		2,632	2,091	1,521	1,672	1,839	3,021	4,175	5,321	5,651	5,221	4,611	4,110	3,838	3,307	3,177	2,726	2,436	1,479	1,110	1,090	1,213	1,262	
NRW ratio (%)	40.1%	31.5%	18.4%	26.8%	18.1%	25.4%	25.3%	34.9%	38.4%	40.4%	39.5%	40.0%	31.7%	33.6%	28.5%	20.6%	27.4%	22.1%	22.2%	10.6%	12.4%	14.2%	19.4%	17.3%
NRWRave.		30.0%	25.6%	21.1%	23.4%	22.9%	28.5%	32.9%	37.9%	39.5%	40.0%	37.1%	35.1%	31.3%	27.6%	25.5%	23.4%	23.9%	18.3%	15.1%	12.4%	15.3%	17.0%	
PM1	36.8%	28.7%	11.8%	24.3%	18.2%	20.7%	19.0%	19.5%	21.3%	19.1%	24.5%	26.8%	19.3%	29.6%	25.0%	18.4%	21.6%	19.1%	26.3%	12.6%	10.9%	10.9%	22.0%	16.3%
		25.8%	21.6%	18.1%	21.1%	19.3%	19.7%	19.9%	20.0%	21.6%	23.5%	23.5%	25.2%	24.6%	24.3%	21.7%	19.7%	22.3%	19.3%	16.6%	11.4%	14.6%	16.4%	
PM2	63.7%	59.2%	52.3%	61.5%	39.5%	37.5%	48.4%	74.2%	56.3%	59.5%	66.4%	84.1%	62.5%	37.3%	15.3%	12.0%	18.1%	19.5%	5.2%	3.3%	11.0%	0.0%	17.1%	13.3%
		58.4%	57.6%	51.1%	46.2%	41.8%	53.4%	59.6%	63.4%	60.7%	70.0%	71.0%	61.3%	38.4%	21.5%	15.1%	16.5%	14.2%	9.3%	6.5%	4.8%	9.4%	10.1%	
PM3	41.0%	30.8%	19.2%	22.3%	14.4%	28.8%	27.7%	41.0%	48.3%	52.2%	47.3%	43.0%	37.9%	37.5%	33.3%	23.9%	33.5%	25.6%	19.2%	9.0%	14.1%	19.3%	16.5%	19.1%
		30.3%	24.1%	18.6%	21.8%	23.6%	32.5%	39.0%	47.2%	49.3%	47.5%	42.7%	39.5%	36.2%	31.6%	30.2%	27.6%	26.1%	17.9%	14.1%	14.2%	16.6%	18.3%	
POC	1,243	1,247	1,265	1,270	1,266	1,269	1,273	1,281	1,286	1,293	1,295	1,294	1,295	1,295	1,311	1,314	1,315	1,315	1,315	1,342	1,343	1,343	1,343	1,347
POCave.		1,252	1,261	1,267	1,268	1,269	1,274	1,280	1,287	1,291	1,294	1,295	1,295	1,300	1,307	1,313	1,315	1,315	1,324	1,333	1,343	1,343	1,344	
PM1	637	639	646	647	643	646	647	655	660	662	662	661	661	661	668	669	669	669	669	680	680	680	680	682
		641	644	645	645	645	649	654	659	661	662	661	661	663	666	669	669	669	673	676	680	680	681	
PM2	42	42	43	43	43	43	44	44	44	44	44	44	44	44	45	45	45	45	45	47	48	48	48	48
		42	43	43	43	43	44	44	44	44	44	44	44	44	45	45	45	45	46	47	48	48	48	
PM3	564	566	576	580	580	580	582	582	582	587	589	589	590	590	598	600	601	601	601	615	615	615	615	617
		569	574	579	580	581	581	582	584	586	588	589	590	593	596	600	601	601	606	610	615	615	616	
NRW/POC (m3/M)	6.2	5.0	3.1	4.1	2.3	3.5	3.7	6.2	6.5	6.1	6.8	6.6	5.5	5.9	5.0	3.3	4.5	3.2	3.0	1.5	1.5	1.7	2.3	2.0
NRW/POCave.		4.7	4.1	3.2	3.3	3.2	4.5	5.5	6.2	6.5	6.5	6.3	6.0	5.5	4.8	4.3	3.6	3.6	2.6	2.0	1.6	1.8	2.0	
PM1	5.6	4.4	1.9	3.6	2.4	2.7	2.6	2.9	2.7	2.1	3.3	3.7	3.0	5.1	4.3	2.8	3.0	2.7	3.7	1.8	1.2	1.3	2.8	2.0
		3.9	3.3	2.6	2.9	2.6	2.7	2.7	2.5	2.7	3.0	3.3	3.9	4.1	4.1	3.4	2.8	3.2	2.7	2.2	1.4	1.8	2.0	
PM2	15.9	17.5	21.4	24.7	10.2	9.7	16.4	34.8	19.4	16.8	25.0	38.8	28.1	7.4	2.7	2.6	4.4	3.9	1.0	0.6	1.9	0.0	2.3	1.6
		18.2	21.2	18.8	14.9	12.1	20.3	23.5	23.7	20.4	26.9	30.7	24.8	12.7	4.2	3.2	3.6	3.1	1.8	1.2	0.9	1.4	1.3	
PM3	6.1	4.8	3.1	3.1	1.7	3.8	4.0	7.8	9.8	9.8	9.4	7.5	6.6	6.8	6.0	3.9	6.0	3.7	2.4	1.2	1.8	2.3	1.8	2.0
		4.6	3.6	2.6	2.9	3.2	5.2	7.2	9.1	9.6	8.9	7.8	7.0	6.5	5.6	5.3	4.5	4.1	2.4	1.8	1.8	2.0	2.1	
Billed Water/POC	9.2	10.8	13.7	11.2	10.6	10.2	10.9	11.5	10.4	9.0	10.4	9.9	11.8	11.7	12.6	12.6	11.8	11.2	10.6	12.5	10.7	10.3	9.6	9.6
Zero Consumption Loss												1,269	1,075	1,118	797	1,097	763	943	806	909	1,144	1,216	1,060	
Zero Consumption NRW Rate												5.9%	4.8%	4.9%	3.4%	5.2%	3.6%	5.0%	4.5%	4.8%	7.0%	7.5%	6.6%	

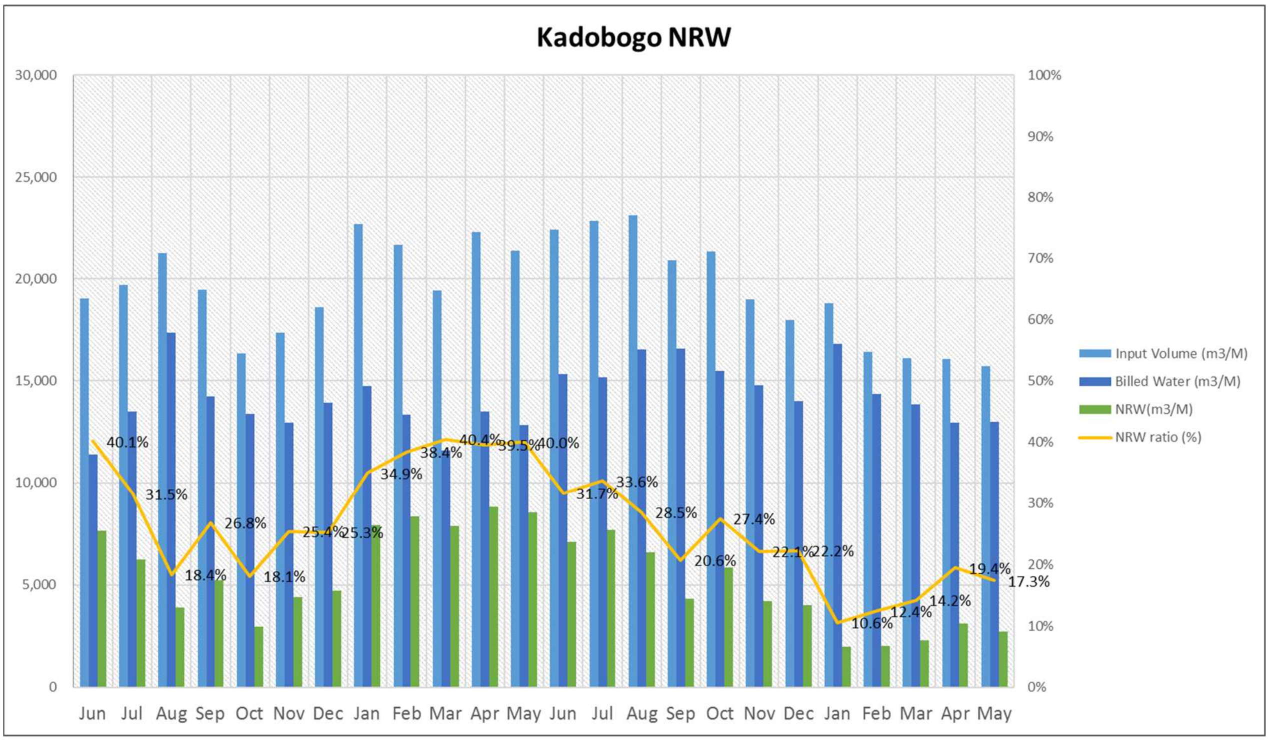


Fig. 2.10.1 Changes in NRW volume in entire Kadobogo Area

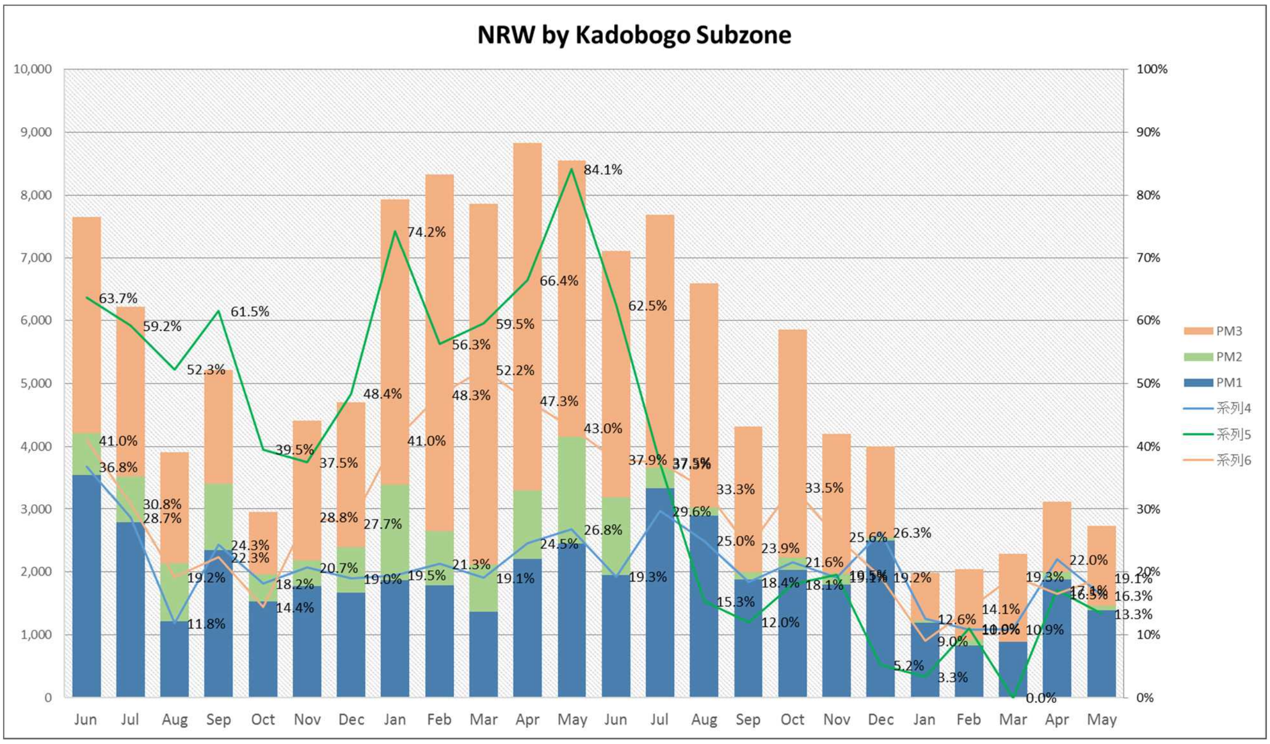
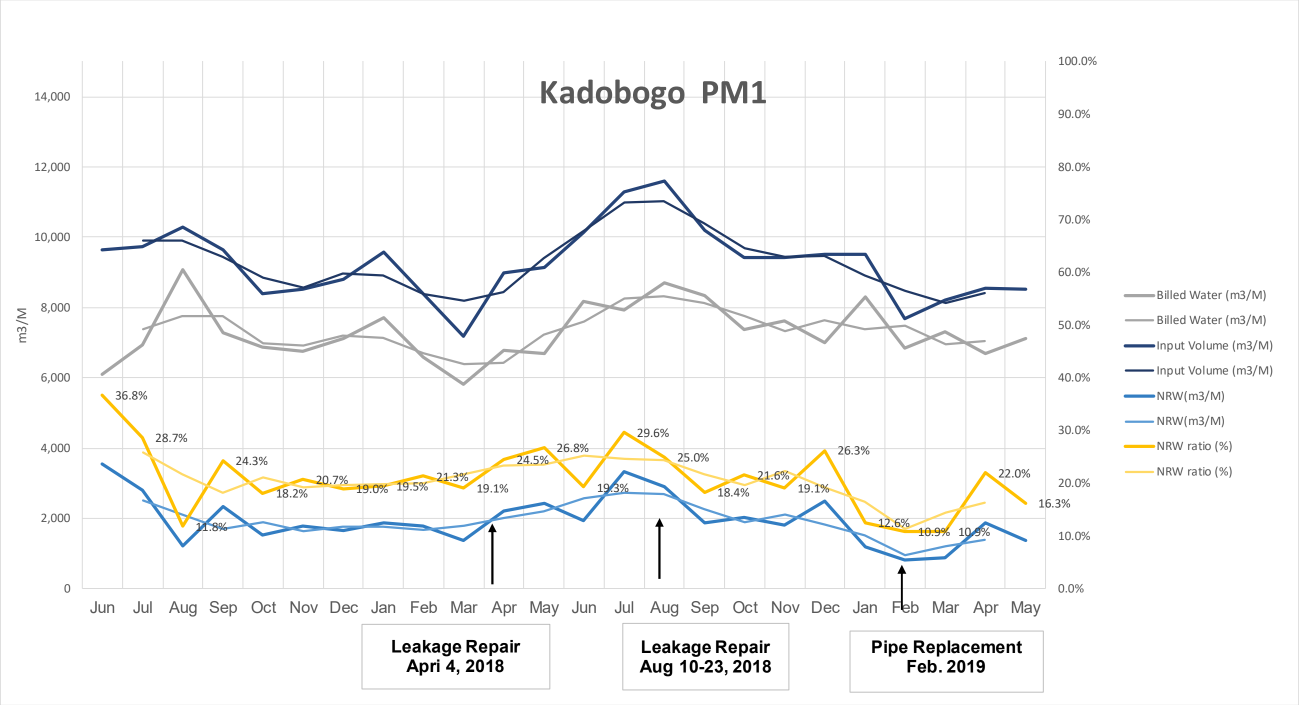


Fig. 2.10.2 NRW volumes and rates in subzones of Kadobogo Area

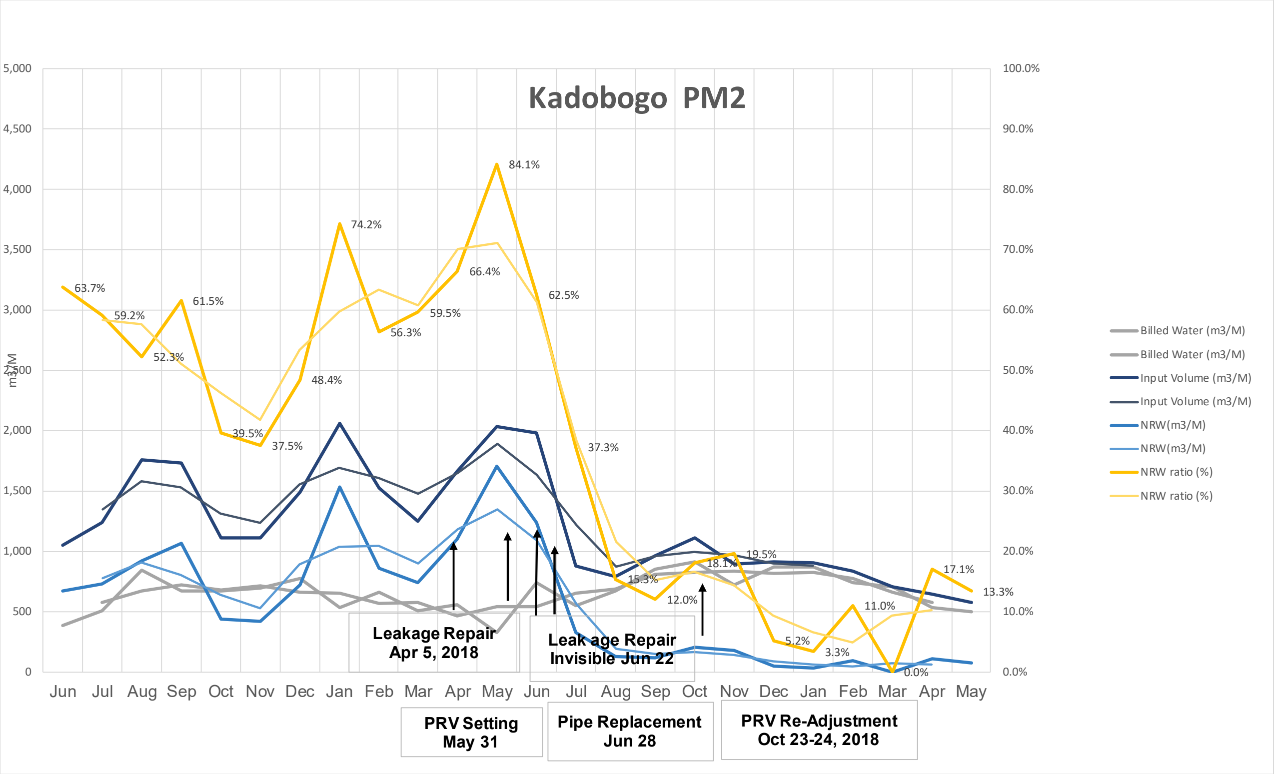


Leakage Repair
Apri 4, 2018

Leakage Repair
Aug 10-23, 2018

Pipe Replacement
Feb. 2019

Fig. 2.10.3 NRW in Subzone PM2 of Kadobogo Area



Leakage Repair
Apr 5, 2018

Leak age Repair
Invisible Jun 22

PRV Setting
May 31

Pipe Replacement
Jun 28

PRV Re-Adjustment
Oct 23-24, 2018

Fig. 2.10.4 NRW in Subzone PM2 of Kadobogo Area

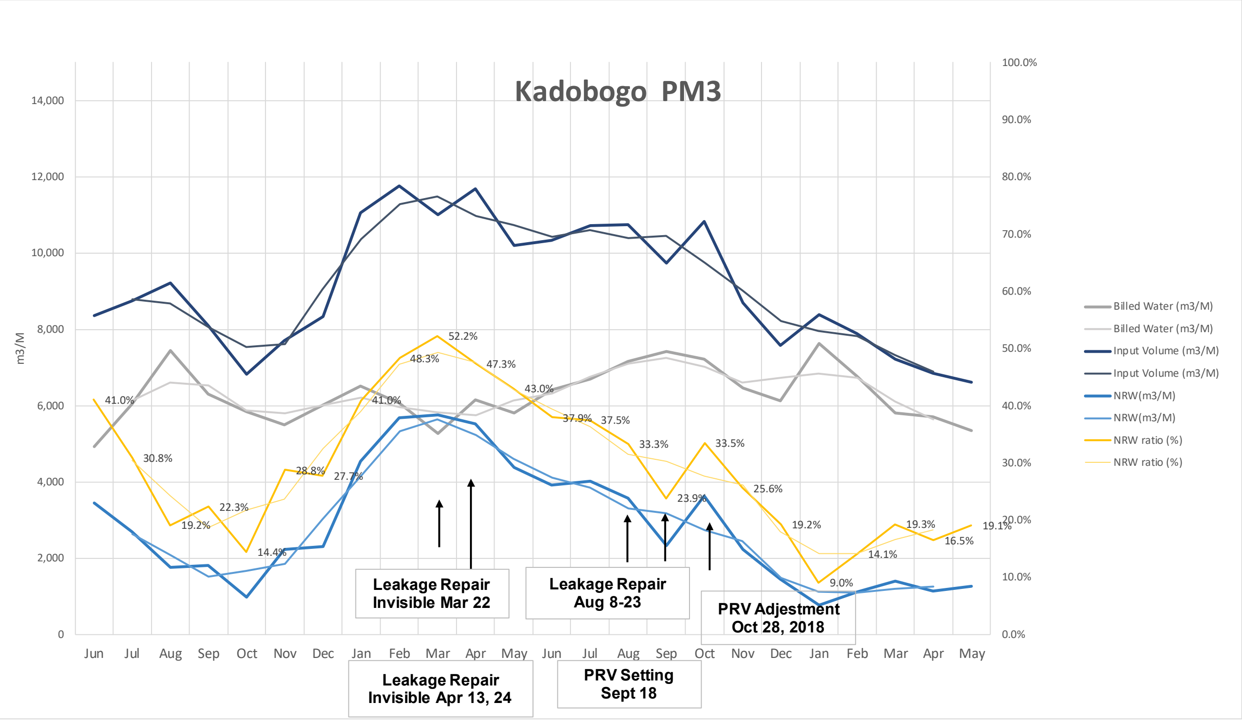


Fig. 2.10.5 NRW in Subzone PM3 of Kadobogo Area

Overall summary

Fig. 2.10.1 shows a temporary reduction in the NRW rate between August and December 2017. The replacement of the defective meters found in the meter accuracy test is not considered to have caused this reduction because the replacement commenced in October. The leakage repair is not consider a cause of the NRW reduction either because, despite water leaks from distribution and service pipes being repaired on a daily basis immediately after such leaks were discovered, the number of repaired water leaks did not increase in this period and the leakage survey and repair in the project commenced in March 2018 (and completed in August 2018).

Because of the abnormally small precipitation, water rationing was introduced in September and October 2017. While the water rationing reduced the water input greatly, it did not change the billed water consumption much. Consequently, the NRW rate was greatly reduced in these months. As the customers in this area usually consumed a small amount of water, the water demand in this area was satisfied to a certain level even while the water rationing was in effect. On the contrary, if the potential input increases, the water leakage increases because of the pressure build-up in pipes.

Note: Relationship between water input and consumption

Water distribution is suspended frequently in Kadobogo for water rationing and leakage repair. The frequent suspension reduces the time and quantity of water distribution. However, as the water consumption of the residents is small, the suspension of water distribution, which limits the time of water availability, is not a direct cause of the reduction in water consumption.

Fig. 3.1.1 shows the relationship between water input (volume of water distribution) and water consumption in the 26 months between June 2017 and July 2019. In the figure, data are arranged in an ascending order of the input. Although some consumption data were far from the approximate line, the variation in the billed water consumption deduced from the approximate line was small (20 %). Meanwhile, the variation in the water input was large (50%). This observation shows that, even if the input increased, the billed water consumption did not increase as much.

The discussion mentioned above shows that the water input varies independently of the water consumption and that the water distribution in this closed pipeline system tends to be controlled more by the transmission and distribution condition on the supply side than water consumption of consumers on the demand side. It is considered that the difference between the input and consumption corresponded to the volume of water leakage and, when the input increases, the water leakage increases by the increment of the input.

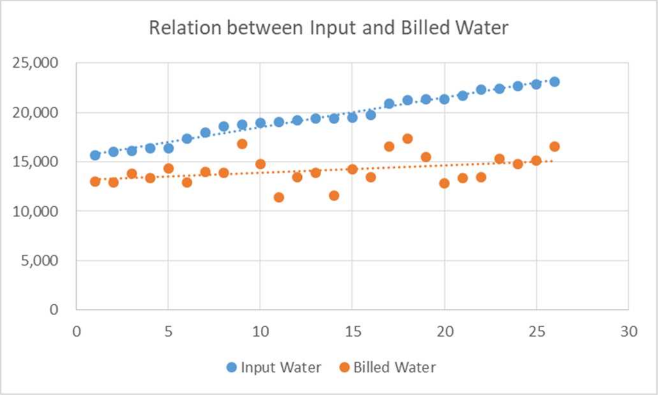


Figure 3.1.1 Relationship between water input and billed water consumption

The three-month moving average of the NRW rate has been clearly and continuously decreasing since April 2018, when the rate was as high as 40.0 %. This finding suggests that the full-scale implementation of the leakage survey and repair and the water pressure reduction with PRVs, which began around then, exerted their effect on the NRW reduction. The effect of the customer meter replacement implemented up to around April on the NRW reduction was not clearly seen in the change in the NRW rate presumably because the correction of positive error and that of negative error by the replacement offset each other, as mentioned in 2.6.1. The NRW rate increased rapidly contrary to the expectation

The moving average of NRW rate decreased from the baseline of 37.3 % to 18.3 % and the target of NRW rate of 20 % or below was achieved in December 2018. The rate continued to decrease to 12.4 %

in February. Then, the trend of decrease reversed and the rate went up to 25.2 % in June 2019. (The target of 20 % or less was satisfied from December 2018 to April 2019.) The pressure settings of PRVs were nullified with intentional valve operation or by malfunction of PRV caused by breakdown. Consequently, the water pressure in the water pipes increased back to the level before the PRV installation and the high water pressure caused the recurrence of water leaks, which led to the increase in NRW rate.

The comparison of the data of water input and consumption of 2017/18 and 2018/2019 (Table 2.10.4) revealed 6.2 % decrease in water input, 6.2 % increase in billed water consumption, 33.5 % decrease in NRW volume, 29.1 % decrease in NRW rate and 33.5 % decrease in NRW/POC. These figures prove the large NRW reduction effect of the NRW reduction activities.

Table 2.10.4 Comparison of water input and consumption data of 2017/18 and 2018/19

PM Number	2017/2018	2018/2019	Improve Ratio
Input Volume (m3/M)	20,229	18,966	6.2%
PM1	9,069	9,496	-4.7%
PM2	1,577	826	47.6%
PM3	9,583	8,644	9.8%
Billed Water (m3/M)	13,895	14,753	6.2%
PM1	7,156	7,500	4.8%
PM2	622	712	14.5%
PM3	6,118	6,541	6.9%
NRW(m3/M)	6,334	4,213	33.5%
PM1	1,914	1,996	-4.3%
PM2	955	114	88.1%
PM3	3,465	2,103	39.3%
NRW ratio (%)	31.3%	22.2%	29.1%
PM1	21.1%	21.0%	0.4%
PM2	60.6%	13.8%	77.2%
PM3	36.2%	24.3%	32.7%
POC	1,278	1,327	3.8%
PM1	652	674	3.3%
PM2	44	46	6.5%
PM3	582	607	4.3%
NRW/POC (m3/M)	4.9	3.2	35.5%
PM1	2.9	3.0	-1.2%
PM2	21.9	2.5	88.6%
PM3	5.9	3.5	41.3%

The effect of the NRW reduction activities in each subzone is described in the following:

PM1

The NRW rate fluctuated gently between 18 % and 25 %. Five leaks were repaired in a month, on average. In August 2018, in which a leakage survey was conducted, three-time more leaks than the average (16 leaks) were repaired. Consequently, the leakage rate has generally been on a downward trend since September 2018.

However, the decrease is not so large. While the replacement of around 1 km-long distribution and service pipes in a subzone in PM1 in February 2019 reduced Qmnf in the subzone, it had little effect on the NRW rate in the entire PM1. The NRW rate increased again in June and July 2019. As high water pressure in the area was obviously the cause of the increase, a PRV was installed at the inlet in the subzone in September 2019 to reduce the pressure.

As malfunction of the mechanical flow meter installed at the inlet was found in the inspection conducted in the end of December 2018, the meter was overhauled (and a foreign object clogged in the meter, which was the cause of the malfunction, was removed) in the Meter Unit of WASAC in January 2019 and re-installed in the end of January. The accuracy test of the meter with an ultrasonic flow meter was conducted on 12 February. The test revealed that the instrumental error of the mechanical meter was + 3.0 %

The comparison of the data of 2017/18 and 2018/19 shown in Table 2.10.4 reveals 4.7 % increase in input, 4.8 % increase in billed water consumption, 4.3 % increase in NRW volume, 0.4 % decrease in NRW rate and 1.2 % increase in NRW/POC. This observation indicates that the NRW reduction activities had little effect in PM1 and NRW reduction in the subzone requires the pressure control with the PRV mentioned above.

PM2

While two leaks were repaired in a month, on average, the NRW rate had remained higher than 50 % in PM2. The resetting of the PRV in May 2018 and the leakage survey and replacement of leak-prone (DN50 and 200 m-long) HDPE pipes in June 2018 reduced the rate drastically. The step test in the night and leak detection based on the Qmnf measurements in May uncovered a large underground water leak with a flow rate of 2.3 m3/h. The uncovered leak was repaired on 22 June. Since the repair, the NRW rate has been stably below the target of 20 % and no leak repair has been conducted.

The NRW rate in PM2 began to decrease obviously and rapidly in May 2018. While it is not possible to evaluate how much each NRW reduction activity, leakage repair, installation and setting of PRV or pipe replacement, contributed to the NRW reduction, the NRW rate decreased markedly after the pressure setting of the PRV was readjusted in October. The NRW rate in PM3 continued to decrease in November and December after a PRV was installed in September. These observations prove that the PRV exerted its NRW reduction effect.

The comparison of the data of 2017/18 and 2018/19 shown in Table 2.10.4 reveals 47.6 % decrease in input, 14.5 % increase in billed water consumption, 88.1 % decrease in NRW volume, 77.2 % decrease in NRW rate and 88.6 % decrease in NRW/POC. This observation proves the large NRW reduction effect of NRW reduction activities.

PM3

Three leaks were repaired in a month, on average, in PM3. Three large underground leaks were discovered and they and five surface leaks were repaired in March and April 2018. After the repair, the NRW rate began to decrease rapidly. After 11 leaks discovered in the leakage survey were repaired in August and a PRV was installed in September, the NRW rate continued to decrease. The target of the NRW rate of 20 % or below was achieved for four months from December 2018 to April 2019. The number of leak repairs also decreased. However, as mentioned above, the water leakage began to increase again in May because of the problem in the operation of the PRV mentioned above.

The comparison of the data of 2017/18 and 2018/19 shown in Table 2.10.4 reveals 9.8 % decrease in input, 6.8 % increase in billed water consumption, 39.3 % decrease in NRW volume, 32.7 % decrease in NRW rate decreased by 32.7 % and 41.3 % decrease in NRW/POC. This observation proves the large NRW reduction effect of NRW reduction activities.

Effective NRW reduction activities

The activities that have proven to be effective in reducing NRW in the pilot area in the preceding paragraphs are summarised below.

- Installation of PRVs in PM1, PM2 and PM3 (for water pressure control)
- Leak detection and leakage repair in PM1, PM2 and PM3 (The underground leakage repair is particularly effective.)
- Replacement of leak-prone distribution pipes in PM2
- Replacement of low-quality HDPE pipes by PPC pipes in PM1

Points of note

The activities mentioned below are required for maintaining the NRW rate below the target value after the target has been achieved.

- Continuation of regular monitoring of NRW rate
- Accuracy control of measuring instruments (flow meters and pressure gauges)
- Maintenance of installed PRVs (control of pressure settings)

(2) Water input and billed water consumption per connection

The water input and billed water consumption in each subzone in each month between June 2017 and March 2018 were calculated by dividing the water input by the number of connections. If the characteristics and water consumption pattern of customers in two subzones are the same, the input per connection in these subzones should be almost the same. However, there was large difference in the input per connection among the subzones as shown in Table 2.10.5. There was small difference in the water input values in PM1 and PM3 as those in PM1 and PM3 were within the ranges of 360 – 560 L/day/connection and 390 – 670 L/day/connection, respectively. Meanwhile, the monthly water input volumes in PM2 (between 830 and 1,620 L/day/connection) was much larger than those in PM1 and PM3. This observation indicates that the water input in PM2, where many water leaks occurred, was particularly large.

The billed water consumption per connection varied less than the input per connection. The difference in the consumption among the three subzones was not so large.

Table 2.10.5 Water consumption per connection (L/day/connection) in each subzone (June 2017 – March 2018)

Number of Connection

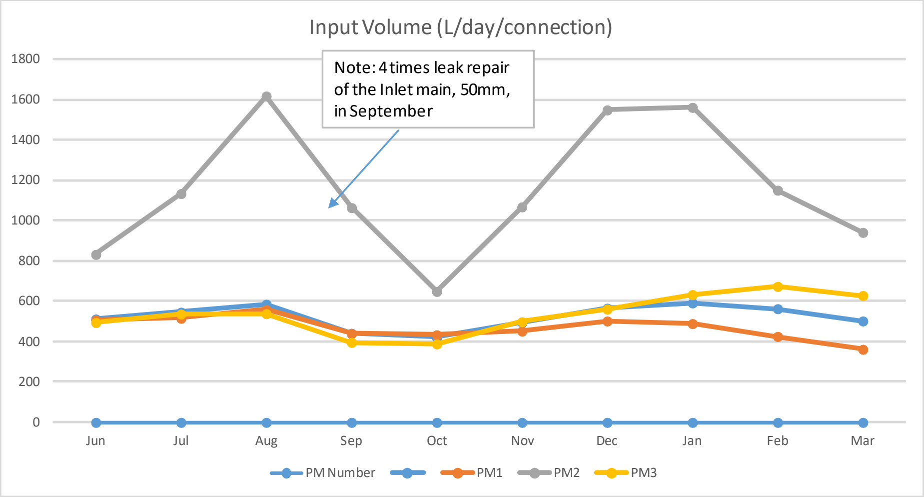
Item	PM Number	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Number of connection		1,240	1,244	1,262	1,266	1,263	1,267	1,270	1,278	1283	1289
	PM1	634	636	643	643	640	644	644	652	657	661
	PM2	42	42	43	43	43	43	44	44	44	44
	PM3	564	566	576	580	580	580	582	582	582	584

Billed Water per Connection (L/day/connection)

Item	PM Number	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Average
Billed Water		305	359	455	372	351	339	362	383	345	297	357
	PM1	317	359	464	372	353	346	362	390	331	289	
	PM2	302	402	650	516	518	536	582	402	503	381	
	PM3	292	356	431	362	336	316	345	374	349	301	

Input Volume per Connection (L/day/connection)

Item	PM Number	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Average
Input Volume		512	546	586	441	421	494	566	592	563	503	522
	PM1	507	516	558	440	434	452	502	490	426	362	
	PM2	833	1,134	1,618	1,064	649	1,068	1,548	1,561	1,151	942	
	PM3	495	537	539	396	389	499	562	633	674	629	



Note: 4times leak repair of the Inlet main, 50mm, in September

Figure 2.10.6 Water input per connection

(3) Breakdown of NRW

Table 2.10.6 shows the estimated breakdown of the baseline NRW rate of 37.3 % into instrumental error of meters, illegal water consumption, surface leaks and underground leaks.

The on-site meter accuracy test revealed that the loss caused by instrumental error of meters was only 0.7 % of the billed water consumption, as explained in 2.6.1. The survey of NRW in the subdivisions of Ruyenzi Pilot Area revealed that the instrumental error accounted for 1 % or less of the NRW rate. The NRW generated at the time of meter replacement was estimated at 1.2 % of the NRW rate of 37.3 %. Illegal water consumption accounted for a minute fraction of NRW, as the number of the uncovered cases of illegal consumption was small (see 2.6.3). The maximum of 5.3 % of the NRW rate was accounted for by the loss resulting from zero billed water consumption caused by such a reason as failure in the meter reading for a certain reason estimated from the billed water consumption in billed months (see 2.6.3). The apparent losses obtained as a total of the four types of water losses mentioned above accounted for around 20 % of the total NRW.

Because of the repair of the underground leaks in PM3 discovered on 22 March, 13 April and 24 April led to the reduction of Qmnf by 4.2 m3/h (or 3,024 m3/month) from 13.5 m3/h measured on 22 February to 9.3 m3/h measured on 19 July. As the average monthly NRW in PM3 between March and July was 6,700 m3/month, the underground leakage was estimated to account for around 50 % (3024/6070) of NRW. As the underground leakage was estimated to account for around 70 % of NRW in 2.7.3, the percentage of underground leakage in the NRW was estimated at 60 %, the mean of the two percentages. As the apparent losses accounted for 20 % of NRW, the real losses (volume of water leakage) was estimated at around 80 %, of which 32 % and 48 % were accounted for by the surface and underground leakage, respectively.

Table 2.10.6 Estimated breakdown of baseline NRW rate (%)

Item	Apparent losses (20 %)				Real losses (80 %)		Total losses
Cause of losses	Instrumental error	Error at meter replacement	Illegal consumption	Zero consumption, Estimation of billed water consumption	Surface leakage	Underground leakage	
Breakdown of NRW rate (%)	0.5	1.2	0.5	5.3	11.9	17.9	37.3
Percentage in the total losses	1	3	1	15	32	48	100

The comparison between measured volume of NRW and Qmnf in each month revealed that the ratio between the two (NRW/Qmnf) varied significantly among the subzones depending on the number of POCs in them: The ratio was around 50 % in PM1 and PM2 (each of which had a large area and more than 500 POCs), while the ratio was almost 100 % in PM2 with around 50 POCs. (See Attachment 2.10.)

2.10. 2 Changes in the number of leakage repairs (preparation of a map showing the locations of leakage repairs with Google Earth Map)

The locations of the leakage repairs conducted in the period between August 2017 and December 2018 were plotted on Google Earth Map (Figure 2.10.7). According to the record of the repairs, leakage repair was conducted at 10 locations/month, on average, in Kadobogo (compared with 28 locations/month, on average, in Ruyenzi. These figures reveal that water leakage occurred more frequently in Ruyenzi, where problems caused by high water pressure were more serious, than in Kadobogo. The map shows that, among the three subzones in Ruyenzi, a particularly large number of the repairs were conducted in RY1 where water was distributed directly from the Nzove Pumping Station through the pipeline that bypassed the Ruyenzi Reservoir).

The map also shows that, many leaks occurred from the existing (HDPE) pipes in Subzone PM1, which were replaced in February 2019, and a (200 m-long) distribution main in PM2 that was replaced in June 2018). As mentioned above, plotting the data of leakage repairs on a map enables visual presentation of areas prone to water leaks and the locations of leaking distribution pipes. Therefore, this method can be an important tool in the preparation of a plan for leakage reduction.

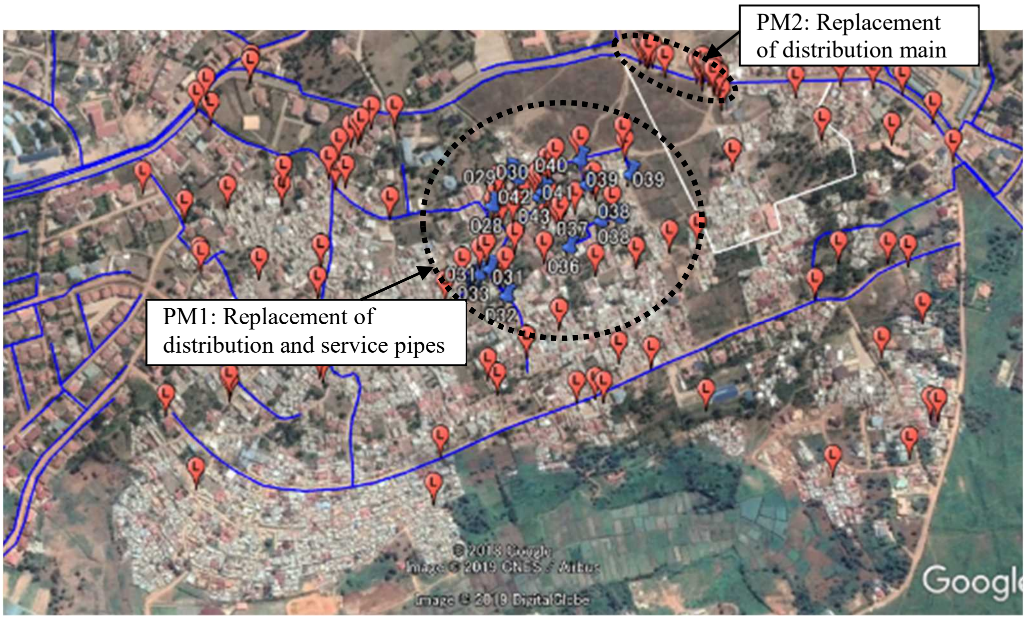
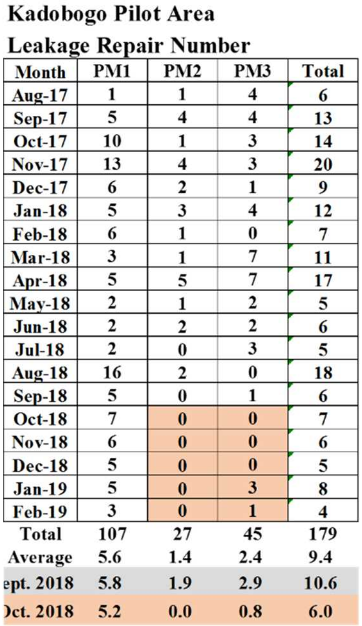


Fig 2.10.7 Plot of leakage repairs location in Kadobogo (Area 1)

The comparison of the numbers of leakage repair in PM2 and PM3 before and after the installation of PRVs shown in the figures below shows that the installation reduced the numbers of leakage repair in the two subzones to almost zero. Meanwhile, as there is no decrease in the number of leakage repair in PM1 without PRV installation. Therefore, PRV installation is proven to be very effective in NRW reduction.



Kadobogo Pilot Area

Leakage Repair Number

Month	PM1	PM2	PM3	Total
Aug-17	1	1	4	6
Sep-17	5	4	4	13
Oct-17	10	1	3	14
Nov-17	13	4	3	20
Dec-17	6	2	1	9
Jan-18	5	3	4	12
Feb-18	6	1	0	7
Mar-18	3	1	7	11
Apr-18	5	5	7	17
May-18	2	1	2	5
Jun-18	2	2	2	6
Jul-18	2	0	3	5
Aug-18	16	2	0	18
Sep-18	5	0	1	6
Oct-18	7	0	0	7
Nov-18	6	0	0	6
Dec-18	5	0	0	5
Jan-19	5	0	3	8
Feb-19	3	0	1	4
Total	107	27	45	179
Average	5.6	1.4	2.4	9.4
ept. 2018	5.8	1.9	2.9	10.6
)ct. 2018	5.2	0.0	0.8	6.0

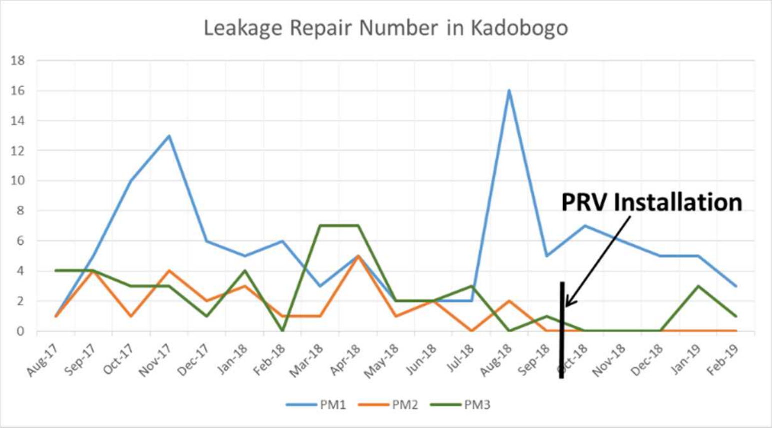


Fig. 2.10.8 Leakage repairs history of Kadobogo

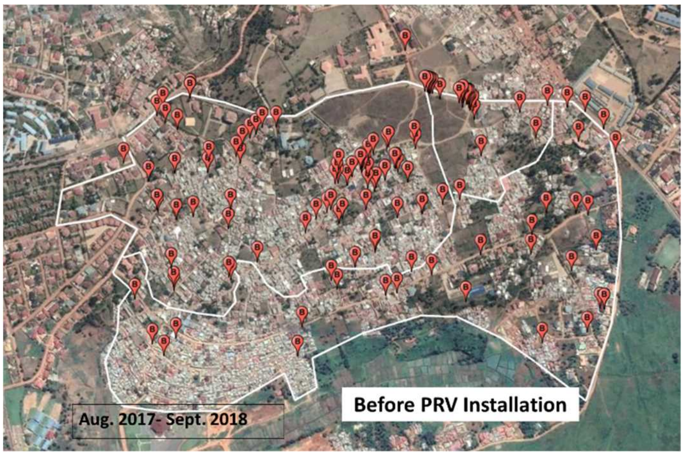
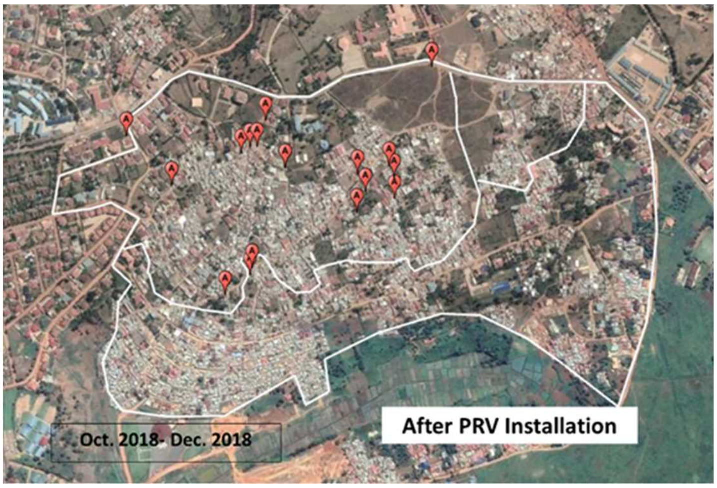


Fig. 2.10.9 Plot of leakage repairs location in Kadobogo



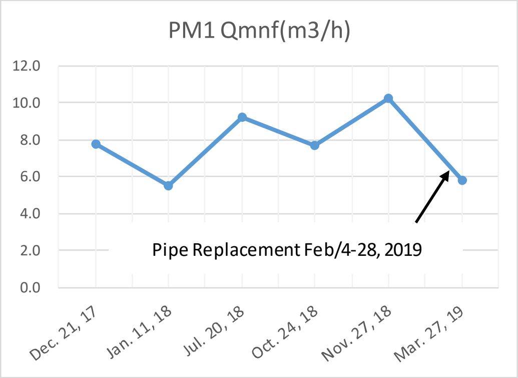
2.10.3 Changes in Qmnf

The measurement of the maximum night flow (Qmnf) is an effective method to monitor and evaluate water leakage. In Kadobogo, Qmnf was markedly reduced by NRW reduction activities of installing PRVs, detecting and repairing underground water leaks and replacing the service pipes, as shown in the figure below.

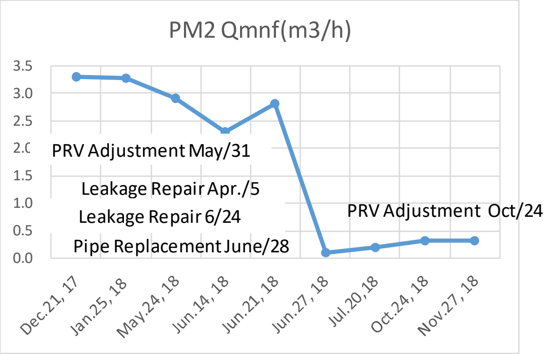
Omnf Trend

Kadobogo

PM1	Qmnf (m3/h)	P (bar)
Dec. 21, 17	7.8	-
Jan. 11, 18	5.5	10.5
Jul. 20, 18	9.2	
Oct. 24, 18	7.7	10.0
Nov. 27, 18	10.2	10.0
Mar. 27, 19	5.8	6.5



PM2	Qmnf (m3/h)	P (bar)
Dec.21, 17	3.3	2.0
Jan.25, 18	3.3	
May.24, 18	2.9	
Jun.14, 18	2.3	4.0
Jun.21, 18	2.8	
Jun.27, 18	0.1	
Jul.20,18	0.2	
Oct.24, 18	0.3	2.5
Nov.27, 18	0.3	2.5



PM3	Qmnf (m3/h)	P (bar)
Dec.21, 17	10.8	9.6
Jan.11,18	12.5	
Feb.23, 18	13.5	7.8
Jul.20, 18	9.3	
Oct.24, 18	5.8	5.5
Nov.27, 18	3.3	2.5
Dec.20, 18	2.9	2.5
Jan.29, 19	4.7	
Feb.6,19	3.5	

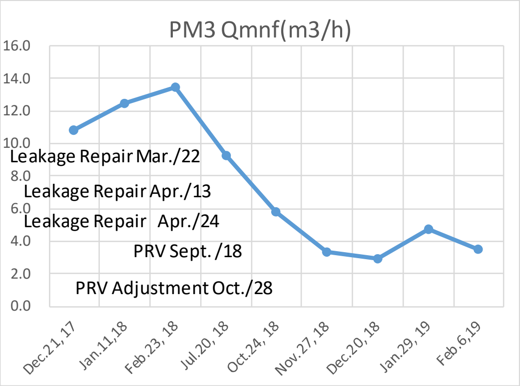


Fig. 2.10.10 Changes in Kadobogo Qmnf

The results of effects measurement of individual PRVs by Qmnf are as shown in the table below.

The reduction rate of Qmnf was measured from 30% to 80%. The results of the effects measurement of the PRVs installed in Ruyenzi are also shown in the table below, for comparison.

Table 2.10.7 Effects of Qmnf reduction after installation of PRVs

Kadobogo (Oct. 2018)

Qmnf Measurement	PM2		PM3	
	Pressure	Flow Rate	Pressure	Flow Rate
1. Baseline	7.0 bar	0.74 m3/h	7.5 bar	9.44 m3/h
2. Effect Measurement	2.5 bar	0.31 m3/h	2.0 bar	5.80 m3/h
3. Reduction Volume		0.43 m3/h		3.64 m3/h
4. Reduction Rate		58%		39%

Ruyenzi (Oct., Nov., 2018)

Qmnf Measurement	PRV1		PRV2		PRV3	
	Pressure	Flow Rate	Pressure	Flow Rate	Pressure	Flow Rate
1. Baseline	9.1bar	7.48 m3/h	8.7 bar	3.74 m3/h	4.0bar	1.84 m3/h
2. Effect Measurement	2.5 bar	1.50 m3/h	6.0bar	2.60 m3/h	0.8bar	0.78 m3/h
3. Reduction Volume		5.98 m3/h		1.14 m3/h		1.06 m3/h
4. Reduction Rate		80%		30%		58%

2.11 Cost-benefit analysis of NRW reduction activities

The implementation of the NRW reduction activities in the pilot project had led to the achievement of the NRW rate reduction target of the project for Kadobogo (Area 1). To evaluate the outcome of the implementation, a cost-benefit analysis of the activities was conducted.

(1) Method and conditions for cost-benefit analysis

i) Benefit and cost of activities

Benefit and cost of an activity were calculated as the differences between those when the activity was to be implemented (With-project) and when it was not to be implemented (Without-project).

ii) Conversion of benefit and cost to “present values”

Benefit is generated and cost is incurred over the years. For an activity that takes time to generate benefit, a value of benefit at a time different from the present is different from that of the same benefit at present. To compare benefit generated and cost incurred over the years, benefit and cost in each year were corrected to those in a reference year, “present values.”

$PV = A \times 1/(1+i)^n$,

where PV : Present value,

A : Benefit generated or cost incurred in the nth years after the implementation of an activity i : Discount rate = 6 % (the average of the consumer price index, inflation rate and bank interest rate in Rwanda for the past 10 years)

Net benefit is obtained by subtracting gross cost from gross benefit. A net present value (NPV) is obtained by subtracting net benefit in the case of Without-project from that in the case With-project.

$NPV = \Sigma\ (Bt-Ct)/(1+i)^{t}$,

where Bt : Benefit in the t th year

Ct : Cost in the t th year

T : Numbers of years after the completion

I : Discount rate

iii) Comparison of benefit and cost

Investment in an activity is considered appropriate if the benefit of implementing it is larger than the cost and the return of the investment is large. The implementation of an activity is considered appropriate if NPV > 0 and B/C > 1, where

- NPV : Net present value
- B/C : Benefit-cost ratio.

iv) Comparison of benefit and cost

The benefit is generated in the following two cases:

Case 1: Increase in the water bill revenue resulting from the increase in the volume of revenue water due to the NRW reduction; and

Case 2: Reduction in the water purification and supply cost (O&M cost) at a purification plant due to the water leakage reduction.

In practice, the quantitative effect of the leakage reduction was measured by the sales of water per water consumption in the service area of Kacyiru Branch (Case 1) and the reduction in the water purification and supply cost per volume at the Nzove Purification Plant, the source of the piped water (Case 2).

v) Miscellaneous issues

- The cost included the costs for the activities for NRW reduction (leakage survey and repair, replacement of meters, etc.) and for the preparation for the NRW reduction activities (installation of flow meters and chambers, etc.) in the pilot areas. The total costs of the project activities are shown below (See attachment 14 for details).

  Total cost including the cost of meter replacement : 64,567,000 RWF (8.39 million JPY)

Total cost excluding the cost of meter replacement : 41,515,000 RWF (5.40 million JPY)

- Period for the calculation: 10 years from 2018
- Values used in the calculation

  In the case of With-project: The actual NRW rate the volumes of billed and distributed water up to March 2019 were used.

  In the case of Without-project: The NRW rate was expected to decrease by 2 % per year. The same value of the volume of billed water as the case of With-project was used. The volume of distributed water was calculated from the volume of billed water using the NRW rate.

  While the values for 2018 were actual values, those for 2019 and later were estimated from the actual values in 2018.
- Water price:

Selling prices:	567 RWF/m3 in Kacyiru and 592 RWF/m3 in Nyarugenge (monthly averages in 2018)
Purified water production cost:	319 RWF/m3 at the Nzove Purification plant (monthly averages in 2018)

The table below shows the total monthly volumes of the billed water in 2018 and the water bills per POC (Frw/POC) and those per the water consumption (Frw/m3) in Kacyiru and Nyarugenge Branches. While the water bills included tax, fee for meter rental (100 Frw) and regulator fee, the average of the water bills per m3 exclusive of the tax and the fees were used in the cost-benefit analysis.

Table 2.54 Monthly average water bill (2018)

Item	Unit	Kacyiru	Nyarugenge	All 20Branch
POC		18,413	18,127	192,349
Consumption	m3	338,058	339,915	2,403,970
Unit Consumption	m3/POC	18.4	18.8	12.5
Billing	Frw	191,590,224	201,278,615	1,232,017,358
Billing/POC	Frw/POC	10,405	11,104	6,405
Billing/m3	Frw/m3	567	592	512

(2) Calculation of benefit

Fig. 2.29 shows the benefit of the project implementation. While the baseline NRW rate was the same in both With- and Without- Project cases, the rate decreased significantly in the cases of With-Project with the implementation of NRW reduction activities. Therefore, there is a difference between the volume of distributed water in the case of Without-Project calculated from the volume of billed water and the actual volume of distributed water in the case of With-Project and the difference between the two shows the volume of the leakage reduction. The benefit is obtained by multiplying the volume of the leakage reduction by the cost of the water supply per volume.

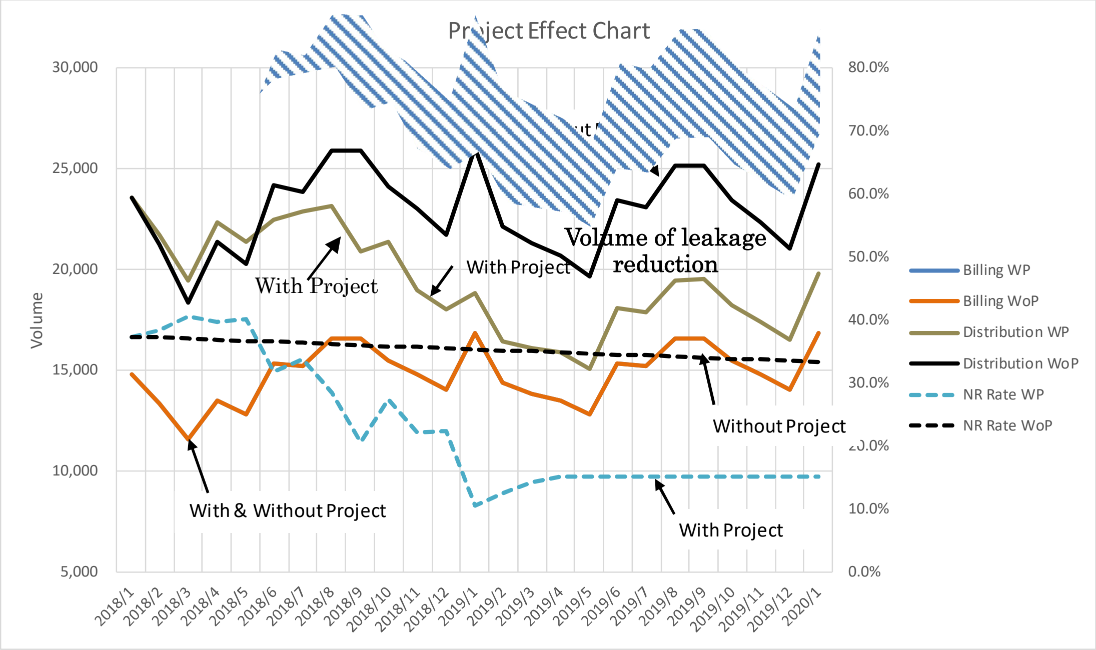


Fig.2.11.1 Diagram used for cost-benefit analysis of NRW reduction activities in Kadobogo

① Overall effect of pilot project in Kadobogo

While the result of the cost-benefit calculation is shown in Attachment 2.11, it is summarized as follows:

In the case where the meter replacement is not included, the benefit is expected to exceed the cost and profit is expected from the first year on after the completion of the main project activities, if the surplus water generated by the NRW reduction is sold, and from the second year on, if the production of purified water is reduced by the volume of NRW reduction. The table below shows the cumulative NPV and B/C in the fifth year after the completion of the project activities. The table suggests that the NRW reduction activities are expected to have a large effect.

Table 2.11.2 Summary of result of cost-benefit calculation (benefit in the 5th year)

Case	NPV(RWF)	NPV(Yen)	B/C	Use
1-1	145,992,177	18,979,000	5.0	Water Selling
1-2	66,144,373	8,599,000	2.8	Saving Production
2-1	122,940,739	15,982,000	3.1	Water Selling
2-2	43,092,935	5,602,000	1.7	Saving Production

Table 2.11.3 Effect of selling surplus water generated by NRW reduction (meter replacement is excluded)

Project Effect Case 1-1

Selling of Surplus Water made by NRW Reduction Activities

Year		Effect of the Project (RWF)			
		Benefit	Cost	NPV	B/C
Project	2018	9,792,908	37,521,482	-27,728,574	0.3
1	2019	48,484,569	37,306,840	11,177,728	1.3
2	2020	84,986,136	37,104,349	47,881,788	2.3
3	2021	119,421,577	36,913,318	82,508,259	3.2
4	2022	151,907,842	36,733,101	115,174,741	4.1
5	2023	182,555,262	36,563,085	145,992,177	5.0
10	2028	311,653,343	35,846,915	275,806,428	8.7

Table 2.11.4 Effect of reducing water production by volume of NRW reduction (meter replacement excluded)

Project Effect Case 1-2

Saving of Production Cost by Deducting Surplus Water

Year		Effect of the Project (RWF)			
		Benefit	Cost	NPV	B/C
Project	2018	5,509,590	37,521,482	-32,011,892	0.1
1	2019	27,277,914	37,306,840	-10,028,926	0.7
2	2020	47,814,070	37,104,349	10,709,721	1.3
3	2021	67,187,801	36,913,318	30,274,482	1.8
4	2022	85,464,906	36,733,101	48,731,805	2.3
5	2023	102,707,458	36,563,085	66,144,373	2.8
10	2028	175,339,359	35,846,915	139,492,444	4.9

Table 2.11.5 Effect of selling surplus water generated by NRW reduction (meter replacement included)

Project Effect Case 2-1

Selling of Surplus Water made by NRW Reduction Activities

Year		Effect of the Project (RWF)			
		Benefit	Cost	NPV	B/C
Project	2018	9,792,908	60,572,920	-50,780,012	0.2
1	2019	48,484,569	60,358,278	-11,873,710	0.8
2	2020	84,986,136	60,155,787	24,830,350	1.4
3	2021	119,421,577	59,964,756	59,456,821	2.0
4	2022	151,907,842	59,784,539	92,123,303	2.5
5	2023	182,555,262	59,614,523	122,940,739	3.1
10	2028	311,653,343	58,898,353	252,754,990	5.3

Table 2.11.6 Effect of reducing water production by volume of NRW reduction (meter replacement included)

Project Effect Case 2-2
Saving of Production Cost by Deducting Surplus Water

Year		Effect of the Project (RWF)			
		Benefit	Cost	NPV	B/C
Project	2018	5,509,590	60,572,920	-55,063,330	0.1
1	2019	27,277,914	60,358,278	-33,080,364	0.5
2	2020	47,814,070	60,155,787	-12,341,717	0.8
3	2021	67,187,801	59,964,756	7,223,044	1.1
4	2022	85,464,906	59,784,539	25,680,367	1.4
5	2023	102,707,458	59,614,523	43,092,935	1.7
10	2028	175,339,359	58,898,353	116,441,006	3.0

② Evaluation of the individual NRW reduction activities in the pilot project

The table below summarizes the result of the cost-benefit analysis of the NRW reduction effect of the replacement of water supply and distribution pipes and installation of PRVs (See Attachment 14 for details). All these activities began to show their effect quickly, as they began to generate benefit larger than the cost between one and ten months after the completion of the activities.

Table 2.11.7 Cost-benefit analysis of installation of PRVs and replacement of water supply and distribution pipes

Kadobogo

Activity	Area	Cost Recovery Month			Qmnf Effect
		Month	NPV (RWF)	B/C	m3/h
Pipe Replacement	PM1	8th	1,186,196	1.2	2.28
PRV Setup	PM2	6th	258,324	1.3	0.43
	PM3	2nd	1,177,220	1.7	3.64

Ruyenzi

Activity	Area	Cost Recovery Month			Qmnf Effect
		Month	NPV (RWF)	B/C	m3/h
PRV Setup	PRV1	1st	342,168	1.2	5.98
	PRV2	10th	308,829	1.1	1.14
	PRV3	3rd	373,155	1.4	1.06

Chapter 3 Lessons Learned and Recommendations Derived from Pilot Project

1. Notes on smooth implementation of activities

It took much longer than planned to implement the pilot project activities (29 months compared with 20 months planned at the commencement of the project). The first reason for this significant extension is that it took long to create DMAs in the pilot area (to study the pipe distribution network drawing, to isolate the entire area and subzones in it hydraulically, to confirm the locations of POCs, to create a list of customers in the area, etc.) because the available information on customers and GIS data were not sufficient for the creation of DMAs and they had not been collected systematically. It also took long to construct the facilities for flow rate measurement (to conduct a field survey, to procure equipment and to install chambers and equipment) at the inlet points.

The implementation period was extended after the commencement of the activities largely because the monthly changes in NRW rates in the pilot projects were analysed to deduce obstacles to NRW reduction and activities against the obstacles which were not in the original PDM (*i.e.*, water pressure control and replacement of distribution and service pipes) were implemented in the project in accordance with the RD revised in the discussion on the additional activities in a SC meeting. It was also necessary to try a new activity when a planned activity had not produced expected effects.

The design of the method for the evaluation of activity also contributed significantly to the extension. To evaluate the effect of each activity with NRW rates, it was so arranged that two or more activities would not be implemented simultaneously. A period was set aside after the completion of an activity for the realisation of its effect and no activity that would have directly affect NRW reduction was implemented in this period. Qmnf was measured in the baseline survey and after the completion of an activity to evaluate its effect. A long time was spent on these evaluation activities.

In addition, activities could be implemented on limited days because of the water rationing, which was sometimes not performed as scheduled. Water supply was suspended frequently for leakage repair. Because the number of valves installed on the pipes is small, such suspension affected water supply in a wide area. For these reasons, the customer meter survey and field survey of water leaks could be implemented on limited days and activities had to be suspended suddenly in many occasions. When water outage occurred during the data logging in the night, the data logging had to be conducted anew.

It is necessary to understand that it takes long to implement a pilot project as mentioned above. While an activity which has been confirmed to produce a good effect should be included in the ordinary work of WASAC without reservation and implemented smoothly, the following points should be noted:

Accuracy of pipe distribution drawings

An accurate pipe distribution drawing is the most important basic material in a leakage survey. However, there are many discrepancies between pipe distribution drawings and actual pipe distribution. When the hydraulic isolation plan and the step test of leakage survey are implemented, it is necessary to listen to the opinions of staff members of branch offices who know the site and, if necessary, conduct test excavation to confirm the locations and conditions of pipes. It is necessary to create a pipe distribution drawing of each main branching point in a pipeline network or each place where many pipelines run in a complicated pattern. It is important to recognize the importance of the pipe distribution drawings and update GIS data steadily and continuously when, for example, there is a discrepancy between GIS data and condition at the site.

Inclusion of new customer data in NRW rate calculation

It is necessary to add monthly billed water consumption of new customers in the area to the calculation of NRW rate. However, it is not possible to confirm whether a new customer is in the area on the drawings without the x-y coordinates of their POCs. The acquisition of the positional information of x-y coordinates of a new customer at the conclusion of a service contract will make it possible to decide whether the new customer is in the area on Google Earth.

Moreover, if a map that displays the boundaries of pilot areas as GIS data is available, it will be possible to verify whether a new customer is in the area. Such a map will enable a CFO, for example, to verify the location of a new customer and give a DMA code to this new POC on site with a mobile terminal. If a system to give a DMA code to a new customer is developed, such a system will enable automatic calculation of a total billed water consumption in a DMA and eliminate the need to identify customers in a DMA from the national POC database and collect the data of billed water consumption of the identified customers with the VLOOKUP function of Microsoft Excel in the calculation of NRW rates

Table 2.1.1 shows the numbers of new customers in 2018. The average numbers of new customer per month in the entire service area and the pilot area of Nyarugenge Branch were 130 and 12, respectively. These numbers were much larger than the corresponding numbers of Kacyiru Branch, 78 and 3 respectively.

Table 3.1.1 Numbers of new customers in 2018

Item	Branch	Kacyiru	Nyarugenge
Branch	Year 2018	937	1,560
	Aver. per month	78	130
Pilot Area	Year 2018	37	150
	Aver. per month	3	12

Creation of maps of sites of leakage repairs with Google Earth Map

Plotting the data of past leakage repairs on a map enables visualisation of areas prone to water leaks and locations of problematic water pipes and the plotted map is useful in the preparation of a water leakage reduction plan. Kacyiru and Nyarugenge Branches began to measure x-y coordinates of the sites of leakage repairs and described them in the record sheet by hand in August 2017. Since June 2018, they have been using personal computers to enter the data into the form provided in the five-year strategic plan (5YSP). Accurate recording and sorting of all leakage repair data in a personal computer in routine work is essential for the analysis of past water leaks and preparation of a work plan for NRW reduction activities. Microsoft Excel is a useful tool for the data analysis.

The Excel data sheet should be so designed that entered data can be easily used in the analysis. The following points should be noted when the data are entered into the form provided in 5YSP:

- Enter x-coordinate and y-coordinate data into separate cells.
- Enter the names of district, sector, cell and village, all of which are required for the analysis, into separate cells.
- When continuous repair of leaks has not reduced the number of the repairs, install PRVs or replace distribution pipes. Confirm whether the number of leakage repairs has fallen after an activity against it was taken to evaluate the effectiveness of the activity.

Creation of DMAs and development of distribution reservoirs

Although the creation of DMAs is necessary for the calculation of NRW volume/rate (maintenance of pipe distribution network), it is not recommended strongly because it is very labour-intensive, time-consuming and costly. However, in an area in which a specific arrangement of distribution pipelines allows easy hydraulic isolation (by isolating distribution pipelines by cutting them or installing valves on them), the creation of DMAs is recommended. While installation of a water flow meter is required if an amount of water distribution is to be measured in a distribution reservoir, a portable UFM can be used if it is to be measured in a distribution network.

If an activity implemented in the pilot area has been demonstrated to have a positive effect without conducting its evaluation, such activity will produce the same effect in any other areas. The NRW reduction activities may have various different types of activities and a DMA with a large area may be created for each distribution reservoir.

A distribution reservoir is an important facility for the water pressure control and leakage management for NRW reduction, as mentioned above. A plan for the construction of new reservoirs and large-scale renovation of the existing ones will be developed in the preparation of MP by AfDB and JICA. However, WASAC should examine the current state of the reservoirs and prepare measures for their improvement by itself to address issues at hand, including the use of bypass pipelines and DMA creation, without waiting for the development of the above-mentioned plan.

Ancillary facilities of pipe distribution network

As the shortage of control valves in the pipe distribution network is evident, the installation of the valves at the major branching points in the network must be promoted. While the installation of a control valve will reduce the size of an area affected by suspension of water supply for repair work, the installed valves can be used for water pressure control to a certain extent. They will also make it easy to conduct the step test in the leakage survey.

2. NRW Reduction Activities

Reduction of high water pressure

A feature of the topography of Kigali is its severely undulating topography. Residences have been formed on the slopes and bottoms of hills, so the water supply and distribution facilities are extremely complex. The facilities have been developed only for the purpose of transmitting and distributing sufficient amount of water, and countermeasures against water pressure have not been taken into consideration. Therefore, there are high water pressures in the distribution pipes, and as a result, water leakages can easily occur.

The record of regular leakage repairs in the pilot area indicates that repair work has been conducted repeatedly at the same leak points discovered in an area where the water pressure in the water pipe is high because water leaks have often recurred after the repair at these points. On average, 10 and 28 repair works had been conducted every month in Kadobogo and Ruyenzi, respectively. The effect of the decrease of the water pressure with the installation of PRVs on the reduction of water leakage has been demonstrated as the pressure reduction has reduced the water leaks markedly.

Unless the high water pressure in the water pipes is reduced, the leakage repair will have limited effect on NRW reduction. The best expected in this case is the maintenance of the current condition with no NRW reduction.

Quality of material of distribution and service pipes and their installation

In almost all cases, the cause of the leaks is on water supply pipes or small-diameter water distribution pipes. From the installation location conditions, HDPE pipes that are easy to construct are widely used.

However, procurement of the pipe that is used is entrusted to the residents, so the material quality is poor (from various aspects such as price, and local availability), and material is not selected by taking into account pressure resistance. Therefore, in many cases, the HDPE pipe cannot withstand the high-pressure and splits causing water leaks.

In high-pressure areas, it is naturally desirable to reduce the pressure as a first priority, but this is difficult to implement. Therefore, it is necessary at least to place importance on material selection to ensure a pressure resistance of (16 bar). In many cases similar type materials are not used, and pipe materials that are different from HDPE, PVC, and SP and moreover that have different pressure resistance are combined to construct the water supply pipe including the upstand parts for the meter, but water leaks can easily occur at the joints. The importance of preventative measures such as compliance with standardized equipment, uniform materials, etc., is recognized. Therefore, the procurement of the materials by customers should be prohibited and WASAC should take the lead in the procurement and installation of the pipes.

Ideal leakage survey

The importance of measuring flow rates (Qmnf) has been recognised in the leakage survey. Measurements of Qmnf can be used for evaluating the extent of water leaks. The step test can be used for narrowing down areas prone to water leaks, which may lead to the identification of points of invisible water leaks and visible leaks that have not been noticed (or reported). A total volume of water leakage from an unnoticed leak point tends to be large because water has leaked from the point for a long time until the leaking pipe is found and repaired.

However, it is not easy to conduct the leakage survey. The existing pipe network has not been developed systematically. Pipes are installed in a complicated pattern and it is very difficult to locate them. The number of valves installed at branching points was small and some of them were not functioning. These circumstances have made the flow rate measurement labour-intensive, time consuming and costly. In other words, large amounts of labour, time and money have to be used for the selection of the sites of UFM installation, excavation at the selected sites to reveal pipes, installation of new valves or replacement of defective valves for the implementation of the step test and multi-point measurement with UFMs when and where it is not possible to implement the step test.

Even if leaking pipes had been identified, a leak noise correlator could not be used to locate a leak point because it was difficult to find two contact points of its sensors on a pipeline because a few valves were installed in the distribution network. It was also difficult to locate leak points with acoustic leak detector because pipes in the ground could not be located precisely, road surface was not paved and resin pipes were used. In the end, leak points had to be identified with repeated excavation of potential leak sites inferred from depressions on the ground and vegetation.

Because of the poor installation of pipe distribution network and ancillary facilities mentioned above, it is particularly difficult to find invisible underground water leaks. However, many visible water leaks that had been unnoticed were discovered in the Pilot Project. When the results of the monitoring of NRW rates and Qmnf suggest the existence of large water leakage, the detection of unnoticed leaks should be prioritised. Invisible underground water leaks may be discovered in the detection process.

Commercial activities

It was revealed that the losses caused by zero billed water consumption and in the estimation of billed water consumption was likely to account for a large proportion of apparent losses. Therefore, NRW reduction requires the reduction in the number of cases of water consumption estimation and zero consumption. Accurate meter reading is the minimum requirement for NRW reduction. Therefore, POC maps should be updated constantly (by entering the data of new customers and correcting the existing data) and CFOs should carry gadgets that enable them to view the POC maps and affix POC stickers on the gates of customers' houses and buildings to provide CFOs, who are casual workers, with quick access to customer meters. Appropriate measures shall be taken on a broken-down or defective meter immediately after the breakdown or defect is discovered in the meter reading or reported by a customer. If the water consumption in the current month is much larger or smaller than that in the previous month, a cause (or causes) of the difference must be identified.

3. Procedure for NRW reduction

The pilot project revealed that water leakage was a major cause of NRW. It also revealed that the high water pressure in the water pipes and poor quality of piping materials were the causes of the leakage. Based on these findings, the use of the work procedures mentioned below is recommended for the implementation of effective NRW reduction activities.

- WASAC has been busy repairing water leaks month after month. However, water leaks recur after the repair. It is important to reduce the number of the leakage repairs not only for NRW reduction but for the improvement of the current work condition in WASAC.
- The cause of the recurrent water leaks is the high water pressure in the water pipes. Pressure control with PRVs is an effective means to reduce the leaks immediately in a wide area. However, the pressure control has limited effect on NRW reduction because it is only effective for the prevention of water leakage.

- The leakage repair is useless unless it is implemented after the pressure control has been established.
- If NRW increases after the installation of PRVs, conduct the leakage survey to discover unnoticed leak points, including those of underground leaks. Also conduct a study to find causes other than water leakage that may have increased NRW.
- Qmnf measurements and NRW rates are used for the estimation of the volume of water leakage. However, the two estimation methods do not always give the same estimate. Monthly error variance is generated in the estimation with NRW rates, because the period for the calculation of a total billed water consumption and that for the measurement of the volume of distributed water are different. The estimation with NRW rates is also influenced by other factors. Therefore, the use of Qmnf measurements is recommended for the water leakage estimation.
- Although the pressure control and leak repair are expected to reduce the volume of water leakage temporarily, the replacement of the distribution and service pipes of poor quality is required for the permanent reduction of water leakage.
- Sites at which the replacement of distribution and service pipes is required can be inferred from a map on which the sites of past water leaks are plotted. It is also important to listen to the views of staff member of the branch offices who know the sites well when the sites for the replacement is to be decided.

The workflow and work procedures prepared with the above-mentioned points taken into consideration are shown in the figure below (Fig. 3.2) and Attachment 2.10, respectively.

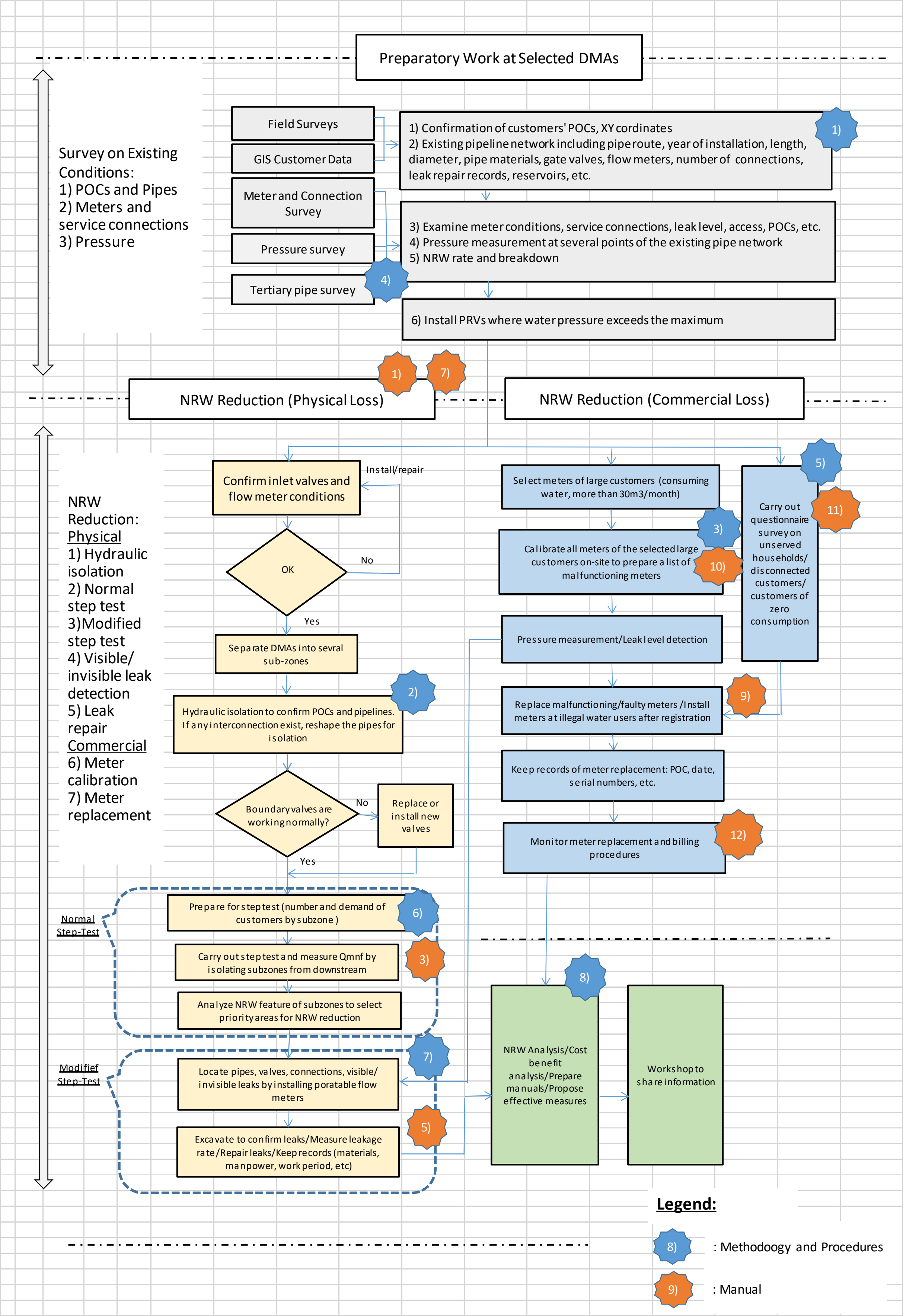


Figure 3.2 Workflow for NRW reduction

Draft work procedures:

1） Methodology and Procedures for POC Survey（See attachment 20-1 for details）
2） Methodology and Procedures for Hydraulic Isolation（See attachment 20-2 for details）
3） Procedures for CLR (Commercial Loss Reduction)-Meter calibration（See attachment 20-3 for details）
4） Methodology and Procedures for Tertiary Pipe Survey（See attachment 20-4 for details）
5） Procedures for CLR-Questionnaire Survey（See attachment 20-5 for details）
6） Procedures for PLR (Physical Loss Reduction) -Normal Step Test（See attachment 20-6 for details）
7） Procedures for PLR-Modified Step Test（See attachment 20-7 for details）

Draft manuals:

Manual-1 Method and Classification of Leak detection
Manual-2 Occurrence and transmission of leakage sound
Manual-3 Handling and attention to use Ultrasonic Flow Meter and Electromagnetic Flow Meter
Manual-4 Analysis of acoustic (sound) investigating
Manual-5 Leak detection
Manual-6 Standard flow of investigation For LDPM_eng
Manual-7 Flow Chart of Leak detection work_rev
Manual-8 Principle of correlation
Manual-9_Meter and Specification
Manual-10 Onsite Meter Calibration
Manual-11 Questionnaire Survey-Design Format
Manual-12 Excel Spreadsheet & Customer Database Analysis

4. Other points of note

4.1 Regular monitoring

Water leaks tend to recur. If a site of a water leak has been identified and the leak has been repaired, the repair often leads to a water leak at another site particularly in an area where pipes of low-quality material are used and the water pressure in these pipes is high. Therefore, it is important to monitor the condition of water distribution pipelines regularly and perform the leakage survey whenever an abnormality has been found.

The measurement of minimum night flow, study of the record of leakage repairs and measurement of NRW rates (ratio of total billed water consumption to the volume of distributed water) may be used for the monitoring.

4.2 Reduction in water leakage with measures against NRW

It is important to plan the use the surplus water generated with NRW reduction (or the water that used to leak from water pipes) after NRW has been reduced. It will be used for 1) supplying water to unconnected households and supplementing the shortage of water supply and 2) adjusting (reducing) the water production. The plan for the use of the surplus water will be incorporated in a water distribution plan and water resource development plan to be developed.

It is necessary to prepare and implement a facility development plan and a plan for the operation of the water transmission and distribution system for each of the two purposes of the use of surplus water. Otherwise, the surplus water generated by the leakage reduction cannot be utilised and the leakage reduction activities will be meaningless. More specifically, the plans should include 1) the extension and improvement of the existing pipe distribution network (including construction of distribution reservoirs) and 2) the control of pumped water transmission (by controlling the number of operating pumps and controlling switches of pumps in accordance with a water level in a reservoir) and water distribution..

As mentioned in 2.10.1(1), it will be necessary to develop water transmission and distribution facilities required for not allowing a water supplier to take the lead in water distribution in a distribution area (or for the separation of distribution and service pipes).

4.3 Facility plan

A distribution reservoir not only controls the volume of water distribution, but also reduces water pressure in water pipes. At many places, water is distributing through pipelines bypassing a reservoir to transmit water to high altitude and to prevent overflow of the reservoirs. The use of these bypass pipelines has led to the distribution of highly pressurised water, which has been a cause of water leakage, in an intended water distribution area. Water distributed through a pipeline that directly branches off from a transmission pipeline is highly pressurised and the distribution of such water has caused water leaks.

While the ideal is to revise the distribution block division based on the re-development of distribution reservoirs, what is basically important is to develop facilities that facilitate the implementation of measures for NRW reduction from the beginning of the project.

6. Improvement of working environment in WASAC

Reduction of leakage repairs

When the occurrence of water leaks has been reduced with the reduction of water pressure in water pipes, the branch offices, which are very busy with the leakage repair, will be able to save the time and labour currently used for the leakage repair and they will need less frequent suspension of water supply for leakage repair. They will be able to improve customer services and implement NRW reduction activities smoothly using the saved time and labour and taking advantage of less frequent suspension of water supply.

Surveys in Night

In principle, the leakage surveys, including the measurement of Qmnf, step test and leak detection, are recommended to be performed in the night because there is no water consumption or noise in the night. However, it is recommended not to perform the surveys in the night, if possible, in this project because of the time and labour required for notification to WASAC and district offices, safety control and working time management. While water flow meters have an automatic logging function, an external battery is required when a meter is to be used where the commercial power supply is not available. The step test may be conducted in the hours in the daytime when water consumption is relatively small.

【Appendix】

1.Materials for Workshops and Conferences related to Activities

1.1 Member List of Project Organization Structure

Member List of Project Organization Structure

No	Position	Field in Charge	Name	Duration	
				From	To
Steering Committee (SC)					
1	Chairman	CEO of WASAC	James Sano	Aug, 2016	Sept. 2017
			Aime Muzora	Sept, 2017	Present
2	Project Director	Director of UWSS	Methode Rutagungira	Aug, 2016	Present
3	Project Manager	Manager of NRW, UWSS	Jean Berchmas Bahige	Aug, 2016	Present
4	Management Team			Aug, 2016	Present
5	Officials from MINIFRA			Aug, 2016	Present
Project Director and Manager					
1	Project Director	Director of UWSS	Methode Rutagungira	Aug, 2016	Present
2	Project manager	Manager of NRW, UWSS	Jean Berchmas Bahige	Aug, 2016	Present
Management Team (9 persons)					
1	Leader	Director of UWSS	Methode Rutagungira	Aug, 2016	Present
2	Co-leader	Director of CS	Lucien Ruterana	Aug, 2016	Sept. 2017
			Felix Gatanazi (Acting)	Sept. 2017	March, 2018
			James Mwijukye	March, 2018	Present
3	Co-leader	Director of CFO	Joseph Ruhingura	Aug. 2016	Sept. 2017
			Samson Hategekimana (Acting)	Sept. 2017	March, 2018
			Ceaser Nkusi Nkwesi	March, 2018	Present
4	Member	Manager of NRW, UWSS	Jean Berchmas Bahige	Aug. 2016	Present
5	Member	Manager of Water Operation Services, UWSS	Innocent Gashugi	Aug. 2016	Present
6	Member	Manager of Utility Planning Services, UWSS	Dominic Murekezi	Aug. 2016	Present
7	Member	Manager of Production services	Monia Logba		
8	Member	Manager of Revenue Management Services, CS	Alex KANSIIME	March, 2018	Present
9	Member	Head of billing and revenue collection, CS:	Désiré Kayiru	Aug. 2016	Present
10	Member	Manager of Customer Service Management, CS	Felix Gatanazi	Aug. 2016	Present
11	Member	Head of Marketing	Marie Therese Masimbi	Jan. 2016	Present
Action Team (31 persons)					
1	Leader	Head of leak detection and pressure management, NRW, UWSS	Désiré Ntamuturano	Aug. 2016	Present
2	Co-Leader	Kacyiru Branch Manager	Musabyeyez Jeanne	Aug. 2016	Present
3	Co-Leader	Gikondo Branch Manager	Mutamba Jane	Aug. 2016	Sept. 2017
			Tuyisenge Vedaste	Sept. 2017	Present
4	Co-Leader	Nyarugenge Branch Manager	Byamugisha Bernard	Aug. 2016	Sept. 2017
			Saranda Catherine		
5	Co-Leader	Nyamirambo Branch Manager	Saranda Catherine	Sept. 2017	Present
6	Co-Leader	Kanonbe Branch Manager	Aimable Ndagijimana	Aug. 2016	Sept. 2017

			Mukiza Anaclet	Sept. 2017	Present
7	Co-Leader	Remera Branch Manager	Gilbert Mulindabigwi	Aug. 2016	Present
8	Member	Head of zoning and mapping services, NRW, UWSS	Jean Paul Kayitare	Aug. 2016	Present
9	Member	Head of water distribution services, WOS, UWSS	Anselme Mugabo Kimenyi	Aug. 2016	Sept. 2017
			Celestin Mwambutsa	Oct. 2017	Present
10	Member	Leak detection and pressure management Officer	Celestin Mwambutsa	Aug. 2016	Oct. 2017
11	Member	Fraud Investigation Officer	Viateur Munyanshongore	Aug. 2016	Present
12	Member	Mapping Officer	Claudien Mazimpaka	Aug. 2016	Present
13	Member	Head of meter management services	Felecien Niringiyimana	Oct. 2016	Present
14	Member	Water Distribution Officer of each Branch			
		Nyarugenge Branch	Jean d'amascene Nsengimana	Aug.2016	Sept. 2017
			Etienne Rutagengwa	Oct.2017	Present
		Kacyiru Branch	Claudien Rwabuneza	Aug. 2016	Sept. 2017
			Patrick		Present
		Remera Branch	Etienne Rutagengwa	Aug. 2016	Sept. 2017
			Jean d'amascene Nsengimana	Oct.2017	Present
		Gikondo Branch	Egide Iyakare	Aug. 2016	Present
		Kanombe Branch	Antoine Muhawenimana	Aug. 2016	Sept. 2017
			Mukimbiri Pierre Claver	Oct. 2017	Present
		Nyamirambo	Mukimbiri Pierre Claver	Aug. 2016	Sept. 2017
			Noel Kanamugire	Oct. 2017	Present
15	Member	Customer Service Officer of each Branch			
		Nyarugenge Branch	Alexandre Ngamije	Aug. 2016	Present
		Kanombe Branch	Laetita Uwamahoro	Aug. 2016	Present
		Kacyiru Branch	Theodosie Nyirabunori	Aug. 2016	Present
		Nyamirambo Branch	Theddy Karwanyi	Aug. 2016	Present
		Gikondo Branch	Claude Mukiza	Aug. 2016	Present
		Remera Branch	Jeannete Uwimana	Aug. 2016	Present
16	Member	Billing Officer of each Branch			
		Nyarugenge Branch	Julienne Murekatete,Yvonne Mugiraneza,Caritas	Aug. 2016	Present
		Kanombe Branch	Justin Nibishaka,Hortense Murorunkwere	Aug. 2016	Present
		Kacyiru Branch	Regine Umurungi	Aug. 2016	Present
		Gikondo Branch	Particie Uwera	Aug. 2016	Present
		Nyamirambo Branch	Tharca Uwingabiye	Aug. 2016	Present
		Remera Branch	Peace Uwamahoro and Adelaide Dusabenimana	Aug. 2016	Present

1.2 Area Selection

Survey report of each

Made by Chiaki Suzuki, JICA Expert

1. Selection requirements

(1) Possibility of isolation: Isolation does not affect high turbidity, low pressure and low quantity. Possible to set the inlet and outlet points within 2 or 3. Also number of household in the pilot plant less than 500.
(2) Possibility of 24 hours and 7 days water supply.
(3) Distribution map accuracy: It makes not only pipeline but also valves, fire hydrant, flashing valves and air valves. Also averrable to location of branch points.
(4) Installed water meter at every households.
(5) Leakage occur situation: Pipeline is aged, new pipeline but material does not appropriate or pressure is high.
(6) Possibility of leak detection: Kind of pavement and location of valves and water meters.

2. Comparison of each Pilot Area

No.	Candidate Area / Requirement	NYARUGENGE			NYAMIRAMBO			GIKONDO	KACYIRU			
		GATSATA (Reduction)	KIMISAGARA Market	RUNDA	RWEZAMEYO	RWARUTABURA	RWAMPALA	NIBOYE	BATSINDA	KIYOVU	GAPOSHO	KAMUTWA
1	Possibility of isolation	○	○	× 1500 households	× Located in 2 branches	○	○	× To much households	△ Too much households	○	×	× Too much households
2	24 hours and 7 days water supply	△ Not averrable in the morning	○	○	No research	○	○	×	○	○	○	○
3	Distribution map accuracy	△	○	×	No research	△	○	△	○	○	○	○
4	Install water meter at every households	○	○	○	No research	○	○	No research	○ Too much public taps	○	No research	○
5	Leakage occur situation	No research	No research	○	○ High pressure	○	○ High pressure	No research	×	○	× New housing area	No research
6	Possibility of leak detection	× Undulation and no pavement	×	×	No research	×	△ Stone Road	× Low pressure	×	△	○	× Diplomatic area
	Evaluation			6		9	11		7	11		

Legend of evaluation　Good: 2 points　Average: 1 point　Bad: 0 point.　JICA Expert Team will support the RUNDA and KIYOVU Pilot Plant.

Survey report of each

Made by Chiaki Suzuki, JICA Expert

1. Selection requirements

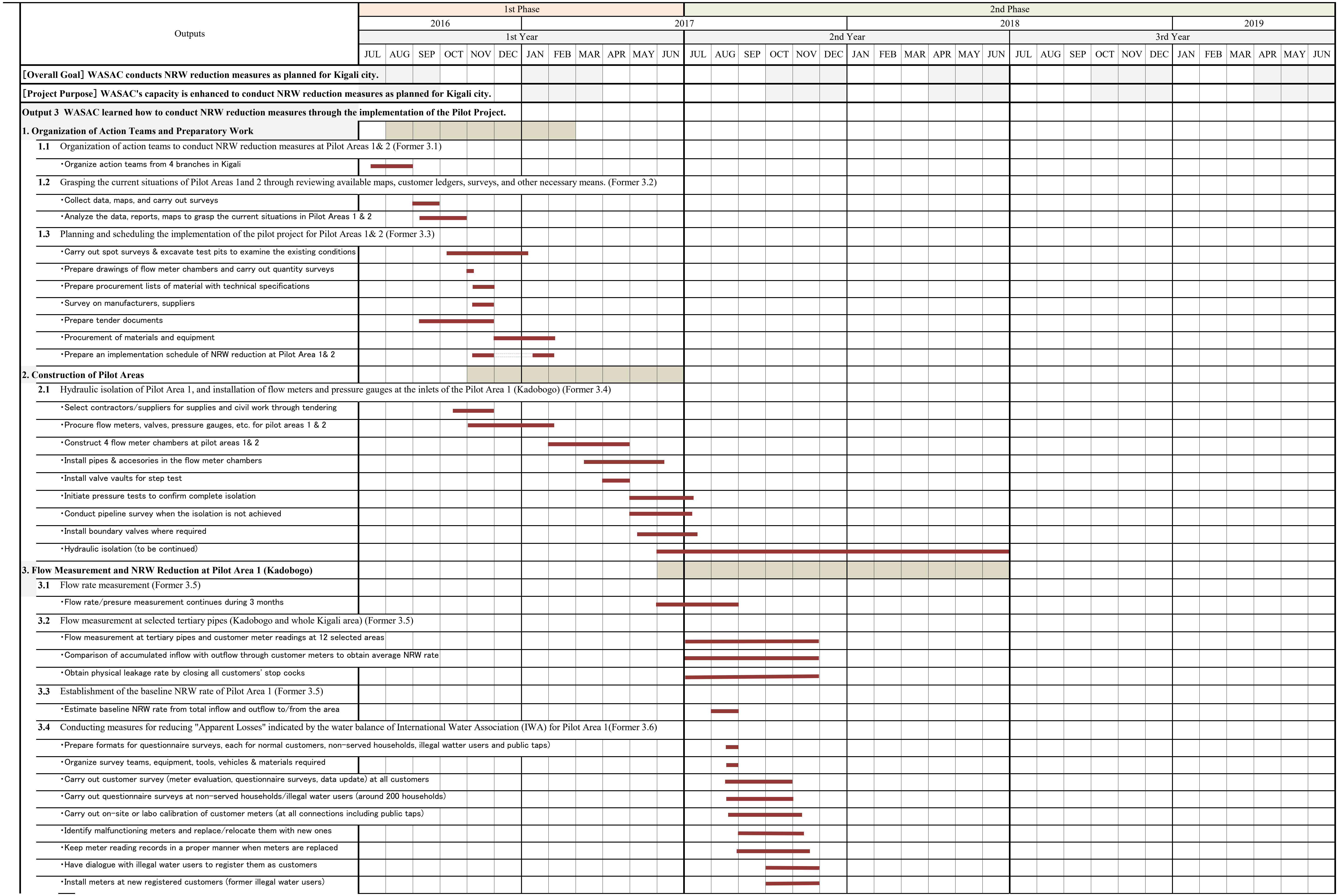
(1) Possibility of isolation: Isolation does not affect high turbidity, low pressure and low quantity. Possible to set the inlet and outlet points within 2 or 3. Also number of household in the pilot plant less than 500.
(2) Possibility of 24 hours and 7 days water supply.
(3) Distribution map accuracy: It makes not only pipeline but also valves, fire hydrant, flashing valves and air valves. Also averrable to location of branch points.
(4) Installed water meter at every households.
(5) Leakage occur situation: Pipeline is aged, new pipeline but material does not appropriate or pressure is high.
(6) Possibility of leak detection: Kind of pavement and location of valves and water meters.

2. Comparison of each Pilot Area

No.	Candidate Area / Requirement	NYARUGENGE		NYAMIRAMBO				GIKONDO	KACYIRU			
		GATSATA (Reduction)	RUNDA	KIMISAGARA Market	RWEZAMEYO	RWARUTABURA	RWAMPALA	NIBOYE	BATSINDA	KIYOVU	GAPOSHO	KAMUTWA
1	Possibility of isolation	G	G	G	B	B	B	G	G	G	B	B
2	24 hours and 7 days water supply	G	G	G	B	B	B	B	G	G	B	B
3	Distribution map accuracy	G	G	G	G	G	G	G	G	G	G	G
4	Install water meter at every households	G	G	G	G	G	G	G	G	G	G	G
5	Leakage occur situation	G	G	G	G	G	G	G	G	G	G	G
6	Possibility of leak detection	G	G	G	G	G	G	G	G	G	G	G
	Evaluation	6/6	6/6	6/6	4/6	4/6	4/6	5/6	6/6	6/6	4/6	4/6

Legend of evaluation Good: 2 points Average: 1 point Bad: 0 point. JICA Expert Team will support the RUNDA and KIYOVU Pilot Area.

1.3 Work Plan for KADOBOGO Pilot Area



[Overall Goal] WASAC conducts NRW reduction measures as planned for Kigali city.

[Project Purpose] WASAC's capacity is enhanced to conduct NRW reduction measures as planned for Kigali city.

Output 3 WASAC learned how to conduct NRW reduction measures through the implementation of the Pilot Project.

1. Organization of Action Teams and Preparatory Work

1.1 Organization of action teams to conduct NRW reduction measures at Pilot Areas 1& 2 (Former 3.1)
- ･Organize action teams from 4 branches in Kigali

1.2 Grasping the current situations of Pilot Areas 1and 2 through reviewing available maps, customer ledgers, surveys, and other necessary means. (Former 3.2)
- ･Collect data, maps, and carry out surveys
- ･Analyze the data, reports, maps to grasp the current situations in Pilot Areas 1 & 2

1.3 Planning and scheduling the implementation of the pilot project for Pilot Areas 1& 2 (Former 3.3)
- ･Carry out spot surveys & excavate test pits to examine the existing conditions
- ･Prepare drawings of flow meter chambers and carry out quantity surveys
- ･Prepare procurement lists of material with technical specifications
- ･Survey on manufacturers, suppliers
- ･Prepare tender documents
- ･Procurement of materials and equipment
- ･Prepare an implementation schedule of NRW reduction at Pilot Area 1& 2

2. Construction of Pilot Areas

2.1 Hydraulic isolation of Pilot Area 1, and installation of flow meters and pressure gauges at the inlets of the Pilot Area 1 (Kadobogo) (Former 3.4)
- ･Select contractors/suppliers for supplies and civil work through tendering
- ･Procure flow meters, valves, pressure gauges, etc. for pilot areas 1 & 2
- ･Construct 4 flow meter chambers at pilot areas 1& 2
- ･Install pipes & accesories in the flow meter chambers
- ･Install valve vaults for step test
- ･Initiate pressure tests to confirm complete isolation
- ･Conduct pipeline survey when the isolation is not achieved
- ･Install boundary valves where required
- ･Hydraulic isolation (to be continued)

3. Flow Measurement and NRW Reduction at Pilot Area 1 (Kadobogo)

3.1 Flow rate measurement (Former 3.5)
- ･Flow rate/presure measurement continues during 3 months

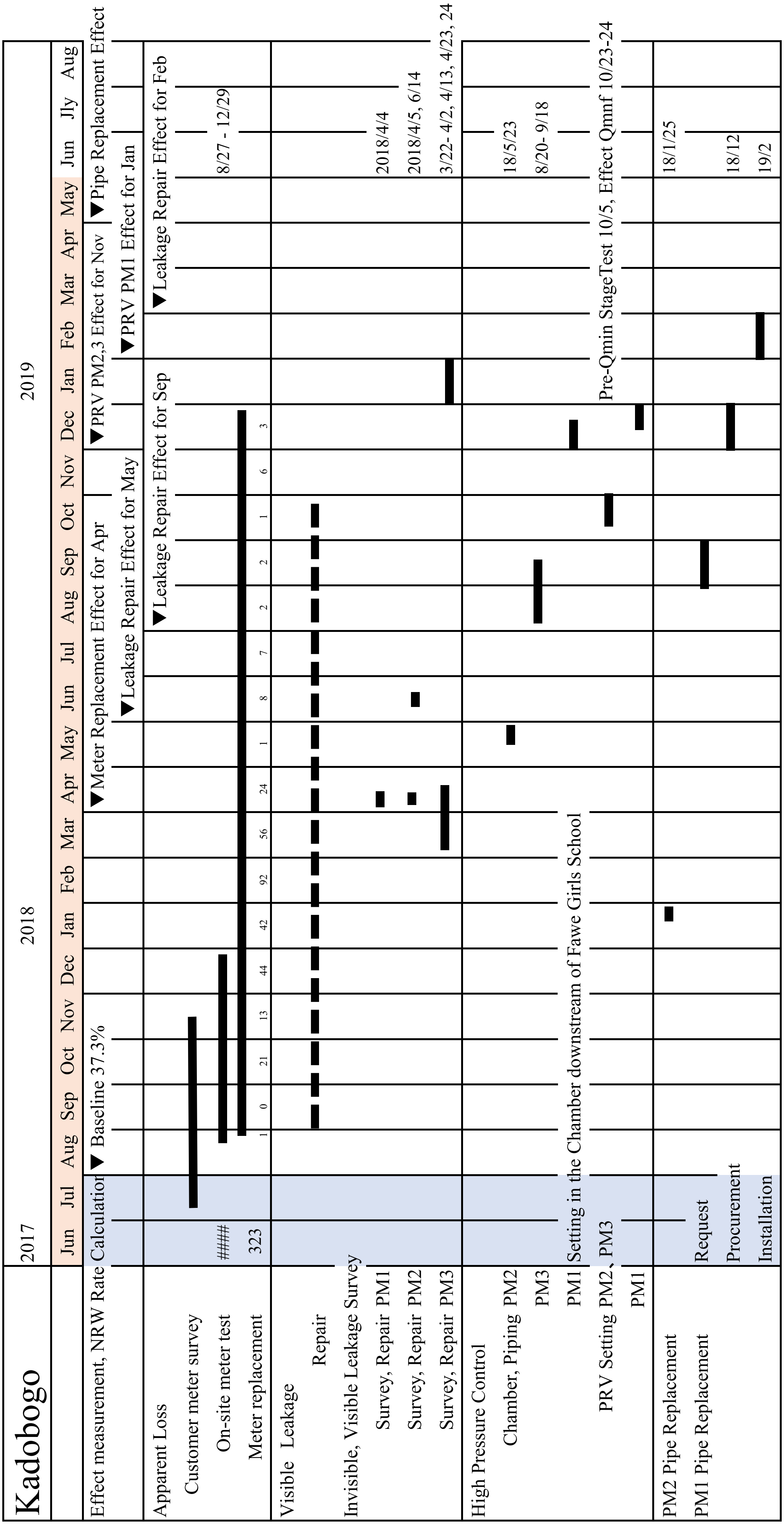
3.2 Flow measurement at selected tertiary pipes (Kadobogo and whole Kigali area) (Former 3.5)
- ･Flow measurement at tertiary pipes and customer meter readings at 12 selected areas
- ･Comparison of accumulated inflow with outflow through customer meters to obtain average NRW rate
- ･Obtain physical leakage rate by closing all customers' stop cocks

3.3 Establishment of the baseline NRW rate of Pilot Area 1 (Former 3.5)
- ･Estimate baseline NRW rate from total inflow and outflow to/from the area

3.4 Conducting measures for reducing "Apparent Losses" indicated by the water balance of International Water Association (IWA) for Pilot Area 1(Former 3.6)
- ･Prepare formats for questionnaire surveys, each for normal customers, non-served households, illegal watter users and public taps)
- ･Organize survey teams, equipment, tools, vehicles & materials required
- ･Carry out customer survey (meter evaluation, questionnaire surveys, data update) at all customers
- ･Carry out questionnaire surveys at non-served households/illegal water users (around 200 households)
- ･Carry out on-site or labo calibration of customer meters (at all connections including public taps)
- ･Identify malfunctioning meters and replace/relocate them with new ones
- ･Keep meter reading records in a proper manner when meters are replaced
- ･Have dialogue with illegal water users to register them as customers
- ･Install meters at new registered customers (former illegal water users)

Outputs	1st Phase												2nd Phase																							
	2016						2017												2018												2019					
	1st Year												2nd Year												3rd Year											
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
3.5 NRW measurement after conducting Activity 3-6 and examines its effectiveness (Former 3.7)																		■																		
3.6 Conducting measures for reducing surface leakage (visible leakage) (Former 3.8)																																				
・Detect visible leakage by inspecting the pipe route																		■	■																	
・Procure materials for leakage repair (WASAC)																		■	■																	
・Measure leak volume before repair																		■	■																	
・Repair all visible leakage and record properly																			■																	
3.7 NRW measurement after conducting Activity 3-6 and examines their effectiveness (Former 3.9)																				■																
3.8 Conducting measures for reducing underground leakage (invisible leakage)(Former 3.10)																																				
・Carry out step test by closing boundary valves of sub-zones																				■																
・Evaluate results of the step test to select prioritized sub-zones																				■																
・Detect invisible leakage by inspecting the pipe route																				■	■	■														
・Procure materials for leakage repair (WASAC)																				■	■	■														
・Measure leak volume before repair																					■	■														
・Repair all invisible leakage and record properly																					■	■														
3.9 NRW measurement after conducting Activity 3-8 and examines their effectiveness (Former 3.11)																							■													
4. Preparation of Reports and Holding of Workshop and Seminars																							▨	▨												
4.1 Reviewing the results from Activities 3-1 to 3-9, and undertaking cost-benefit analysis of NRW for each Activity of 3-4, 3-6, and 3-8 (Former 3.12)																						■	■	■												
4.2 Summarizing of activities and results from Activities 1-1 to 4-1, preparation and submission of the completion report on the pilot project for Pilot Area 1(Former 3.13)																							■	■												
4.3 Holding a workshop and presentation of the completion report of the pilot project(Former 3.14)																								■												
5. NRW Measurement and Reduction at Pilot Area 2 (Ruyenzi)													▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
5.1 Activities 1-1 to 4-3 at Pilot Area 2 (Former 3.15)													**Pilot Area 2 Constructing DMA**												**Verifying for Outputs of NRW reduction**											
・Activiites 2-1 to 4-3 at Pilot Area 2 (whereas Activities 1-1 to 1-3 for Pilot Area 2 were completed above) (Former 3.15)																								■	■	■	■	■	■	■	■	■	■	■	■	
5.2 Preparation of manuals on methods and use of survey equipment learned through the pilot project, and holding seminars in order to share them with WASAC and other concerned parties (Former 3.16)																									■	■										

Attachment 9. Implementation Schedule of Pilot Project



August 10,2017

Activities in the KADOBOGO Pilot Area

Chiaki Suzuki, NRW Reduction 1

●Duration: Sep 1, 2017 to July 31, 2018

1. Preparation of NRW survey

(1) Summarize and Analyze the data

Summarize and analyze the data which got from door to door survey by the NRW team in KADOBOGO.

(2) Preparation of customer data

-Determination of the total number of the customer inside KADOBOGO

-Make the customer list inside KADOBOGO to combine custom data of commercial department with GIS data

-Extract the customer who did not use the water during three months by analyze the customer data

(3) Interview for the KACYIRU Branch

Confirm to the billing officer and billing inspector about illegal users and defected meters

(4) Interview to the illegal users – See page 7

Interview illegal users by the check list which expect the illegal users based on the confirmation of billing officer and customer data analysis.

(5) Establish the Pilot Area

1)Confirmation of isolation

-Confirmation of zero pressure at the tap where is near the boundary of Isolate area.

-Confirmation of valves which use for the step test.

2. Activities in the Pilot Area – See page 4

(1) Implementation of the baseline survey

Determination of NRW rate by the deference between indication of bulk meter and customer meters.

(2) Confirmation of water meter accuracy – See page 6
1)Preparation of water meter accuracy (Record form, Implementation map, Joints which connect between test meter and customer meters etc.)
2)Implementation of water meter accuracy for every water meters inside the Pilot Area.
-Establish the survey teams
-Make the record form

(3) Exchange the water meter
Exchange the defected and unreadable water meters to the new water meter which supplied by JICA.

(4) Implementation of 2nd NRW measurement

(5) Leakage detection and repair
1)Establish the leakage detection teams
2)Surface leakage detection and repair
3)Confirmation of valves for step test
4)Underground leakage and repair

(6) Implementation of 3rd NRW measurement

(5) Tertiary pipe survey – See page 5
1)Establish the survey teams
2)Choose the survey area
3)Implementation of survey

(7) Countermeasure of water pressure
1)Establish the teams
2)Pressure survey
3)Install the PRV

(8) Implementation of 4th NRW measurement

(9) Complete the water balance sheet

3. After the Activities
(1) Instruction of continuation of survey
Instruction of continuation of survey for the NRW and Blanches teams when JICA

Expert is out.

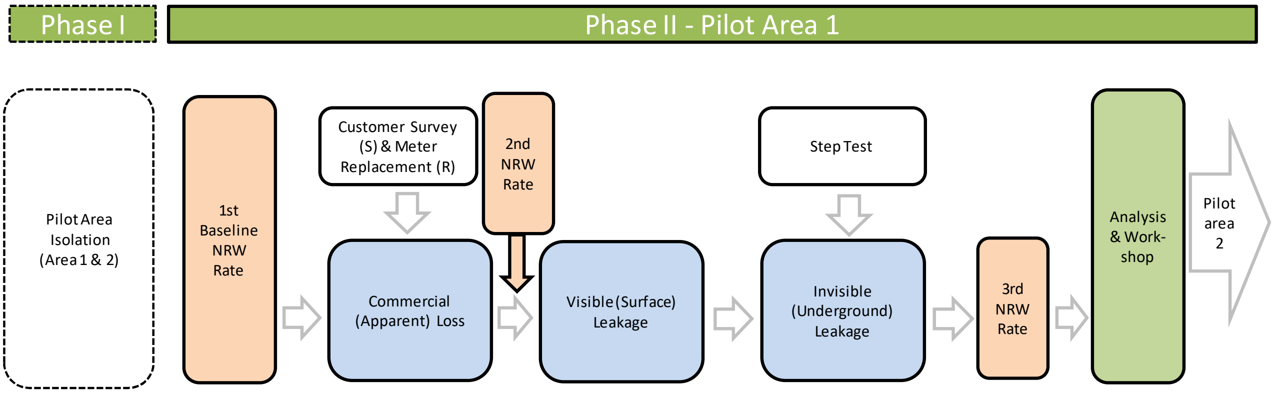
(2) Make the materials which for the workshop and seminar

Make the materials which for the workshop and seminar by the summarize the results of activities in this time.

4. Schedule

Outputs	1st Year												2nd Year												3rd Year											
	2016						2017												2018												2019					
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
1. Preparation to organize Action team and to construct of Pilot Area		▨																																		
2. Construction of Pilot Area 1 (KADOBOGO) and Pilot Area2 (RUYENZI)			▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																						
3. Measuring NRW and implementation of NRW reduction activities on the Pilot Aria 1															▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨											
4. Preparing and holding the workshop and seminar																							▨	▨	▨											
5. Measuring NRW and implementation of NRW reduction activities on the Pilot Aria 2																				▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨						
6. Preparing and holding the workshop and seminar																															▨	▨	▨			

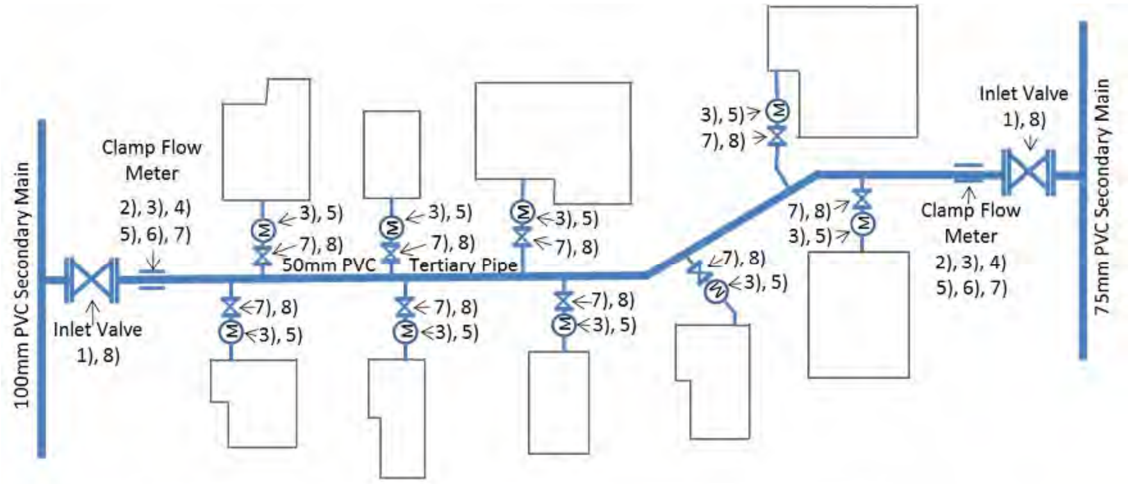
5. Detail of survey team and equipment for activities



Work	1) Confirm isolation 2) Measure monthly inflow rate 3) Tertiary pipe survey 4) Measure leakage vs pressure	1) Customer survey 2) Survey on non-served households 3) Calibrate meters by test meters and/or test bench 4) Replace meters 5) Data update & analysis 6) NRW rate	1) Pipeline survey 2) Leakage repair 3) NRW rate	1) Step test 2) Leak detection 3) Leak repair 4) Data compilation & analysis	1) Flow measurement 2) NRW rate 3) NRW analysis 4) Prepare manuals & propose measures 5) Prepare materials for Workshop 6) Organize/carry out workshop/seminar
Period	2.0 months (continued from Phase I) July – August 2017	3.5 months Sep – Mid Dec 2017	2.0 month Mid Dec – Mid Feb 2018	2.5 months Mid Feb – April 2018	2.0 months May – Jun 2018
Nos. of Teams	1 team	2 teams each for S & R	2 teams	2 teams	1 team
Technicians	1 + 2	Total S: 1+ 2 + 2	1	1	1 + 3 engineers
Plumbers	1	Total R: 2 + 2	1 + 1	1 + 1	All plumbers for workshop
Workers	1	2 each for S & R	2 + 2	2 + 2	None
Total	5	13 in Total: 7 for S & 6 for R	7	7	4 engineers for analysis & all plumbers for workshop
Tools & Equipment	Existing mechanical meter/Ultrasonic flow meter: one set	Test meter: 3 sets GPS: 2 sets Camera: 2sets Pressure gauge: 2 sets Othert tools: pipe cutters, threaders, wrench, etc.	Tools: pipe cutters, threaders, wrench, etc. GPS: 2 sets Bucket: 2sets Camera: 2 sets	Ultrasonic Flow Meter Electric sound bar with FSJ-1 Tools: pipe cutters, threaders, wrench, etc. GPS: 2 sets Bucket: 2sets Camera: 2 sets	None
Materials	None	PVC, HDPE, GSP pipes, unions, meters, cocks, sealing materials, etc.	PVC, HDPE, GSP pipes, unions, valves, etc.	PVC, HDPE, GSP pipes, unions, valves, etc.	None
Vehicles	2	3 (1 for S & 2 for R)	2	2	None
Products	1) NRW rate 2) Relation between pressure and leakage	1) Breakdown commercial loss 2) Defective meter characteristics 3) NRW rate	1) Breakdown visible leakage (cost, materials, manpower) 2) NRW rate	1) Breakdown invisible leakage (cost, materials, manpower) 2) NRW rate	1) NRW evaluation report 2) Cost benefit analysis 3) Reduction manuals 4) Proposal for pressure control 5) Evaluation report of trainees
Remark	- Isolation to be confirmed by valve closure	-Survey on non-served households may focus on their water sources and willingness to connect	-	-If invisible leakage were not found by normal detection, detailed step tests would be carried out.	-Training/seminar will be carried out before workshop

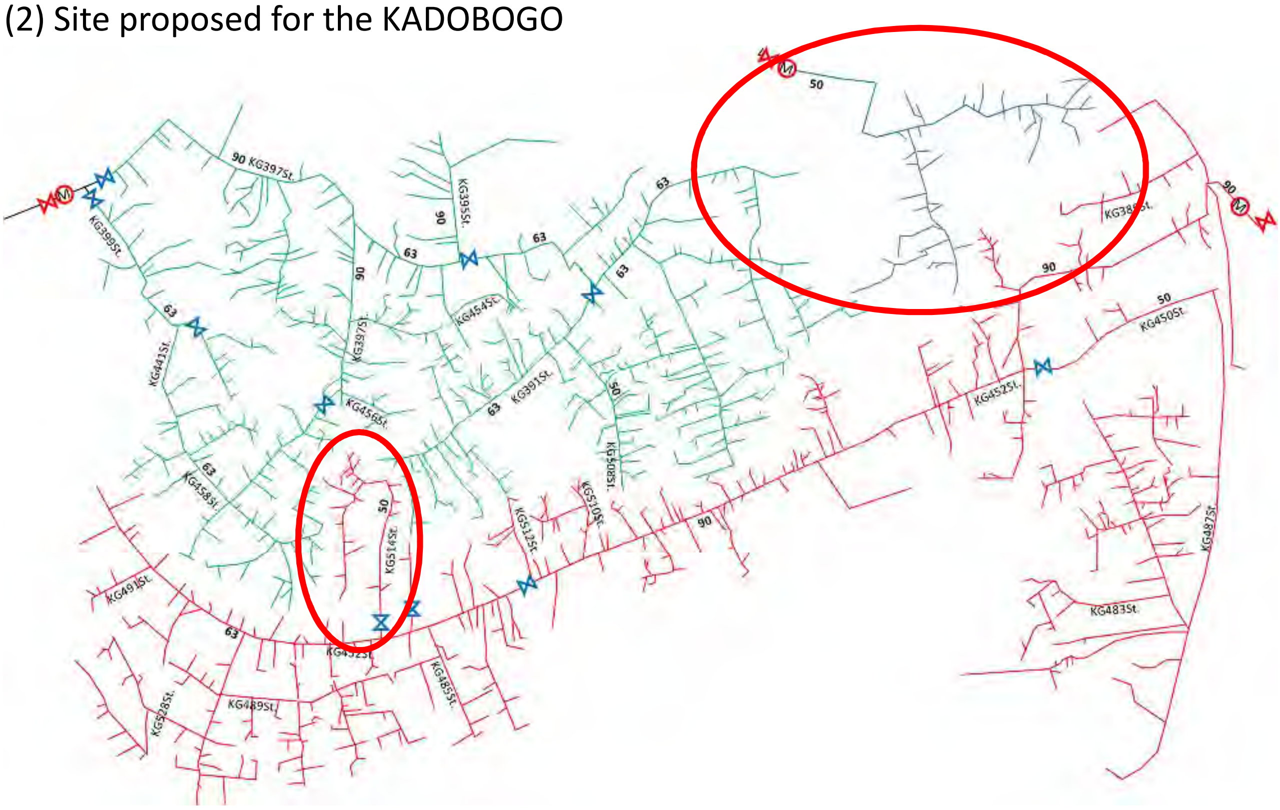
6. Tertiary pipe survey

(1) Image of tertiary pipe survey

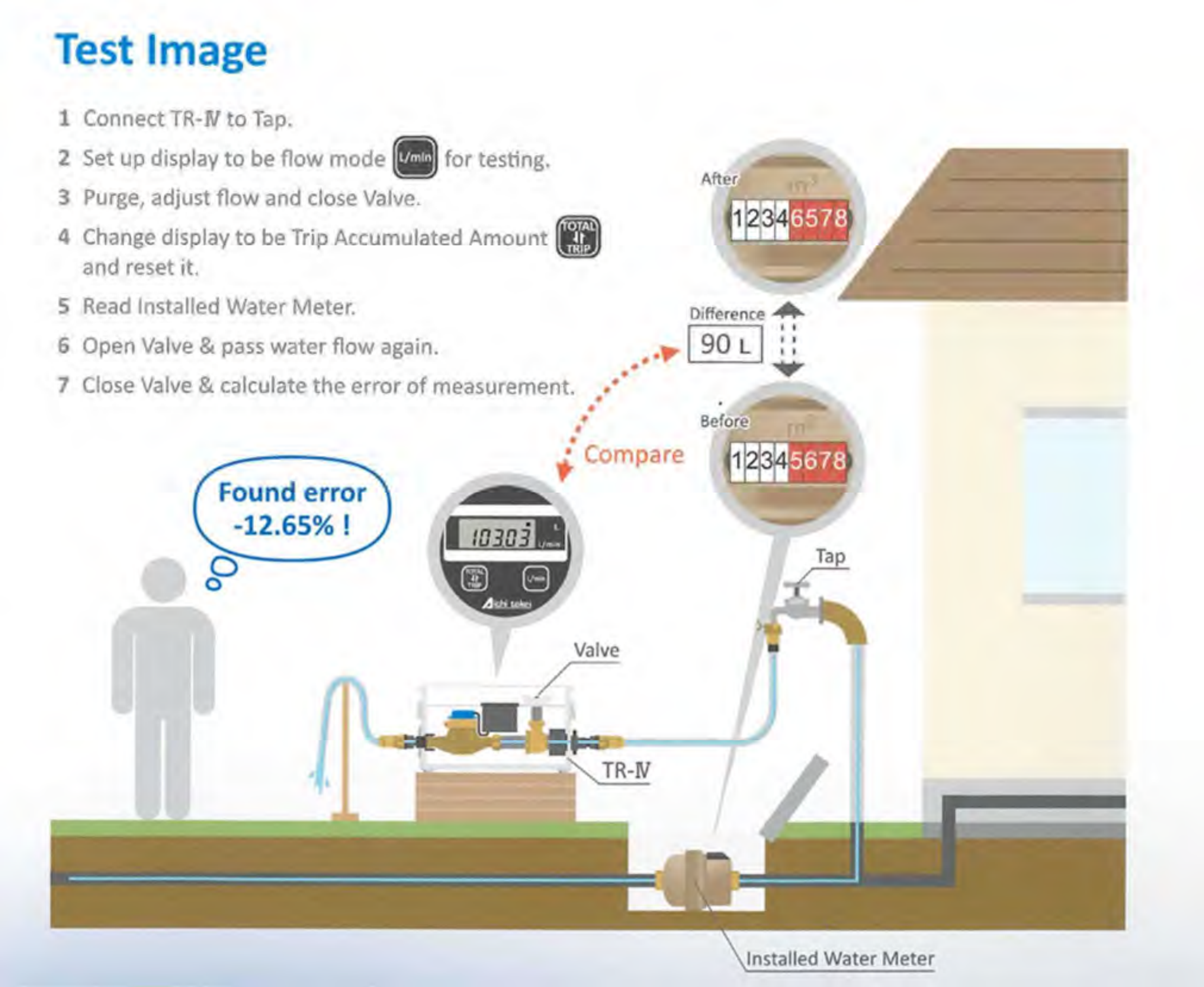


Note:
1) Hydraulic isolation by boundary valves' closure
2) Install ultra-sone (clamp) flow meters
3) Start measurement
4) Record reading by ultra-sonic flow meters at one hour interval
5) After 24 hours, read all meters
6) Estimate NRW rate
7) Measure leakage by stopcock closure
8) Measure leakage by stepwise closure of inlet valves to obtain relationship between pressure and leakage

(2) Site proposed for the KADOBOGO



7. How to install the test meter



Test Image

1 Connect TR-Ⅳ to Tap.
2 Set up display to be flow mode L/min for testing.
3 Purge, adjust flow and close Valve.
4 Change display to be Trip Accumulated Amount TOTAL TRIP and reset it.
5 Read Installed Water Meter.
6 Open Valve & pass water flow again.
7 Close Valve & calculate the error of measurement.

Reference: Aichi Tokei Denki Co., Ltd.

8. Questionnaire for illegal users

Questionnaire for illegal users

Sheet Number: KADOBOGO - 00000

【User data】	
Name of user	
Latitude・Longitude・Altitude	
POC	
Meter Cereal Number	
Investigation day	
【Questions】	
Q1: How do you get the water?	
Q2: How do you use the water?	
Q3: Why do not subscribe the WASAC water service?	
A3-1: High water tariff	Yes ・ No
Q3-1: How much do you accept the water tariff?	RF
A3-2: High cost of construction	Yes ・ No
Q3-2: How much do you accept the construction cost?	RF
A3-3: You do not satisfy the water service	Yes ・ No
Q3-3: Intermittent water supply	Yes ・ No
Q3-4: High/low pressure	Yes ・ No
Q3-5: Low water quality	Yes ・ No
A4: Other complaints	
【Comments & Remarks】	

REVISED WORK PLAN (Output 3)

- Procedures, Duration and Specific Activities for NRW Reduction

This work plan is the updated version of the previous plan to summarize approach and procedures for NRW reduction at the selected pilot areas in Kigali city, focusing on time duration, procedures and specific activities required. Minor amendment was made reflecting recent activities and findings by WASAC and JICA Team. Attachment-1 attached hereto is the detailed work schedule for implementing the NRW reduction (Output 3).Attachment-2 exhibits our revised work flow diagram for NRW reduction.

Phase I Activities

1. Organization of an action team and preparatory work for NRW reduction
   (1) Duration: August 15, 2016 to February28, 2016
   (2) Specific activities: selection of pilot areas, field surveys to confirm hydraulic isolation of the pilot areas, analyses of customer database, GIS data review, customer surveys, commercial and physical loss reduction, registration of illegal water users, flow measurement for obtaining NRW rate, cost-benefit analysis, etc. as outlined below.

2. Construction of Pilot Area 1 (KADOBOGO)and Area 2 (RUYENZI) for Isolation
   (1) Duration: December 1, 2016 to June 30, 2017
   (2) Specific activities:
   1) Review of GIS pipeline database,
   2) Field surveys for confirmation of pipeline alignment,
   3) Pressure test at the inlet mains,
   4) Hydraulic separation of the Pilot Area and installation of boundary valves for establishment of subzone areas, and
   5) Construction of flow meter chambers with necessary appurtenances at the inlets of the Pilot Areas, including flow meters, gate valves, flange adapters, manhole cover, and pressure gauges.

Phase II Activities

3. NRW measurement, reduction at the Pilot Areas and additional flow measurement surveys at Kigali whole service area (12 selected tertiary mains)

   (1) Duration: July 1, 2017 to June 30, 2018
   (2) Specific Activities:

1) Organization of survey teams

To carry out NRW reduction in an effective and efficient way, survey teams shall be organized on a timely manner as well as proper procurement of materials, equipment, tools and vehicles required. Tentative schedule, work period, and outline survey teams are summarized in Table below and also given in Attachment-3 Survey Team and Equipment.

Table-1 Survey Team Organization

Work	Baseline NRW Rate 1) Confirm isolation 2) Measure monthly inflow rate 3) Tertiary pipe survey 4) Measure leakage vs pressure	Commercial (Apparent) Loss Reduction 1) Customer survey 2) Survey on non-served households 3) Calibrate meters by test meters and/or test bench 4) Replace meters 5) Data update & analysis 6) NRW rate	Surface (Visible) Leakage Reduction 1) Pipeline survey 2) Leakage repair 3) NRW rate	Invisible (Underground) Leakage Reduction 1) Step test & analysis 2) Leak detection 3) Leak repair 4) Data compilation & analysis	Endline NRW Rate, Analysis & Workshop 1) Flow measurement 2) NRW rate 3) NRW analysis 4) Prepare manuals & propose measures 5) Prepare materials for Workshop 6) Organize/carry out workshop/seminar
Period	2.0 months (continuing from Phase I) July – August 2017	3.5 months Sep – Mid Dec 2017	2.0 month Mid Dec – Mid Feb 2018	2.5 months Mid Feb – April 2018	2.0 months May – Jun 2018
Nos. of Teams	1 team	2 teams each for S & R	2 teams	2 teams	1 team
Technicians	1 + 2	Total S: 1+ 2 + 2	1	1	1 + 3 engineers
Plumbers	1	Total R: 2 + 2	1 + 1	1 + 1	All plumbers for workshop
Workers	1	2 each for S & R	2 + 2	2 + 2	None
Total	5	13 in Total: 7 for S & 6 for R	7	7	4 engineers for analysis & all plumbers for workshop

WASAC branch office and HQ are responsible for the survey teams' organization throughout the project period. Manpower input will be maximized during the period of "Commercial Loss Reduction", requiring 5 technicians, 4 plumbers, and 4 unskilled labors, organized into 4 teams.

2) Confirmation of hydraulic isolation by closing valves

It is important to confirm complete hydraulic isolation of the area. By closing all boundary valves, the isolation of the pilot areas shall be confirmed before initiation of the NRW reduction. Otherwise, the entire activities would be falsely managed resulting in fundamental errors.

3) NRW measurement at Pilot Areas 1 and 2 for 2 months to obtain baseline NRW rate (Actually for 3 months as started from 1 June, and expected to complete by the end of 31 August)

All mechanical flow meters installed on the inlets to Kadobogo and Ruyenzi areas will be monitored for logging at a proper interval (every week/month). Measurement results are compared to metering/billing records obtained in the same period to compute the baseline NRW rate, one of key performance indicators.

4) Three types of NRW Reduction

We plan to demonstrate three types of NRW reduction, a. "Survey Based on JICA SW", b. "Step Test", c. "Tertiary Main Survey" and. They have their own characteristics as summarized in the table below.

Table-2 Three Types of Survey Method

NRW Reduction	a. Survey Based on JICA SW	b. Step Test	c. Tertiary Main Survey
1. Survey concept/method	By cause	By area (subzone)	By pipe
2. Survey area	Whole pilot area	Whole pilot area	Representative short length of tertiary mains
3. Nature	Full-fledged NRW reduction	Preliminary	Preliminary
4. Data Required	Pipe network and customer and non-served population	Customer information by subzone	Customer information in the survey area
5. Period Required	Long period	Relatively short	Relatively short
6. Materials required	Pipes and meters for replacement	Valves and pipes for isolation	No materials
7. Possible combination	a+b, a+c	a+b	a+c

5) Outline of the tertiary main survey in Kadobogo area (two survey areas) and in Kigali service area (ten survey areas), 12 survey areas in total

As stated above, flow measurement at twelve(12) survey areas selected from whole service area in Kigali, will be carried out to obtain average rate of NRW taking place at tertiary mains and service piping including customer meters. In this procedure, flow rate measurement by ultrasonic flow meters installed on tertiary main inlets for 24 hours will be compared to customers’ water consumption obtained by on-site customer meter reading at the survey area. Furthermore, actual physical leakage rate can be obtained, by closing all customers' stop cocks and by gauging the inflow rate at the tertiary main inlets simultaneously. Number of target customers contained in each survey area may be around 30-50.

The baseline NRW rate may contains NRW at all pipe network, while the above rate represents a basis for the average NRW at tertiary mains and service pipelines in Kigali city. The balance between the baseline NRW rate and the above, hence, stands for the average NRW at the remaining primary and secondary mains, consisting of mainly leakage. General feature of the current Kigali Water Supply system, thus, will be identified as rates of NRW, commercial and physical leakage, i.e., key parameters of the Five Year NRW Reduction Plan.

6) Major work for NRW reduction

Work schedule was carefully worked out to reduce NRW effectively as shown in Attachments-1 Work Plan &-2 Work Flow Diagram. Major work contained in these activities includes the following;

Measurement of Baseline NRW Rate

- Confirm isolation of the pilot area and subzones by valve closure
- Tertiary pipe survey and leakage measurement
- Measure inflow and outflow rate to/from the area to obtain baseline NRW rate

Commercial (Apparent) Loss Reduction

- Customer surveys for update of customer database
- Survey on non-served households
- Onsite or in-room calibration of the installed customer meters
- Replace malfunctioning meters by new ones
- Identify Illegal connections and conduct flow measurement of unauthorized consumption
- Register illegal status of water users as normal customers through dialogue and confirmation
- Measure inflow and outflow rate to/from the area

Visible Leakage Reduction

- Pipeline survey to identify visible leakage
- Repair leakage
- Measure inflow and outflow rate to/from the area

Invisible Leakage Reduction

- Preparatory work for step test, including valve installation and relocation of pipelines
- Step test by closing valves
- Analysis of test results to select prioritized areas
- Leakage detection and repair at all subzones to be carried out in order of priority
- Analysis of test results to select prioritized areas

- Leakage detection and repair at prioritized subzones
- Measure inflow and outflow rate to/from the area to obtain breakdown and end-line NRW rate.

4. Preparing materials and holding the workshop and seminar
    - (1) Duration: May 1, 2018 to 30June 2018
    - (2) Specific Activities:
    - 1) Review and cost-benefit analysis of NRW reduction

      All costs required for reducing commercial (apparent) loss and visible/invisible leakage may include those of civil works for excavation, repair, replacement, and of procurement of meters, fittings, pipes, stop cocks, unions, tools, equipment, vehicles, workers, staff and engineers.

      In return, the water loss reduction yields enormous benefit to all aspects of water supply business. Major benefits, above all, are increase in water sales and supply efficiency, reduced O&M costs, and delayed development of water sources due to an increase of the water distribution.

      Despite these apparent costs and benefits, it is difficult to quantify them properly as financial, economical, social and environmental values. It is, therefore, considered adequate to compute unit cost of rehabilitation in comparison with unit expansion cost, and/or to compare simply the increase in water sales with the direct costs required for the NRW reduction.

    - 2) Prepare manuals of the NRW reduction procedures and of the equipment
    - 3) Prepare completion report
    - 4) Carry out workshop and seminar to share information with institution and agencies concerned

5. Construction of Pilot Area 2 (RUYENZI)
    - (1) Duration: (To be determined)
    - (2) Specific Activities: same as Pilot Area 1

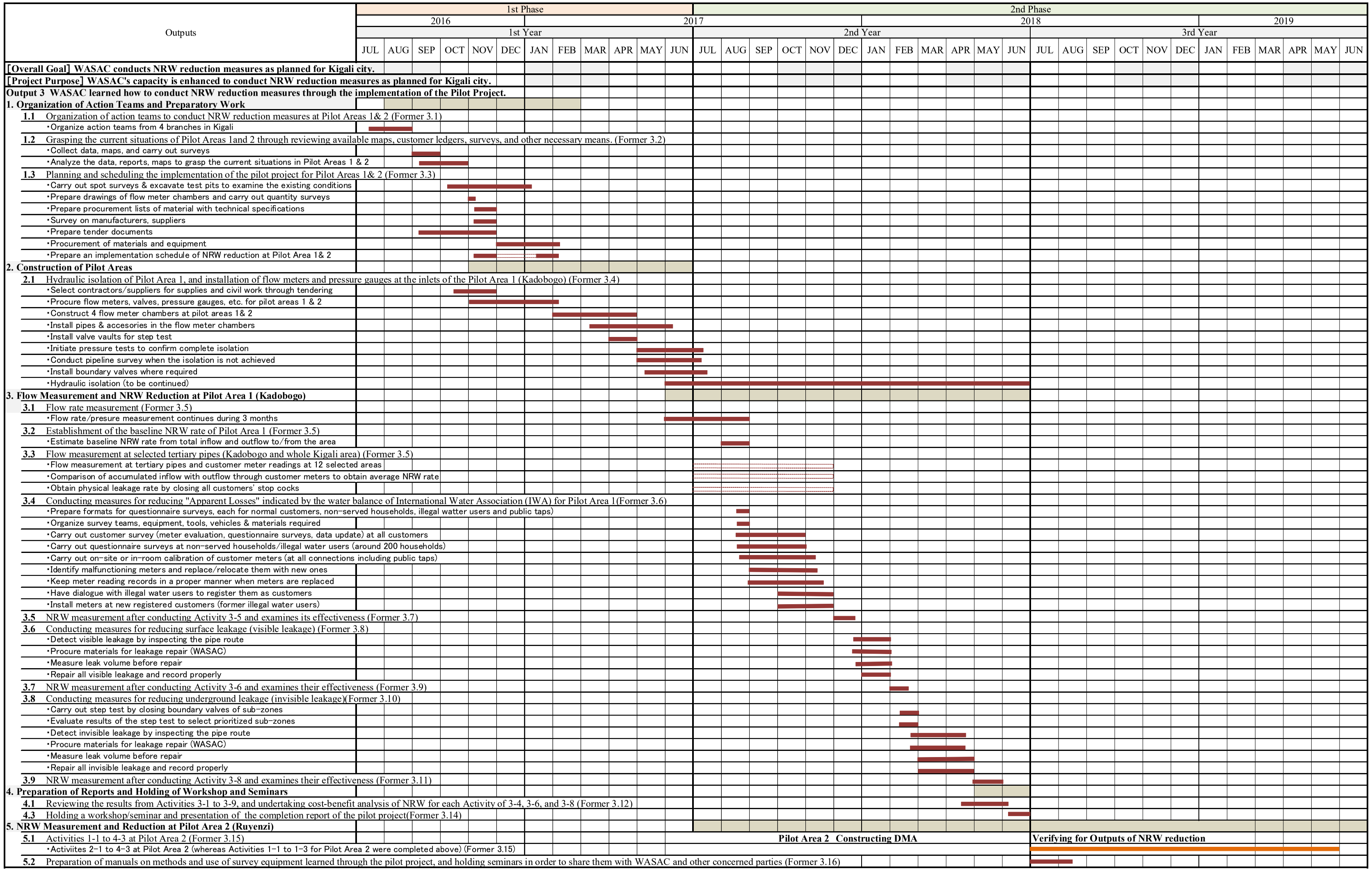
6. NRW measurement and reduction at the Pilot Area 2
    - (1) Duration:(To be determined)
    - (2) Specific Activities: same as Pilot Area 1

7. Preparing and holding the workshop and seminar

   (1) Duration: (To be determined)

   (2) Specific Activities: same as Pilot Area 1

Attachment-1 Work Plan for Implementing the Project
(Output 3)



[Overall Goal] WASAC conducts NRW reduction measures as planned for Kigali city.

[Project Purpose] WASAC's capacity is enhanced to conduct NRW reduction measures as planned for Kigali city.

Output 3 WASAC learned how to conduct NRW reduction measures through the implementation of the Pilot Project.

1. Organization of Action Teams and Preparatory Work

1.1 Organization of action teams to conduct NRW reduction measures at Pilot Areas 1& 2 (Former 3.1)
- Organize action teams from 4 branches in Kigali

1.2 Grasping the current situations of Pilot Areas 1and 2 through reviewing available maps, customer ledgers, surveys, and other necessary means. (Former 3.2)
- Collect data, maps, and carry out surveys
- Analyze the data, reports, maps to grasp the current situations in Pilot Areas 1 & 2

1.3 Planning and scheduling the implementation of the pilot project for Pilot Areas 1& 2 (Former 3.3)
- Carry out spot surveys & excavate test pits to examine the existing conditions
- Prepare drawings of flow meter chambers and carry out quantity surveys
- Prepare procurement lists of material with technical specifications
- Survey on manufacturers, suppliers
- Prepare tender documents
- Procurement of materials and equipment
- Prepare an implementation schedule of NRW reduction at Pilot Area 1& 2

2. Construction of Pilot Areas

2.1 Hydraulic isolation of Pilot Area 1, and installation of flow meters and pressure gauges at the inlets of the Pilot Area 1 (Kadobogo) (Former 3.4)
- Select contractors/suppliers for supplies and civil work through tendering
- Procure flow meters, valves, pressure gauges, etc. for pilot areas 1 & 2
- Construct 4 flow meter chambers at pilot areas 1& 2
- Install pipes & accesories in the flow meter chambers
- Install valve vaults for step test
- Initiate pressure tests to confirm complete isolation
- Conduct pipeline survey when the isolation is not achieved
- Install boundary valves where required
- Hydraulic isolation (to be continued)

3. Flow Measurement and NRW Reduction at Pilot Area 1 (Kadobogo)

3.1 Flow rate measurement (Former 3.5)
- Flow rate/presure measurement continues during 3 months

3.2 Establishment of the baseline NRW rate of Pilot Area 1 (Former 3.5)
- Estimate baseline NRW rate from total inflow and outflow to/from the area

3.3 Flow measurement at selected tertiary pipes (Kadobogo and whole Kigali area) (Former 3.5)
- Flow measurement at tertiary pipes and customer meter readings at 12 selected areas
- Comparison of accumulated inflow with outflow through customer meters to obtain average NRW rate
- Obtain physical leakage rate by closing all customers' stop cocks

3.4 Conducting measures for reducing "Apparent Losses" indicated by the water balance of International Water Association (IWA) for Pilot Area 1(Former 3.6)
- Prepare formats for questionnaire surveys, each for normal customers, non-served households, illegal watter users and public taps)
- Organize survey teams, equipment, tools, vehicles & materials required
- Carry out customer survey (meter evaluation, questionnaire surveys, data update) at all customers
- Carry out questionnaire surveys at non-served households/illegal water users (around 200 households)
- Carry out on-site or in-room calibration of customer meters (at all connections including public taps)
- Identify malfunctioning meters and replace/relocate them with new ones
- Keep meter reading records in a proper manner when meters are replaced
- Have dialogue with illegal water users to register them as customers
- Install meters at new registered customers (former illegal water users)

3.5 NRW measurement after conducting Activity 3-5 and examines its effectiveness (Former 3.7)

3.6 Conducting measures for reducing surface leakage (visible leakage) (Former 3.8)
- Detect visible leakage by inspecting the pipe route
- Procure materials for leakage repair (WASAC)
- Measure leak volume before repair
- Repair all visible leakage and record properly

3.7 NRW measurement after conducting Activity 3-6 and examines their effectiveness (Former 3.9)

3.8 Conducting measures for reducing underground leakage (invisible leakage)(Former 3.10)
- Carry out step test by closing boundary valves of sub-zones
- Evaluate results of the step test to select prioritized sub-zones
- Detect invisible leakage by inspecting the pipe route
- Procure materials for leakage repair (WASAC)
- Measure leak volume before repair
- Repair all invisible leakage and record properly

3.9 NRW measurement after conducting Activity 3-8 and examines their effectiveness (Former 3.11)

4. Preparation of Reports and Holding of Workshop and Seminars

4.1 Reviewing the results from Activities 3-1 to 3-9, and undertaking cost-benefit analysis of NRW for each Activity of 3-4, 3-6, and 3-8 (Former 3.12)

4.3 Holding a workshop/seminar and presentation of the completion report of the pilot project(Former 3.14)

5. NRW Measurement and Reduction at Pilot Area 2 (Ruyenzi)

5.1 Activities 1-1 to 4-3 at Pilot Area 2 (Former 3.15)
- Activiites 2-1 to 4-3 at Pilot Area 2 (whereas Activities 1-1 to 1-3 for Pilot Area 2 were completed above) (Former 3.15)

5.2 Preparation of manuals on methods and use of survey equipment learned through the pilot project, and holding seminars in order to share them with WASAC and other concerned parties (Former 3.16)

Attachment-2 Work Flow Diagram for NRW Reduction

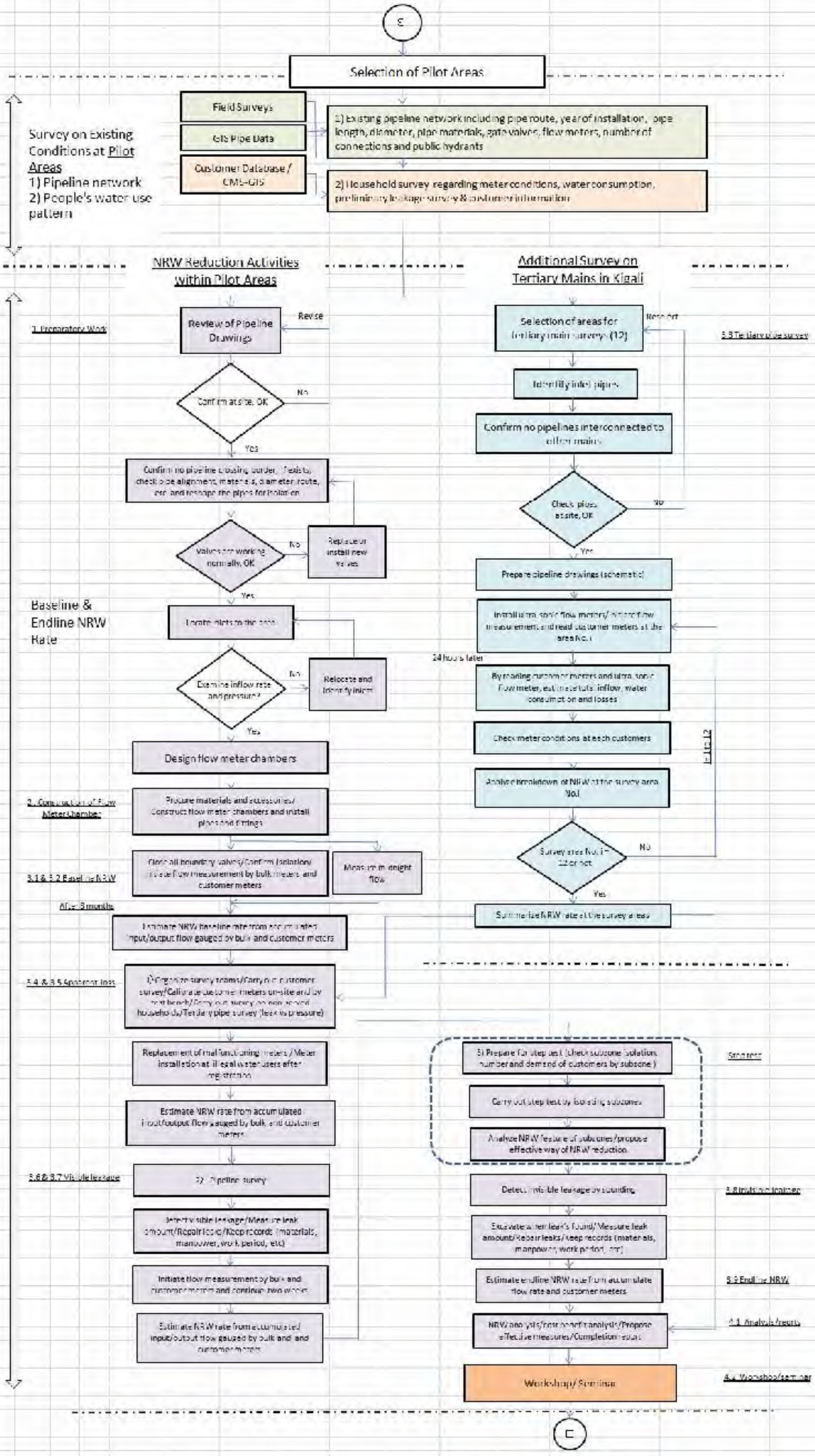
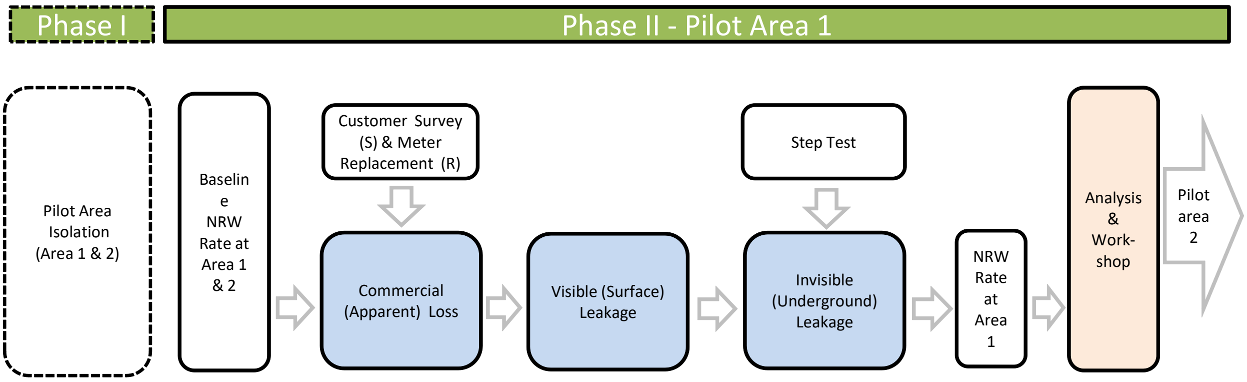


Figure-A2 Workflow Diagram for Pilot NRW Reduction Activities

Attachment-3 Survey Team and Equipment



Work	1) Confirm isolation 2) Measure monthly inflow rate 3) Tertiary pipe survey 4) Measure leakage vs pressure	1) Customer survey 2) Survey on non–served households 3) Calibrate meters by test meters and/or test bench 4) Replace meters 5) Data update & analysis 6) NRW rate	1) Pipeline survey 2) Leakage repair 3) NRW rate	1) Step test 2) Leak detection 3) Leak repair 4) Data compilation & analysis	1) Flow measurement 2) NRW rate 3) NRW analysis 4) Prepare manuals & propose measures 5) Prepare materials for Workshop 6) Organize/carry out workshop/seminar
Period	2.0 months (continued from Phase I) July – August 2017	3.5 months Sep – Mid Dec 2017	2.0 month Mid Dec – Mid Feb 2018	2.5 months Mid Feb – April 2018	2.0 months May – Jun 2018
Nos. of Teams	1 team	2 teams each for S & R	2 teams	2 teams	1 team
Technicians	1 + 2	Total S: 1+ 2 + 2	1	1	1 + 3 engineers
Plumbers	1	Total R: 2 + 2	1 + 1	1 + 1	All plumbers for workshop
Workers	1	2 each for S & R	2 + 2	2 + 2	None
Total	5	13 in Total: 7 for S & 6 for R	7	7	4 engineers for analysis & all plumbers for workshop
Tools & Equipment	Ultrasonic flow meter: one set	Test meters: 3 sets GPS: 2 sets Cameras: 2sets Pressure gauges: 2 sets Othert tools: pipe cutters, threaders, wrench, etc.	Tools: pipe cutters, threaders, wrench, etc. GPS: 2 sets Buckets: 2sets Cameras: 2 sets	Tools: pipe cutters, threaders, wrench, etc. GPS: 2 sets Buckets: 2sets Cameras: 2 sets	None
Materials	None	PVC, PHDE, GSP pipes, unions, meters, cocks, sealing materials, etc.	PVC, PHDE, GSP pipes, unions, valves, etc.	PVC, PHDE, GSP pipes, unions, valves, etc.	None
Vehicles	2	3 (1 for S & 2 for R)	2	2	None
Products	1) NRW rate 2) Relation between pressure and leakage	1) Breakdown commercial loss 2) Defective meter characteristics 3) NRW rate	1) Breakdown visible leakage (cost, materials, manpower) 2) NRW rate	1) Breakdown invisible leakage (cost, materials, manpower) 2) NRW rate	1) NRW evaluation report 2) Cost benefit analysis 3) Reduction manuals 4) Proosal for pressure control 5) Evaluation report of trainees
Remark	– Isolation to be confirmed by valve closure	–Survey on non–served households may focus on their water sources and willingness to connect	–	–If invisible leakage were not found by normal detection, detailed step tests would be carried out.	–Training/seminar will be carried out before workshop

Figure–A3 Survey Team and Equipment for NRW Reduction at Pilot Area 1

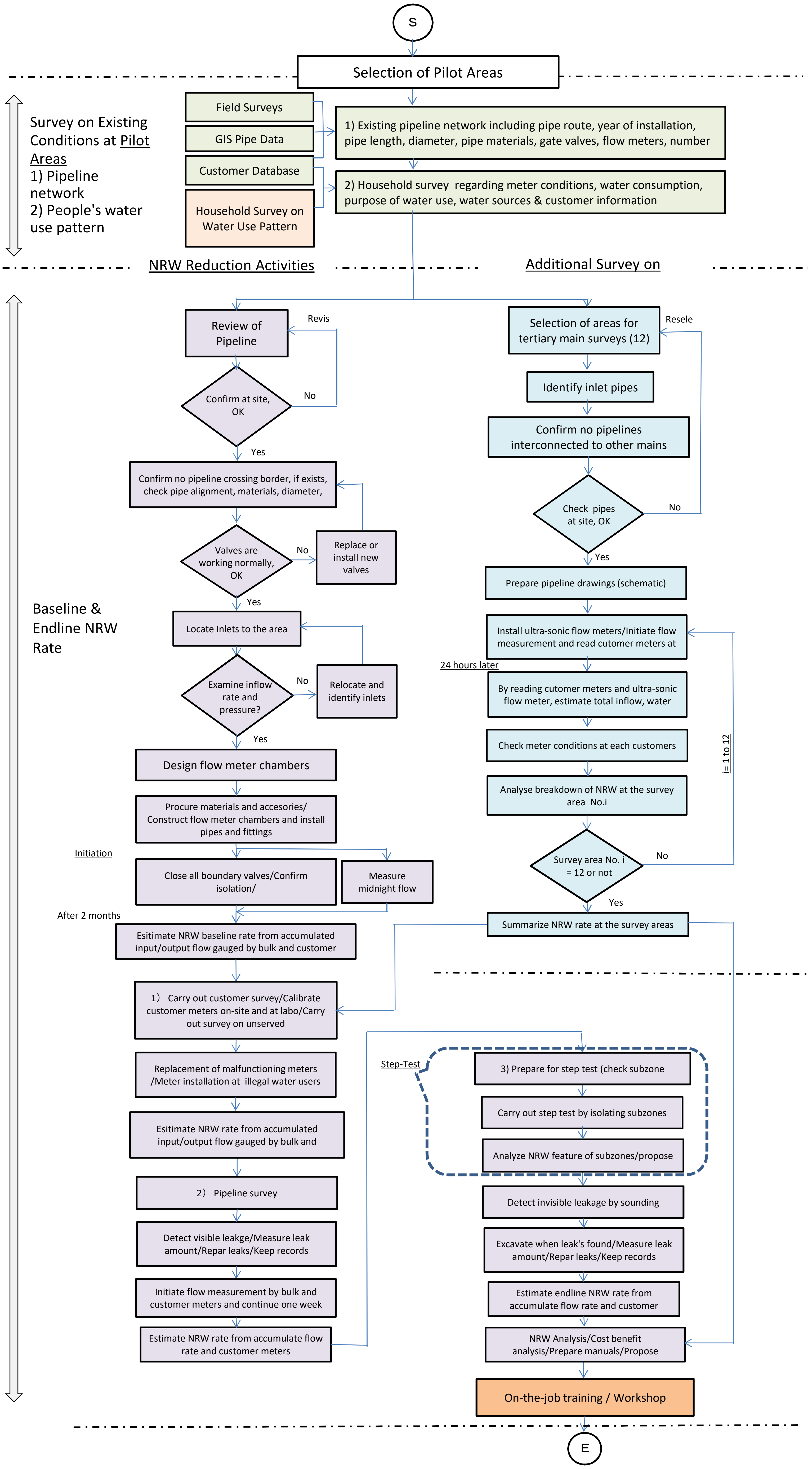


Fig – Pilot NRW Reduction Activities

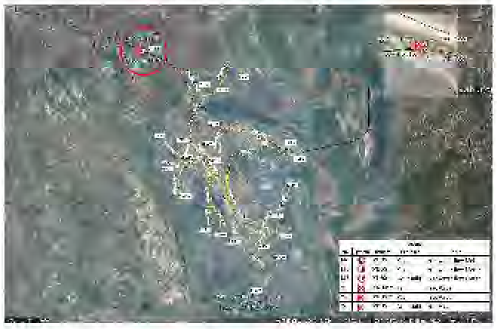
Output 3
Activities in Pilot Area

PROJECT FOR STRENGTHENING NON-REVENUE
WATER CONTROL IN KIGALI CITY WATER NETWORK
At Management Meeting on August 9 in 20017

Chiaki Suzuki, JICA Expert

Kadobogo (Kiyovu) DMA

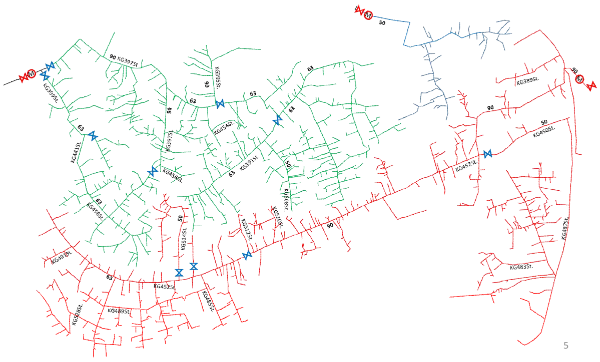
Ruyenzi (Runda) DMA



Data of KADOBOGO Pilot Area

KADOBOGO PILOT AREA (as of July 2016)	
Area	100.4ha
Population	15,329
Served Population (=Number of connections x 5)	4,940
Service Coverage Rate(%)	32
Number of Connections	938
Domestic	906
Public taps	1
Collectivity	2
Commercial	27
Industry	0
Government	2
Monthly Water Consumption (m3/month)	13,157
Average Consumtion per Capita (L/day)	86
Number of Illegal Connections	19
Number of Meter Problems	98
(including screen and index status problems)	
Percentage of Illegal and Meter Problems	12%

Distribution Blocks in KADOBOGO

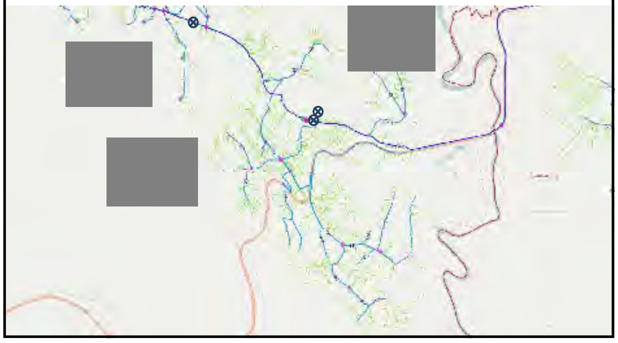


Data of RUYENZI Pilot

RUYENZI PILOT AREA (as of July 2016)	
Area	648.2ha
Population	32,467
Served Population (=Number of connections x 5)	5,925
Service Coverage Rate(%)	18
Number of Connections	885
Domestic	854
Public taps	6
Collectivity	3
Commercial	18
Industry	0
Government	4
Monthly Water Consumption(m3/month)	12,259
Average Consumtion per Capita (L/day)	67
Number of Illegal Connections	14
Number of Meter Problems	50
(including screen and index status problems)	
Percentage of Illegal and Meter Problems	7%

Challenges of RUYENZI

200m difference of altitude



[redacted]

[redacted]

[redacted]

Pressure measurement

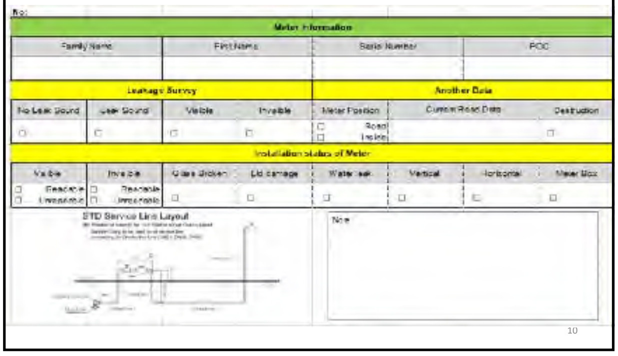
[redacted]

Point No.	Date/Time	Pressure(bar)	Altitude(m)	Serial No.
1	Apr. 25, 2017	1.5 – 2.0	1536	D12UA5H4520
2	Apr. 25, 2017	1.0	1533	D12UA138328
3	Apr. 25, 2017	2.0	1555	D14UA125925
4	Apr. 25, 2017	7.5	1455	D12CA062578
5	Apr. 25, 2017	10.5 – 11.0	1384	D12CA056849
6	Apr. 25, 2017	16.0	1365	D12UA542674
7	Apr. 25, 2017	5.5	1376	D12CA055725
8	Apr. 25, 2017	3.5	1492	D11UA086814
9	Apr. 25, 2017	4.0	1460	93850646
10	Apr. 25, 2017	1.0	1482	D11UA092732
11	Apr. 25, 2017	10.0	1393	I11BA388904
12	Apr. 25, 2017	1.0	1441	D14UA108518
13	Apr. 25, 2017	3.5	1462	D12UA573180

Preparation of Pilot Area

- ✓ (1) Establish the Action team
- ✓ (2) Chamber and Plumbing
  - Design and Procure
- ✓ (3) Survey of the current situation
  - Analyze the Customer data
- ✓ (4) Prepare the document and Form
  - "Leakage survey report" etc.

Leakage survey sheet



No:

Meter Information

Family Name	First Name	Serial Number	POC

Leakage Survey / **Another Data**

No Leak Sound	Leak Sound	Visible	Invisible	Meter Position	Current Road Data	Destruction
☐	☐	☐	☐	☐ Road ☐ Inside		☐

Installation status of Meter

Visible	Invisible	Glass Broken	Lid damage	Water leak	Vertical	Horizontal	Meter Box
☐ Readable ☐ Unreadable	☐ Readable ☐ Unreadable	☐	☐	☐	☐	☐	☐

STD Service Line Layout

Note

[redacted]

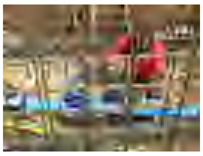
[redacted]

[redacted]

[redacted]

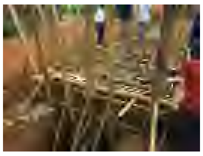
Construction of Chamber

Base concrete



Structure of Reinforced by wall

Construction of Top slab



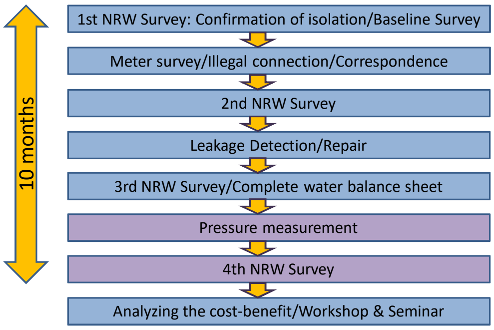
Construction of Top slab

Activities in Pilot Area

- Main activities

1. Implementation of NRW reduction activities
   - Pilot Area 1: Sep 1, 2017 to July 31, 2018
   - Pilot Area 2: Feb 1, 2018 to Mar 30, 2019
2. Specific activities plan for each area
   - 1st NRW measurement(Isolation test/Baseline survey)
   - Survey for water meter accuracy and illegal connection
   - Change the defected meters and cut off the illegal connections
   - 2nd NRW measurement
   - Leakage detection and Repair
   - 3rd NRW measurement and complete the water balance sheet
   - Water pressure measurement
   - 4th NRW measurement

Activities in Pilot Area



1st NRW Survey: Confirmation of isolation/Baseline Survey

Meter survey/Illegal connection/Correspondence

2nd NRW Survey

Leakage Detection/Repair

3rd NRW Survey/Complete water balance sheet

Pressure measurement

4th NRW Survey

Analyzing the cost-benefit/Workshop & Seminar

Water meter accuracy

Reference: Aichi Tokei Denki Co., Ltd.

“Door to door” leak detection

After Activities in Pilot Area

1. Preparing and holding the workshop and seminar
   - Duration(PA1): May 1, 2018 to July 31, 2018
   - Duration(PA2): Jan 1, 2019 to Mar 28,2019
2. Specific Activities
   - Reviewing and summarizing of the activities
   - Analyzing the cost-benefit
   - Preparation of manuals of the methods and equipment
   - Preparation of presentation materials

Schedule

Outputs	1st Year												2nd Year												3rd Year											
	2016						2017												2018												2019					
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
1. Preparation to organize Action team and to construct of Pilot Area		■																																		
2. Construction of Pilot Area 1 (KADOBOGO) and Pilot Area2 (RUYENZI)			■	■	■	■	■	■	■	■	■	■	■	■																						
3. Measuring NRW and implementation of NRW reduction activities on the Pilot Aria 1															■	■	■	■	■	■	■	■	■	■	■											
4. Preparing and holding the workshop and seminar																							■	■	■											
5. Measuring NRW and implementation of NRW reduction activities on the Pilot Aria 2																				■	■	■	■	■	■	■	■	■	■	■						
6. Preparing and holding the workshop and seminar																															■	■	■			

Japan International Cooperation Agency

PROJECT FOR STRENGTHENING NON-REVENUE WATER CONTROL IN KIGALI CITY WATER NETWORK

Output 3

Activities in Pilot Area

By Desire

Outline of the Presentation

- Introduction
- Selection Criterias of the Pilot area
- Kadobogo Pilot area (Map)
- Current Situation in kadobogo
- Ruyenzi (Map)
- Chamber design and Construction
- Pictures

Introduction

- **Pilot Area/DMA**: is an area or District Metered Area well isolated and metered in water distribution network.
- It is usually created by closing boundary valves to facilitate in monitoring water input ,output and billing in the area which lead to calculation of Non-Revenue Water rate inside the area.

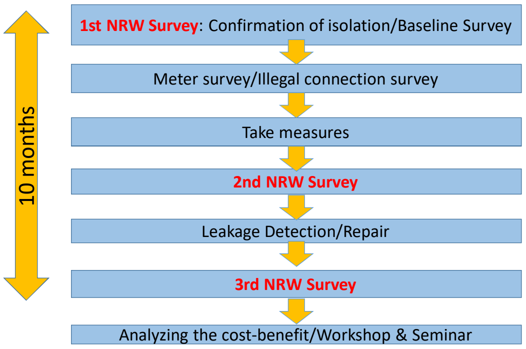
Selection Criteria's for Pilot Area

- ● Possibility of isolation
- ● 24 hours and 7 days water supply
- ● Accuracy of distribution map
- ● Water meter is installed at every houses
- ● Frequent leakages
- ● Possibility of leak detection

Activities before creation of Pilot Area

- ● Preparation of Pilot Area
- ✓ (1) Establish the Action team
- Site visit, Checking Maps and selection of pilot area
- ✓ (2) Chamber and Plumbing
- ✓ (3) Survey of the current situation
- Analyze the Customer data
- ✓ (4) Prepare the document and Form "Leakage survey report" etc.

Activities carried out in Pilot Area



1st NRW Survey: Confirmation of isolation/Baseline Survey

Meter survey/Illegal connection survey

Take measures

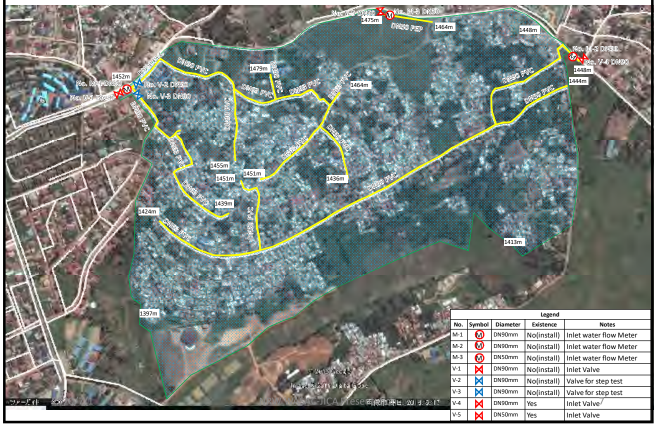
2nd NRW Survey

Leakage Detection/Repair

3rd NRW Survey

Analyzing the cost-benefit/Workshop & Seminar

KADOBOGO Pilot Area



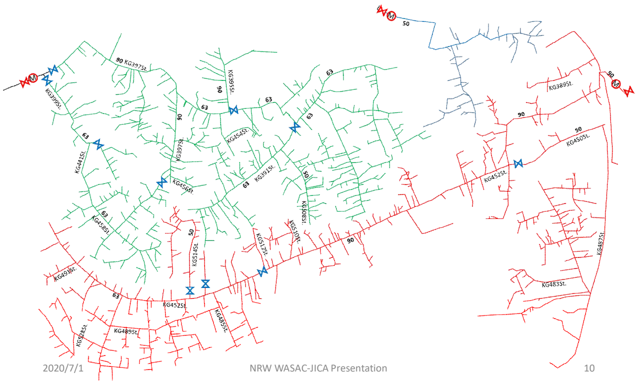
Legend				
No.	Symbol	Diameter	Existence	Notes
M-1	Ⓜ	DN90mm	No(install)	Inlet water flow Meter
M-2	Ⓜ	DN90mm	No(install)	Inlet water flow Meter
M-3	Ⓜ	DN50mm	No(install)	Inlet water flow Meter
V-1	⋈	DN90mm	No(install)	Inlet Valve
V-2	⋈	DN90mm	No(install)	Valve for step test
V-3	⋈	DN90mm	No(install)	Valve for step test
V-4	⋈	DN90mm	Yes	Inlet Valve
V-5	⋈	DN50mm	Yes	Inlet Valve

Data of Pilot Areas

KADOBOGO PILOT AREA (as of July 2016)	
Area	100.4ha
Population	15,329
Served Population (=Number of connections x 5)	4,940
Number of Connections	938
Monthly Water Consumption (m3/month)	13,157
RUYENZI PILOT AREA (as of July 2016)	
Area	648.2ha
Population	32,467
Served Population (=Number of connections x 5)	5,925
Number of Connections	885
Monthly Water Consumption(m3/month)	12,259

Challenges of KADOBOGO

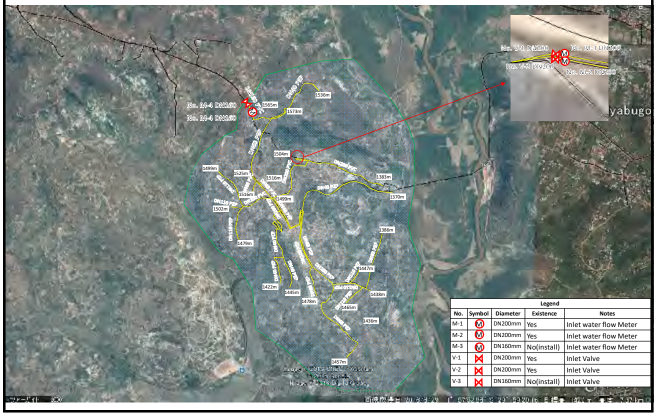
Distribution Blocks in KADOBOGO



Current Situation for KADOBOGO

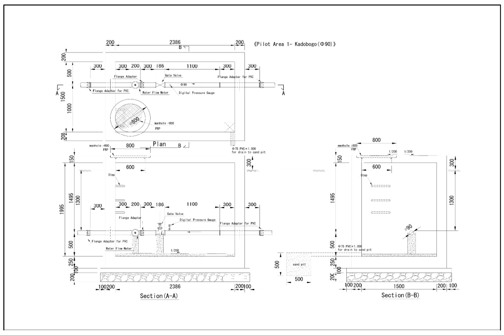
- Meter visited: 1200.
- Meters tested using Portable Meter test: 638
- Meters beyond +- 5% : 149 =23%
- Replaced meters: 110
- NRW baseline : 36.3% (Avairage June-August)
- **Challenges:**
- Some customers do not open their gates.
- Leakages and intermittent supply in the area.

RUYENZI Pilot Area



Legend				
No.	Symbol	Diameter	Existence	Notes
M-1	Ⓜ	DN200mm	Yes	Inlet water flow Meter
M-2	Ⓜ	DN200mm	Yes	Inlet water flow Meter
M-3	Ⓜ	DN160mm	No(install)	Inlet water flow Meter
V-1	⋈	DN200mm	Yes	Inlet Valve
V-2	⋈	DN200mm	Yes	Inlet Valve
V-3	⋈	DN160mm	No(install)	Inlet Valve

Chamber Design & Construction



Base Concrete

Structure of Reinforced Still.

Construction of Chamber

Finished

Inside the Chamber

Schedule of activities in Pilot Area

- ● Main activities

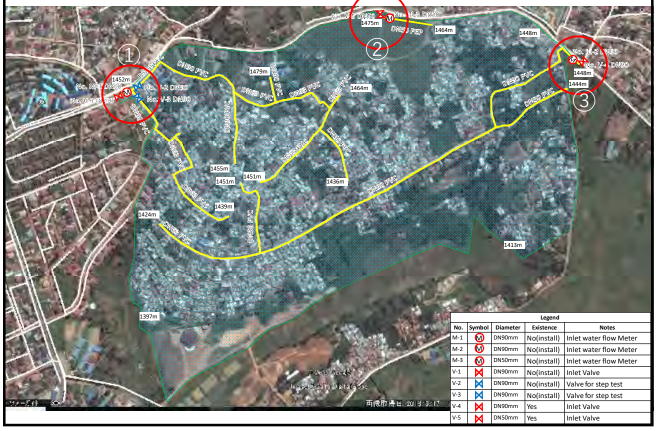
1. NRW reduction activities in PM1 & PM2.
   - ➢ Pilot Area 1: Sep 1, 2017 to Jun 30, 2018
   - ➢ Pilot Area 2: Apr 1, 2018 to Mar 30, 2019
2. Specific activities plan for each area
   - ➢ NRW measurement(Isolation test/Baseline survey)
   - ➢ Survey for water meter, Illegal connection and unauthorized consumption
   - ➢ NRW measurement(Evaluation)
   - ➢ Leakage detection and Repair
   - ➢ NRW measurement (Re-evaluation)

“Door to door” leak detection

1.4 Isolation of DMA

Location of the Inflow Facilities in Pilot Areas

Kadobogo (Kiyovu) DMA



Legend				
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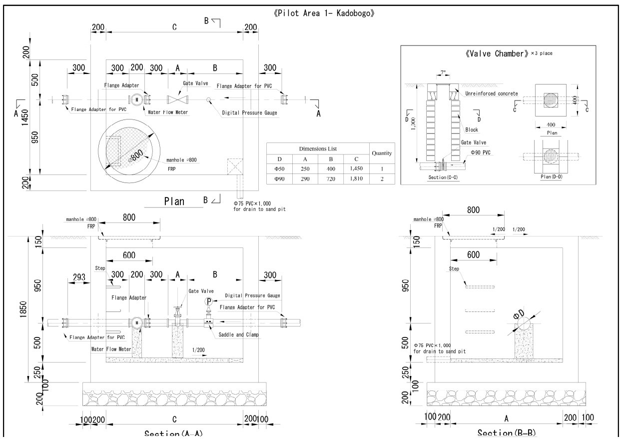
V-1	⋈	DN90mm	No(install)	Inlet Valve
V-2	⋈	DN90mm	No(install)	Valve for step test
V-3	⋈	DN90mm	No(install)	Valve for step test
V-4	⋈	DN90mm	Yes	Inlet Valve
V-5	⋈	DN50mm	Yes	Inlet Valve

Kadobogo ①

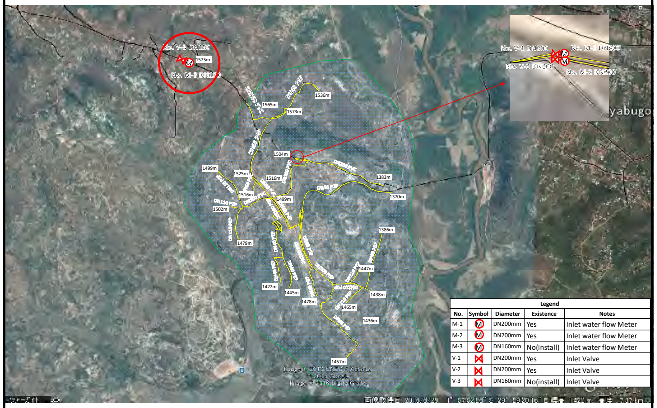
Kadobogo ②

Kadobogo ③



Dimensions List				Quantity
D	A	B	C	
Φ50	250	400	1,450	1
Φ90	290	720	1,810	2

Ruyenzi (Runda) DMA



Legend				
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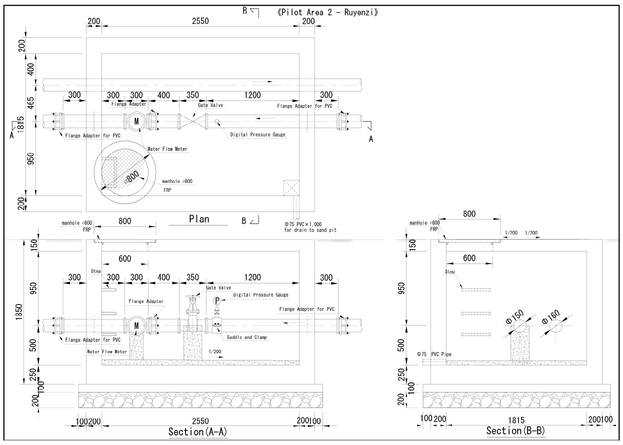
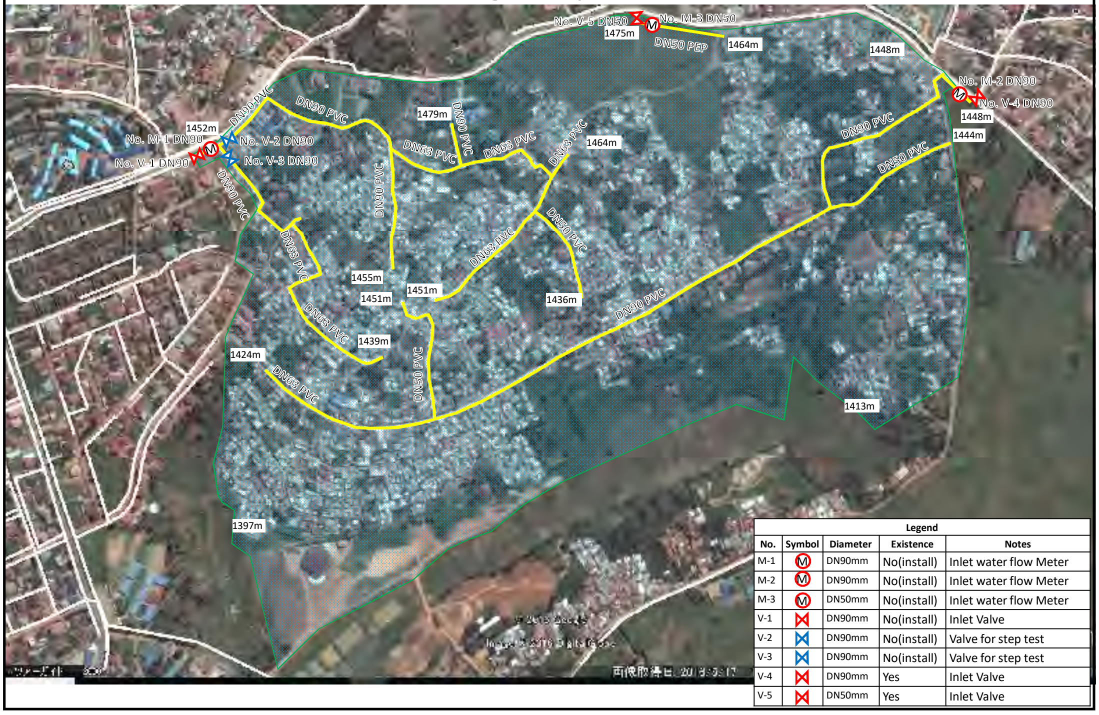
M-1	Ⓜ	DN200mm	Yes	Inlet water flow Meter
M-2	Ⓜ	DN200mm	Yes	Inlet water flow Meter
M-3	Ⓜ	DN160mm	No(install)	Inlet water flow Meter
V-1	⋈	DN200mm	Yes	Inlet Valve
V-2	⋈	DN200mm	Yes	Inlet Valve
V-3	⋈	DN160mm	No(install)	Inlet Valve

Ruyenzi ①



Kadobogo (Kiyovu) DMA

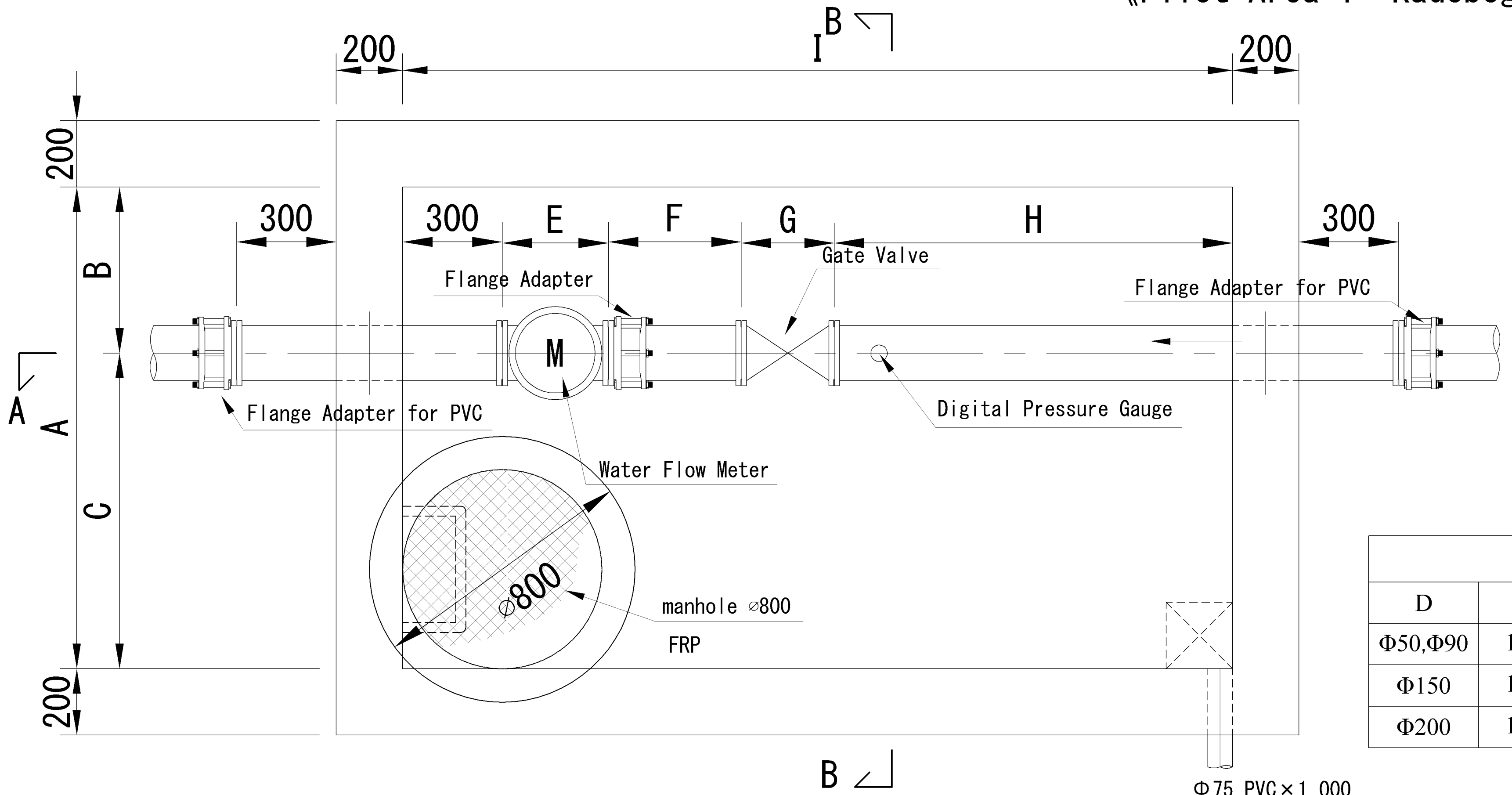


Legend				
No.	**Symbol**	**Diameter**	**Existence**	**Notes**
M-1	Ⓜ	DN90mm	No(install)	Inlet water flow Meter
M-2	Ⓜ	DN90mm	No(install)	Inlet water flow Meter
M-3	Ⓜ	DN50mm	No(install)	Inlet water flow Meter
V-1	⋈	DN90mm	No(install)	Inlet Valve
V-2	⋈	DN90mm	No(install)	Valve for step test
V-3	⋈	DN90mm	No(install)	Valve for step test
V-4	⋈	DN90mm	Yes	Inlet Valve
V-5	⋈	DN50mm	Yes	Inlet Valve

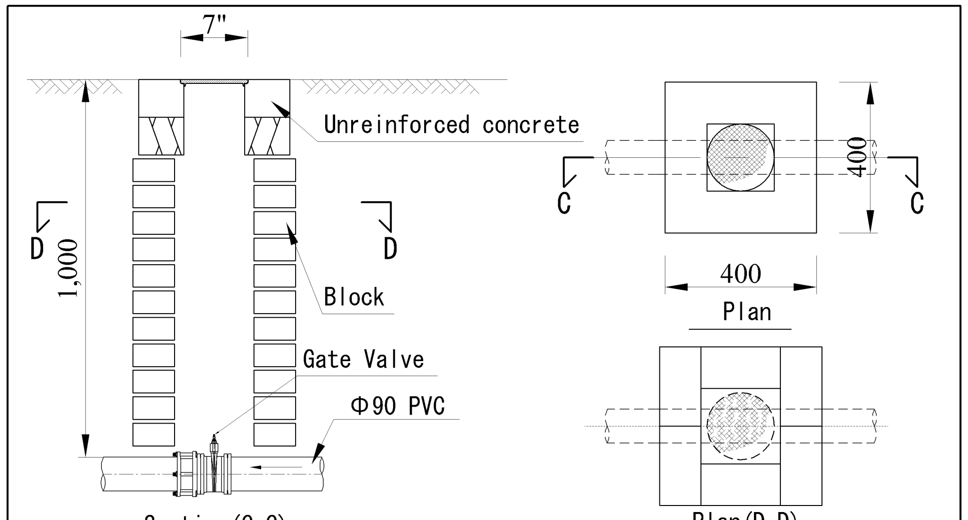
Ruyenzi (Runda) DMA

Legend				
No.	**Symbol**	**Diameter**	**Existence**	**Notes**
M-1	Ⓜ	DN200mm	Yes	Inlet water flow Meter
M-2	Ⓜ	DN200mm	Yes	Inlet water flow Meter
M-3	Ⓜ	DN160mm	No(install)	Inlet water flow Meter
V-1	⋈	DN200mm	Yes	Inlet Valve
V-2	⋈	DN200mm	Yes	Inlet Valve
V-3	⋈	DN160mm	No(install)	Inlet Valve

《Pilot Area 1- Kadobogo》



Plan

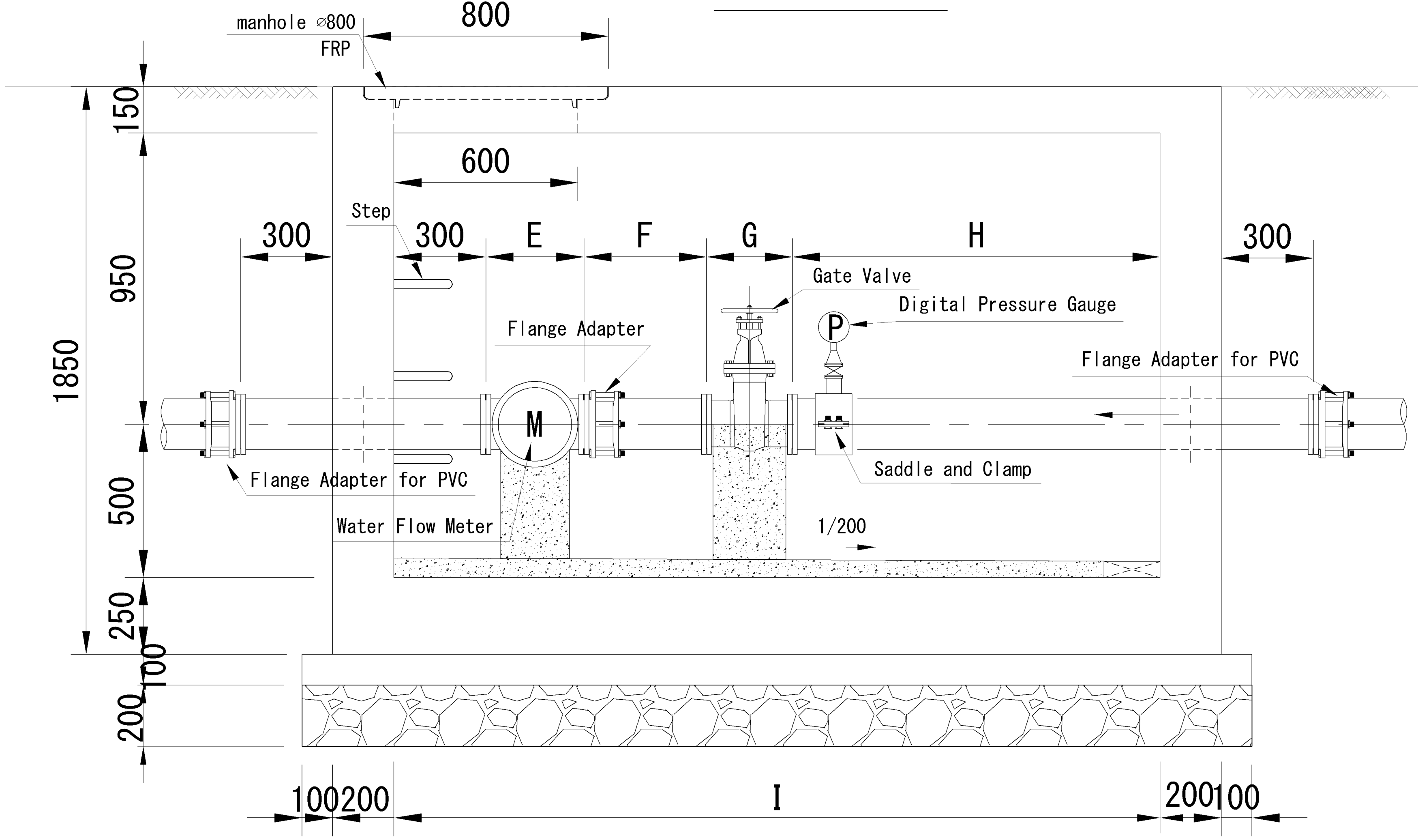


Section(C-C)

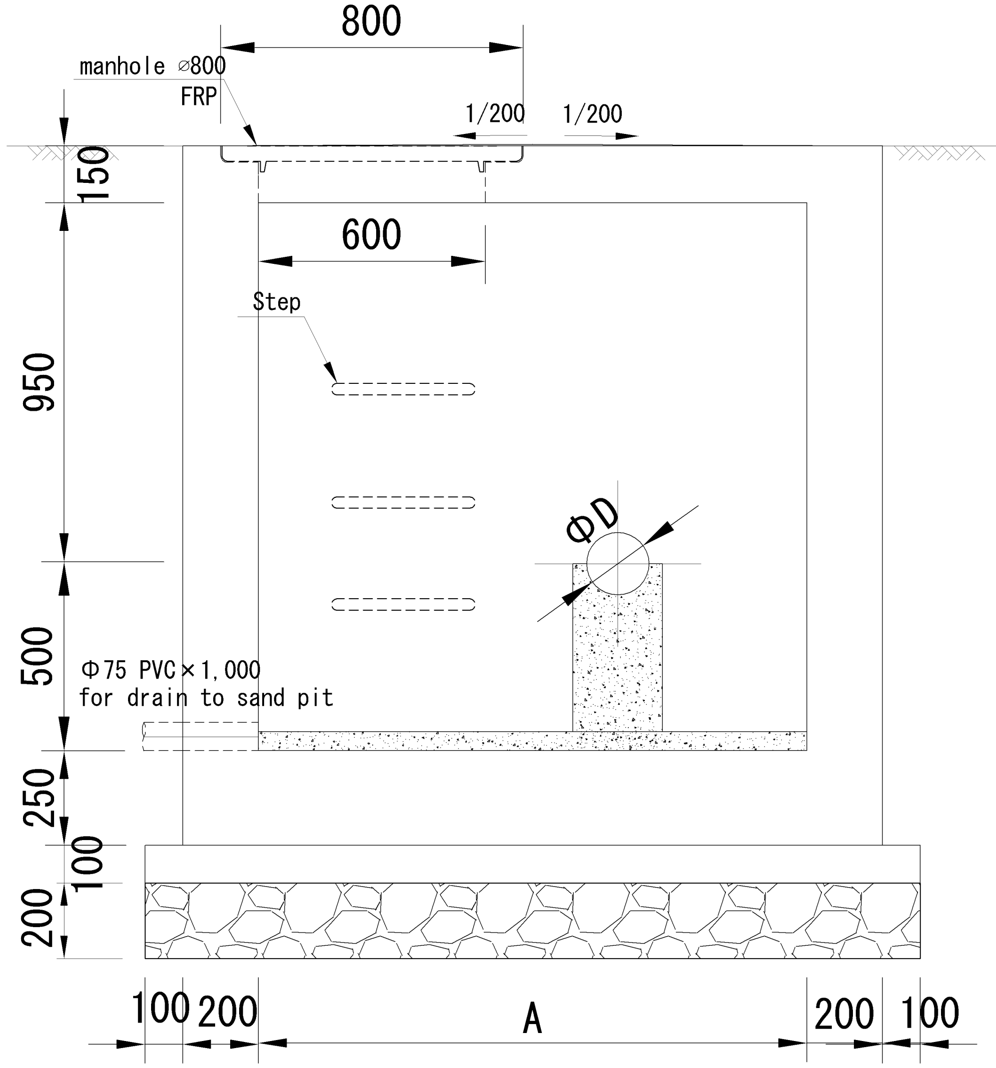
Plan(D-D)

×1 place

Dimensions List									Quantity
D	A	B	C	E	F	G	H	I	
Φ50,Φ90	1,100	400	700	250	300	250	720	1,820	2
Φ150	1,450	500	950	300	400	280	1,200	2,480	0
Φ200	1,450	500	950	350	500	300	1,600	3,050	0

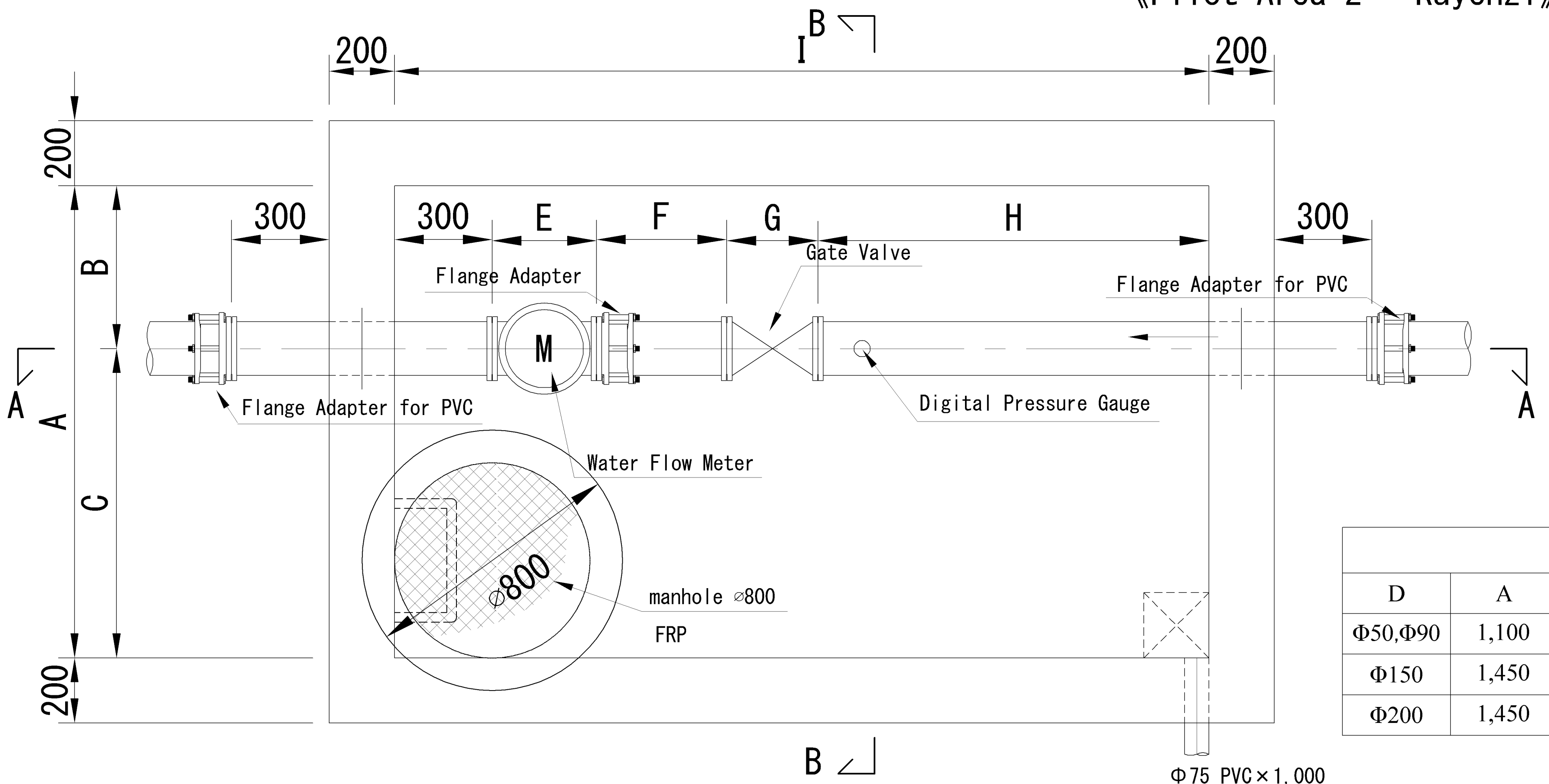


Section(A-A)

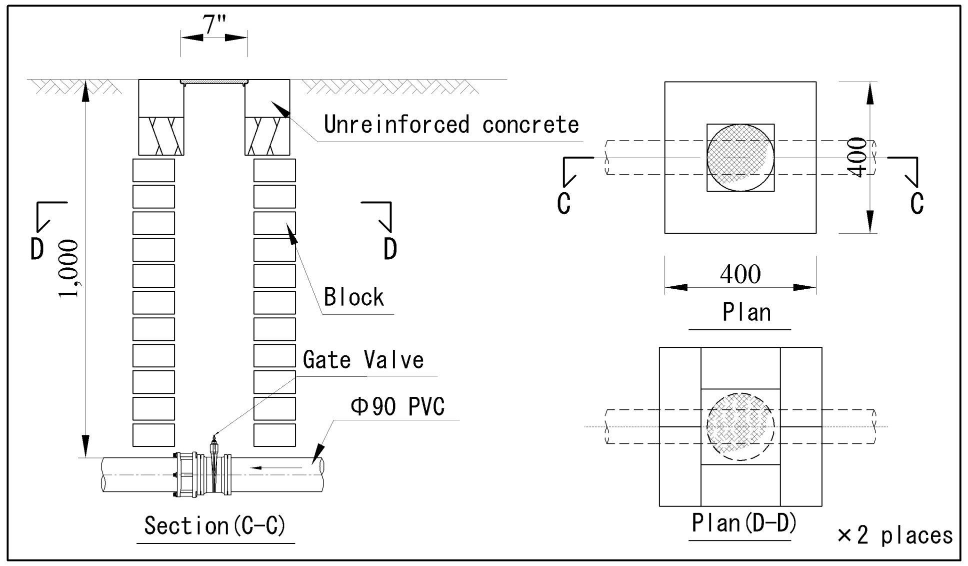


Section(B-B)

《Pilot Area 2 - Ruyenzi》



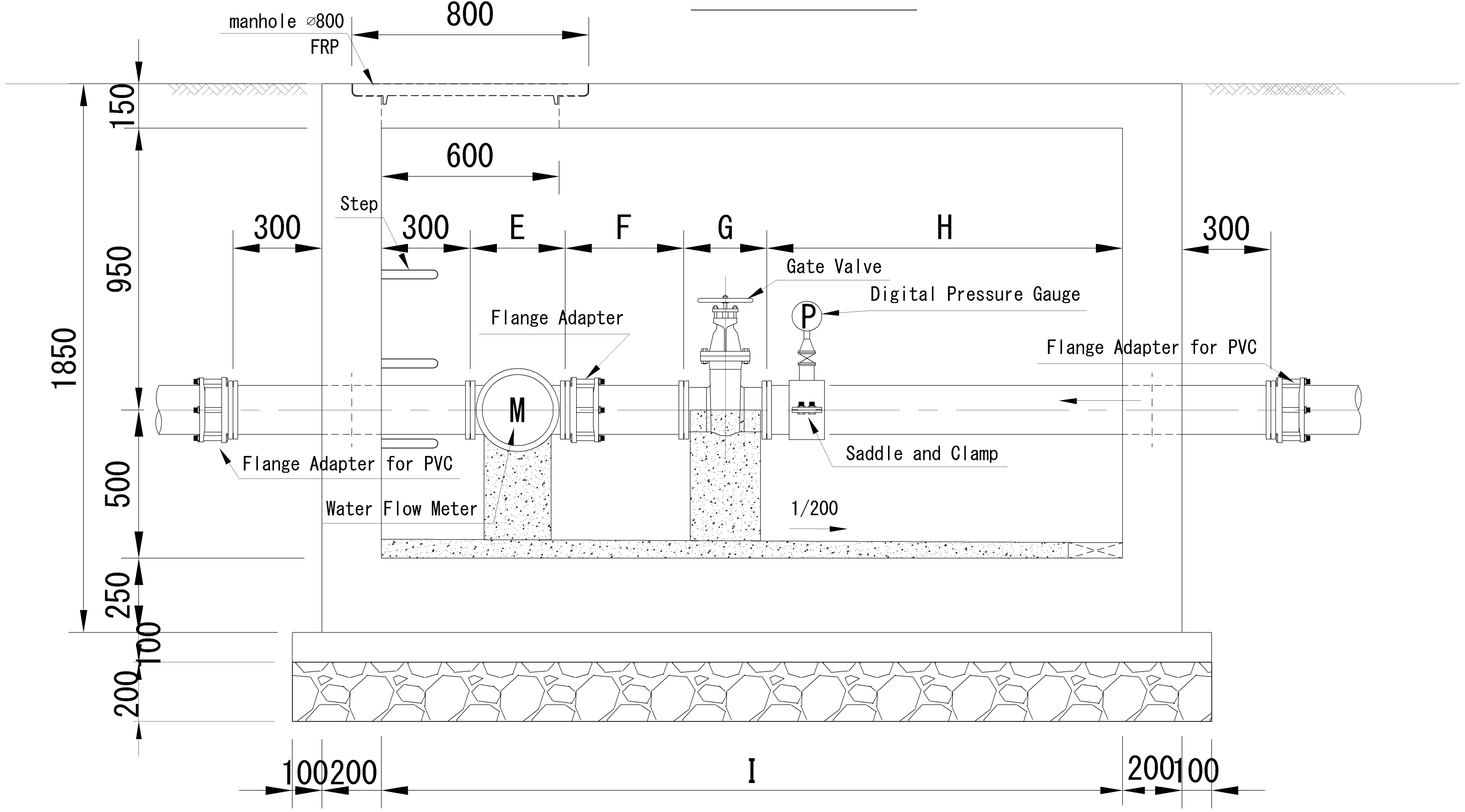
Plan



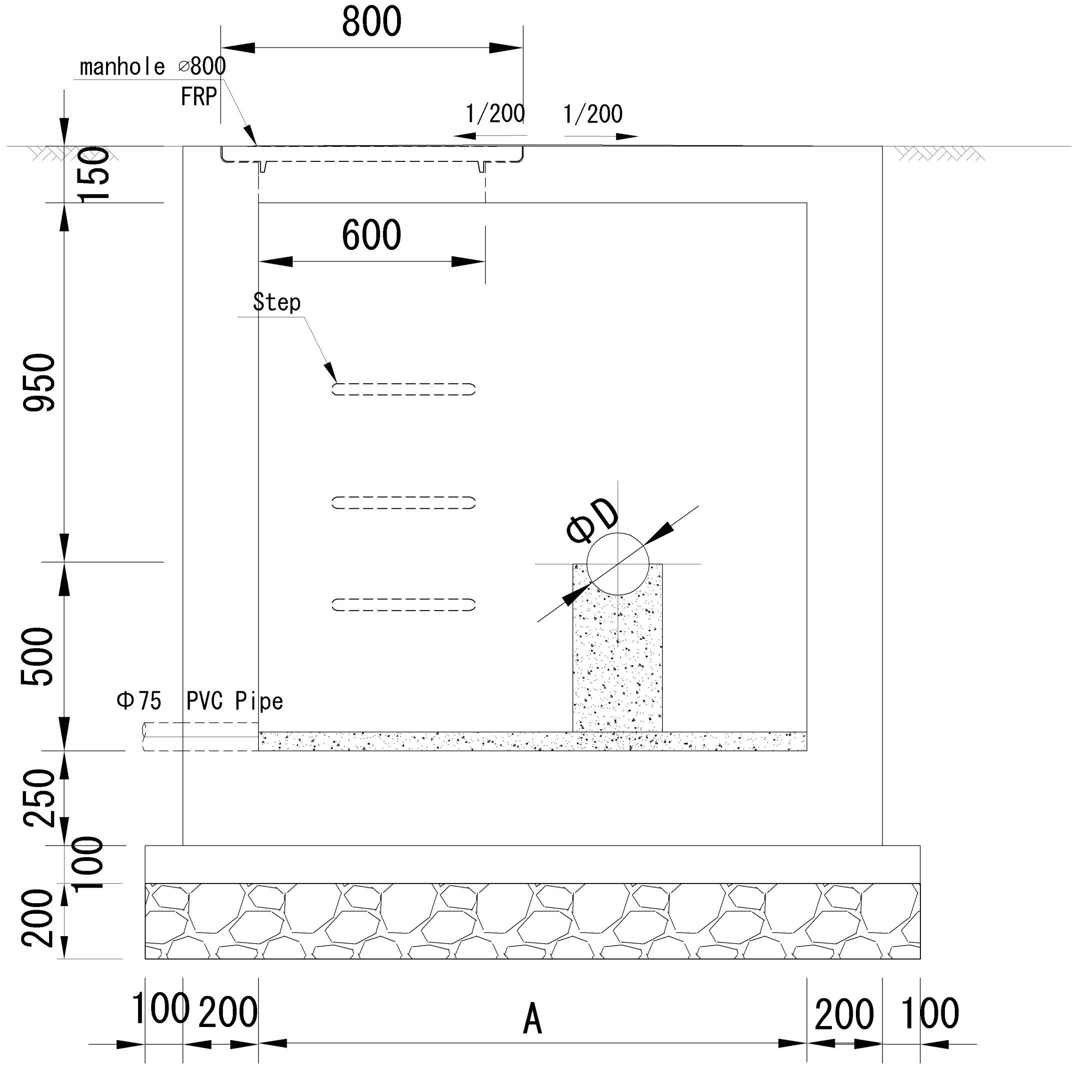
Section(C-C)

Plan(D-D)

Dimensions List									Quantity
D	A	B	C	E	F	G	H	I	
Φ50,Φ90	1,100	400	700	250	300	250	720	1,820	0
Φ150	1,450	500	950	300	400	280	1,200	2,480	1
Φ200	1,450	500	950	350	500	300	1,600	3,050	0

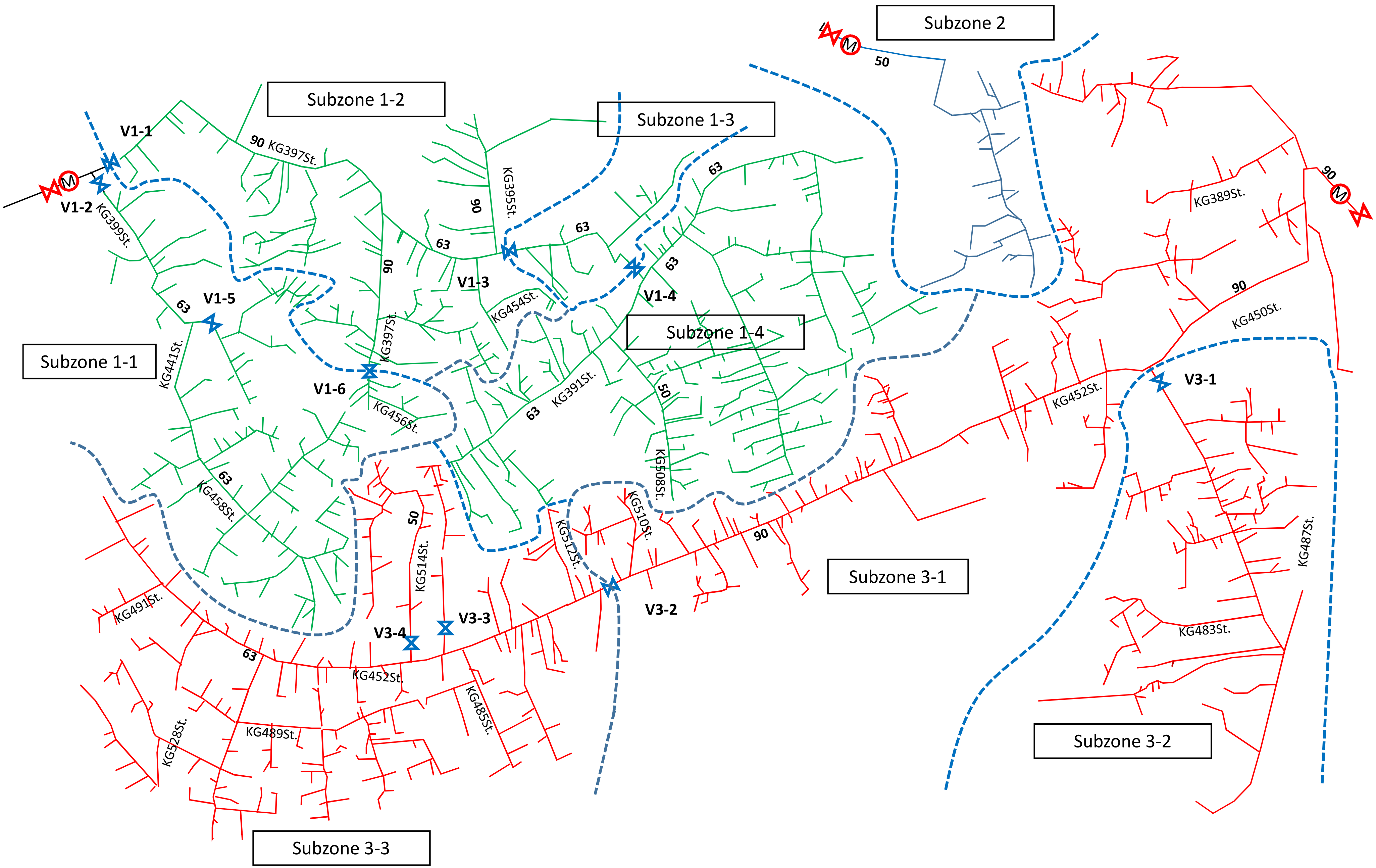


Section(A-A)

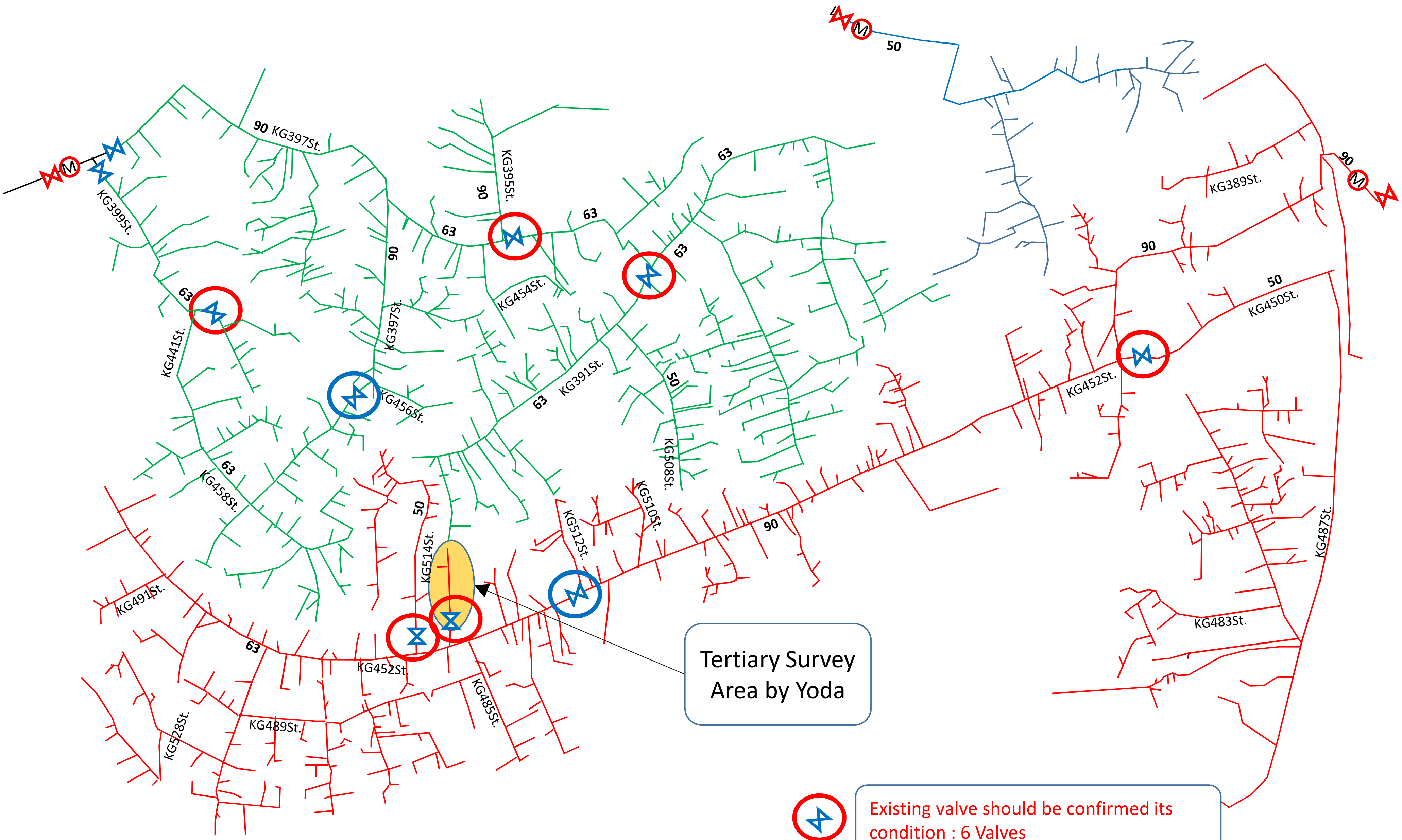


Section(B-B)

Kadobogo Subzone Map



Kadobogo DMA Pipe Line Map



Tertiary Survey Area by Yoda

Existing valve should be confirmed its condition : 6 Valves

New valve should be installed by WASAC : 2 Valves

INSPECTION OF THE METERS INSTALLED INSIDE OF KADOBOGO PILOT AREA

The valves were installed according to map proposed by Mr Suzuki, that case those meters are for good management of pilot area, for verification the interconnection the pipeline inside the Kadobogo, after the three inlets supplying water.

The Kacyiru branch was responsible in installation of all valves, but all new valves were installed for replace the existing old valves damaged, because of they were under soil (underground installation).

The visit on 28th July 2017, we inspect six new valves installed, composed by five valves DE 65 and one valve DE 50. The last which is DE 40 will be also installed after getting the accessories (adaptors). The problem is all valves were installed are also underground. WASAC Kacyiru branch has not possibility(budget) for construction of six operating valves.

PHOTOS

The map attached, the valve with yellow colors are installed and which is pink color not yet.

1.5 Apparent Loss

Meter and Connection Survey

Schedule

- Responsible Section:
- CSD & GIS section in cooperation with JICA Team
- Preparation: Leak level detectors (three sets), and Worksheet
- Survey Period: one month (4 week)
- Efficiency of survey:360POCs in a week by three teams, 30 POCs/team/day (90POCs x 4 days)
- Team organization: (one engineer + one technician) x three teams

---

Basic consideration

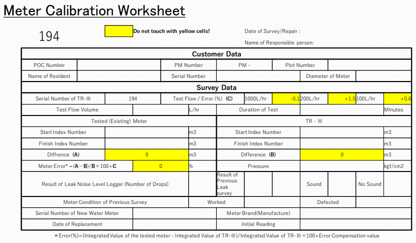
- Purpose: Issues related to **NRW**
  1) Leak level, a key for **leakage detection**
  2) Meter status and illegal water use, a part of **commercial losses**
- Purpose: Basic information for **meter calibration and replacement**

- Efficiency: shorten time required for survey
- Simplicity: avoid duplication, minimizing items in GIS customer data – simple format (choice boxes)

Items to be Checked

- POC, Zone (1, 2, 3), Date surveyed, By whom
- User category, Meter size, Yard connection or not, Other sources (wells)
- User: 1) Owner, 2) Tenant
- Encased in meter box: 1) No, 2) Yes, locked, 2) Yes, not locked
- Meter condition: 1) Working or not, 2) Readable or not, 3) Blocked, 4) Broken, 5) No meters, 6) Others (red ball, improper installation, needs of MR, ________________________)
- Connection status: 1) Disconnected (before or after meters), 2) Leak level (by detector) and possible leak points, 3) Located above or underground, 4) Others (gate closed daytime, stop valve not working, no support, traces of illegal use, improper pipe & meter size, poor quality pipe materials, ________________)
- Any opinions by customers & Observation by surveyor
- Water consumption more than 30m3/month (to be checked later)

Survey Worksheet (to be prepared)



Meter Calibration Worksheet

194

Do not touch with yellow cells!

Date of Survey/Repair :

Name of Responsible person:

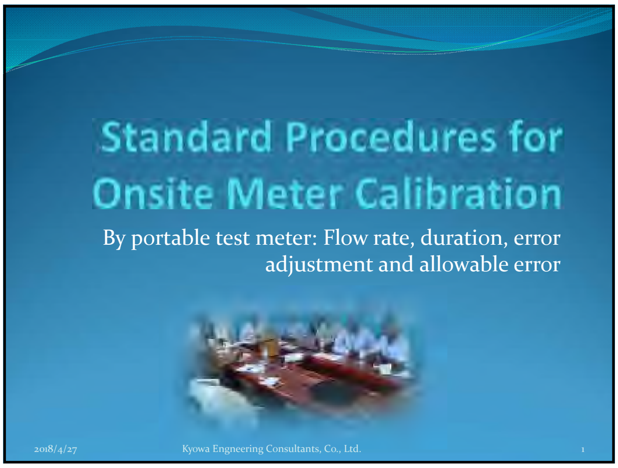
<table>
<tr><th colspan="14">Customer Data</th></tr>
<tr><td colspan="2">POC Number</td><td colspan="3"></td><td colspan="2">PM Number</td><td colspan="2">PM -</td><td colspan="2">Plot Number</td><td colspan="3"></td></tr>
<tr><td colspan="2">Name of Resident</td><td colspan="3"></td><td colspan="2">Serial Number</td><td colspan="3"></td><td colspan="2">Diameter of Meter</td><td colspan="2"></td></tr>
<tr><th colspan="14">Survey Data</th></tr>
<tr><td colspan="3">Serial Number of TR-III</td><td colspan="2">194</td><td colspan="3">Test Flow / Error (%) (C)</td><td>1000L/hr</td><td>-0.1</td><td>200L/hr</td><td>+1.5</td><td>100L/hr</td><td>+0.6</td></tr>
<tr><td colspan="4">Test Flow Volume</td><td colspan="2"></td><td>L/hr</td><td colspan="3">Duration of Test</td><td colspan="3"></td><td>Minutes</td></tr>
<tr><td colspan="7">Tested (Existing) Meter</td><td colspan="7">TR - III</td></tr>
<tr><td colspan="3">Start Index Number</td><td colspan="3"></td><td>m3</td><td colspan="3">Start Index Number</td><td colspan="3"></td><td>m3</td></tr>
<tr><td colspan="3">Finish Index Number</td><td colspan="3"></td><td>m3</td><td colspan="3">Finish Index Number</td><td colspan="3"></td><td>m3</td></tr>
<tr><td colspan="3">Diffrence (A)</td><td colspan="3">0</td><td>m3</td><td colspan="3">Difference (B)</td><td colspan="3">0</td><td>m3</td></tr>
<tr><td colspan="4">Meter Error* =(A－B)/B×100+C</td><td colspan="2">0</td><td>%</td><td colspan="3">Pressure</td><td colspan="3"></td><td>kgf/cm2</td></tr>
<tr><td colspan="6">Result of Leak Noise Level Logger (Number of Drops)</td><td></td><td>Result of Previous Leak survey</td><td></td><td></td><td>Sound</td><td></td><td>No Sound</td><td></td></tr>
<tr><td colspan="6">Meter Condition of Previous Survey</td><td colspan="2">Worked</td><td colspan="2"></td><td colspan="2">Defected</td><td colspan="2"></td></tr>
<tr><td colspan="4">Serial Number of New Water Meter</td><td colspan="3"></td><td colspan="3">Meter Brand(Manufacture)</td><td colspan="4"></td></tr>
<tr><td colspan="4">Date of Replacement</td><td colspan="3"></td><td colspan="3">Initial Reading</td><td colspan="4"></td></tr>
</table>

＊Error(%)=(Integrated Value of the tested meter - Integrated Value of TR-III)/Integrated Value of TR-III ×100+Error Compensation value

---

Customer Particulars by GIS Section

- ID Data_Collection_Date provide_plot_number
- Latitude Longitude Altitude is_there_wasac_water
- is_there_regi_water type_of_customer particular_customer_or_institution
- name_of_the_institution Family_name First_name
- is_the_person_on_bill_the_owner_of_the_house
- family_name_of_owner_or_representative first_name_of_owner_or_representative
- nationality id_type id_number birth_date birth_place
- sex marital_status point_of_connection_poc phone_number
- street_number house_number email_address how_many_water_users
- is_water_meter_available water_meter_manufacturer
- give_the_name_of_the_other_meter_found meter_nominal_flow_rate
- year_of_manufacture serial_number metrological_class meter_type
- physical_status_of_meter meter_sealing screen_status index_status
- current_index_reading inlet_pipe_connection_diameter connection_model
- presence_of_water_meter_box presence_of_water_tank
- tank_capacity_in_liters tank_material tank_position
- other_water_storage_capacity_in_liters presence_of_swimming_pool
- swimming_pool_capacity_in_liters connection_legality Village
- Cell Sector District Province Connection Status



Standard Procedures for Onsite Meter Calibration

By portable test meter: Flow rate, duration, error adjustment and allowable error

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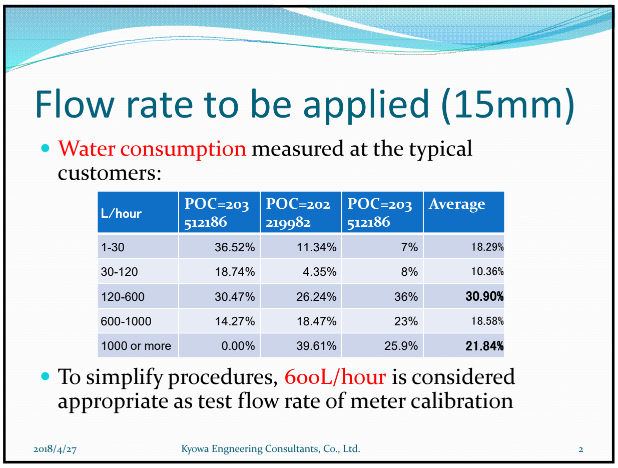

Flow rate to be applied (15mm)

- Water consumption measured at the typical customers:

L/hour	POC=203 512186	POC=202 219982	POC=203 512186	Average
1-30	36.52%	11.34%	7%	18.29%
30-120	18.74%	4.35%	8%	10.36%
120-600	30.47%	26.24%	36%	**30.90%**
600-1000	14.27%	18.47%	23%	18.58%
1000 or more	0.00%	39.61%	25.9%	**21.84%**

- To simplify procedures, 600L/hour is considered appropriate as test flow rate of meter calibration

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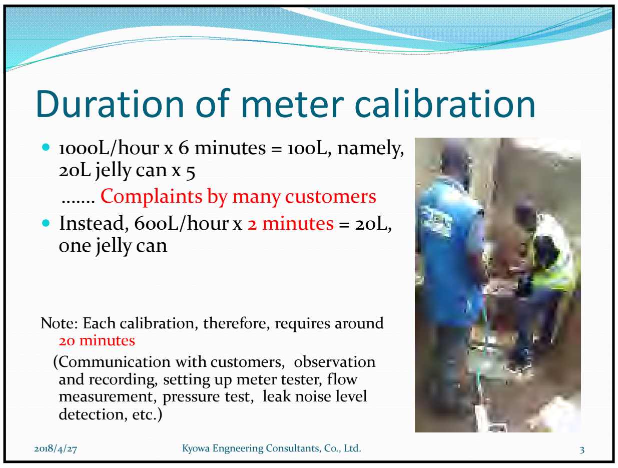
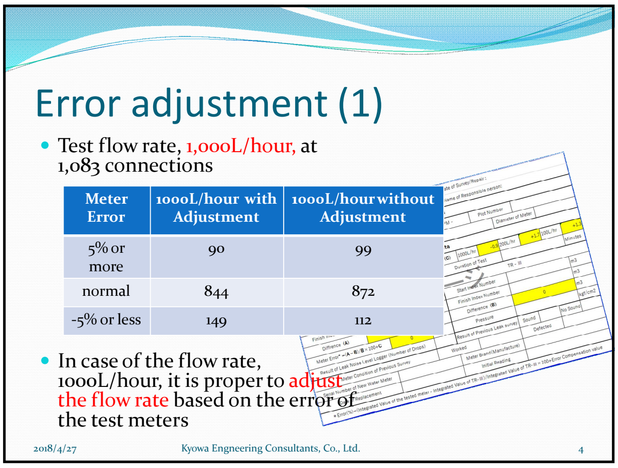


Duration of meter calibration

- 1000L/hour x 6 minutes = 100L, namely, 20L jelly can x 5
  ……. Complaints by many customers
- Instead, 600L/hour x 2 minutes = 20L, one jelly can

Note: Each calibration, therefore, requires around 20 minutes

(Communication with customers, observation and recording, setting up meter tester, flow measurement, pressure test, leak noise level detection, etc.)



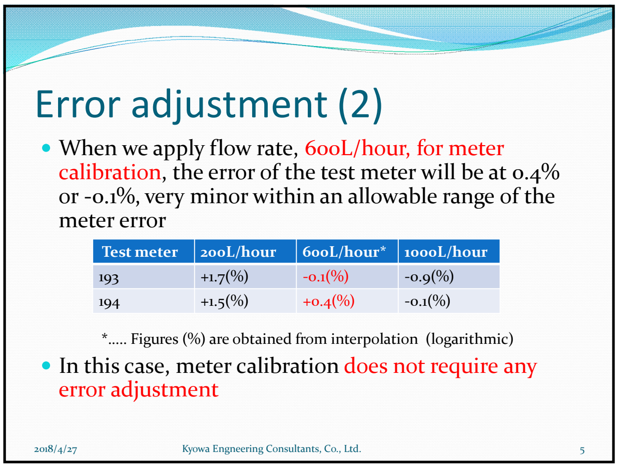
Error adjustment (1)

- Test flow rate, 1,000L/hour, at 1,083 connections

Meter Error	1000L/hour with Adjustment	1000L/hour without Adjustment
5% or more	90	99
normal	844	872
-5% or less	149	112

- In case of the flow rate, 1000L/hour, it is proper to adjust the flow rate based on the error of the test meters

---



Error adjustment (2)

- When we apply flow rate, 600L/hour, for meter calibration, the error of the test meter will be at 0.4% or -0.1%, very minor within an allowable range of the meter error

Test meter	200L/hour	600L/hour*	1000L/hour
193	+1.7(%)	-0.1(%)	-0.9(%)
194	+1.5(%)	+0.4(%)	-0.1(%)

*….. Figures (%) are obtained from interpolation (logarithmic)

- In this case, meter calibration does not require any error adjustment

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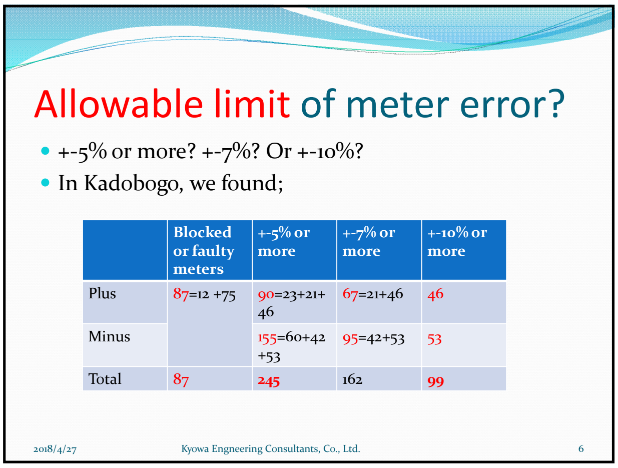
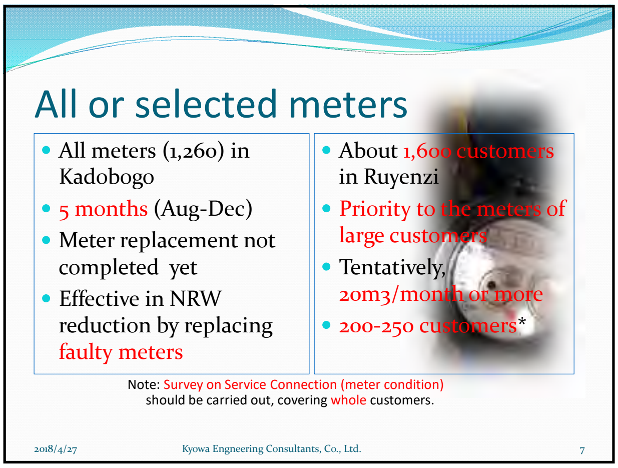


Allowable limit of meter error?

- +-5% or more? +-7%? Or +-10%?
- In Kadobogo, we found;

	Blocked or faulty meters	+-5% or more	+-7% or more	+-10% or more
Plus	87=12 +75	90=23+21+ 46	67=21+46	46
Minus		155=60+42 +53	95=42+53	53
Total	87	245	162	99



All or selected meters

- All meters (1,260) in Kadobogo
- 5 months (Aug-Dec)
- Meter replacement not completed yet
- Effective in NRW reduction by replacing faulty meters

- About 1,600 customers in Ruyenzi
- Priority to the meters of large customers
- Tentatively, 20m3/month or more
- 200-250 customers*

Note: Survey on Service Connection (meter condition) should be carried out, covering whole customers.

Thanks for attention!

Water Consumption Survey

The water consumption of three ordinary households in kadobogo Pilot Area was recorder in the survey.

Figure-8 Locations of the surveyed households

The table below(Table-5) shows the monthly water consumption (m3/M) of the three households between June and December 2017

Table-5 Monthly water consumption of households

S/NO	POC	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1080	203512186	9	18	22	9	8	14	20
603	202219982	14	26	0	31	19	14	19
622	204717248	10	4	14	12	9	9	10

The result of the analysis of water consumption of the three households by consumption rate is described in the following.

No,1 POC No, 203512186

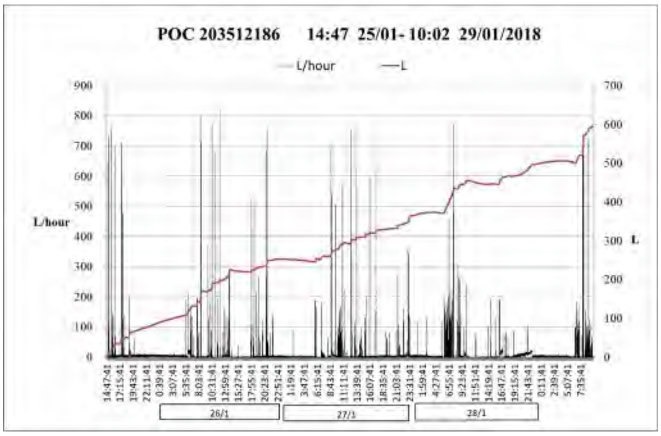


Figure-9 Cumulative water consumption breakdown by consumption rate

Table-6 Volumes and proportion of water consumption by consumption rate

L/hour	Volume	%
1-30	217.3	36.52%
30-120	111.5	18.74%
120-600	181.3	30.47%
600-1000	84.9	14.27%
1000-3000	0.0	0.00%
	595.1	100.00%

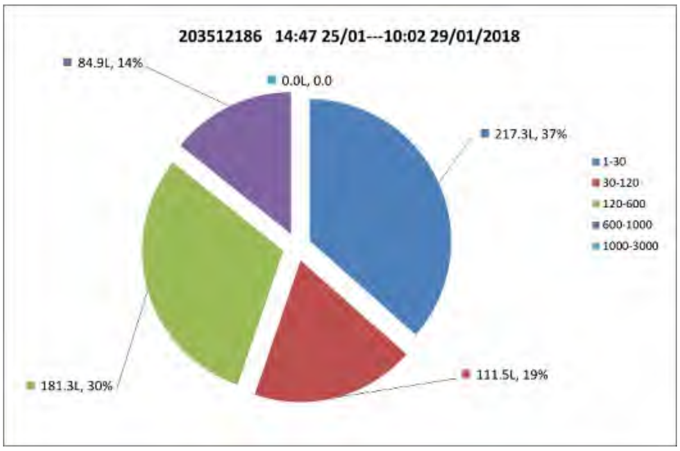


Figure-10 Pie chart of Volumes and proportion of water consumption by consumption rate

No,2 POC No, 202219982

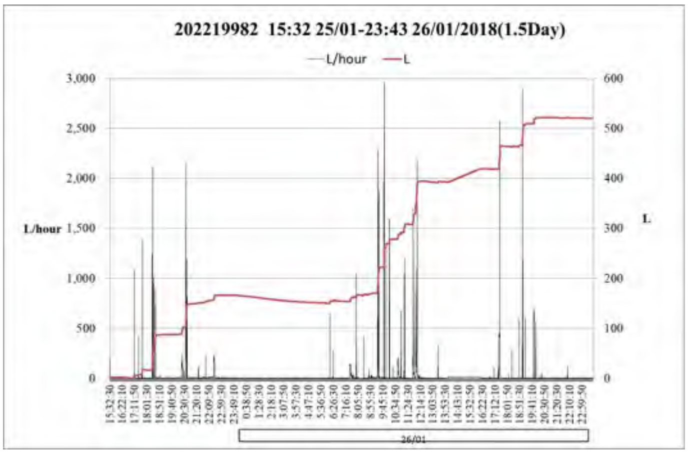


Figure-11Cumulative water consumption breakdown by consumption

Table-7 Volumes and proportion of water consumption by consumption rate

	Volume	%
1-30	58.9	11.34%
30-120	22.6	4.35%
120-600	136.4	26.24%
600-1000	96.0	18.47%
1000-3000	205.9	39.61%
	519.8	100.00%

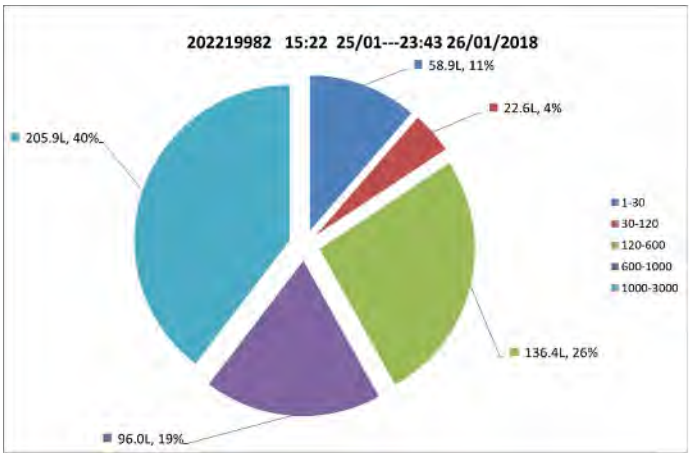


Figure-12 Pie chart of Volumes and proportion of water consumption by consumption rate

No,3　POC No, 203512186

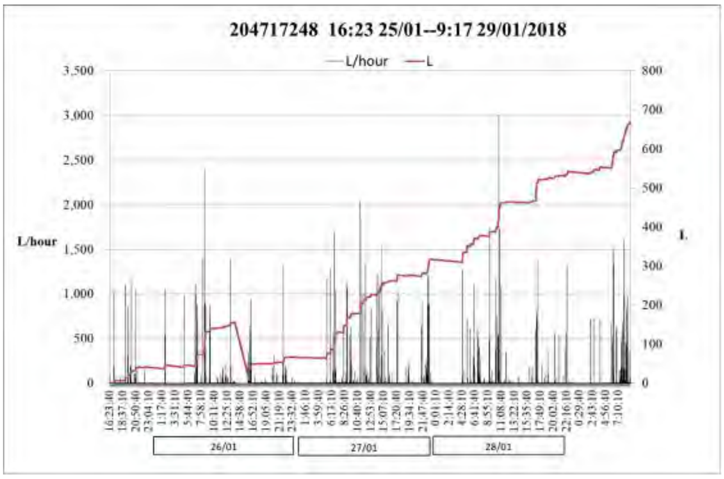


Figure-13　Cumulative water consumption breakdown by consumption rate

Table-8　Volumes and proportion of water consumption by consumption rate

	Volume	%
1-30	45	7%
30-120	54	8%
120-600	242	36%
600-1000	153	23%
1000-3000	168	25%
3000-3500	6	0.90%
	668	100.00%

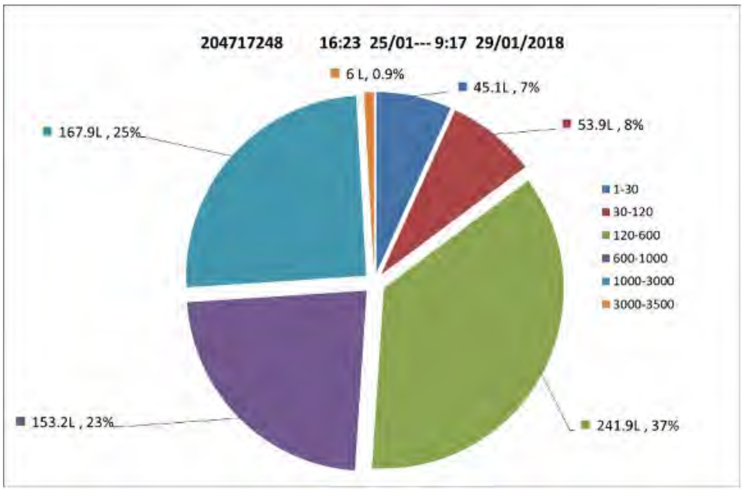


Figure-14　Pie chart of Volumes and proportion of water consumption by consumption rate

Work Plan 2017

Activities in November and December

---

1) Priority work at Kadobogo Area – Commercial loss

- Onsite meter calibration and replacement of malfunctioning meters
- Questionnaire survey about willingness to connect of non-served households and disconnected customers
- In-room calibration of meters by test bench
- Hydraulic isolation at PM1, PM2 & PM3 (and step test)
- Flow measurement at PM1, PM2 and PM3
- POC map update
- Analysis of apparent loss and measurement of NRW rate
- Analysis of B/C

---

2) Priority work at Kadobogo area – Visible and invisible leakage

- Leakage and pressure test at PM2
- OJT and In-room Training on how to utilize the leak survey equipment
- Design patrol and detection method including team organization
- Patrol and sounding for locating visible and invisible leakage

---

Priority work at Ruyenzi area – Preparatory work

- Prepare POC map (GIS section & Branch)
- Estimate monthly NRW rate
- Review consumption data to list up customers of zero consumption
- Conduct hydraulic isolation and update the POC map
- Design how to carry out pressure management

Actual Progress at Kadobogo

---

1) Onsite Meter Calibration

- As of November 20, 2017, the team had checked 1,082 meters at site, and found the malfunctioning meters as follows:

Error of Accuracy(%)	Number of Meters
More than +10	**51**
From +5 to +10	57
From -5 to -10	**50**
Less than -10	**36**
Total	**194**

Defected Meters
69

Default Stopcocks
more than 20?

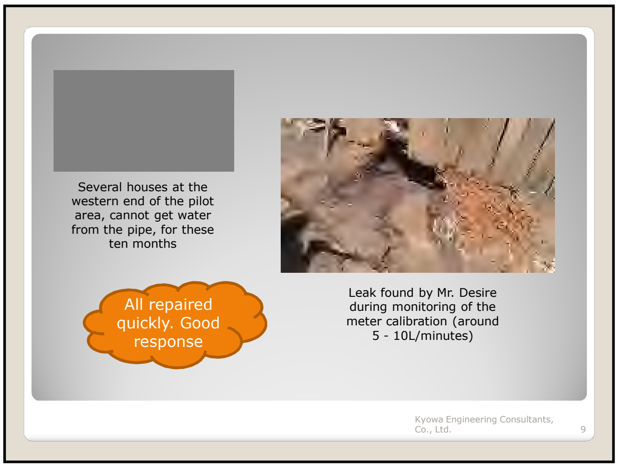
Meter calibration at the flow rate, 1,000L/hr

Many leakage from the broken elbow, when the tap is opened (Being controlled by the stopcock installed under the ground), POC=204710059

Broken stopcock, ausing water stoppage POC=204716418

Meter-box locked by owner, protecting from any access

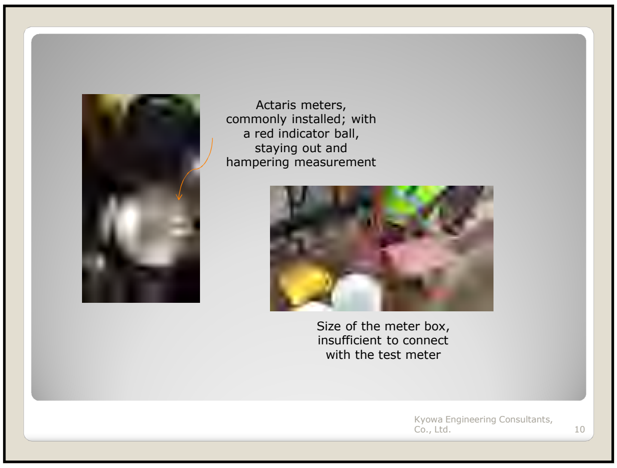
Pressure regulator or non-return valve(?), inserted in the pipes



Several houses at the western end of the pilot area, cannot get water from the pipe, for these ten months

All repaired quickly. Good response

Leak found by Mr. Desire during monitoring of the meter calibration (around 5 - 10L/minutes)

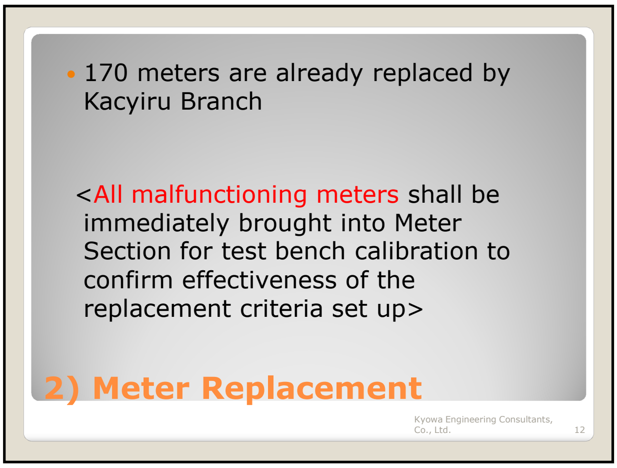


Actaris meters, commonly installed; with a red indicator ball, staying out and hampering measurement

Size of the meter box, insufficient to connect with the test meter

Pipe breakage (hair crack) of PE, 50m from PM2

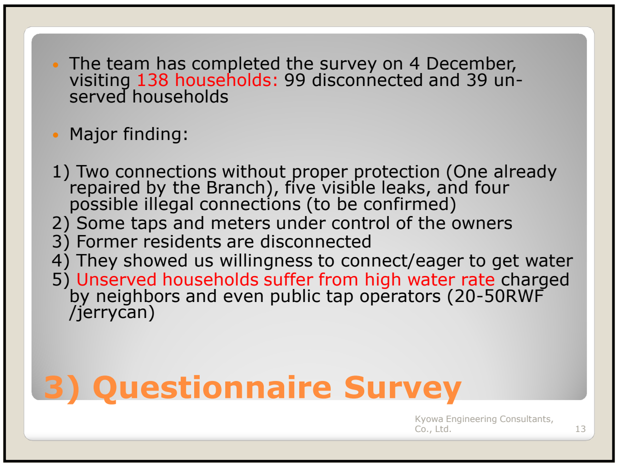
Leak repair by Kacyiru branch



- 170 meters are already replaced by Kacyiru Branch

<All malfunctioning meters shall be immediately brought into Meter Section for test bench calibration to confirm effectiveness of the replacement criteria set up>

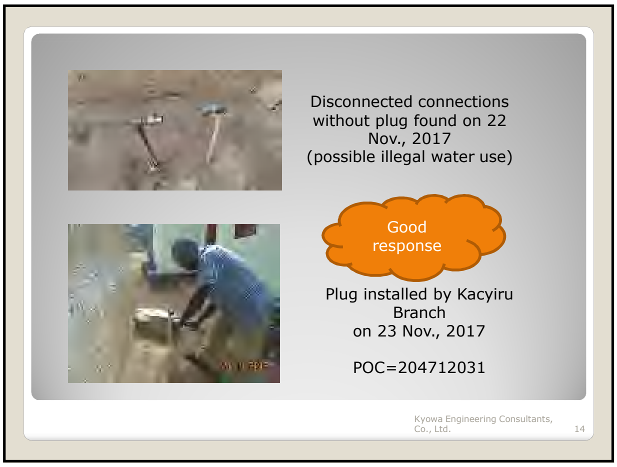
2) Meter Replacement



3) Questionnaire Survey

- The team has completed the survey on 4 December, visiting 138 households: 99 disconnected and 39 un-served households
- Major finding:

1) Two connections without proper protection (One already repaired by the Branch), five visible leaks, and four possible illegal connections (to be confirmed)
2) Some taps and meters under control of the owners
3) Former residents are disconnected
4) They showed us willingness to connect/eager to get water
5) Unserved households suffer from high water rate charged by neighbors and even public tap operators (20-50RWF /jerrycan)

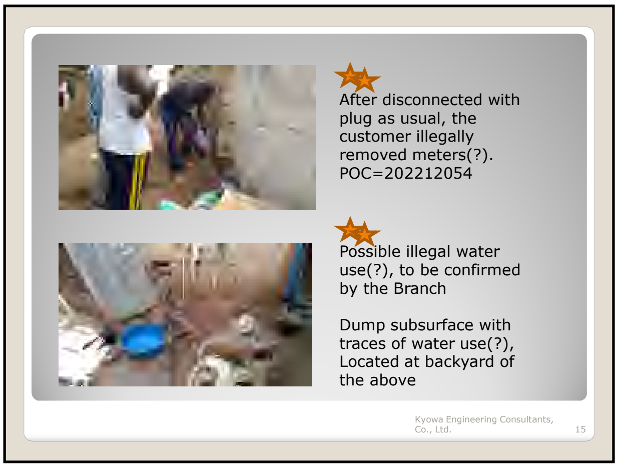


Disconnected connections without plug found on 22 Nov., 2017
(possible illegal water use)

Good response

Plug installed by Kacyiru Branch
on 23 Nov., 2017

POC=204712031



After disconnected with plug as usual, the customer illegally removed meters(?). POC=202212054

Possible illegal water use(?), to be confirmed by the Branch

Dump subsurface with traces of water use(?), Located at backyard of the above

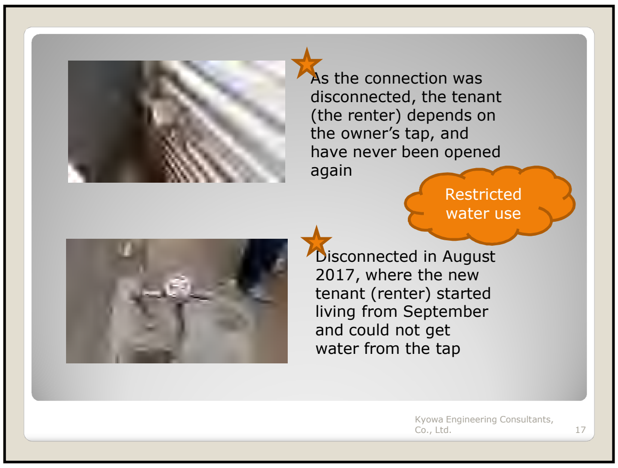
---

Disconnected connection after meter (usually observed)

Disconnected connection before meter (the meter owned by the Branch)

Disconnected connection before meter (the meter owned by the customer)

What are the disconnection criteria?



As the connection was disconnected, the tenant (the renter) depends on the owner's tap, and have never been opened again

Restricted water use

Disconnected in August 2017, where the new tenant (renter) started living from September and could not get water from the tap

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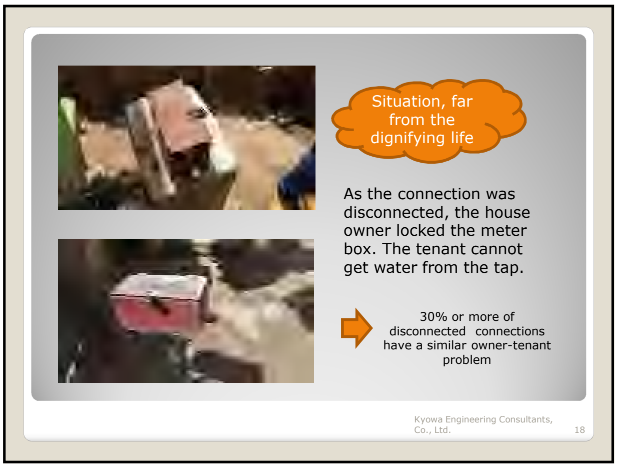
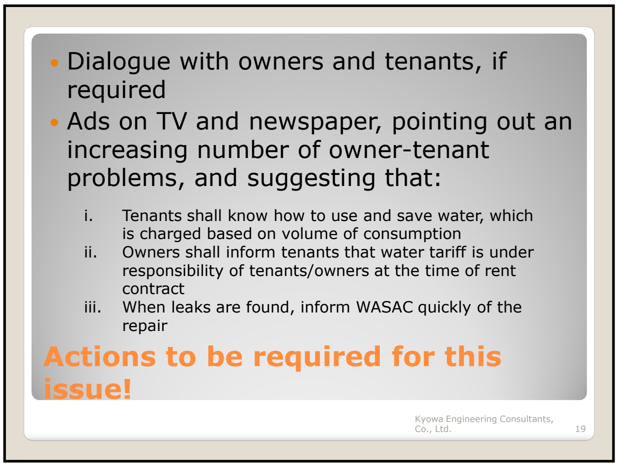


Situation, far from the dignifying life

As the connection was disconnected, the house owner locked the meter box. The tenant cannot get water from the tap.

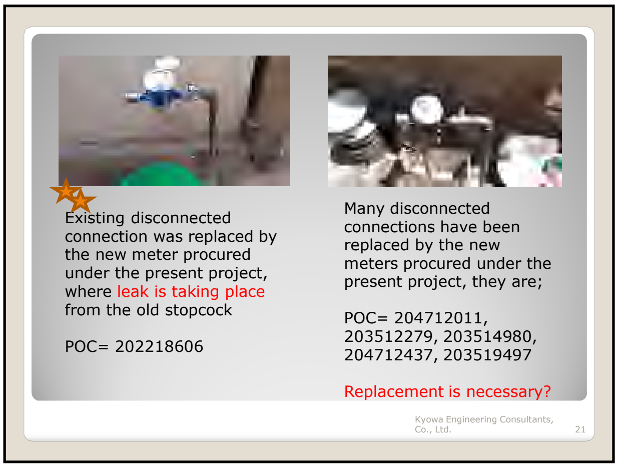
30% or more of disconnected connections have a similar owner-tenant problem



Actions to be required for this issue!

- Dialogue with owners and tenants, if required
- Ads on TV and newspaper, pointing out an increasing number of owner-tenant problems, and suggesting that:
  - i. Tenants shall know how to use and save water, which is charged based on volume of consumption
  - ii. Owners shall inform tenants that water tariff is under responsibility of tenants/owners at the time of rent contract
  - iii. When leaks are found, inform WASAC quickly of the repair

Findings in this week (27, November - 1, December)



Existing disconnected connection was replaced by the new meter procured under the present project, where leak is taking place from the old stopcock

POC= 202218606

Many disconnected connections have been replaced by the new meters procured under the present project, they are;

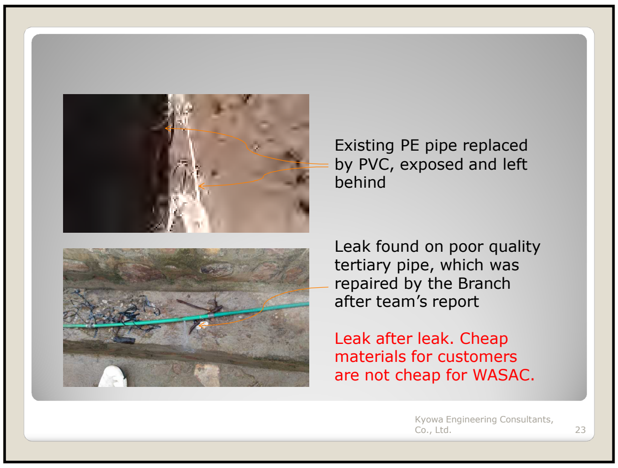
POC= 204712011, 203512279, 203514980, 204712437, 203519497

Replacement is necessary?

Recently disconnected customer. New tenant cannot get water, as owner locked the meter box. (many owner- tenant problems are observed in the area)

As the former resident was disconnected, new resident has branched before meter. The old meter left there is not in use.
(Is it a proper procedure? How to reduce arrears?)

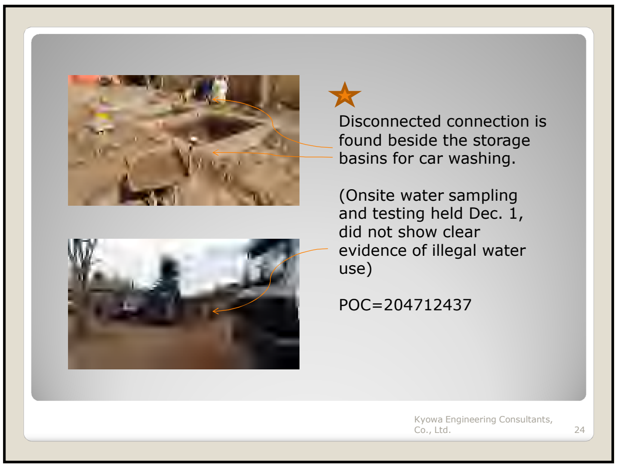
POC= 204714206



Existing PE pipe replaced by PVC, exposed and left behind

Leak found on poor quality tertiary pipe, which was repaired by the Branch after team's report

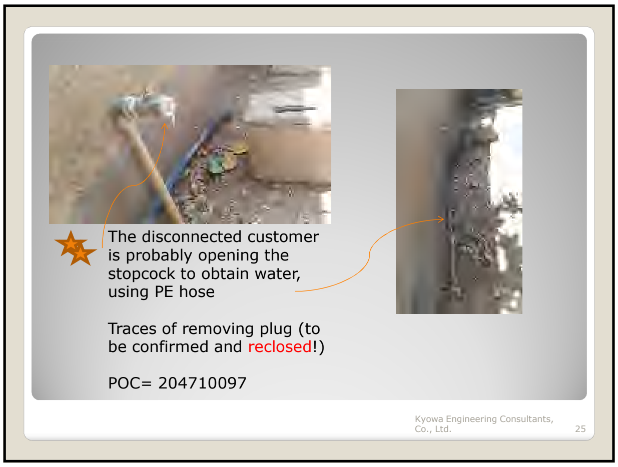
Leak after leak. Cheap materials for customers are not cheap for WASAC.



Disconnected connection is found beside the storage basins for car washing.

(Onsite water sampling and testing held Dec. 1, did not show clear evidence of illegal water use)

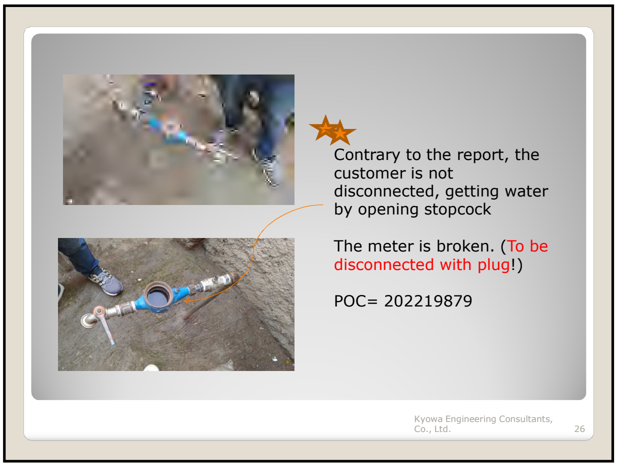
POC=204712437



The disconnected customer is probably opening the stopcock to obtain water, using PE hose

Traces of removing plug (to be confirmed and reclosed!)

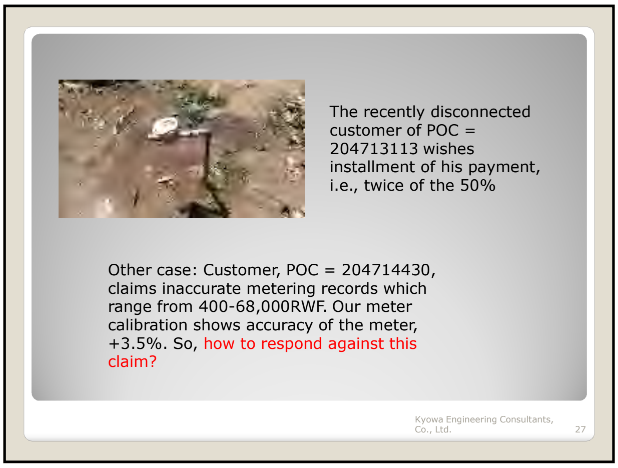
POC= 204710097



Contrary to the report, the customer is not disconnected, getting water by opening stopcock

The meter is broken. (To be disconnected with plug!)

POC= 202219879



The recently disconnected customer of POC = 204713113 wishes installment of his payment, i.e., twice of the 50%

Other case: Customer, POC = 204714430, claims inaccurate metering records which range from 400-68,000RWF. Our meter calibration shows accuracy of the meter, +3.5%. So, how to respond against this claim?

Issues to be focused on

- Disconnected customers are not for meter replacement
- Pipe repair and replacement
- Poor quality materials
- Some customers are selling water to the poor with a rate, 50RWF/jerrycan
- Emblem (mark) , POC on gates or walls
- Analyses of on-site meter calibration and questionnaire survey
- Other analyses: meter calibration by test bench, pressure vs. leak rate, etc. for continuous innovation

Priority Work to be initiated immediately

At Kadobogo and Ruyenzi Pilot Areas

At Kadobogo Pilot Area

The Kacyiru branch shall carry out the following:

- Replace malfunctioning meters (at the remaining 123 connections/meters)
- Confirm the customer POCs, not found at the site during the survey (around 50 POCs)
- Continue the onsite meter calibration at the remaining, 124 POCs

- Update POC map (GIS section, CMD, and Kacyiru Branch)

At Ruyenzi Pilot Area

New Nyarugenge branch office shall initiate the preparatory work for NRW reduction as follows:

- Prepare POC map of Ruyenzi pilot area in cooperation with GIS section and in accordance with the GIS Procedure Guide
  1) Customer data of CMD and GIS section shall be examined in comparison
  2) List up mismatched POCs
  3) Gain X-Y coordinate of the POCs
- Estimate monthly NRW rate of the area, based on monthly inflow rate and water consumption measured since June 2017 to date
- Review consumption data to list up customers of zero consumption

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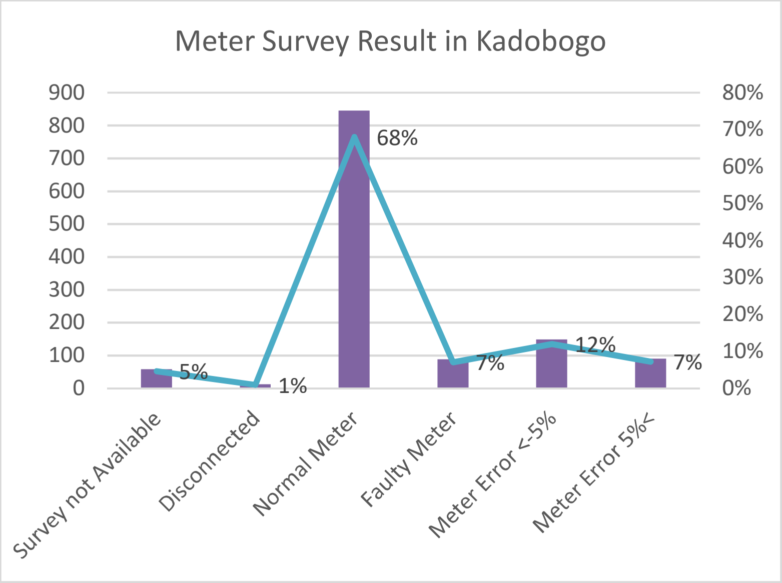
<Reference>

Table-1 List of POCs, not found in Customer List for Kadobogo

NO.	POC Number	PM Number	Day of Record
1	202210063	PM1	
2	202214925	PM1	
3	202215145	PM1	14/9/2017
4	202216289	PM1	14/9/2017
5	202216526	PM1	09/10/2017
6	202216626	PM1	09/10/2017
7	202216628	PM1	09/10/2017
8	202216649	PM1	09/10/2017
9	202216710	PM1	09/10/2017
10	202216792	PM1	09/10/2017
11	202217810	PM1	09/10/2017
12	202218024	PM1	05/10/2017
13	202218203	PM1	09/10/2017
14	202218592	PM1	09/10/2017
15	202218691	PM1	05/10/2017
16	202218890	PM1	09/10/2017
17	202219613	PM1	21/9/2017
18	202219635	PM1	09/10/2017
19	202717914	PM3	05/10/2017
20	203512193	PM1	18/11/2017
21	203519060	PM1	09/10/2017
22	203519332	PM1	09/10/2017
23	203519360	PM1	09/10/2017
24	203519419	PM1	14/9/2017
25	203519967	PM1	09/10/2017
26	203719084	PM1	03/10/2017
27	204710269	PM1	04/10/2017
28	204710368	PM1	16/11/2017
29	204711315	PM1	04/10/2017
30	204711649	PM1	17/11/2017
31	204711650	PM3	13/9/2017
32	204712795	PM1	09/10/2017
33	204712998	PM3	06/9/2017
34	204713205	PM3	13/9/2017
35	204714248	PM1	09/10/2017
36	204716036	PM1	02/11/2017
37	204716177	PM1	17/10/2017
38	204716818	PM3	
39	204718334	PM3	18/10/2017
40	294710615	PM3	11/10/2017
41	2035119881	PM3	16/10/2017
42	2047141087	PM3	23/10/2017
43	2047174029	PM3	10/10/2017

Meter Survey Result in Kadobogo

Sub-zone	Survey not Available	Disconnected	Normal Meter	Faulty Meter	Meter Error <-5%	Meter Error 5%<	Total
PM1	36	10	467	49	82	52	696
PM2	1	0	39	1	5	5	51
PM3	21	2	339	38	62	33	495
TOTAL	58	12	845	88	149	90	1242
%	5%	1%	68%	7%	12%	7%	100%



Meter Survey of Kadobogo (Pilot Area 1)

Attachment 10. Result of customer meter test

Number Surveyed

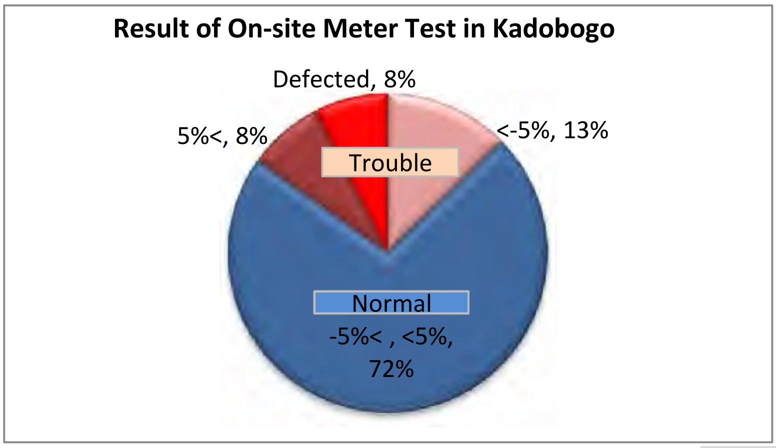
Sub-zone	List of POC Sept. 2017	Survey not Available	Total Surveyed
PM1	696	36	660
PM2	51	1	50
PM3	495	21	474
TOTAL	1,242	58	1,184
%	100%	5%	95%

Result of Site Survey

Sub-zone	Meter Tested	Defected	Dis connected	Total Surveyed
PM1	601	49	10	660
PM2	49	1	0	50
PM3	434	38	2	474
TOTAL	1084	88	12	1184
%	92%	7%	1%	100%

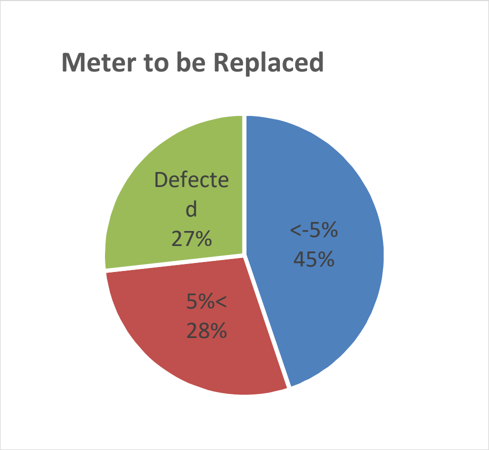
Result of On-site Meter Test

Sub-zone	Meter Error			Faulty/ Defected	Total
	<-5%	-5%< , <5%	5%<		
	Trouble	Normal	Trouble	Trouble	
PM1	82	467	52	49	650
PM2	5	39	5	1	50
PM3	62	339	33	38	472
TOTAL	149	845	90	88	1172
%	13%	72%	8%	8%	100%



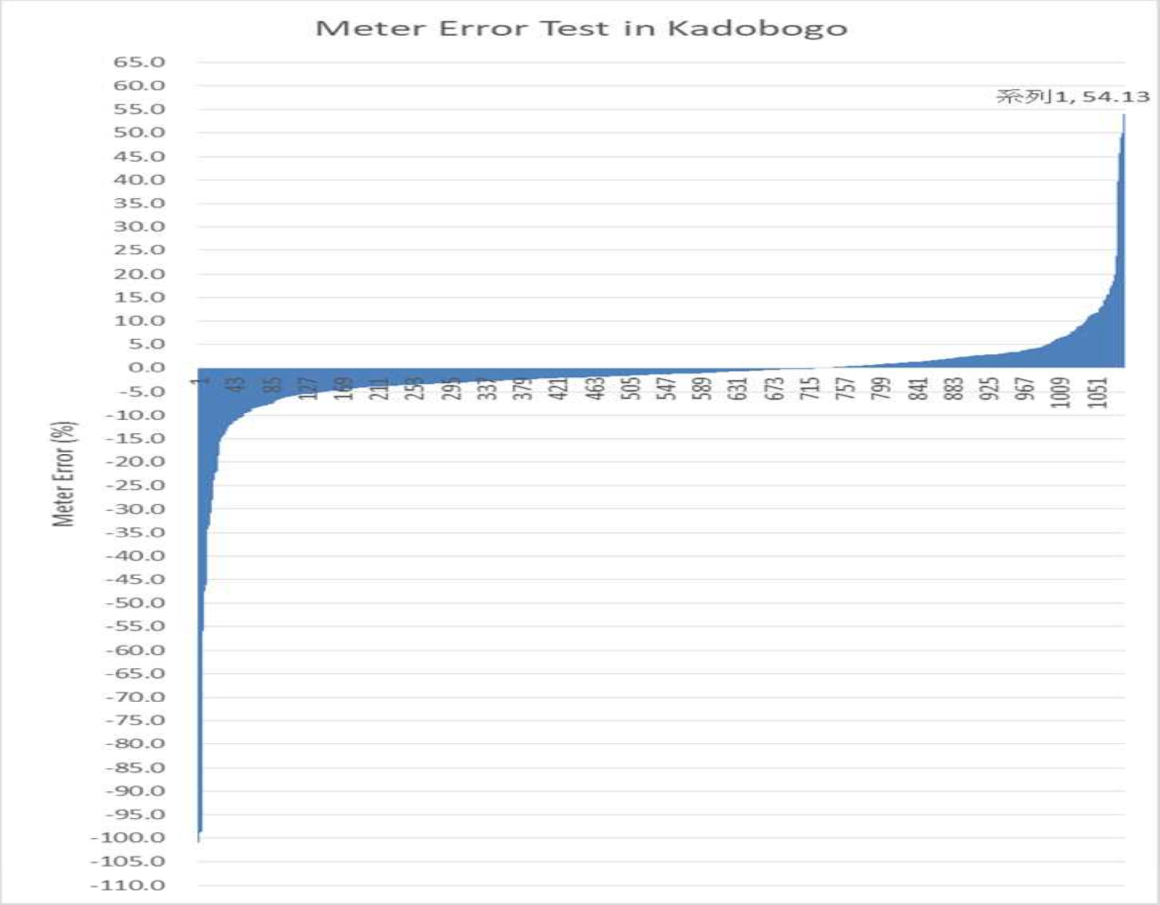
Meter to be Replaced (Trouble)

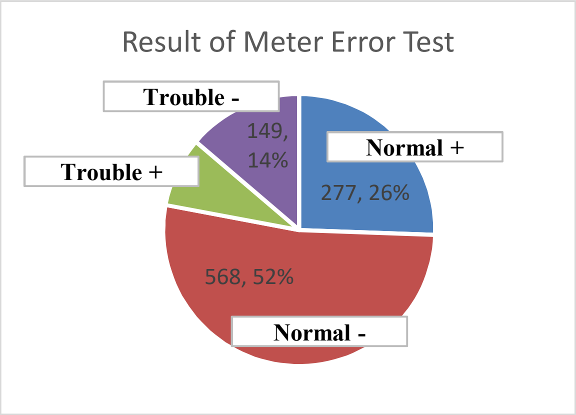
Sub-zone	Meter Error		Faulty/ Defected	Total
	<-5%	5%<		
PM1	82	52	49	183
PM2	5	5	1	11
PM3	62	33	38	133
TOTAL	149	90	88	327
%	46%	28%	27%	100%

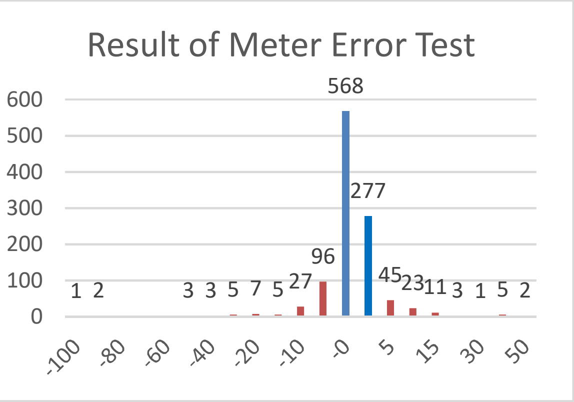


Result of Meter Error Test

Error%	-100	-90	-80	-70	-60	-50	-40	-30	-20	-15	-10	-5	-0	0	5	10	15	20	30	40	50	
Qut	1	2	0	0	0	3	3	5	7	5	27	96	568	277	45	23	11	3	1	5	2	1084
%	0.1	0.2	0.0	0.0	0.0	0.3	0.3	0.5	0.6	0.5	2.5	8.9	52.4	25.6	4.2	2.1	1.0	0.3	0.1	0.5	0.2	100%







Normal		Trouble		
+	-	+	-	Total
277	568	90	149	1084
26%	52%	8%	14%	100%

List of Customer Meter Replaced
Kacyiru Branch, Kadobogo Pilot Area

No.	POC Number	PM Number	Replaced Month	Meter Number	Meter Error (%)
1	202210743	PM3	2018/1	A09S626446	Faulty
2	202211271	PM3	2018/3	D12UA543953	9.26
3	202211274	PM3	2018/3	A09S626429	Faulty
4	202211347	PM1	2017/12	A095624529	Faulty
5	202211411	PM1	2017/12	00434711	-2.04
6	202212554	PM3	2018/3	A10S024743	Faulty
7	202213249	PM3	2018/1	C071B090552U	4.93
8	202213648	PM3	2018/2	A09S625717	-11.15
9	202214084	PM3	2018/4	A10S031275	6.76
10	202214120	PM1	2017/10	05-657732	-6.11
11	202214206	PM3	2018/1	A10S029494	-33.43
12	202214500	PM3	2018/3	DA12CA06557	8.79
13	202214567		2018/3		
14	202214597	PM3	2018/1	A09S626379	Faulty
15	202214687	PM1	2018/3	B10S000961	-0.80
16	202214720	PM3	2018/4		-5.88
17	202214835	PM1	2018/3	05-654735	-9.16
18	202215127	PM3	2018/1	A09S626437	16.99
19	202215143	PM1	2018/3	A09S624535	Faulty
20	202215719	PM1	2018/2	89-835301	-18.72
21	202215986	PM3	2018/8	B10S001719	17.06
22	202215998	PM1	2018/2	Unreadable	Faulty
23	202216113	PM3	2018/1	A09S626375	-15.70
24	202216127	PM1	2018/1	A09S627423	Faulty
25	202216264	PM1	2017/12	A10S031319	-3.32
26	202216287	PM3	2018/4	08-08262	-5.42
27	202216344	PM1	2018/1	B10S00158	Faulty
28	202216365	PM1	2017/12	A10S029111	6.46
29	202216431	PM3	2018/3	A09S627309	Faulty
30	202216518	PM3	2018/1	A09S627435	52.23
31	202216584	PM1	2017/12	A10S024824	Faulty
32	202216609	PM2	2017/10	623771	39.73
33	202216660		2017/10		
34	202216726	PM1	2018/6	D12CA060012	-5.52
35	202216781	PM1	2018/2	A10S624640	Faulty
36	202216820	PM3	2018/3	A11S239096	44.32
37	202216877	PM1	2017/11	D12UA544182	5.16
38	202216899		2017/10		
39	202216900	PM3	2018/4	A10S029113	Faulty
40	202216906	PM3	2018/3	A09S624651	-14.39
41	202216942	PM3	2018/2	A09S624639	Faulty
42	202217058	PM1	2018/2	A10S031301	-10.48
43	202217059	PM3	2018/2	A11S239486	-14.08
44	202217064	PM3	2018/1	0 8015096	23.99
45	202217087	PM1	2017/11	12CA058437	11.38
46	202217113	PM1	2018/6	A105031696	-8.40
47	202217291	PM3	2018/2	A10S029693	-7.83
48	202217377	PM3	2018/1	D11UA087985	5.52
49	202217677	PM2	2017/10	11-07841345	Faulty
50	202217682	PM1	2017/12	A09S624637	Faulty
51	202217714	PM1	2017/12	A10S031299	11.57
52	202217922		2017/8		
53	202218021	PM3	2018/3	A10S032069	-6.24
54	202218048	PM1	2018/1	A10S031689	-10.69
55	202218107	PM1	2018/4	B10S001782	3.16
56	202218130	PM3	2018/3	625721A095	-8.22
57	202218242	PM1	2017/12	A10S031737	11.42
58	202218261		2017/12		
59	202218334	PM1	2018/3	A10S031273	Faulty
60	202218508	PM1	2017/12	D11UA089035	13.05
61	202218606	PM1	2018/4	A10S027759	8.85
62	202218677	PM1	2018/2	A10S025186	Faulty

63	202218808	PM1	2018/2	D13UA598657	4.36
64	202218921	PM1	2018/1	A09S624656	-14.69
65	202218934	PM1	2018/2	11-08115783	-55.86
66	202219000	PM1	2018/2	A10S027515	-12.15
67	202219002	PM3	2018/3	A09S626027	-5.39
68	202219003	PM1	2018/2	B10S1272	Faulty
69	202219013	PM1	2018/4	A10S029141	11.46
70	202219024		2018/4		
71	202219041	PM1	2018/2	A10S023268	-5.98
72	202219047	PM1	2017/12	A10S029171	11.78
73	202219066	PM1	2018/2	D12UA54414	-13.13
74	202219073	PM3	2018/4	D12UA579526	-6.00
75	202219105	PM1	2018/1	A105029140	7.12
76	202219134	PM1	2018/4	D12CA048116	-5.53
77	202219206	PM3	2018/3	A10S031268	-5.43
78	202219282	PM1	2018/1	D12CA052691	9.80
79	202219295	PM1	2018/2	A10S029787	Faulty
80	202219296	PM3	2018/2	83 322279	-23.32
81	202219300	PM3	2018/1	D12UA573437	-10.36
82	202219309	PM3	2018/2	A10S025897	-55.89
83	202219327	PM1	2017/11	A10S026755	11.04
84	202219331	PM3	2018/1	A09S627470	6.54
85	202219344	PM3	2018/1	A10S625346	6.91
86	202219345		2018/7		
87	202219394	PM1	2017/11	A11S238905	-23.90
88	202219631	PM1	2017/12	A10S028937	12.66
89	202219703	PM1	2018/4	A11S138322	-12.78
90	202219736	PM1	2018/1	A10S02824	49.90
91	202219879	PM1	2018/2	A10S024908	Faulty
92	202219897	PM3	2018/2	A10S001221	Faulty
93	202219925	PM1	2018/1	A095624527	Faulty
94	202219964	PM3	2018/2	UNREADABLE	Faulty
95	202219982		2018/7		
96	203511092	PM3	2018/2	A09S623772	-7.81
97	203511093	PM3	2018/2	A09S623174	13.08
98	203511096	PM3	2018/2	A10S025239	-10.70
99	203511098	PM3	2018/2	A10S031826	Faulty
100	203511293	PM1	2018/4	A09S626438	18.49
101	203511326	PM1	2018/2	A10S029687	49.12
102	203511418	PM1	2017/12	A10S029572	4.50
103	203511480	PM3	2018/2	A10S028017	-100.90
104	203511482	PM3	2018/2	A10S025610	-13.43
105	203511493	PM3	2018/2	A11S238806	-10.30
106	203511534	PM1	2018/1	unreadable	Faulty
107	203511631	PM1	2018/2	05-658260	-9.05
108	203511643	PM1	2017/12	A10S029228	-8.53
109	203511664		2018/11		
110	203511722	PM1	2018/6	B10S001126	Faulty
111	203512071	PM3	2018/2	B10S001220	Faulty
112	203512161	PM1	2018/4	D12CA052685	-5.02
113	203512186	PM1	2017/11	D14UA126986	4.33
114	203512304	PM1	2018/3	A10S031688	-6.38
115	203512316	PM1	2017/12	05-301544	-47.52
116	203512317	PM1	2018/12	01-281112	-5.48
117	203512583	PM1	2017/12	A10S024916	5.53
118	203512597	PM1	2017/11	A10S024969	-11.86
119	203512616	PM1	2018/2	A10S029509	49.15
120	203512619	PM1	2017/12	11-07841195	Faulty
121	203512621	PM1	2017/12	A10S029932	Faulty
122	203512622	PM1	2018/1	A10S029517	Faulty
123	203512623	PM1	2017/12	A10S029934	Faulty
124	203512624	PM1	2017/12	A10S029984	6.64
125	203512625	PM1	2017/12	A10S029927	-8.36
126	203512626	PM1	2017/12	A10S029519	Faulty
127	203512630	PM1	2018/3	D12CA055063	15.52
128	203512761	PM1	2017/12	A10S029577	Faulty
129	203512762	PM1	2018/1	11-07841231	Faulty

130	203512769	PM1	2017/12	11-07841352	Faulty
131	203512785	PM1	2017/12	A10S009928	13.92
132	203512860	PM1	2017/12	A10S029520	9.37
133	203512967	PM3	2018/2	S60624757	5.58
134	203514274	PM1	2017/11	2010-068	Faulty
135	203514275	PM3	2018/2	A09S624697	Faulty
136	203514410	PM1	2018/2	A10S025074	-11.29
137	203514448		2018/11		
138	203514506	PM3	2018/2	A10S031730	Faulty
139	203514534	PM3	2018/2	ILLISIBLE	Faulty
140	203514540	PM1	2017/12	A10S024822	-12.03
141	203514749		2017/10		
142	203514753	PM1	2017/12	A10S029176	54.13
143	203514909	PM3	2018/6	B10S001067	-7.68
144	203514957	PM1	2018/2	B10S001492	-11.26
145	203514980	PM1	2017/12	A10S029936	Faulty
146	203515138	PM3	2018/2	11-07908638	Faulty
147	203515176	PM1	2018/6	A10S024941	8.39
148	203515187	PM3	2018/3	A10S027429	Faulty
149	203515428	PM1	2017/12	A11S239116	-11.23
150	203515806	PM3	2018/1	1107841180	-8.46
151	203516118	PM3	2018/2	Illisible	5.57
152	203516272	PM1	2018/2	11-08113280	Faulty
153	203519084	PM1	2018/3	D12UA572673	-6.13
154	203519109	PM1	2018/2	Unreadable	Faulty
155	203519164	PM1	2018/3	Unreadable	Faulty
156	203519210	PM1	2017/10	A11S239092	-7.51
157	203519235		2018/12		
158	203519265	PM1	2018/2		-32.50
159	203519356	PM1	2018/2	11-08116273	Faulty
160	203519435	PM1	2018/3	A09S625241	-9.63
161	203519478	PM1	2018/2	11-07841257	Faulty
162	203519482		2018/9		
163	203519484	PM1	2018/2	A11S238739	11.08
164	203519486	PM3	2018/2	11-07911041	-98.70
165	203519497	PM1	2018/7	B10S001510	Faulty
166	203519499	PM1	2018/1	11-07911034	Faulty
167	203519500	PM1	2018/2	08-15095	Faulty
168	203519559	PM2	2018/3	12CA036932	-6.29
169	203519568	PM3	2018/1	A11S239139	-22.23
170	203519579	PM3	2018/2	D12CA054194	4.27
171	203519604		2017/10		
172	203519624	PM1	2017/10	11-08113574	-5.43
173	203519631	PM1	2018/2	01-9284392	-12.61
174	203519647	PM3	2018/2	A11S238732	-11.77
175	203519657	PM3	2018/2	A09S624763	Faulty
176	203519861	PM1	2018/2	A11S238354	7.69
177	203519880	PM1	2018/6	11-08116225	Faulty
178	203519881	PM3	2018/1	0	-2.99
179	203519962	PM3	2018/3	11-07910236	Faulty
180	203582393	PM3	2018/11	D12CA060063	-8.25
181	204710018	PM3	2018/3	A11S238266	Faulty
182	204710059	PM3	2018/4	A11S238848	-6.51
183	204710099	PM3	2018/2	11-08116518	Faulty
184	204710104	PM1	2018/2	D14UA136050	11.68
185	204710110	PM3	2018/2	11-08116706	Faulty
186	204710146	PM3	2018/2	11-08115789	Faulty
187	204710148	PM1	2017/11	11-08115788	12.69
188	204710214	PM3	2018/3	11-08116528	-98.78
189	204710241	PM3	2018/2	1108116358	-46.43
190	204710246	PM1	2018/1	D12UA579554	9.55
191	204710255	PM1	2017/12	11-07908697	Faulty
192	204710275	PM3	2018/4	D12UA581256	-5.37
193	204710308	PM2	2018/3	D14UA131817	10.33
194	204710326	PM1	2018/4	D14UA130121	-6.49
195	204710327	PM3	2018/2	D11UA089215	17.62
196	204710349	PM3	2018/3	UNREADABLE	6.29

197	204710378	PM1	2018/2, 2018/12	D12CA052687	Faulty
198	204710391	PM1	2017/11	A09S629401	-9.44
199	204710399	PM3	2018/2	D13UA610810	6.08
200	204710422	PM1	2017/12	D11UA090441	-5.75
201	204710428	PM1	2018/3	D12CA054186	-8.00
202	204710461	PM1	2018/2	A10S029137	Faulty
203	204710523	PM1	2018/6	D11UA089515	-8.45
204	204710537	PM3	2018/3	D13UA089208	-5.11
205	204710550	PM2	2017/10	D11UA086691	Faulty
206	204710582	PM3	2018/3	D13UA600550	-5.35
207	204710615	PM3	2018/4	D13UA587932	Faulty
208	204710704	PM1	2018/4	D11UA090544	-11.21
209	204710732	PM1	2018/7	D11UA08928	-5.44
210	204710797	PM3	2018/1	D11UA086688	-7.97
211	204710832	PM1	2017/11	D11UA088983	Faulty
212	204710902		2018/8		
213	204710965	PM1	2018/3	D11UA085661	Faulty
214	204710977	PM1	2017/12, 2018/12	D11UA089379	-34.30
215	204711025	PM1	2017/11	D12CA056975	6.09
216	204711056		2018/1		
217	204711074	PM1	2018/4	D12CA056969	5.09
218	204711124		2018/11		
219	204711135		2018/1		
220	204711148	PM1	2018/4	D12CA061379	10.90
221	204711153	PM1	2018/2	D12CA065181	6.68
222	204711163	PM2	2018/3	D12CA064066	Faulty
223	204711196	PM1	2018/4	D12CA06413	3.50
224	204711201		2018/11		
225	204711203	PM3	2018/3	D12CA065035	-5.44
226	204711209	PM1	2017/12	ILLISIBLE	4.08
227	204711244	PM1	2018/3	12CA065177	-5.05
228	204711287	PM1	2018/4	D12CA062365	-50.56
229	204711375	PM1	2018/3	D12CA050814	19.90
230	204711385	PM3	2018/2	D12CA063621	8.91
231	204711427	PM3	2018/2	D12CA061131	-9.58
232	204711436	PM1	2017/12	D11UA089286	-7.90
233	204711449	PM2	2018/3	92890262	-5.18
234	204711481	PM3	2018/1	D12CA061273	8.40
235	204711523	PM1	2017/12	D12UA574972	3.00
236	204711550		2018/2		
237	204711592	PM1	2018/1		14.33
238	204711620		2018/3		
239	204711667	PM3	2018/1	D12CA048270	-8.43
240	204711746	PM1	2018/2	D12CA049980	-7.98
241	204711802	PM1	2018/3	CO71B0904350	-5.51
242	204711898	PM2	2017/10	D12UA548300	-8.24
243	204712007	PM1	2018/3	D12UA548768	-5.02
244	204712082	PM3	2018/2	D12UA549021	10.10
245	204712120	PM1	2017/12	D12UA544254	Faulty
246	204712273	PM3	2018/5	D12UA546116	22.09
247	204712437	PM1	2018/3	D13UA610190	Faulty
248	204712515	PM3	2018/1	D12UA578874	Faulty
249	204712533	PM3	2018/3	D12UA563010	-5.52
250	204712562	PM1	2017/11	D12UA563099	-38.91
251	204712563	PM1	2018/7	D12UA560274	3.75
252	204712584	PM3	2018/3	D12UA573736	-5.22
253	204712702	PM3	2018/3	D12UA579680	-5.66
254	204712709	PM1	2018/1	D12UA579660	-5.81
255	204712719	PM1	2018/2	D12UA577681	-7.64
256	204712859	PM3	2018/3	D12UA577543	-6.65
257	204712880	PM1	2018/2	D12UA577599	3.12
258	204712889	PM1	2017/12	D12UA579192	15.57
259	204712919	PM1	2018/1	DU12UA577611	-7.55
260	204712943	PM3	2018/4	D12UA577501	-9.66
261	204712954	PM1	2018/3	D12UA573648	-5.16
262	204713017	PM1	2018/6	D12UA577653	-5.11
263	204713036	PM2	2017/10	D12UA12579510	7.67

264	204713093	PM1	2017/12	08-04699	-30.89
265	204713380		2018/3		
266	204713388		2018/9		
267	204713402	PM3	2018/3	DA2UA558264	-5.66
268	204713551	PM1	2017/12	D12UA560998	-10.41
269	204713746	PM1	2018/2	D12UA559328	-5.46
270	204713877	PM1	2018/2	D12UA582467	-5.66
271	204713894		2017/10		
272	204714016	PM3	2017/10, 2018/1	D14UA137522	3.03
273	204714200		2018/3		
274	204714349	PM1	2018/3	D13UA605667	8.48
275	204714350	PM1	2018/2	D13UA605666	5.15
276	204714386	PM1	2018/2	0	3.93
277	204714448	PM1	2018/2	D13UA598237	-5.79
278	204714537	PM3	2018/1	D13UA602099	-10.95
279	204714565	PM1	2018/2	D13UA598315	-28.20
280	204714622	PM3	2018/2	D13UA608185	-7.21
281	204714641	PM3	2018/2	D13UA608099	-6.95
282	204714726	PM1	2018/2	D13UA11813	-6.65
283	204714815	PM3	2018/3	D13UA608997	13.17
284	204714852	PM3	2018/2	D13UA609000	Faulty
285	204714870	PM1	2018/1	D13UA609108	5.84
286	204714986	PM2	2017/10	D12UA581237	4.81
287	204715032	PM1	2018/2	D13UA608889	-5.02
288	204715049	PM2	2017/10	D13UA612147	14.77
289	204715085	PM3	2018/3	D13UA609078	2.93
290	204715155	PM1	2018/2	D13UA588391	-5.93
291	204715190	PM3	2018/2	D13UA588409	11.63
292	204715205	PM1	2018/2	D13UA588401	-6.29
293	204715210	PM2	2017/10	D13UA588405	2.89
294	204715299		2018/12		
295	204715304	PM1	2018/2	D13UA587991	-7.51
296	204715397		2018/11		
297	204715417	PM3	2018/10	D13UA585116	Faulty
298	204715485	PM1	2017/11	D13UA584555	45.74
299	204715533	PM1	2018/3	D14UA137525	-5.53
300	204715538	PM1	2017/12	D14UA137526	6.48
301	204715721		2018/2		
302	204715798	PM3	2018/1	D14UA126561	7.74
303	204715853	PM1	2017/12	D14UA134213	6.81
304	204715989	PM3	2018/4	D14UA128362	-6.80
305	204716076	PM1	2018/1	D14UA103124	2.82
306	204716096		2018/3		
307	204716109	PM3	2018/2	D14UA141377	23.79
308	204716177	PM1	2018/3	D14UA135656	19.06
309	204716191	PM3	2018/2	D14UA136310	12.27
310	204716291	PM2	2017/10	D14UA110082	9.90
311	204716361	PM2	2017/10	D14UA109190	4.41
312	204716375	PM1	2017/12	D14UA110046	0.61
313	204716454	PM2	2017/10	D14UA110907	7.04
314	204716689	PM1	2018/1	D14UA127617	5.82
315	204716724	PM1	2018/2	D14UA127582	5.03
316	204717179	PM1	2017/12	L16BA384185	4.70
317	204717286	PM2	2017/10	Unreadable	15.13
318	204717542	PM1	2018/7	01-195884	-28.56
319	204717568	PM3	2018/2	01-19598	-27.39
320	204717636	PM3	2018/2	L16BA390802	Faulty
321	204717711	PM3	2018/2	L16BA390823	-7.55
322	204717760	PM1	2018/3	D11UB16881	Faulty
323	204717875	PM3	2018/7	D11UB017524	-6.63

Replaced	323
JICA	294
WASAC	29

Monthly Replacement Number of Meter

Year	Month	Number
2017	Jul	0
	Aug	1
	Sep	0
	Oct	21
	Nov	13
	Dec	44
2018	Jan	42
	Feb	92
	Mar	56
	Apr	24
	May	1
	Jun	8
	Jul	7
	Aug	2
	Sep	2
	Oct	1
	Nov	6
	Dec	3
Total		323

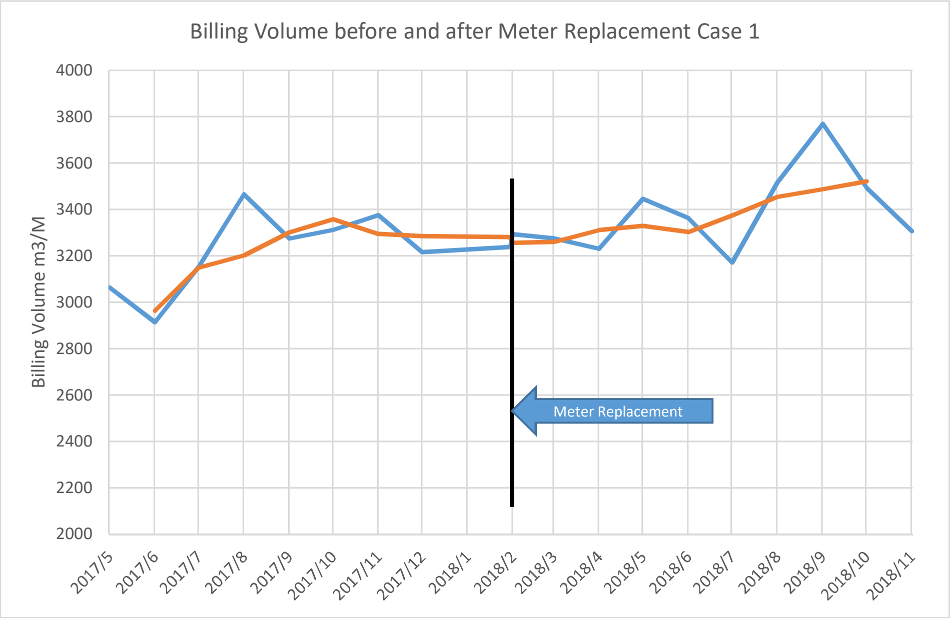
Billing Rate Before and After Meter Replacement: Case 1

	POC Number	2017/1	2017/2	2017/3	2017/4	2017/5	2017/6	2017/7	2017/8	2017/9	2017/10	2017/11	2017/12	2018/1	2018/2	2018/3	2018/4	2018/5	2018/6	2018/7	2018/8	2018/9	2018/10	2018/11	2018/12
1	202210743		28	27	25	25	39	23	24	36	0	0	23	17	14	14	13	10	13	14	13	13	19	3	13
2	202211271	7	5	6	9	7	7	9	7	7	5	5	5	5	5	4	4	7	0	0	27	9	7	6	
3	202211274	0	0	0	0	1	10	10	0	10	12	8	10	5	10	12	14	7	10	12	9	26	10	5	
4	202211347			3	10	10	10	10	0	10	10	11	11	5	10	11	10	7	11	8	10	9	9	7	0
5	202211411			7	0	0	0	30	7	6	0	0	0	10	9	0	0	0	0	0	20	0	25	11	8
6	202212554	0	8	7	8	11	5	8	8	8	10	8	10	10	5	0	11	6	11	10	9	10	8	9	
7	202213249		67	45	33	44	64	44	36	36	36	29	30	38	47	36	31	38	54	39	42	23	22	19	23
8	202213648	13	10	11	12	15	9	10	18	12	8	7	16	10	11	8	10	9	12	8	8	10	13	13	12
9	202214084	0	0	23	8	9	11	14	10	0	19	12	0	0	20	10	9	13	13	11	15	12	13		
10	202214120					26	11	19	29	35	11	18	21	20	21	45	38	31	57	34	37	126	53	38	21
11	202214206		7	7	8	5	8	8	7	0	18	0	13	11	7	8	14	8	9	7	8	10	8	11	7
12	202214500	20	20	20	20	20	13	0	6	18	20	20	20	20	13	16	0	39	15	16	20	20	16	21	
13	202214567	0	0	0	0	0	0	0	0	0	0	0	0	0	35	50	33	201	35	27	24	22	54	41	
14	202214597		0	0	0	0	0	0	6	18	0	30	13	0	0	0	0	0	0	0	0	0	0	0	0
15	202214687	12	7	11	6	0	6	0	0	54	18	0	28	0	36	25	22	15	18	22	22	20	15	17	
16	202214720	7	12	10	8	10	14	9	9	9	16	15	15	9	17	9	11	5	10	10	10	10	10		
17	202214835	14	11	12	13	11	15	16	11	11	9	10	10	10	11	16	13	16	18	20	23	23	20	21	
18	202215127		23	20	16	15	19	20	20	23	21	19	15	22	16	18	12	15	12	14	14	13	18	16	16
19	202215143	0	0	0	0	50	0	23	10	10	11	0	15	15	0	17	0	20	10	10	21	15	14	0	
20	202215719	12	8	10	11	14	9	10	16	10	11	11	13	10	7	6	9	13	12	8	10	11	9	11	10
21	202215998	234	265	167	173	222	94	101	184	165	156	25	177	92	118	67	145	80	182	113	108	200	142	106	108
22	202216113		21	19	18	20	23	19	23	25	20	17	17	21	26	18	15	19	20	17	20	23	22	24	22
23	202216127		33	40	31	39	49	35	31	40	35	33	28	39	41	33	32	41	35	31	40	44	43	32	29
24	202216264			7	4	4	0	14	5	0	0	8	4	7	6	6	6	6	5	2	5	4	6	7	5
25	202216287	6	7	8	5	8	7	5	5	6	4	5	2	3	5	5	5	5	6	7	7	6	0		
26	202216344		17	12	0	22	0	31	15	0	32	11	5	20	0	27	8	0	0	37	13	11	13	11	12
27	202216365			22	18	17	17	25	16	17	24	20	12	19	22	22	18	16	16	18	21	16	15	19	16
28	202216431	2	0	8	7	6	8	8	8	6	8	7	8	8	0	20	0	0	0	0	0	0	0	26	5
29	202216518		21	15	10	14	18	14	14	19	15	13	12	11	14	8	9	8	11	8	9	11	8	10	10
30	202216584			15	10	10	11	17	12	15	10	10	10	10	20	17	21	20	18	21	19	16	14	20	16
31	202216609					10	0	2	5	5	5	4	6	7	5	2	0	0	0	0	0	0	0	0	1
32	202216660					0	0	54	5	15	15	10	20	10	7	8	0	18	7	5	0	4	7	0	9
33	202216781	10	10	10	10	10	10	10	10	10	10	10	16	10	9	6	8	5	5	5	8	10	9	19	0
34	202216820	14	10	25	15	5	15	9	19	26	15	26	15	15	15	12	14	16	14	16	20	19	21	19	19
35	202216877				–	23	12	11	15	10	13	19	9	7	16	11	14	12	15	8	15	14	9	10	12
36	202216899					8	6	5	7	0	0	0	0	4	6	6	9	4	7	11	5	3	1	1	7
37	202216900	25	7	9	9	9	10	6	6	12	10	8	0	8	7	6	6	7	0	15	9	8	9	9	9
38	202216906	8	11	14	16	12	12	16	16	15	16	22	20	17	17	21	12	13	14	12	18	11	13	18	14
39	202216942	18	11	11	12	15	11	12	15	15	10	11	12	12	9	9	6	12	16	12	13	5	23	14	13
40	202217058	7	3	4	6	0	11	5	2	0	5	2	3	4	0	3	0	4	1	0	3	2	2	2	3
41	202217059	8	8	6	7	8	7	9	10	10	6	8	8	10	0	14	7	8	8	11	10	8	8	7	8
42	202217064		34	19	11	14	20	18	22	28	18	12	15	18	18	21	9	18	17	15	23	16	17	18	18
43	202217087				14	6	14	13	14	11	11	18	11	8	15	12	9	10	11	9	10	7	7	7	10
44	202217113	0	3	3	4	0	4	0	7	0	11	3	0	7	0	7	6	6	0	0	13	5	5	5	5
45	202217291	5	3	0	9	4	6	7	6	5	4	5	5	5	3	4	0	0	12	0	0	17	6	7	8
46	202217377		0	0	0	51	14	12	12	17	13	22	14	21	40	28	11	9	6	7	9	0	12	5	7
47	202217677					13	13	9	13	15	10	12	14	11	14	10	13	12	15	12	12	11	15	12	11
48	202217682			8	5	5	5	6	7	9	11	9	10	5	10	9	8	7	6	7	8	7	9	6	7
49	202217714			17	13	11	15	21	14	20	25	19	12	23	19	0	30	15	15	13	20	16	19	17	18
50	202217922					10	10	10	10	10	10	10	0	0	5	9	6	5	7	6	7	7	8	7	0
51	202218021	0	32	14	12	8	9	11	10	11	7	13	12	14	9	13	9	7	8	8	9	6	6	8	8
52	202218048		6	6	6	6	11	11	10	13	9	5	10	10	9	7	8	8	7	9	7	7	8	7	7
53	202218107	10	10	8	8	10	13	11	10	9	10	12	11	10	12	9	9	12	11	12	10	10	9	9	9
54	202218130	17	13	8	19	13	17	20	19	18	10	16	18	14	17	18	16	16	21	18	18	18	17	14	14
55	202218242			7	5	0	12	8	0	0	43	14	6	12	9	10	0	22	10	14	17	14	15	19	13
56	202218261			19	11	13	16	18	18	14	16	14	6	17	16	7	13	14	7	7	5	0	13	7	5
57	202218334	11	6	7	9	0	22	7	10	10	10	10	10	10	6	8	7	7	5	7	9	5	4	8	8
58	202218508			6	5	5	4	6	5	7	10	5	2	6	6	6	4	4	6	4	5	4	5	6	2
59	202218606	0	0	0	0	0	0	0	0	0	0	0	0	2	14	0	21	9	9	11	9	9	11	9	9
60	202218677	25	9	9	11	14	12	13	18	17	0	37	18	15	9	10	12	10	12	11	12	12	0	36	15
61	202218808	0	0	54	19	21	14	18	27	24	21	24	23	28	20	21	19	19	30	23	22	24	22	27	27
62	202218921		9	7	5	1	17	8	8	16	11	6	10	6	7	7	5	0	0	21	7	6	0	19	11
63	202218934	0	10	0	10	0	11	5	7	5	6	5	6	6	5	6	5	7	6	6	7	0	13	8	6
64	202219000	6	6	4	6	10	9	0	20	11	0	14	0	0	9	9	9	10	6	8	0	16	8	0	14
65	202219002	7	6	7	9	6	9	10	8	6	7	6	6	10	3	3	2	2	6	4	7	9	6	6	6
66	202219003	15	7	0	10	10	10	10	10	10	10	10	7	24	17	10	10	8	16	15	16	16	13	14	10
67	202219013	9	5	11	8	14	20	19	15	11	12	11	0	6	5	10	14	12	18	11	7	12	0	10	10
68	202219024	13	16	23	15	20	20	19	26	26	27	25	2	23	18	15	26	14	15	17	15	16	17	16	16
69	202219041	24	21	18	22	31	22	30	25	25	14	33	40	40	26	23	26	29	33	26	27	34	27	29	25
70	202219047			15	19	22	27	34	25	31	40	38	34	37	19	17	12	13	12	12	22	15	15	18	15
71	202219066	8	6	5	6	8	8	8	10	10	6	6	7	7	6	5	0	0	19	6	6	8	6	6	6
72	202219073	8	7	0	23	11	15	16	12	11	0	30	9	4	17	11	13	12	11	16	12	15	12	12	12
73	202219105		9	12	11	12	16	11	15	14	18	16	12	29	14	5	9	12	8	15	13	12	17	13	14
74	202219134	6	11	12	40	13	4	7	6	6	7	8	8	4	7	4	4	4	6	5	5	5	4	4	4
75	202219206	4	3	4	5	4	4	5	4	5	5	4	5	5	6	1	4	5	5	4	6	6	4	5	5
76	202219282		4	5	3	5	6	4	6	7	8	5	10	4	4	4	5	4	3	2	2	2	0	6	3
77	202219295	30	27	24	27	33	26	20	30	30	30	30	0	30	20	24	22	25	25	27	34	39	33	36	34
78	202219296	12	9	9	9	13	0	18	13	12	10	11	13	12	14	12	12	11	14	10	13	13	13	14	17
79	202219300		11	6	7	8	10	10	10	14	14	10	6	13	10	11	7	11	10	10	10	14	12	9	8
80	202219309	6	4	2	5	6	3	4	6	5	3	3	5	5	5	3	4	2	4	0	2	3	5	4	5
81	202219327				6	11	18	13	18	13	17	46	46	10	30	25	29	29	13	19	0	0	31	0	0
82	202219331		12	0	13	8	12	7	9	11	11	9	8	16	9	11	5	17	11	12	8	12	12	12	12
83	202219344		15	16	16	23	24	8	21	27	27	23	15	37	32	49	26	37	22	36	25	40	59	69	34
84	202219394				0	54	26	0	32	13	16	–	0	51	45	13	20	18	18	12	0	32	0	28	17

	POC Number	2017/1	2017/2	2017/3	2017/4	2017/5	2017/6	2017/7	2017/8	2017/9	2017/10	2017/11	2017/12	2018/1	2018/2	2018/3	2018/4	2018/5	2018/6	2018/7	2018/8	2018/9	2018/10	2018/11	2018/12
85	202219631			17	13	11	19	23	16	18	29	19	11	16	16	16	22	12	15	16	20	15	13	21	16
86	202219703	6	9	10	11	13	8	11	19	10	3	10	10	10	23	16	17	20	18	21	16	16	12	12	12
87	202219736		0	68	21	21	27	16	22	27	23	21	24	24	14	17	7	9	8	8	8	9	10	0	17
88	202219879	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	3	4	7	6	7	8	5	5	5
89	202219897	4	4	5	8	4	4	3	10	2	5	7	8	10	2	7	2	5	3	6	14	8	9	7	10
90	202219925		17	21	15	16	25	18	22	31	27	0	11	35	25	21	16	18	16	22	0	39	21	18	17
91	202219964	0	3	7	3	3	0	0	8	6	4	10	5	0	10	8	7	10	8	8	8	9	9	11	6
92	203511092	9	10	0	28	24	0	36	18	15	16	7	14	10	19	16	20	14	17	17	15	23	14	16	15
93	203511093	18	11	11	15	18	15	16	18	17	17	12	18	13	21	13	23	19	18	24	19	23	21	19	22
94	203511096	7	5	6	6	11	8	7	9	6	9	5	20	13	0	16	11	7	11	7	7	4	3	0	14
95	203511098	0	0	0	0	0	0	0	23	0	0	0	15	11	15	9	14	13	15	16	12	13	18	19	12
96	203511293	3	4	7	6	3	5	3	3	4	4	5	4	4	5	8	9	6	7	9	7	7	9	9	9
97	203511326	22	12	14	15	17	20	35	51	21	20	14	20	18	13	10	11	0	27	13	20	16	13	15	12
98	203511418			7	5	5	8	7	7	7	10	8	4	10	10	8	7	5	6	5	6	6	6	8	5
99	203511480	10	10	10	10	10	10	10	10	10	10	10	0	36	15	0	26	0	33	12	0	28	12	3	0
100	203511482	8	5	5	5	9	6	6	7	5	7	4	7	5	7	4	6	5	7	6	6	8	6	6	4
101	203511493	12	8	6	7	8	7	9	11	10	9	6	9	6	7	5	0	－	－	－	－	－	32	14	7
102	203511534		17	16	9	0	25	20	30	30	30	20	7	3	14	17	13	16	16	14	12	11	16	11	14
103	203511631	5	4	3	4	4	3	6	7	4	5	3	4	2	4	5	5	4	6	4	6	7	4	3	3
104	203511643			7	5	5	4	0	10	5	7	6	3	7	4	3	4	4	3	4	4	3	5	5	5
105	203511722	20	20	20	20	22	20	20	20	0	20	20	20	20	31	23	23	37	28	0	12	12	12	12	12
106	203512071	10	10	10	10	10	11	14	16	14	13	11	12	11	9	11	12	8	7	9	9	10	10	9	10
107	203512161	8	9	9	9	8	8	10	9	8	3	22	5	4	5	3	5	5	10	9	9	5	3	3	3
108	203512186				9	9	10	17	15	9	18	22	9	8	14	20	15	6	0	16	12	7	4	6	7
109	203512304	22	9	10	17	13	12	23	19	16	16	20	25	25	15	0	0	32	8	8	0	19	10	14	12
110	203512316			5	6	3	6	9	7	11	12	10	5	9	11	7	6	8	7	6	9	5	10	8	6
111	203512583			7	6	0	13	8	5	7	8	8	6	12	10	9	6	4	7	6	8	6	5	8	6
112	203512597				8	9	5	9	11	8	9	11	8	9	0	11	11	10	8	9	10	10	11	9	9
113	203512616	0	0	0	61	31	3	9	13	10	9	11	12	15	0	12	0	0	9	4	2	3	0	6	2
114	203512619			7	4	4	4	0	13	0	17	8	0	14	7	11	7	6	7	6	6	8	9	7	10
115	203512621			19	10	13	13	16	15	15	16	18	17	12	22	22	15	10	15	20	21	17	15	21	15
116	203512622		10	10	10	0	14	5	7	15	13	6	4	6	9	5	5	5	5	8	6	6	8	8	6
117	203512623			13	11	9	10	16	11	16	16	10	10	9	16	14	14	11	14	13	17	11	13	14	11
118	203512624			0	27	5	19	17	12	14	17	15	12	9	14	13	16	13	14	15	17	13	12	5	10
119	203512625			8	3	3	5	6	5	5	6	7	5	3	6	8	6	3	5	4	2	5	7	8	7
120	203512626			0	0	0	4	0	0	5	21	2	7	4	8	9	9	5	10	8	11	8	8	9	7
121	203512630	3	3	3	4	4	5	5	5	3	3	4	2	3	3	3	3	5	4	4	5	0	6	2	2
122	203512761			0	17	6	23	2	10	13	8	6	12	8	5	6	9	6	5	8	10	13	11	12	10
123	203512762		4	3	3	4	0	11	3	8	7	4	7	10	9	7	6	6	6	0	12	7	6	0	0
124	203512769			10	5	3	6	4	5	5	6	10	10	10	3	6	6	10	8	10	8	8	10	10	9
125	203512785			3	3	2	0	0	0	0	3	3	0	2	6	4	4	3	4	3	11	0	3	4	0
126	203512860			6	4	3	4	5	0	12	6	4	0	6	4	4	4	6	4	4	4	5	5	6	4
127	203512967	12	9	7	12	15	9	10	13	12	60	60	0	0	9	9	14	12	13	19	14	25	24	9	14
128	203514274				9	8	7	10	12	10	13	13	12	12	0	12	10	11	8	6	7	10	11	10	12
129	203514275	22	0	34	0	45	15	19	0	38	11	14	14	22	15	15	15	22	13	15	16	19	15	12	15
130	203514410	14	11	8	7	8	5	7	7	7	7	10	3	8	6	6	8	6	6	5	8	8	4	7	7
131	203514448				20	20	20	10	10	10	10	10	20	20	26	20	20	20	20	20	20	20	20	20	20
132	203514506	10	10	10	31	12	11	15	21	17	16	15	26	19	25	18	17	18	17	18	18	18	18	18	15
133	203514534	10	10	10	10	10	10	11	15	11	0	0	6	9	7	8	8	8	8	14	9	10	11	9	11
134	203514540			1	3	2	3	3	2	5	6	4	5	5	5	4	5	3	3	4	5	5	5	6	5
135	203514749					－	－	－	－	－	－	－	10	7	21	15	20	20	0	5	9	0	2	8	7
136	203514753			10	4	6	9	10	10	6	12	10	8	10	17	11	7	0	19	8	11	7	7	7	11
137	203514909	0	0	0	31	7	5	7	10	10	8	5	10	10	11	9	7	11	12	12	9	9	9	9	9
138	203514957	1	2	1	2	2	0	0	4	1	1	3	2	1	0	8	0	2	0	0	0	0	5	0	2
139	203514980			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140	203515138	14	10	11	10	13	9	10	10	10	10	10	14	25	12	11	12	10	12	10	9	14	12	12	10
141	203515176	4	4	4	6	4	4	3	4	3	3	4	3	5	7	3	0	9	4	6	4	4	4	4	4
142	203515187	3	3	3	3	4	7	6	2	3	2	0	7	5	5	0	5	5	0	0	0	3	0	6	6
143	203515428			4	3	4	6	6	4	5	6	5	5	5	6	0	15	4	5	4	7	6	5	7	5
144	203515806		8	5	0	8	6	0	9	7	0	11	5	7	7	7	0	8	4	7	6	0	11	0	12
145	203516118	8	11	8	13	11	10	19	20	11	10	10	7	7	9	7	9	8	9	9	8	6	5	4	0
146	203516272	11	8	4	6	8	6	2	2	34	0	10	39	11	16	1	0	0	16	1	16	20	19	35	35
147	203519084	7	5	6	6	13	12	14	12	3	14	7	11	10	7	5	5	7	8	9	9	7	9	6	6
148	203519109	0	20	8	11	13	12	15	19	8	7	9	11	11	13	6	11	13	15	10	16	8	8	8	6
149	203519164	20	20	20	20	0	0	20	20	20	20	20	20	20	0	0	23	19	16	16	19	19	22	20	20
150	203519210					3	3	3	3	4	3	3	4	2	2	4	5	6	5	5	3	5	3	3	3
151	203519235			16	4	4	4	7	6	5	8	7	6	5	9	9	2	3	0	5	0	4	10	0	10
152	203519265	2	1	0	0	0	0	0	1	0	0	3	1	1	1	2	1	2	2	2	1	2	0	0	0
153	203519356	6	3	5	7	7	8	5	3	4	3	3	4	4	3	0	0	0	0	0	2	3	3	3	3
154	203519435	10	10	10	10	10	10	10	10	0	0	0	10	10	6	11	10	4	6	5	7	0	21	7	7
155	203519478	0	0	3	5	5	4	10	0	10	10	10	10	10	0	7	5	0	7	0	7	5	4	3	4
156	203519484	7	4	6	0	0	3	5	10	7	6	6	8	5	6	5	6	9	5	4	5	3	3	4	4
157	203519486	10	6	6	5	12	7	8	10	9	9	3	13	10	0	1	8	7	9	9	8	8	7	6	6
158	203519499		7	6	5	9	10	5	8	9	8	8	6	8	14	25	11	14	16	10	15	14	15	24	11
159	203519500	0	0	0	0	0	0	0	0	27	0	5	0	5	2	1	1	0	2	2	0	3	2	2	3
160	203519559	9	7	11	13	10	13	12	3	13	11	8	11	10	13	14	10	20	15	14	14	13	15	14	14
161	203519568		22	14	15	18	26	11	19	0	49	25	18	25	28	28	31	27	27	23	17	16	16	17	16
162	203519579	7	7	10	12	10	9	9	11	4	21	9	11	10	10	12	15	13	0	24	6	12	11	3	4
163	203519604					10	10	10	10	10	10	10	10	11	9	11	11	12	10	10	11	11	8	4	3
164	203519624					10	20	10	10	10	10	10	10	10	10	12	14	12	12	14	12	10	13	9	9
165	203519631	4	5	0	0	0	2	5	10	6	5	4	4	6	4	5	6	6	7	8	9	7	6	6	9
166	203519647	11	10	8	11	11	9	10	13	11	9	10	11	12	4	6	10	6	8	11	9	9	6	1	4
167	203519657	11	6	6	8	9	9	10	6	10	10	10	10	10	13	11	11	15	18	12	12	14	11	14	15
168	203519861	10	10	10	0	10	13	24	19	20	26	16	11	9	8	0	0	0	25	5	11	5	0	14	6
169	203519880	0	0	0	7	0	0	0	7	0	0	11	0	0	0	7	7	7	0	10	3	3	3	3	3

	POC Number	2017/1	2017/2	2017/3	2017/4	2017/5	2017/6	2017/7	2017/8	2017/9	2017/10	2017/11	2017/12	2018/1	2018/2	2018/3	2018/4	2018/5	2018/6	2018/7	2018/8	2018/9	2018/10	2018/11	2018/12
170	203519881		21	17	15	13	12	12	12	14	16	13	12	18	15	15	14	16	16	18	17	19	18	17	15
171	203519962	0	3	2	2	0	3	0	0	0	0	0	0	6	0	39	7	29	53	38	32	25	21	13	13
172	204710018	8	10	0	0	0	0	0	0	0	10	10	10	11	11	13	10	13	17	14	9	12	15	12	12
173	204710059	5	4	7	6	5	7	7	5	6	6	6	6	5	8	4	6	4	4	4	4	4	5	5	5
174	204710099	0	10	3	3	3	2	4	5	4	5	5	0	3	1	0	9	4	3	4	3	3	3	3	2
175	204710104	23	26	26	30	35	24	0	61	32	21	31	31	34	21	25	42	9	17	22	19	19	16	16	16
176	204710110	0	12	3	5	7	4	6	6	6	4	4	0	6	0	7	3	4	3	3	3	5	4	6	5
177	204710146	10	7	11	13	16	14	15	17	13	13	12	9	13	2	8	7	6	5	6	7	8	6	8	11
178	204710148				4	3	3	3	3	3	2	3	3	2	3	2	3	2	2	2	2	2	2	1	3
179	204710214	7	8	10	0	19	9	11	11	10	4	0	0	0	43	8	8	10	10	11	10	11	5	7	7
180	204710241	7	5	3	5	5	5	5	6	6	6	5	6	8	2	6	7	5	7	7	7	6	6	6	5
181	204710246		7	8	7	8	12	5	8	0	0	24	10	18	0	0	5	7	6	4	1	12	12	9	7
182	204710255			6	8	6	6	7	6	5	6	7	4	2	5	8	6	4	5	4	4	7	5	7	8
183	204710275	13	14	12	8	11	15	12	2	12	10	14	10	6	10	8	9	10	12	10	12	11	12	12	12
184	204710308	6	2	0	0	13	4	6	4	5	6	4	5	5	4	6	9	8	9	8	6	5	10	8	8
185	204710326	8	8	10	11	12	13	14	11	0	21	10	9	7	8	7	0	20	12	12	12	12	8	8	8
186	204710327	7	5	6	8	0	0	7	11	9	10	4	10	10	9	6	6	6	8	6	6	0	0	0	6
187	204710349	0	12	6	7	5	0	0	27	8	8	9	6	6	9	12	0	19	14	11	14	0	0	17	9
188	204710378	6	5	0	1	0	0	6	9	0	0	21	4	1	0	7	6	8	7	0	0	22	5	12	4
189	204710391				16	14	11	21	5	13	11	24	16	10	24	19	23	16	15	17	15	16	14	18	16
190	204710399	26	11	10	32	33	20	0	2	9	9	11	13	12	14	14	30	24	32	0	13	23	14	0	32
191	204710422			0	8	2	4	6	4	6	7	7	6	4	11	13	8	9	8	7	12	9	9	11	11
192	204710428	2	3	3	4	3	4	4	3	3	3	4	4	3	2	4	2	3	2	3	4	3	3	3	3
193	204710461	10	0	10	0	2	2	0	8	2	3	3	3	2	2	0	4	3	3	2	0	0	8	4	2
194	204710523	0	6	3	3	2	2	2	3	3	0	4	3	5	6	2	4	0	4	3	3	3	3	3	3
195	204710537	4	3	4	4	4	4	5	6	4	4	5	4	6	4	0	7	5	3	5	5	0	9	4	4
196	204710550					10	10	10	10	10	10	10	10	10	26	19	24	22	27	20	20	22	22	18	22
197	204710582	11	8	13	13	10	12	18	18	13	13	14	18	17	19	20	12	9	14	11	15	15	10	11	11
198	204710615	9	6	7	5	10	12	7	5	7	6	9	9	4	6	4	3	6	6	7	6	6	7	7	7
199	204710704	3	0	0	0	23	0	6	5	4	6	5	6	7	11	7	6	4	6	7	9	9	6	6	6
200	204710797		12	3	0	10	5	32	22	21	14	10	11	14	0	38	22	24	32	21	30	28	27	31	38
201	204710832				5	5	0	6	4	1	5	5	10	40	7	2	2	0	0	0	0	0	0	0	0
202	204710965	10	10	10	7	8	7	7	7	8	8	7	7	7	8	3	17	10	12	17	17	19	21	16	16
203	204710977			19	14	13	10	14	0	22	16	10	8	14	0	21	12	12	9	10	8	11	10	12	12
204	204711025				15	6	6	7	29	0	4	11	11	5	11	0	0	5	8	5	9	8	7	15	49
205	204711056		13	11	9	11	13	14	8	21	11	112	13	5	8	11	13	12	11	11	11	13	12	13	13
206	204711074	0	0	0	0	0	4	5	5	6	7	7	6	5	6	5	4	3	4	5	5	5	5	5	5
207	204711124				13	8	3	12	5	8	11	15	13	11	10	10	10	10	10	10	13	10	10	10	10
208	204711135		23	15	13	15	17	15	15	17	7	8	159	15	25	15	0	28	0	29	18	16	14	18	15
209	204711148	2	1	3	0	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	4	4	3	3
210	204711153	3	2	2	1	3	2	3	0	8	34	4	4	6	2	5	7	4	4	4	3	5	0	9	4
211	204711163	5	2	0	0	0	0	0	0	0	0	1	2	3	7	7	0	0	0	11	4	5	0	7	3
212	204711196	5	5	11	0	0	20	4	5	0	0	20	0	10	6	5	4	3	5	8	0	0	0	3	3
213	204711201				6	0	0	9	4	4	3	4	0	0	8	4	5	0	0	1	0	0	0	5	5
214	204711203	8	5	0	0	0	0	0	50	20	0	5	6	6	3	3	5	2	4	4	2	4	5	5	5
215	204711209			0	1	3	2	4	4	4	5	4	3	1	0	4	1	3	1	2	2	4	2	7	4
216	204711244	0	1	9	12	11	11	11	10	9	11	10	10	7	9	8	12	12	11	12	9	10	10	12	10
217	204711287	20	0	23	6	3	7	6	7	6	7	6	5	1	6	5	3	3	5	7	6	7	0	3	3
218	204711375	7	4	5	6	4	5	4	7	7	8	10	7	10	8	8	5	4	0	9	0	12	3	0	4
219	204711385	6	3	4	8	3	5	13	12	11	9	7	12	3	10	9	7	8	8	8	8	10	8	10	8
220	204711427	7	6	4	6	8	6	7	7	8	9	8	8	9	3	7	9	6	7	5	7	5	6	7	6
221	204711436			9	7	7	8	9	7	10	10	10	5	14	9	7	5	3	6	2	8	6	8	9	6
222	204711449	0	3	0	1	1	3	33	26	13	66	159	49	20	2	36	42	58	7	0	175	244	0	21	20
223	204711481		9	6	7	8	10	7	7	6	8	9	5	12	11	10	12	6	8	12	9	10	12	14	9
224	204711523			5	3	0	6	5	0	0	18	5	5	5	9	0	8	12	7	8	0	16	8	9	11
225	204711550	35	72	31	2	28	20	20	20	20	30	30	20	20	34	67	41	49	30	48	0	79	55	63	39
226	204711592		0	9	3	4	5	5	6	7	4	4	4	8	4	3	2	3	3	0	6	4	5	5	4
227	204711620	0	15	8	6	7	9	1	5	5	5	5	5	8	17	6	6	9	9	21	18	14	14	15	15
228	204711667		0	17	6	9	9	7	8	10	6	9	8	8	8	5	5	5	5	5	6	6	5	5	0
229	204711746	9	5	6	0	0	2	6	8	8	8	8	8	8	9	8	8	9	8	7	9	9	8	8	6
230	204711802	12	13	13	22	18	25	32	16	20	14	17	15	15	16	12	15	19	18	17	32	21	6	2	2
231	204711898					7	6	5	6	8	5	5	8	6	4	11	8	5	6	5	7	2	3	6	7
232	204712007	6	5	6	6	5	6	6	6	4	0	12	6	6	6	6	6	6	7	8	8	8	12	14	14
233	204712082	10	0	0	27	18	7	4	11	10	4	6	4	3	1	4	3	0	6	6	7	15	23	18	20
234	204712120			5	4	3	4	5	4	4	6	2	4	5	5	3	3	3	2	2	4	4	5	5	4
235	204712273	3	3	3	4	5	3	3	3	2	2	2	2	4	3	4	5	3	5	4	3	4	4	4	4
236	204712437	0	0	0	0	0	0	0	0	0	0	0	0	13	23	19	18	35	24	26	21	14	22	16	16
237	204712515		29	23	19	0	0	10	12	20	16	16	10	11	16	12	10	14	13	14	13	17	16	15	9
238	204712533	7	6	9	7	7	8	12	8	12	7	8	10	6	8	7	8	8	10	9	9	0	17	4	
239	204712562				98	29	47	0	106	46	53	68	32	22	38	22	18	21	25	16	16	15	13	20	23
240	204712584	15	0	29	17	19	22	32	18	18	7	10	20	10	17	18	11	22	18	21	16	14	10	11	11
241	204712702	15	12	20	21	15	17	20	17	15	15	15	23	21	26	23	19	23	27	27	25	28	20	22	22
242	204712709		8	6	7	11	30	8	7	9	7	9	8	11	13	3	2	3	4	3	2	9	6	8	6
243	204712719	14	15	12	6	33	16	11	13	13	14	10	12	13	11	7	8	9	7	0	18	13	12	12	14
244	204712859	75	0	0	0	0	−	20	18	8	8	8	5	9	4	6	7	5	0	9	1	9	8	6	6
245	204712880	14	9	7	10	13	10	10	15	12	0	0	33	13	0	19	10	10	0	0	39	16	9	0	23
246	204712889			15	11	8	11	12	9	8	9	9	10	10	8	9	18	20	7	15	16	12	15	17	14
247	204712919		6	6	0	10	6	4	4	6	4	3	6	6	6	6	6	8	6	8	6	5	0	14	6
248	204712943	18	27	21	11	13	24	17	14	19	22	23	21	18	19	23	14	14	52	65	62	73	54	50	50
249	204712954	14	9	11	19	18	21	20	28	14	18	19	20	20	12	17	14	22	16	14	25	22	22	21	20
250	204713036					26	12	14	14	16	11	13	25	13	19	14	2	10	15	9	9	4	17	16	28
251	204713093			0	6	2	4	5	4	6	7	7	3	15	9	12	11	8	9	7	10	8	7	9	9
252	204713380	0	0	0	0	0	0	0	0	−	−	−	−	0	69	87	163	146	39	17	44	18	16	17	17
253	204713402	0	8	3	0	8	0	10	4	5	5	3	0	0	3	0	10	7	0	0	0	4	5	5	5
254	204713551			7	5	4	5	6	7	14	12	14	3	13	13	28	14	11	17	20	29	0	112	46	19

	POC Number	2017/1	2017/2	2017/3	2017/4	2017/5	2017/6	2017/7	2017/8	2017/9	2017/10	2017/11	2017/12	2018/1	2018/2	2018/3	2018/4	2018/5	2018/6	2018/7	2018/8	2018/9	2018/10	2018/11	2018/12
255	204713746	9	0	12	6	9	0	13	8	7	6	6	8	7	6	8	10	8	10	9	8	4	9	11	11
256	204713877	14	8	3	4	5	9	8	13	9	0	24	0	14	4	5	5	6	10	6	7	9	9	7	14
257	204713894					2	10	10	10	10	10	10	10	4	5	0	16	5	5	0	15	0	13	10	9
258	204714016		82	38	26	47	37	34	48	11	38	31	40	44	62	31	23	38	35	30	59	42	48	40	33
259	204714200	10	8	11	12	10	10	18	16	17	16	15	11	20	14	9	13	14	13	15	15	16	12	14	14
260	204714349	4	3	4	4	0	0	14	4	3	0	9	6	3	3	0	1	2	2	2	3	1	2	2	2
261	204714350	4	2	2	4	4	4	5	5	5	5	4	4	4	4	3	5	4	5	2	3	5	3	3	3
262	204714386	1	5	2	11	0	4	4	0	10	3	4	0	0	2	3	1	2	2	3	3	1	3	3	0
263	204714448	0	5	5	0	7	0	0	2	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0
264	204714537		3	3	2	3	2	5	5	5	4	5	5	5	5	5	4	5	5	4	6	7	7	8	8
265	204714565	15	12	6	7	5	5	4	4	8	9	14	26	20	25	21	0	45	46	29	36	38	23	18	21
266	204714622	13	10	7	14	18	16	19	21	13	15	12	14	16	7	16	20	14	14	16	18	15	14	13	12
267	204714641	5	5	4	7	4	6	7	9	8	0	11	6	7	2	3	4	3	2	4	6	6	10	11	11
268	204714726	10	7	5	7	0	16	8	15	11	8	9	10	12	8	10	12	9	0	18	8	9	6	6	8
269	204714815	3	3	2	4	3	3	4	4	4	1	0	0	12	5	6	5	6	5	4	7	5	6	6	6
270	204714852	6	8	6	10	11	9	9	7	7	5	5	4	6	9	9	11	10	13	9	0	18	10	9	6
271	204714870		11	37	34	19	22	14	17	8	9	10	10	19	14	13	15	19	21	21	14	18	18	21	23
272	204714986					5	3	1	4	3	4	6	9	4	4	5	0	4	0	9	4	2	6	5	5
273	204715032	24	16	13	16	18	17	17	27	22	19	17	23	21	13	20	19	19	19	22	17	20	15	19	18
274	204715049					0	0	0	0	0	0	0	9	3	0	0	0	0	0	1	0	0	0	0	0
275	204715085	12	12	16	20	14	19	19	19	17	5	9	7	10	6	6	9	13	12	12	17	13	14	13	13
276	204715155	6	4	4	5	5	4	5	5	6	5	5	2	4	2	5	4	5	6	5	6	8	6	6	4
277	204715190	11	12	12	17	25	19	22	18	14	13	25	0	21	13	16	20	16	14	13	15	19	0	0	33
278	204715205	0	4	0	12	10	8	8	0	25	10	13	0	26	9	9	12	13	0	0	8	8	10	0	11
279	204715210					5	5	3	4	7	6	6	8	6	4	4	6	4	5	3	6	2	5	7	7
280	204715299			24	9	6	7	10	9	10	12	12	9	9	9	10	9	7	8	7	3	0	10	10	10
281	204715304	7	6	6	6	9	7	9	8	8	7	7	9	9	11	5	8	6	9	13	9	10	8	9	8
282	204715485				8	33	20	42	49	18	37	54	47	22	33	27	25	28	16	14	25	16	12	19	17
283	204715533	16	7	8	10	13	13	11	9	6	7	10	8	7	5	6	7	0	19	7	6	8	18	7	7
284	204715538			0	12	14	30	37	43	47	78	39	37	21	37	62	39	31	49	55	67	60	68	46	38
285	204715721	11	9	7	9	10	9	11	12	10	8	9	10	10	4	10	12	12	7	9	10	8	10	8	8
286	204715798		9	9	6	5	9	6	7	10	6	5	2	7	5	6	5	6	5	4	4	5	5	0	0
287	204715853			6	10	7	7	14	9	11	13	10	5	13	10	8	9	7	5	7	9	9	12	9	9
288	204715989	2	3	4	0	4	3	2	0	4	2	6	5	4	6	3	5	6	4	4	0	12	7	7	7
289	204716076		3	2	2	2	4	3	3	4	2	2	2	0	3	4	3	6	6	4	3	4	4	3	4
290	204716096	7	5	0	11	0	6	4	3	5	3	0	5	8	0	5	4	3	3	0	9	0	4	4	4
291	204716109	0	0	18	0	0	0	28	7	7	5	0	0	0	2	5	7	6	8	9	9	7	10	8	10
292	204716177	5	1	3	6	2	4	6	5	5	6	5	7	6	5	7	6	6	4	5	7	3	6	7	7
293	204716191	16	2	7	8	0	0	7	9	7	10	2	6	5	9	5	8	4	8	6	5	4	5	4	3
294	204716291					8	2	3	4	5	7	0	18	8	10	10	12	7	2	6	0	0	29	16	13
295	204716361					27	12	9	14	9	9	8	16	18	16	28	30	0	54	25	46	27	32	22	17
296	204716375			8	3	1	0	6	2	2	4	3	4	1	4	7	7	8	9	5	9	7	8	8	8
297	204716454					10	6	4	5	6	1	5	7	6	7	0	6	8	8	3	4	2	3	6	4
298	204716689		0	3	3	5	6	6	7	6	6	6	5	5	6	5	6	6	4	5	7	10	9	8	7
299	204716724	3	0	4	5	0	12	7	7	5	7	4	5	6	2	5	4	3	4	5	6	5	6	6	6
300	204717179			–	–	0	0	6	0	8	6	5	7	4	0	10	4	5	4	4	6	5	5	6	4
301	204717286					–	–	–	–	8	8	4	4	4	5	4	3	3	4	2	2	1	5	5	10
302	204717568	–	–	–	–	–	0	3	11	5	6	8	6	10	3	0	5	8	7	8	10	11	7	6	9
303	204717636	–	–	–	–	–	–	1	3	5	5	5	5	5	2	5	5	5	4	6	4	5	5	4	5
304	204717711	–	–	–	–	–	–	0	10	0	14	8	8	8	4	4	5	7	6	5	7	7	7	8	7
305	204717760	–	–	–	–	–	–	0	2	8	10	3	10	10	7	4	6	3	6	10	6	10	9	11	11
	Total				2721	3064	2914	3154	3466	3275	3312	3376	3215	3238	3293	3275	3231	3446	3363	3171	3516	3769	3493	3307	3053
	4 Month Average						2963	3150	3202	3302	3357	3295	3285	3281	3255	3259	3311	3329	3303	3374	3455	3487	3521		



Billing Volume before and after Meter Replacement Case 1

Billing Rate Before and After Meter Replacement: Case 2

	POC Number	2017/1	2017/2	2017/3	2017/4	2017/5	2017/6	2017/7	2017/8	2017/9	2017/10	2017/11	2017/12	2018/1	2018/2	2018/3	2018/4	2018/5	2018/6	2018/7	2018/8	2018/9	2018/10	2018/11	2018/12
1	202210743	28	27	25	25	39	23	24	36	0	0	23	17	14	14	13	10	13	14	13	13	19	3	13	7
2	202211271	11	7	5	6	9	7	7	9	7	7	5	5	5	5	5	4	4	7	0	0	27	9	7	6
3	202211274	0	0	0	0	0	1	10	10	0	10	12	8	10	5	10	12	14	7	10	12	9	26	10	5
4	202211347	3	10	10	10	10	0	10	10	11	11	5	10	11	10	7	11	8	10	9	9	7	0	13	11
5	202211411	7	0	0	0	30	7	6	0	0	0	10	9	0	0	0	0	0	20	0	25	11	8	7	10
6	202212554	2	0	8	7	8	11	5	8	8	8	10	8	10	10	5	0	11	6	11	10	9	10	8	9
7	202213249	67	45	33	44	64	44	36	36	36	29	30	38	47	36	31	38	54	39	42	23	22	19	23	25
8	202213648	13	10	11	12	15	9	10	18	12	8	7	16	10	11	8	10	9	12	8	8	10	13	13	12
9	202214084	0	22	0	0	23	8	9	11	14	10	0	19	12	0	0	20	10	9	13	13	11	15	12	13
10	202214120	26	11	19	29	35	11	18	21	20	21	45	38	31	57	34	37	126	53	38	21	40	49	33	19
11	202214206	7	7	8	5	8	8	7	0	18	0	13	11	7	8	14	8	9	7	8	10	8	11	7	7
12	202214500	20	20	20	20	20	20	13	0	6	18	20	20	20	20	13	16	0	39	15	16	20	20	16	21
13	202214567	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	50	33	201	35	27	24	22	54	41
14	202214597	0	0	0	0	0	0	6	18	0	30	13	0	0	0	0	0	0	0	0	0	0	0	0	0
15	202214687	5	12	7	11	6	0	6	0	0	54	18	0	28	0	36	25	22	15	18	22	22	20	15	17
16	202214720	14	9	7	12	10	8	10	14	9	9	9	16	15	15	9	17	9	11	5	10	10	10	10	10
17	202214835	13	14	11	12	13	11	15	16	11	11	9	10	10	10	11	16	13	16	18	20	23	23	20	21
18	202215127	23	20	16	15	19	20	20	23	21	19	15	22	16	18	12	15	12	14	14	13	18	16	16	17
19	202215143	0	0	0	0	0	50	0	23	10	10	11	0	15	15	0	17	0	20	10	10	21	15	14	0
20	202215719	12	8	10	11	14	9	10	16	10	11	11	13	10	7	6	9	13	12	8	10	11	9	11	10
21	202215986	6	6	4	6	9	0	20	10	9	7	8	6	8	5	6	8	8	6	9	16	8	10	8	8
22	202215998	234	265	167	173	222	94	101	184	165	156	25	177	92	118	67	145	80	182	113	108	200	142	106	108
23	202216113	21	19	18	20	23	19	23	25	20	17	17	21	26	18	15	19	20	17	20	23	22	24	22	21
24	202216127	33	40	31	39	49	35	31	40	35	33	28	39	41	33	32	41	35	31	40	44	43	32	29	28
25	202216264	7	4	4	0	14	5	0	0	8	4	7	6	6	6	6	5	2	5	4	6	7	5	5	6
26	202216287	12	8	6	7	8	5	8	7	5	5	6	4	5	2	3	5	5	5	5	6	7	7	6	0
27	202216344	17	12	0	22	0	31	15	0	32	11	5	20	0	27	8	0	0	37	13	11	13	11	12	14
28	202216365	22	18	17	17	25	16	17	24	20	12	19	22	22	18	16	16	18	21	16	15	19	16	17	17
29	202216431	2	2	0	8	7	6	8	8	8	6	8	7	8	8	0	20	0	0	0	0	0	0	0	26
30	202216518	21	15	10	14	18	14	14	19	15	13	12	11	14	8	9	8	11	8	9	11	8	10	10	12
31	202216584	15	10	10	11	17	12	15	10	10	10	10	20	17	21	20	18	21	19	16	14	20	16	20	8
32	202216609	10	0	2	5	5	5	4	6	7	5	2	0	0	0	0	0	0	0	0	1	3	1	3	4
33	202216660	0	0	54	5	15	15	10	20	10	7	8	0	18	7	5	0	4	7	0	9	5	0	0	0
34	202216726	11	9	8	7	9	8	8	10	7	10	9	12	11	9	10	7	8	16	8	6	8	2	148	22
35	202216781	10	10	10	10	10	10	10	10	10	10	10	16	10	9	6	8	5	5	5	8	10	9	19	0
36	202216820	21	14	10	25	15	5	15	9	19	26	15	26	15	15	15	12	14	16	14	16	20	19	21	19
37	202216877	–	23	12	11	15	10	13	19	9	7	16	11	14	12	15	8	15	14	9	10	12	8	9	8
38	202216899	8	6	5	7	0	0	0	0	4	6	6	9	4	7	11	5	3	1	1	7	11	7	10	10
39	202216900	0	0	25	7	9	9	9	10	6	6	12	10	8	0	8	7	6	6	7	0	15	9	8	9
40	202216906	16	8	11	14	16	12	12	16	16	15	16	22	20	17	17	21	12	13	14	12	18	11	13	18
41	202216942	18	11	11	12	15	11	12	15	15	10	11	12	12	9	9	6	12	16	12	13	5	23	14	13
42	202217058	7	3	4	6	0	11	5	2	0	5	2	3	4	0	3	0	4	1	0	3	2	2	2	3
43	202217059	8	8	6	7	8	7	9	10	10	6	8	8	10	0	14	7	8	8	11	10	8	8	7	8
44	202217064	34	19	11	14	20	18	22	28	18	12	15	18	18	21	9	18	17	15	23	16	17	18	18	17
45	202217087	14	6	14	13	14	11	11	18	11	8	15	12	9	10	11	9	10	7	7	7	10	6	6	6
46	202217113	0	0	0	9	0	3	3	4	0	4	0	7	0	11	3	0	7	0	7	6	6	0	0	13
47	202217291	5	3	0	9	4	6	7	6	5	4	5	5	5	3	4	0	0	12	0	0	17	6	7	8
48	202217377	0	0	0	51	14	12	12	17	13	22	14	21	40	28	11	9	6	7	9	0	12	5	7	5
49	202217677	13	13	9	13	15	10	12	14	11	14	10	13	12	15	12	12	11	15	12	11	15	13	19	13
50	202217682	8	5	5	5	6	7	9	11	9	10	5	10	9	8	7	6	7	8	7	9	6	7	8	7
51	202217714	17	13	11	15	21	14	20	25	19	12	23	19	0	30	15	15	13	20	16	19	17	18	18	17
52	202217922	10	10	10	10	10	0	0	5	9	6	5	7	6	7	7	8	7	0	19	11	7	8	10	11
53	202218021	0	0	32	14	12	8	9	11	10	11	7	13	12	14	9	13	9	7	8	8	9	6	6	8
54	202218048	6	6	6	6	11	11	10	13	9	5	10	10	9	7	8	8	7	9	7	7	8	7	7	7
55	202218107	10	10	10	10	8	8	10	13	11	10	9	10	12	11	10	12	9	9	12	11	12	10	10	9
56	202218130	18	17	13	8	19	13	17	20	19	18	10	16	18	14	17	18	16	16	21	18	18	18	17	14
57	202218242	7	5	0	12	8	0	0	43	14	6	12	9	10	0	22	10	14	17	14	15	19	13	11	11
58	202218261	19	11	13	16	18	18	14	16	14	6	17	16	7	13	14	7	7	5	0	13	7	5	0	15
59	202218334	12	11	6	7	9	0	22	7	10	10	10	10	10	10	6	8	7	7	5	7	9	5	4	8
60	202218508	6	5	5	4	6	5	7	10	5	2	6	6	6	4	4	6	4	5	4	5	6	2	3	4
61	202218606	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	14	0	21	9	9	11	9	9	11
62	202218677	25	9	9	11	14	12	13	18	17	0	37	18	15	9	10	12	10	12	11	12	12	0	36	15
63	202218808	0	0	54	19	21	14	18	27	24	21	24	23	28	20	21	19	19	30	23	22	24	22	27	27
64	202218921	9	7	5	1	17	8	8	16	11	6	10	6	7	7	5	0	0	21	7	6	0	19	11	12
65	202218934	0	10	0	10	0	11	5	7	5	6	5	6	6	5	6	5	7	6	6	7	0	13	8	6
66	202219000	6	6	4	6	10	9	0	20	11	0	14	0	0	9	9	9	10	6	8	0	16	8	0	14
67	202219002	8	7	6	7	9	6	9	10	8	6	7	6	6	10	3	3	2	2	6	4	7	9	6	6
68	202219003	15	7	0	10	10	10	10	10	10	10	10	7	24	17	10	10	8	16	15	16	16	13	14	10
69	202219013	15	10	9	5	11	8	14	20	19	15	11	12	11	0	6	5	10	14	12	18	11	7	12	0
70	202219024	22	11	13	16	23	15	20	20	19	26	26	27	25	2	23	18	15	26	14	15	17	15	16	17
71	202219041	24	21	18	22	31	22	30	25	25	14	33	40	40	26	23	26	29	33	26	27	34	27	29	25
72	202219047	15	19	22	27	34	25	31	40	38	34	37	19	17	12	13	12	12	22	15	15	18	15	16	15
73	202219066	8	6	5	6	8	8	8	10	10	6	6	7	7	6	5	0	0	19	6	6	8	6	6	6
74	202219073	13	9	8	7	0	23	11	15	16	12	11	0	30	9	4	17	11	13	12	11	16	12	15	12
75	202219105	9	12	11	12	16	11	15	14	18	16	12	29	14	5	9	12	8	15	13	12	17	13	14	13
76	202219134	8	8	6	11	12	40	13	4	7	6	6	7	8	8	4	7	4	4	4	6	5	5	5	4
77	202219206	4	4	3	4	5	4	4	5	4	5	5	4	5	5	6	1	4	5	5	4	6	6	4	5
78	202219282	4	5	3	5	6	4	6	7	8	5	10	4	4	4	5	4	3	2	2	2	0	6	3	4
79	202219295	30	27	24	27	33	26	20	30	30	30	30	0	30	20	24	22	25	25	27	34	39	33	36	34
80	202219296	12	9	9	9	13	0	18	13	12	10	11	13	12	14	12	12	11	14	10	13	13	13	14	17
81	202219300	11	6	7	8	10	10	10	14	14	10	6	13	10	11	7	11	10	10	10	14	12	9	8	7
82	202219309	6	4	2	5	6	3	4	6	5	3	3	5	5	5	3	4	2	4	0	2	3	5	4	5
83	202219327	6	11	18	13	18	13	17	46	46	10	30	25	29	29	13	19	0	0	31	0	0	41	14	15
84	202219331	12	0	13	8	12	7	9	11	11	9	8	16	9	11	5	17	11	12	8	12	12	12	12	10

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85	202219344	15	16	16	23	24	8	21	27	27	23	15	37	32	49	26	37	22	36	25	40	59	69	34	28
86	202219345	23	21	15	20	33	19	23	29	23	22	22	25	27	29	20	18	21	27	7	26	22	22	14	13
87	202219394	0	54	26	0	32	13	16	–	0	51	45	13	20	18	18	12	0	32	0	28	17	14	21	11
88	202219631	17	13	11	19	23	16	18	29	19	11	16	16	16	22	12	15	16	20	15	13	21	16	19	21
89	202219703	14	8	6	9	10	11	13	8	11	19	10	3	10	10	10	23	16	17	20	18	21	16	16	12
90	202219736	0	68	21	21	27	16	22	27	23	21	24	24	14	17	7	9	8	8	8	9	10	0	17	9
91	202219879	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	3	4	7	6	7	8	5	5	5
92	202219897	4	4	5	8	4	4	3	10	2	5	7	8	10	2	7	2	5	3	6	14	8	9	7	10
93	202219925	17	21	15	16	25	18	22	31	27	0	11	35	25	21	16	18	16	22	0	39	21	18	17	18
94	202219964	0	3	7	3	3	0	0	8	6	4	10	5	0	10	8	7	10	8	8	8	9	9	11	6
95	202219982	42	12	0	0	30	14	26	0	31	19	14	19	20	17	16	18	18	19	12	27	26	26	24	20
96	203511092	9	10	0	28	24	0	36	18	15	16	7	14	10	19	16	20	14	17	17	15	23	14	16	15
97	203511093	18	11	11	15	18	15	16	18	17	17	12	18	13	21	13	23	19	18	24	19	23	21	19	22
98	203511096	7	5	6	6	11	8	7	9	6	9	5	20	13	0	16	11	7	11	7	7	4	3	0	14
99	203511098	0	0	0	0	0	0	0	23	0	0	0	15	11	15	9	14	13	15	16	12	13	18	19	12
100	203511293	5	4	3	4	7	6	3	5	3	3	4	4	5	4	4	5	8	9	6	7	9	7	7	9
101	203511326	22	12	14	15	17	20	35	51	21	20	14	20	18	13	10	11	0	27	13	20	16	13	15	12
102	203511418	7	5	5	8	7	7	7	10	8	4	10	10	8	7	5	6	5	6	6	6	8	5	5	7
103	203511480	10	10	10	10	10	10	10	10	10	10	10	0	36	15	0	26	0	33	12	0	28	12	3	0
104	203511482	8	5	5	5	9	6	6	7	5	7	4	7	5	7	4	6	5	7	6	6	8	6	6	4
105	203511493	12	8	6	7	8	7	9	11	10	9	6	9	6	7	5	0	–	–	–	–	–	32	14	7
106	203511534	17	16	9	0	25	20	30	30	30	20	7	3	14	17	13	16	16	14	12	11	16	11	14	15
107	203511631	5	4	3	4	4	3	6	7	4	5	3	4	2	4	5	5	4	6	4	6	7	4	3	3
108	203511643	7	5	5	4	0	10	5	7	6	3	7	4	3	4	4	3	4	4	3	5	5	5	7	7
109	203511722	20	20	20	20	20	20	20	20	22	20	20	20	0	20	20	20	20	31	23	23	37	28	0	12
110	203512071	10	10	10	10	10	11	14	16	14	13	11	12	11	9	11	12	8	7	9	9	10	10	9	10
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112	203512186	9	9	10	17	15	9	18	22	9	8	14	20	15	6	0	16	12	7	4	6	7	3	6	6
113	203512304	0	22	9	10	17	13	12	23	19	16	16	20	25	25	15	0	0	32	8	8	0	19	10	14
114	203512316	5	6	3	6	9	7	11	12	10	5	9	11	7	6	8	7	6	9	5	10	8	6	6	5
115	203512317	0	25	13	11	0	0	0	9	11	12	11	11	8	0	19	11	11	9	11	9	10	10	12	11
116	203512583	7	6	0	13	8	5	7	8	8	6	12	10	9	6	4	7	6	8	6	5	8	6	9	8
117	203512597	8	9	5	9	11	8	9	11	8	9	0	11	11	10	8	9	10	10	11	9	9	9	8	8
118	203512616	0	0	0	61	31	3	9	13	10	9	11	12	15	0	12	0	0	9	4	2	3	0	6	2
119	203512619	7	4	4	4	0	13	0	17	8	0	14	7	11	7	6	7	6	6	8	9	7	10	12	9
120	203512621	19	10	13	13	16	15	15	16	18	17	12	22	22	15	10	15	20	21	17	15	21	15	19	10
121	203512622	10	10	10	0	14	5	7	15	13	6	4	6	9	5	5	5	5	8	6	6	8	8	6	5
122	203512623	13	11	9	10	16	11	16	16	10	10	9	16	14	14	11	14	13	17	11	13	14	11	16	14
123	203512624	0	27	5	19	17	12	14	17	15	12	9	14	13	16	13	14	15	17	13	12	5	10	9	12
124	203512625	8	3	3	5	6	5	5	6	7	5	3	6	8	6	3	5	4	2	5	7	8	7	7	6
125	203512626	0	0	0	4	0	0	5	21	2	7	4	8	9	9	5	10	8	11	8	8	9	7	8	8
126	203512630	3	3	3	3	4	4	5	5	5	3	3	4	2	3	3	3	3	5	4	4	5	0	6	2
127	203512761	0	17	6	23	2	10	13	8	6	12	8	5	6	9	6	5	8	10	13	11	12	10	16	11
128	203512762	4	3	3	4	0	11	3	8	7	4	7	10	9	7	6	6	6	0	12	7	6	0	0	20
129	203512769	10	5	3	6	4	5	5	6	10	10	10	3	6	6	10	8	10	8	8	10	10	9	11	11
130	203512785	3	3	2	0	0	0	0	3	3	0	2	6	4	4	3	4	3	11	0	3	4	0	6	2
131	203512860	6	4	3	4	5	0	12	6	4	0	6	4	4	4	6	4	4	4	5	5	6	4	3	4
132	203512967	12	9	7	12	15	9	10	13	12	60	60	0	0	9	9	14	12	13	19	14	25	24	9	14
133	203514274	9	8	7	10	12	10	13	13	12	12	0	12	10	11	8	6	7	10	11	10	12	13	10	13
134	203514275	22	0	34	0	45	15	19	0	38	11	14	14	22	15	15	15	22	13	15	16	19	15	12	15
135	203514410	14	11	8	7	8	5	7	7	7	7	10	3	8	6	6	8	6	6	5	8	8	4	7	7
136	203514448	20	20	20	10	10	10	10	10	20	20	26	20	20	20	20	20	20	20	20	20	20	20	15	23
137	203514506	10	10	10	31	12	11	15	21	17	16	15	26	19	25	18	17	18	17	18	18	18	18	18	15
138	203514534	10	10	10	10	10	10	11	15	11	0	0	6	9	7	8	8	8	8	14	9	10	11	9	11
139	203514540	1	3	2	3	3	2	5	6	4	5	5	5	4	5	3	3	4	5	5	5	6	5	6	4
140	203514749	–	–	–	–	–	–	–	10	7	21	15	20	20	0	5	9	0	2	8	7	9	4	5	4
141	203514753	10	4	6	9	10	10	6	12	10	8	10	17	11	7	0	19	8	11	7	7	7	11	9	8
142	203514909	7	7	6	9	0	0	0	31	7	5	7	10	10	8	5	10	10	11	9	7	11	12	12	9
143	203514957	1	2	1	2	2	0	0	4	1	1	3	2	1	0	8	0	2	0	0	0	0	5	0	2
144	203514980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
145	203515138	14	10	11	10	13	9	10	10	10	10	10	14	25	12	11	12	10	12	10	9	14	12	12	10
146	203515176	5	3	3	3	4	4	4	6	4	4	3	4	3	3	4	3	5	7	3	0	9	4	6	4
147	203515187	3	3	3	3	3	4	7	6	2	3	2	0	7	5	5	0	5	5	0	0	0	3	0	6
148	203515428	4	3	4	6	6	4	5	6	5	5	5	6	0	15	4	5	4	7	6	5	7	5	5	0
149	203515806	8	5	0	8	6	0	9	7	0	11	5	7	7	7	0	8	4	7	6	0	11	0	12	5
150	203516118	8	11	8	13	11	10	19	20	11	10	10	7	7	9	7	9	8	9	9	8	6	5	4	0
151	203516272	11	8	4	6	8	6	2	2	34	0	10	39	11	16	1	0	0	16	1	16	20	19	35	35
152	203519084	11	7	5	6	6	13	12	14	12	3	14	7	11	10	7	5	5	7	8	9	9	7	9	6
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154	203519164	20	20	20	20	20	0	0	20	20	20	20	20	20	20	0	0	23	19	16	16	19	19	22	20
155	203519210	3	3	3	3	4	3	3	4	2	2	4	5	6	5	5	3	5	3	3	3	4	0	9	4
156	203519235	16	4	4	4	7	6	5	8	7	6	5	9	9	2	3	0	5	0	4	10	0	10	5	13
157	203519265	2	1	0	0	0	0	0	1	0	0	3	1	1	1	2	1	2	2	2	1	2	0	0	0
158	203519356	6	3	5	7	7	8	5	3	4	3	3	4	4	3	0	0	0	0	0	2	3	3	3	3
159	203519435	10	10	10	10	10	10	10	10	10	0	0	0	10	10	6	11	10	4	6	5	7	0	21	7
160	203519478	0	0	3	5	5	4	10	0	10	10	10	10	10	0	7	5	0	7	0	7	5	4	3	4
161	203519482	0	7	0	0	0	3	2	3	6	10	7	13	15	10	2	0	10	10	10	10	10	5	1	11
162	203519484	7	4	6	0	0	3	5	10	7	6	6	8	5	6	5	6	9	5	4	5	3	3	4	4
163	203519486	10	6	6	5	12	7	8	10	9	9	3	13	10	0	1	8	7	9	9	8	8	7	6	6
164	203519497	10	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	10	8	5	7	5
165	203519499	7	6	5	9	10	5	8	9	8	8	6	8	14	25	11	14	16	10	15	14	15	24	11	11
166	203519500	0	0	0	0	0	0	0	0	27	0	5	0	5	2	1	1	0	2	2	0	3	2	2	3
167	203519559	13	9	7	11	13	10	13	12	3	13	11	8	11	10	13	14	10	20	15	14	14	13	15	14
168	203519568	22	14	15	18	26	11	19	0	49	25	18	25	28	28	31	27	27	23	17	16	16	17	16	12
169	203519579	7	7	10	12	10	9	9	11	4	21	9	11	10	10	12	15	13	0	24	6	12	11	3	4

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170	203519604	10	10	10	10	10	10	10	10	11	9	11	11	12	10	10	11	11	8	4	3	0	10	13	10
171	203519624	10	20	10	10	10	10	10	10	10	10	12	14	12	12	14	12	10	13	9	9	8	0	17	8
172	203519631	4	5	0	0	0	2	5	10	6	5	4	4	6	4	5	6	6	7	8	9	7	6	6	9
173	203519647	11	10	8	11	11	9	10	13	11	9	10	11	12	4	6	10	6	8	11	9	9	6	1	4
174	203519657	11	6	6	8	9	9	10	6	10	10	10	10	10	13	11	11	15	18	12	12	14	11	14	15
175	203519861	10	10	10	0	10	13	24	19	20	26	16	11	9	8	0	0	0	25	5	11	5	0	14	6
176	203519880	0	0	0	0	0	0	0	7	0	0	0	7	0	0	11	0	0	0	7	7	7	0	10	3
177	203519881	21	17	15	13	12	12	12	14	16	13	12	18	15	15	14	16	16	18	17	19	18	17	15	15
178	203519962	0	0	3	2	2	0	3	0	0	0	0	0	0	6	0	39	7	29	53	38	32	25	21	13
179	204710018	10	8	10	0	0	0	0	0	0	0	10	10	10	11	11	13	10	13	17	14	9	12	15	12
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182	204710104	23	26	26	30	35	24	0	61	32	21	31	31	34	21	25	42	9	17	22	19	19	16	16	16
183	204710110	0	12	3	5	7	4	6	6	6	4	4	0	6	0	7	3	4	3	3	3	5	4	6	5
184	204710146	10	7	11	13	16	14	15	17	13	13	12	9	13	2	8	7	6	5	6	7	8	6	8	11
185	204710148	4	3	3	3	3	3	2	3	3	2	3	2	3	2	2	2	2	2	2	1	3	2	0	4
186	204710214	12	7	8	10	0	19	9	11	11	10	4	0	0	0	43	8	8	10	10	11	10	11	5	7
187	204710241	7	5	3	5	5	5	5	6	6	6	5	6	8	2	6	7	5	7	7	7	6	6	6	5
188	204710246	7	8	7	8	12	5	8	0	0	24	10	18	0	0	5	7	6	4	1	12	12	9	7	0
189	204710255	6	8	6	6	7	6	5	6	7	4	2	5	8	6	4	5	4	4	7	5	7	8	14	12
190	204710275	18	15	13	14	12	8	11	15	12	2	12	10	14	10	6	10	8	9	10	12	10	12	11	12
191	204710308	10	6	2	0	0	13	4	6	4	5	6	4	5	5	4	6	9	8	9	8	6	5	10	8
192	204710326	12	12	8	8	10	11	12	13	14	11	0	21	10	9	7	8	7	0	20	12	12	12	12	8
193	204710327	7	5	6	8	0	0	7	11	9	10	4	10	10	9	6	6	6	8	6	6	0	0	0	6
194	204710349	3	0	12	6	7	5	0	0	27	8	8	9	6	6	9	12	0	19	14	11	14	0	0	17
195	204710378	6	5	0	1	0	0	6	9	0	0	21	4	1	0	7	6	8	7	0	0	22	5	12	4
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209	204710832	5	5	0	6	4	1	5	5	10	40	7	2	2	0	0	0	0	0	0	0	0	0	0	0
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215	204711074	5	4	0	0	0	0	0	4	5	5	6	7	7	6	5	6	5	4	3	4	5	5	5	5
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251	204712702	19	15	12	20	21	15	17	20	17	15	15	15	23	21	26	23	19	23	27	27	25	28	20	22
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254	204712859	−	75	0	0	0	0	−	20	18	8	8	8	5	9	4	6	7	5	0	9	1	9	8	6

	POC Number	2017/1	2017/2	2017/3	2017/4	2017/5	2017/6	2017/7	2017/8	2017/9	2017/10	2017/11	2017/12	2018/1	2018/2	2018/3	2018/4	2018/5	2018/6	2018/7	2018/8	2018/9	2018/10	2018/11	2018/12
255	204712880	14	9	7	10	13	10	10	15	12	0	0	33	13	0	19	10	10	0	0	39	16	9	0	23
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269	204713894	2	10	10	10	10	10	10	10	4	5	0	16	5	5	0	15	0	13	10	9	10	5	5	0
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291	204715210	5	5	3	4	7	6	6	8	6	4	4	6	4	5	3	6	2	5	7	7	6	5	5	5
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308	204716375	8	3	1	0	6	2	2	4	3	4	1	4	7	7	8	9	5	9	7	8	8	8	8	9
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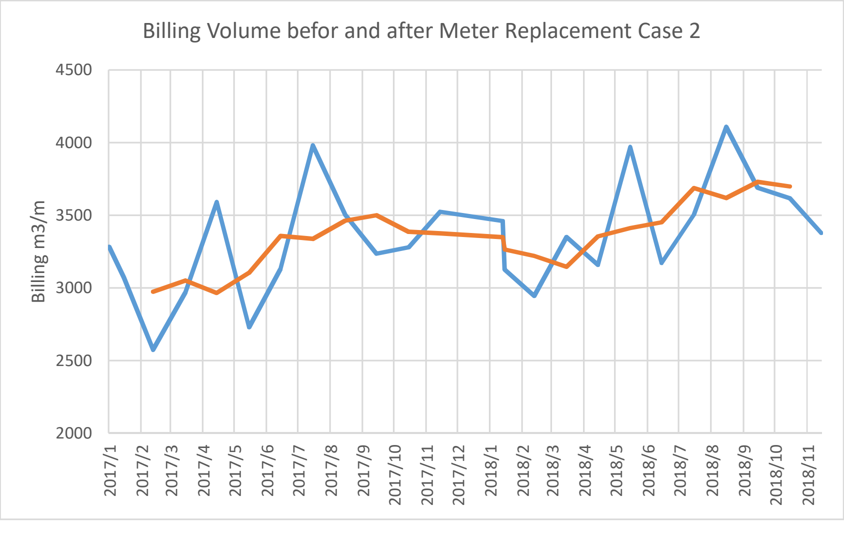
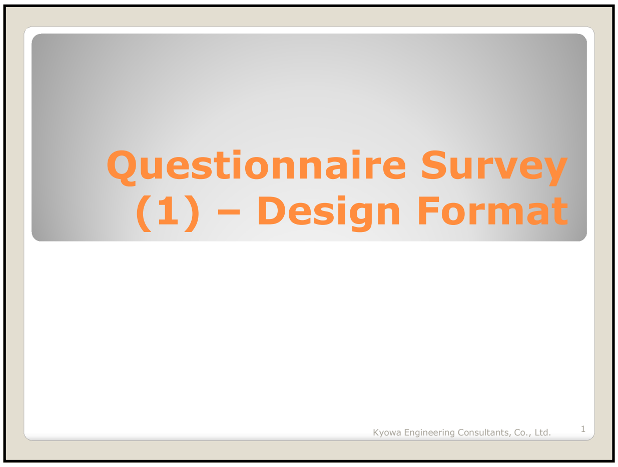
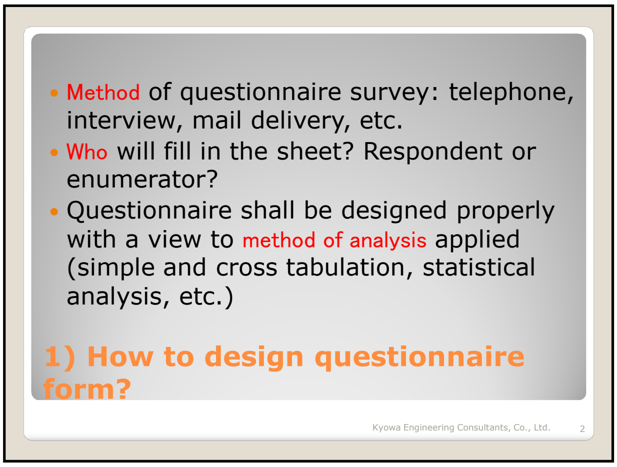
	Total	3282	3070	2574	2969	3590	2729	3129	3980	3505	3236	3279	3525	3461	3125	2945	3350	3159	3968	3171	3504	4108	3689	3616	3379
	4 Month Average			2974	3051	2966	3104	3357	3336	3463	3500	3386	3375	3348	3264	3220	3145	3356	3412	3451	3688	3618	3729	3698	



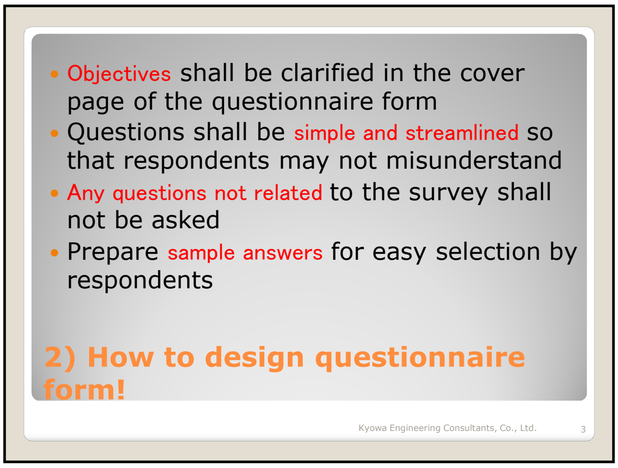


Questionnaire Survey (1) – Design Format



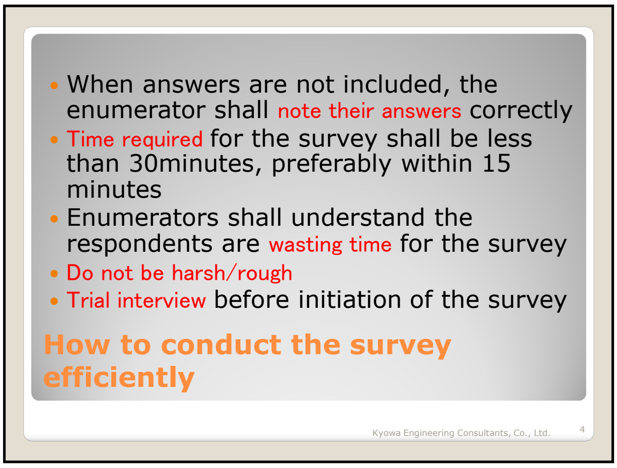
1) How to design questionnaire form?

- Method of questionnaire survey: telephone, interview, mail delivery, etc.
- Who will fill in the sheet? Respondent or enumerator?
- Questionnaire shall be designed properly with a view to method of analysis applied (simple and cross tabulation, statistical analysis, etc.)



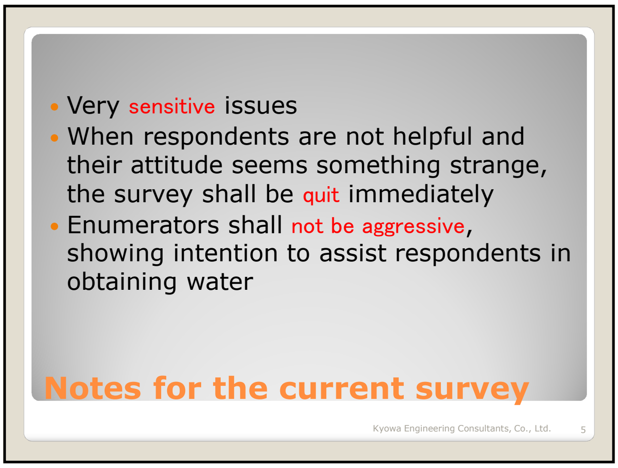
2) How to design questionnaire form!

- Objectives shall be clarified in the cover page of the questionnaire form
- Questions shall be simple and streamlined so that respondents may not misunderstand
- Any questions not related to the survey shall not be asked
- Prepare sample answers for easy selection by respondents



How to conduct the survey efficiently

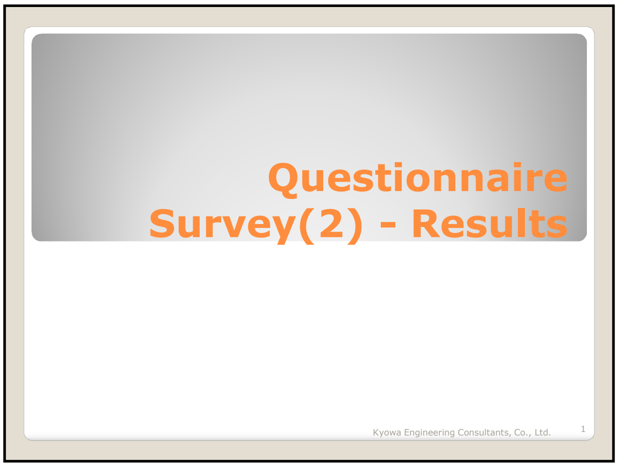
- When answers are not included, the enumerator shall note their answers correctly
- Time required for the survey shall be less than 30minutes, preferably within 15 minutes
- Enumerators shall understand the respondents are wasting time for the survey
- Do not be harsh/rough
- Trial interview before initiation of the survey



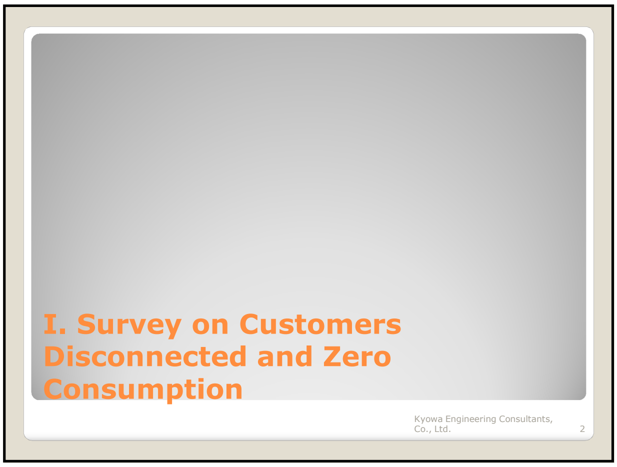
Notes for the current survey

- Very sensitive issues
- When respondents are not helpful and their attitude seems something strange, the survey shall be quit immediately
- Enumerators shall not be aggressive, showing intention to assist respondents in obtaining water

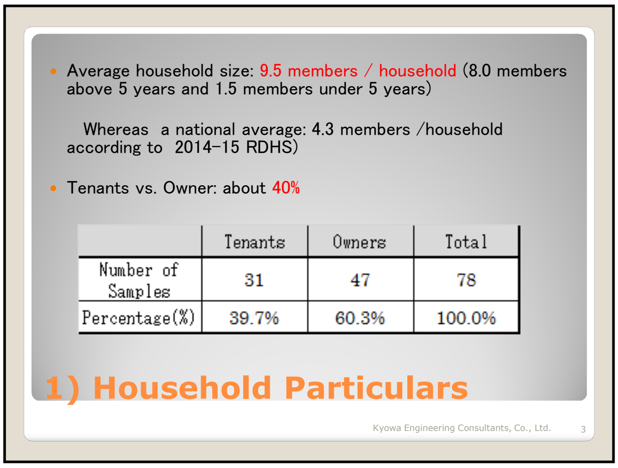
Thanks for Attention



Questionnaire Survey(2) - Results



I. Survey on Customers Disconnected and Zero Consumption



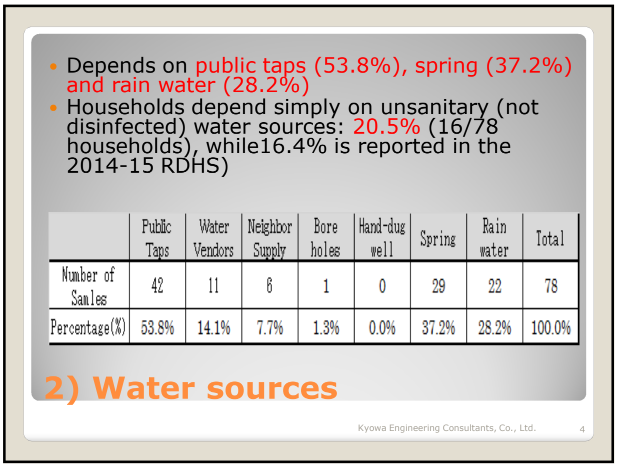
1) Household Particulars

- Average household size: 9.5 members / household (8.0 members above 5 years and 1.5 members under 5 years)

  Whereas a national average: 4.3 members /household according to 2014–15 RDHS)

- Tenants vs. Owner: about 40%

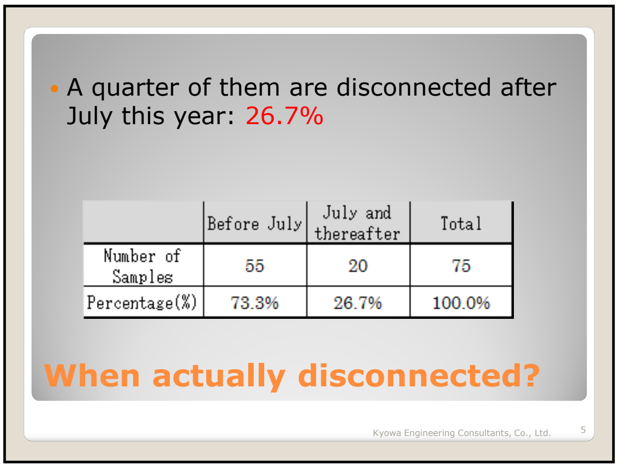
	Tenants	Owners	Total
Number of Samples	31	47	78
Percentage(%)	39.7%	60.3%	100.0%



2) Water sources

- Depends on public taps (53.8%), spring (37.2%) and rain water (28.2%)
- Households depend simply on unsanitary (not disinfected) water sources: 20.5% (16/78 households), while16.4% is reported in the 2014-15 RDHS)

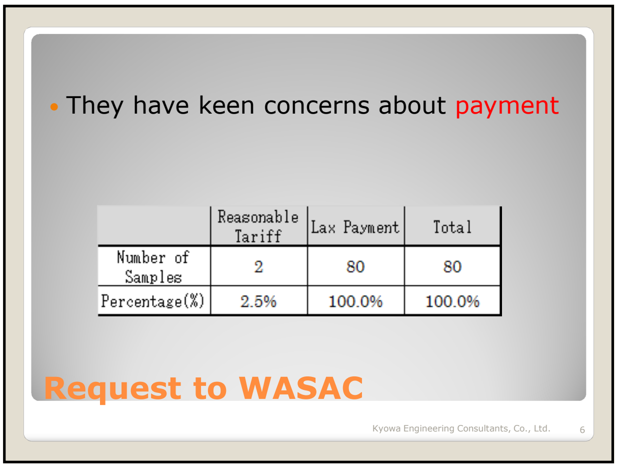
	Public Taps	Water Vendors	Neighbor Supply	Bore holes	Hand-dug well	Spring	Rain water	Total
Number of Sanles	42	11	6	1	0	29	22	78
Percentage(%)	53.8%	14.1%	7.7%	1.3%	0.0%	37.2%	28.2%	100.0%



When actually disconnected?

- A quarter of them are disconnected after July this year: 26.7%

	Before July	July and thereafter	Total
Number of Samples	55	20	75
Percentage(%)	73.3%	26.7%	100.0%



Request to WASAC

- They have keen concerns about payment

	Reasonable Tariff	Lax Payment	Total
Number of Samples	2	80	80
Percentage(%)	2.5%	100.0%	100.0%

II. Survey on Non-served Households

Houseold Particulars

- Household size:4.8 members / household (3.8 members above 5 years and 1.0 member below 5 years) – slightly larger than the national average (4.3 members)
- Unemployment Ratio:35% (14/40samples) – quite high in comparison with the national average (15%)

Water Sources

- Nearly 50% of the households depends on public taps and spring water
- Households depend simply on unsanitary (not disinfected) water sources: 10% (4/40 households), much lower than 20.5% in case of disconnected customers

	Public Taps	Water Vendors	Neighbor Supply	Borehole	Hand-dug well	Spring	Rain Water	Total
Number of Samples	19	5	12	2	0	19	13	40
Percentage (%)	47.5%	12.5%	30.0%	5.0%	0.0%	47.5%	32.5%	100.0%

Request to WASAC

- Majority of the households requests more reasonable tariff
- Some households (12.5%=5/40samples) claims about WASAC response and behavior

	Continuous Supply	Reasonable Tariff	WASAC Behavior	Lax payent
Number of Samples	1	36	5	1
Percentage (%)	2.5%	90.0%	12.5%	2.5%

Thanks for Attention

Water and Sanitation Corporation (WASAC)
Dignifying life!

Questionnaire on Water Use Pattern in Kigali for unserved

Objective: Government policy is to supply safe and clean water to whole Rwandan by the year 2020. The present questionnaire survey, therefore, has been organized by WASAC and JICA (Japan International Cooperation Agency) with an aim to save people who are suffering from sever water shortage by collecting information on their typical water use pattern, complaints and request to WASAC.

Date:	**Enumerator:**	
Sheet Number: Kadobogo-US-	**PM area:**	**Subzone:**
B1: Name of head of household	**:**	**Ownership: 1. Rent, 2. Owner 3. Other**
B2: Household address	**:**	
B3: Respondent	**: Relationship with the head: 1. Self, 2. Spouse, 3. Son, 4. Daughter, 5. Others (__________________)**	
B4: Household occupation	**: 1. Farmer, 2. Commerce, 3. Industry, 4. Service, 5. Tentatively no job**	
B5: Number of household members	**: More than 5 years old (_______________) 5 years old or less (__________________)**	

【Questions】

Q1: Where do you get water?

1. Regional supply, 2. Public taps, 3. Neighbor supply, 4. Water vendor,
5. Borehole, 6. Handdug well, 7 Mineral water, 8. River water,
9. Spring, 10. Rain water, 11. Other water sources (______________________)

Q2: How often do you fetch water from your water source?

1. Less than once a day, 2. Once-Twice a day, 3. Three times or more in a day

Q3: How much Fran do you pay for water in a day?

1. Less than 50 RWF a day, 2. 50-100 RWF a day, 3. 100-200 RWF a day,
4. More than 200 RWF a day in average (_________________RWF a day)

Q4: Which aspect do you request most to WASAC to be improved?

1. Continuous water supply, 2. More reasonable water tariff,
3. Safe and clean water, 4. High quality connection/meters
5. Attitude of WASAC officers, 6. Lax payment method,
8. Others, if any (_____________________________)

Q6: If answered 'No' above, what is a reason why you answered 'No'?

1. I have the other stable and safe water source, 2. I'm not able to pay for water,
3. I have tentatively no job although I want, 4. Others
(_______________________________)

<Onsite water quality test by Enumerator>
Residual chlorine (__________) mg/l, Electricial conductivity (____________)

<Comment/impression by Enumerator>

Water and Sanitation Corporation (WASAC)
Dignifying life!

Questionnaire on Water Use Pattern in Kigali (ZD) for disconnected

Objective: Government policy is to supply safe and clean water to whole Rwandan by the year 2020. The present questionnaire survey, therefore, has been organized by WASAC and JICA (Japan International Cooperation Agency) with an aim to save people who are suffering from sever water shortage by collecting information on their typical water use pattern, complaints and request to WASAC.

Date:	**Enumerator:**	
Sheet Number: Kadobogo-ZD-	**PM:**	**User category:**
B1: Name of registered household	**:**	
B2: Household address	**:**	
B3: Ownership:	**: 1. Rent, 2. Owner, 3. Other**	
B4: Respondent	**: Relationship with registered household: 1. Self, 2. Spouse, 3. Son, 4. Daughter, 5. Others (_____________________)**	
B5: Number of household members	**: More than 5 years old (______________) 5 years old or less (_________________)**	
B6: POC number	**:**	**: 1. Confirmed on POC map, 2. Not confirmed**
<Enumerator shall check service connections whether they are in use or not.>		
B6: Connection status	**: 1. Already disconnected at 1-1. Inlet pipes underground, 1-2. Inlet pipes above ground, 1-3. before Meter, by installing (cap, valves, blind flange, others) 2. Not disconnected**	
B7: Type of connection	**: 1. Normal conncection, 2. Yard connection, 3. Others**	
<If not disconnected, Enumerator shall check meter conditions>		
B8: Meter Status	**:1. Working normally, 2. Not working because of: 2-1. Blocked, 2-2. Not readable, 2-3: Others**	

B9: Meter Diameter	:
B10: Meter Serial Number	:

【Questions】

Q1: When WASAC services stopped or disconnected?

1. July 2017, 2. August 2017, 3. September 2017, 4. October 2017,
5. Month____, Year______, before July 2017

Q2: After stoppage of water supply, how do you get water?

1. Regional supply, 2. Public taps, 3. Neighbor supply, 4. Water vendor,
5. Borehole, 6. Handdug well, 7 Mineral water, 8. River water,
9. Spring, 10. Rain water, 11. Other water sources (______________________)

Q3: Which aspects do you want WASAC to be improved further?

1. Continuous water supply, 2. More reasonable water tariff,
3. Safe and clean water, 4. High quality connection/meters
5. Attitude of WASAC officers, 6. Lax payment method,
8. Others, if any (________________________________)

Q5: If the above were improved, do you want to be a customer of WASAC?
1. Yes, 2. No

Q6: If answered 'No' above, what is a reason why you answered 'No'?

1. I have the other stable and safe water source, 2. I'm not able to pay for water,
3. I have tentatively no job, 4. Others (_________________________________)

<Onsite water quality test by Enumerator>
Residual chlorine (__________) mg/l, Electrical conductivity (____________)

<Comment/impression by Enumerator>

Water and Sanitation Corporation (WASAC)
Dignifying life!

Questionnaire on Water Use Pattern in Kigali (US)

Objective: Government policy is to supply safe and clean water to whole Rwandan by the year 2020. The present questionnaire survey, therefore, has been organized by WASAC and JICA (Japan International Cooperation Agency) with an aim to save people who are suffering from sever water shortage by collecting information on their typical water use pattern, complaints and request to WASAC.

Date:	**Enumerator:**	
Numero yurupapuro: Kadobogo-US-	**Indango ya PM:**	**Subzone:**
B1:Amazina rya nyirurugo	**:**	**Inzu niye?: 1. Arakodesha, 2. Nyirinzu, 3. Ibindi**
B2: Aho iherereye	**:**	
B3: Ubazwa	**: Isano afitanye na nyirurugo.** **1. Nyirurugo, 2. Umudamu we, 3.Umuhungu we,** **4. Daughter Umukobwa we, 5. Ibindi (__________________)**	
B4: Akazi ka Nyirurugo	**: 1. Umuhinzi, 2. Umucuruzi, 3. akora muruganda,** **4. Service akora muri serivisi, 5.Nta kazi agira**	
B5:Umubare wabahatuye	**: Hejuru y'imyaka 5 (_______________)** **Munsi y 'Imyaka itanu (__________________)**	

【Questions】

Q1: Nihe ukura amazi?

1. Amazi akwirakwiza mu karere, 2. Akazu k'amazi, 3. Kumuturanyi uyafite,
4. Umuntu uyagurisha, 5. Amazi aturuka mubutaka, 6. Kwivomo ryimpompe,
7. Amazi yasukuwe ninganda, 8. Amazi yumugezi, 9. Amazi yisoko,
10. Amazi y'imvura, 11. Ahandi hantu (______________________)

Q2:Ni kangahe ujya kuvoma?

1. Nta na rimwe, 2. Rimwe cg Kabiri kumunsi, 3. Hejuru ya gatatu kumunsi

Q3:Wishyura angahe kumazi?

1. Munsi ya ma Fr50, 2. Hagati ya ma Fr 50-100, 3. Hagati ya ma Fr 100-200,
4. Hejuru ya ma Fr 200 kumunsi ugereranyije (_________________RWF a day)

Q4:Mumikorere ya WASAC nihe wifuza ko havugururwa?

1. Kutugezaho amazi ahoraho, 2. Igiciro cyigereranyije cy'amazi
3. Amazi meza kandi asukuye, 4. Ibindi niba bihari (
______________________________)

Q5: Ibi tuvuze haruguru bihindutse wakwifuza kuba umufatabuguzi wa WASAC?
1. Yego, 2.Oya

Q6: Niba ari Oya mwatubwira impanvu

1. Fite ahandi nyakura, 2. Sishoboye kuyishyura,
3. Ndayakeneye ariko nta bushobozi, 4. Ibindi (______________________________)

< Igenzurwa ryumwimerere wamazi nubaza
Residual chlorine (__________) mg/l, Electricial conductivity (____________)

<Ubusesenguzi bwubaza>

Water and Sanitation Corporation (WASAC)
Dignifying life!

Questionnaire on Water Use Pattern in Kigali (ZD)

Objective: Government policy is to supply safe and clean water to whole Rwandan by the year 2020. The present questionnaire survey, therefore, has been organized by WASAC and JICA (Japan International Cooperation Agency) with an aim to save people who are suffering from sever water shortage by collecting information on their typical water use pattern, complaints and request to WASAC.

Date:	**Enumerator:**	
Numero yurupapuro : Kadobogo-ZD-	**PM:**	**User category:**
B1 Amazina ya nyirurugo	**:**	
B2: Aderesi y'urugo	**:**	
B3: Inzu niye:	**: 1. Arakodesha, 2. Nyirinzu, 3. Other Ikindi**	
B4:Ubazwa	**: Isano afitanye na Nyirurugo: 1. Nyirurugo, 2. Umufasha, 3. Umuhungu we, 4. Umukobwa we, 5. bindi (______________________)**	
B5: Umubare wabahatuye	**: Hejuru y'imyaka 5 (_______________) Munsi y'imyaka 5 (___________________)**	
B6: Numero yifatabuguzi	**:**	**: 1. Yemejwe kwikarita 2. Ntiyemejwe**
<Ubaza areba ko zikoreshwa cg zidakoreshwa.>		
B7: Connection status	**: 1. Yarakupiwe kuri 1-1. , itiyo ivana amazi mubutaka, 1-2. ituyo iri hejuru yubutaka , 1-3. imbere ya mubazi (cap, valves, blind flange, ibindi) 2. ntabwo yakupiwe**	
B8: Type of connection	**: 1. Amazi agera munzu, 2. Amazi agarukira hanze, 3. Ibindi**	
<If not disconnected, Enumerator shall check meter conditions>		

B9: Uko Mubazi ihagaze	:1. Irakora neza, 2. Ntikora kubera: 2-1. Yarangiritse, 2-2. Ntisomeka, 2-3: Ibindi
B10: Ingano ya mubazi	:
B11: Numero iranga mubazi	:

【Questions】

Q1: Ni ryari WASAC yabafungiye?

1. Nyakanga 2017, 2. Kanama 2017, 3. Nzeri 2017, 4. Ukwakira 2017,
5. Ukwezi____, Umwaka______, mbere ya Nyakanga July 2017

Q2: Nyuma yo kugufungira ni hehe ukura amazi?

1. Amazi yakarere 2. Akazu kamazi, 3.k'Umuturanyi uyafite , 4. Umuntu uyagurisha,
5. Amazi aturuka mubutaka, 6. Amazi ya pompage, 7 Amazi yasukuwe n'inganda,
8.Amazi y'umugezi, 9. Amazi y'isoko, 10. Amazi y'imvura, 11. Ahandi (
______________________)

Q3: Nihe mwasaba WASAC kurushaho kunoza imokorere yayo?

1. Kutugezaho amazi ahoraho, 2. Igiciro cyumvikana cy'amazi,
3. Amazi yizewe asukuwe, 4. High quality connection/meters
5. Uko abakozi bitwara, 6. Lax payment method,
7. Ibindi niba bihari (_________________________________)

Q4: Ibi tuvuze haruguru bihindutse wakwifuza kuba umufatabuguzi wa WASAC?
1. Yego, 2. Oya

Q5: Niba ari oya mwatubwira impamvu

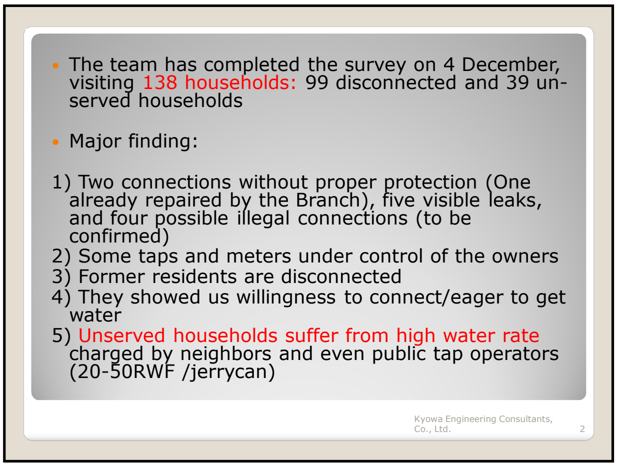
1. Fite ahandi nyakura, 2. Sishoboye kuyishyura,
3. Ndayakeneye ariko nta bushobozi, 4.Ibindi (__________________________________)

<Igenzurwa ryumwimerere wamazi rikorwa nubaza>
Residual chlorine (___________) mg/l, Electrical conductivity (_____________)

<ubugenzuzi bw ubaza>

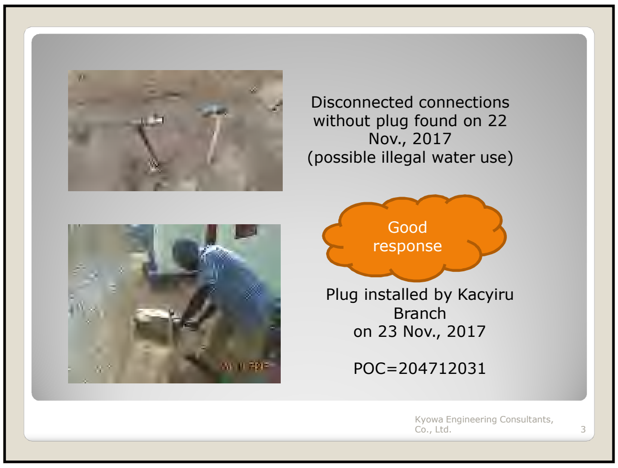
未給水者・給水停止者水利用状況調査の概要

11月30日



- The team has completed the survey on 4 December, visiting 138 households: 99 disconnected and 39 un-served households
- Major finding:

1) Two connections without proper protection (One already repaired by the Branch), five visible leaks, and four possible illegal connections (to be confirmed)
2) Some taps and meters under control of the owners
3) Former residents are disconnected
4) They showed us willingness to connect/eager to get water
5) Unserved households suffer from high water rate charged by neighbors and even public tap operators (20-50RWF /jerrycan)

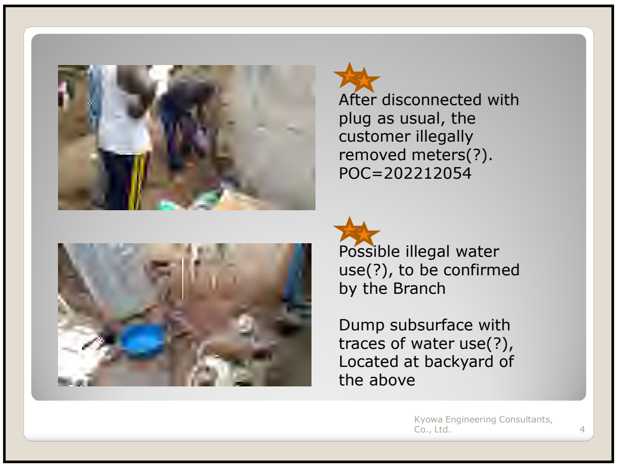


Disconnected connections without plug found on 22 Nov., 2017 (possible illegal water use)

Good response

Plug installed by Kacyiru Branch on 23 Nov., 2017

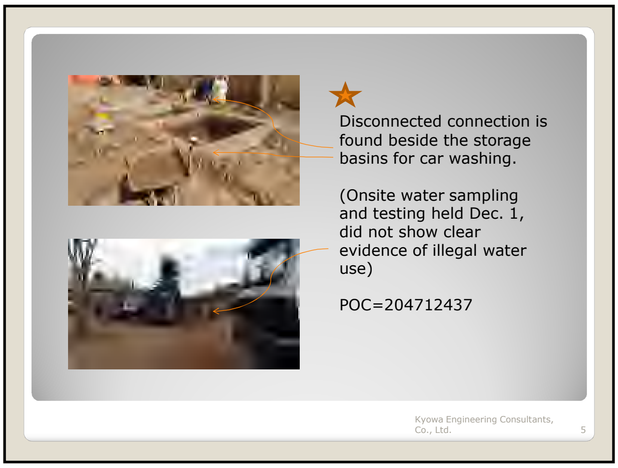
POC=204712031



After disconnected with plug as usual, the customer illegally removed meters(?). POC=202212054

Possible illegal water use(?), to be confirmed by the Branch

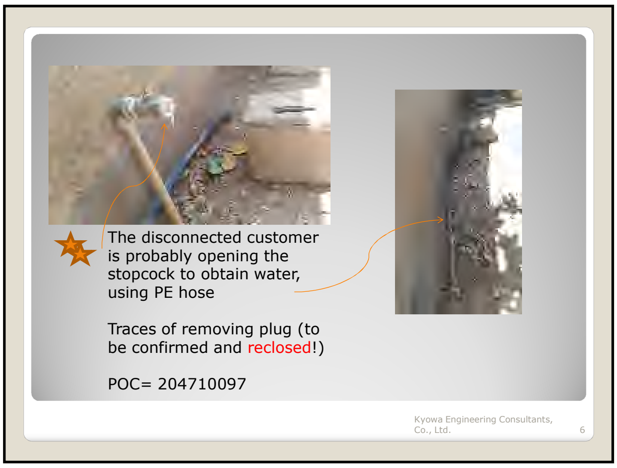
Dump subsurface with traces of water use(?), Located at backyard of the above



Disconnected connection is found beside the storage basins for car washing.

(Onsite water sampling and testing held Dec. 1, did not show clear evidence of illegal water use)

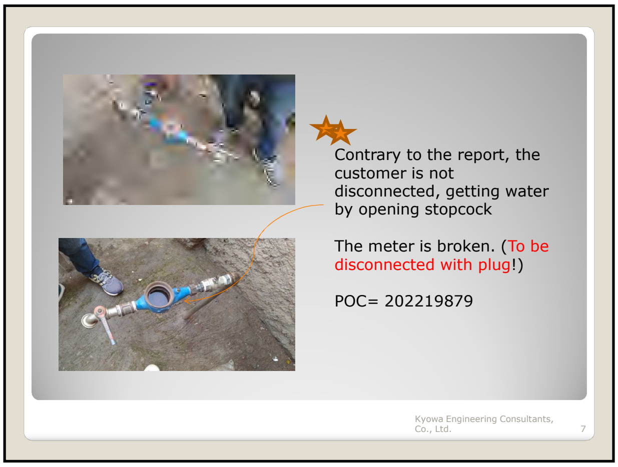
POC=204712437



The disconnected customer is probably opening the stopcock to obtain water, using PE hose

Traces of removing plug (to be confirmed and reclosed!)

POC= 204710097



Contrary to the report, the customer is not disconnected, getting water by opening stopcock

The meter is broken. (To be disconnected with plug!)

POC= 202219879

Disconnected connection after meter (usually observed)

Disconnected connection before meter (the meter owned by the Branch)

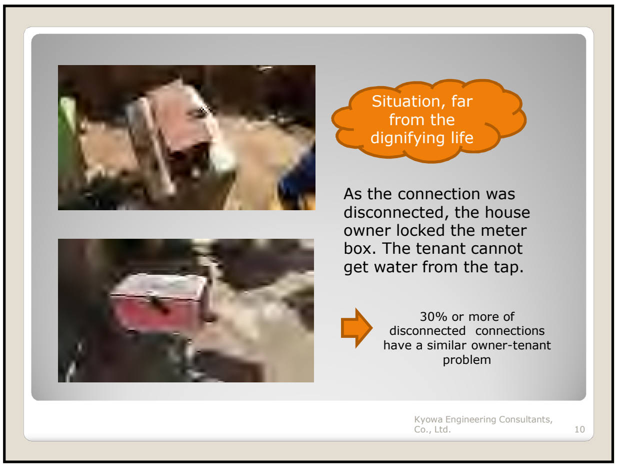
Disconnected connection before meter (the meter owned by the customer)

What are the disconnection criteria?

As the connection was disconnected, the tenant (the renter) depends on the owner's tap, and have never been opened again

Restricted water use

Disconnected in August 2017, where the new tenant (renter) started living from September and could not get water from the tap



Situation, far from the dignifying life

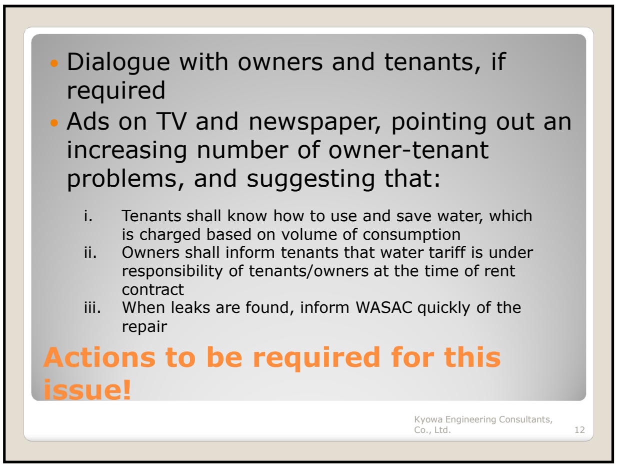
As the connection was disconnected, the house owner locked the meter box. The tenant cannot get water from the tap.

30% or more of disconnected connections have a similar owner-tenant problem

Recently disconnected customer. New tenant cannot get water, as owner locked the meter box. (many owner- tenant problems are observed in the area)

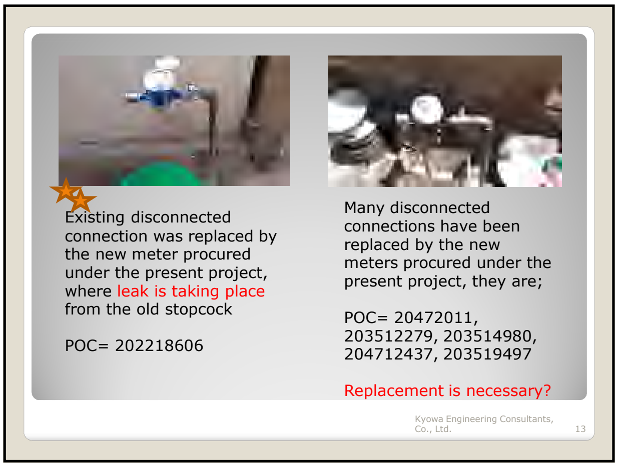
As the former resident was disconnected, new resident has branched before meter. The old meter left there is not in use.
(Is it a proper procedure? How to reduce arrears?)

POC= 204714206



- Dialogue with owners and tenants, if required
- Ads on TV and newspaper, pointing out an increasing number of owner-tenant problems, and suggesting that:
  - i. Tenants shall know how to use and save water, which is charged based on volume of consumption
  - ii. Owners shall inform tenants that water tariff is under responsibility of tenants/owners at the time of rent contract
  - iii. When leaks are found, inform WASAC quickly of the repair

Actions to be required for this issue!



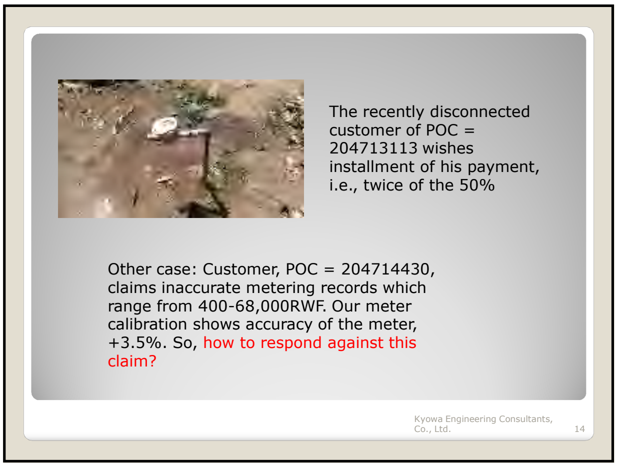
Existing disconnected connection was replaced by the new meter procured under the present project, where leak is taking place from the old stopcock

POC= 202218606

Many disconnected connections have been replaced by the new meters procured under the present project, they are;

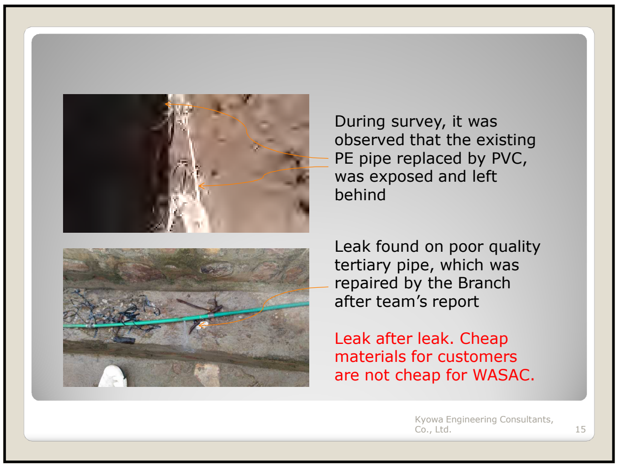
POC= 20472011, 203512279, 203514980, 204712437, 203519497

Replacement is necessary?



The recently disconnected customer of POC = 204713113 wishes installment of his payment, i.e., twice of the 50%

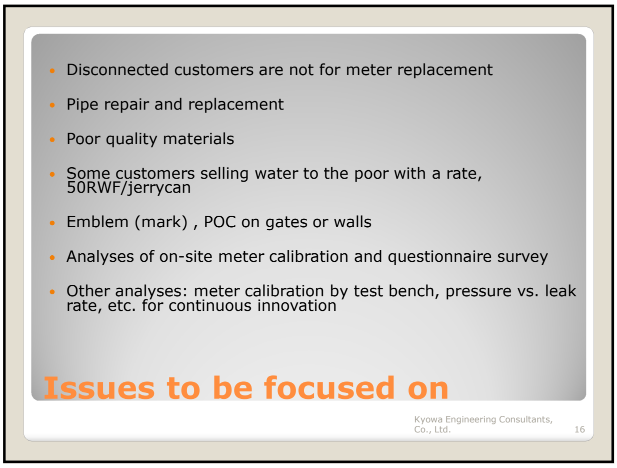
Other case: Customer, POC = 204714430, claims inaccurate metering records which range from 400-68,000RWF. Our meter calibration shows accuracy of the meter, +3.5%. So, how to respond against this claim?



During survey, it was observed that the existing PE pipe replaced by PVC, was exposed and left behind

Leak found on poor quality tertiary pipe, which was repaired by the Branch after team's report

Leak after leak. Cheap materials for customers are not cheap for WASAC.



- Disconnected customers are not for meter replacement
- Pipe repair and replacement
- Poor quality materials
- Some customers selling water to the poor with a rate, 50RWF/jerrycan
- Emblem (mark) , POC on gates or walls
- Analyses of on-site meter calibration and questionnaire survey
- Other analyses: meter calibration by test bench, pressure vs. leak rate, etc. for continuous innovation

Issues to be focused on

Questionnaire on Water Use Pattern In Kigali, Kadobogo Pilot Area

Presented by NSENGIMANA Anicet
JICA Coordinator

Divided in two Categories:

A. Disconnected People and Zero Consumption (86 samples)

B. No served - non Supply customer (40 samples)

A. Disconnected and zero consumption Format composed by following information;

- Address of customer(Name, POC, PM number..)
- User category
- Householder information(Family member)
- Connection status
- Type of connection
- Meter Condition
- When actually Disconnected?
- Source of Water after Disconnected
- Request to WASAC

A. Disconnected and zero consumption

A.I Subdivision of sample according to the PM

PM number	PM1	PM2	PM3	Total
Number of household visited	33	9	44	86
Total No. of Disconnected house(Nov)	104	9	64	177
Percentage of Sample	31.7	100	66.66	48.58

A.II Household

- ❖ Average householder size from this interview shows: 9.5 members / household whereas a national statistics said: 4.3 members / household according to 2014-15 RDHS
- ➢ Disconnected house needs more water than house of national average.

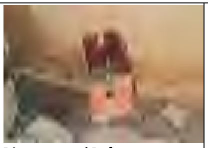
- ❖ To those all household visited Tenants occupied 40% and Owner 60%
- ➢ Number of owner is bigger than tenants. So Owner must be discuss with tenants before contract regarding water payment.

A.III Connection status

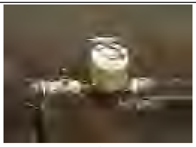
	With cap after meter	With cap before meter	Disconnected without cap	Pipe supply stolen	Total
Number of samples	74	7	4	1	86
Percentage (%)	86.05	8.14	4.65	1.16	100

- ➢ It's better to disconnected with cap after meter according to the questionnaire, most of customer want to connect again with WASAC water when the financial situation become better. On the other hand if customer stolen water by illegal connection many times, WASAC have to remove all pipeline immediately.

A.III Connection status Pictures



Disconnected Before meter



Disconnected after meter

A.IV Type of connection

- ❖ In all houses visited the yard connection covered 91.86% while inside connection is 8.14%
- ➢ Sometimes WASAC meter reader Not access to the water meter location easily due to the gate closed. So WASAC can establish the water meter installation standard to the customers.

A.V Meter size

	3/4'' Meter size	1'' Meter size	Total
Number of Samples	82	4	86
Percentage of sample (%)	95.35	4.65	100
Percentage in Kadobogo (%)	99.994	0.0056	100

- ➢ Almost disconnected user are belong to ¾'' meter size (domestic category) that is same percentage as Kadobogo area.

A.VI Meter status

	Meter working well	Defected Meter	Unreadable	Meter stolen	Meter removed by Kacyiru branch	Total
Number of sample	63	9	2	1	4	79
Percentage (%)	79.75	11.39	2.53	1.27	5.06	100

- ➢ Defected meter is 11.39% and unreadable is 2.53%, In order to prevent the disconnection customers due to the water meter malfunction, meter reader should report those situation to the WASAC quickly and WASAC replace the defected meter quickly as well.

A.VII When actually Disconnected

	Before 2017	2017 Before July	After July 2017	Total
Number of Samples	36	20	20	76
Percentage(%)	47.37	26.32	26.32	100

- ➢ A half of disconnection customers never access the WASAC water more than one year, in order to keep public health , WASAC keep in touch with customer after disconnected.

A. VIII Source of water after disconnected

	Public Taps	Water vendor	Neighbor Supply	Bore hole	Hand-dug	Spring	Rain Water	Total
Number of Samples	44	7	4	0	0	18	5	78
Percentage(%)	56.41	8.97	5.13	0.00	0.00	23.08	6.41	100

- ❖ Depends on public taps (56.41%), spring (23.08%) and rain water (6.41%)
- ➢ Households depend simply on unsafe (not disinfected) water sources: 29.49% (23/78 households), while16.4% is reported in the 2014-15 RDHS)

A. IX What Disconnected People Request to WASAC

	Reasonable tariff	Payment by installment	Total
Number of Samples	2	80	82
Percentage(%)	2.44	97.56	100

- ➢ All customers accept to Pay but 97.56% of disconnection customer want to pay by installment in 2 or 3times. WASAC have to consider to pay by installment.

B. No served (non Supply customer) Format composed by following information;

- Address of customer(Name, POC, PM number..)
- Sub zone
- Householder information(Family member)
- Occupation
- Source of Water after
- Amount using to buy water per day
- Request to WASAC
- Would you like to become WASAC’s customer?

B. No served (non Supply customer)

B. I Non supply Visited according to PM

	PM1	PM2	PM3	Total
Number of Samples	14	6	20	40

- ➢ The big number of non supply households are in PM1 and PM3, because those PM located in high slope which facilitate the low income people to live there, also are closely with spring easy to get spring water simply other things is that the installment of pipeline in high slope area is expensive.

B. II Householder

- ❖ Household size:4.8 members / household – slightly larger than the national average 4.3 members/ household.
- ❖ Tenants on those household members occupied 57.5% of total number of non supply household.

B. III Occupation

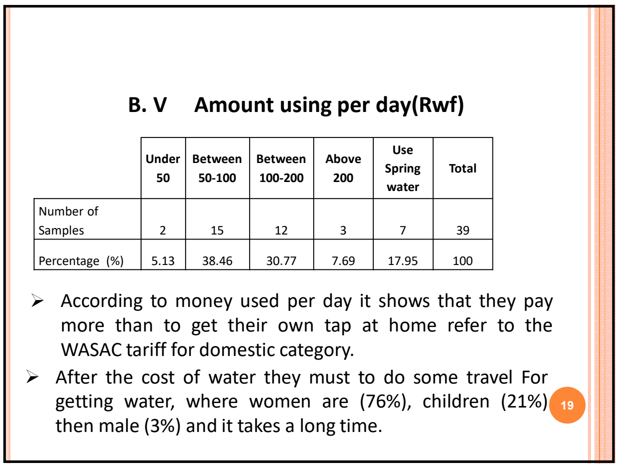
	Business	Cultivator	Industry	No job	Service	Total
Samples	9	6	8	14	3	40
Percentage (%)	22.5	15	20	35	7.5	100

- ❖ Unemployment Ratio:35% (14/40samples) – quite high in comparison with the national average (15%)
- ➢ For low income people can not access to clean and safe water.

B. IV Source of Water

	Public Taps	Water vendors	Neighbor Supply	Bore hole	Hand-dug	Spring	Rain Water	Total
Number of Samples	15	6	7	0	0	8	4	40
Percentage(%)	37.5	15	17.5	0.00	0.00	20	10	100

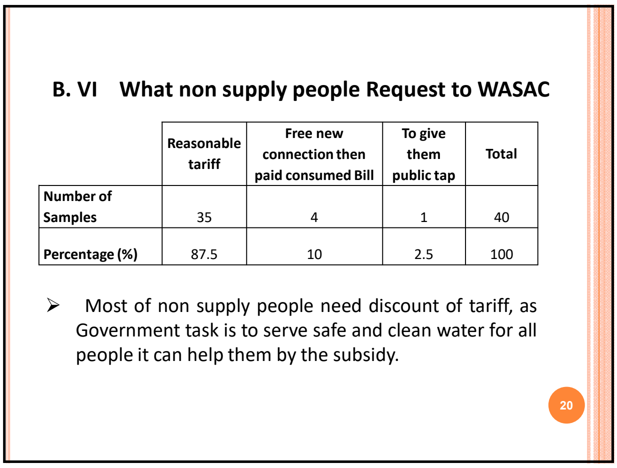
- ❖ The high percentage of the households depends on public taps and spring water
- ➢ Households depend simply on unsanitary (not disinfected) water sources: 30% (12/40 households), greater than 23.08% in case of disconnected customers.



B. V Amount using per day(Rwf)

	Under 50	Between 50-100	Between 100-200	Above 200	Use Spring water	Total
Number of Samples	2	15	12	3	7	39
Percentage (%)	5.13	38.46	30.77	7.69	17.95	100

- According to money used per day it shows that they pay more than to get their own tap at home refer to the WASAC tariff for domestic category.
- After the cost of water they must to do some travel For getting water, where women are (76%), children (21%) then male (3%) and it takes a long time.



B. VI What non supply people Request to WASAC

	Reasonable tariff	Free new connection then paid consumed Bill	To give them public tap	Total
Number of Samples	35	4	1	40
Percentage (%)	87.5	10	2.5	100

- Most of non supply people need discount of tariff, as Government task is to serve safe and clean water for all people it can help them by the subsidy.

THANK YOU!

Question and Request

To Kacyiru Branch, 23 March, 2018

New Customers

- R1: List of New customers up to March 2018
- Q1: Which POCs are in Kadobogo?

Month	New customer	In Kadobogo
Jun-17	172	11
Jul-17	0	-
Aug-17	92	12
Sep-17	80	4
Oct-17	14	0
Nov-17	107	0
Dec-17	99	0

Meter Replacement

- Q2: How many meters have been replaced so far? 252 meters up to Feb-2018?
- From inconsistent records – 219 meters are found already replaced after September
- Q3: Why normal meters (less than 5% error) have been replaced? Whereas, 15 out of 39 meters due to our fault.


Meter Replacement in Kadobogo

Billing after Meter Replacement

- Q4: After meter replacement, Pread starts from zero?
- Q5: If not, what cases are expected?
- Q6: How to bill the water, consumed before meter replacement?

Table – Reading at POCs after Meter replacement

POC	Cread January	Pread February	Cread February
202215719	1243	0	7
202215998	12792	0	118
202216942	1062	0	9
202217058	284	0	0
202217059	655	0	0
202217291	660	0	3
202218677	721	0	9

POC	Cread January	Pread February	Cread February
204710426	847	829	850
204711062	862	814	831
204714565	207	46	71
203511092	1311	42	61
203511480	711	36	51
203511096	752	33	33
202219003	1231	31	48
202216781	930	26	35
202213648	1131	25	36

Note: 12, out of 93 meters replaced in February do not start from zero.

Reading and Recording

- R2: Accurate data on meter replacement
- "1" in the table, means inconsistency when Cread in previous month is not same to Pread in current month
- Q7: what is taking place, when this situation occurs twice in one year? – seven customers found in Kadobogo,

  204714016 204711056
  204710255 203519624
  203514534 202219300
  202211347

POC	July	August	September	October	November	December	January	February
202210063	–	–	–	–	–	–	–	–
202210743	0	0	0	0	0	0	1	0
202211265	0	0	0	0	0	0	0	0
202211266	0	0	0	0	0	0	0	0
202211268	0	0	0	0	0	0	0	0
202211271	0	0	0	0	0	0	0	0
202211272	0	0	0	0	0	0	0	0
202211274	0	0	0	0	1	0	0	0
202211275	0	0	0	0	0	0	0	0
202211347	0	0	1	0	0	1	0	0
202211411	0	0	0	0	0	1	0	0
202211798	0	0	0	0	0	0	0	0
202212054	0	0	0	0	0	0	0	0
202212526	0	0	0	0	0	0	0	0
202212554	0	0	0	0	0	0	0	0
202213041	0	0	0	0	0	0	0	0

Disconnected Customers

- Q8: Disconnected customers: 183 customers have been disconnected up to December 2017 (?) and when? How many disconnected customer are there in Kadobogo as of March 2018?

POC	201706	201707	201708	201709	201710	201711	201712
204716919	64548.91	19172.58	118	118	118	118	118
Billed water	74	39	0	0	0	0	0
203582393	76157.69	83799.87	118	118	118	118	118
Billed water	199	219	0	0	0	0	0

- R3: A list of disconnected customers (monthly)
- R4: A list of deregistered (closed) customers, if any

Leak Repair

- List of Leak Repair Provided by the Branch

September	Pipes repaired	Y cordinate	X cordinate	PM
01/09/2017	2.Kagugu dn 25 hdpe	-1.912828	30.086526	PM3?
06/09/2017	6. Kiyovu kagugu dn 25 hdpe	-1.91485	30.082245	PM3
06/09/2017	9.Kabuhunde dn 90 pvc	-1.917285	30.08185	PM2
08/09/2017	5.Kagugu MT meru dn 50	-1.912687	30.083532	PM2?
09/09/2017	3.Kagugu kadobogo DN63	-1.915487	30.080199	PM2
13/09/2017	5. Kiyovu dn 25 hdpe	-1.914206	30.078398	PM1
14/09/2017	1.kagugu mt meru dn 50 hdpe	-1.91261	30.083078	PM2?
14/09/2017	4. Kagugu dn 25 hdpe	-1.912737	30.086097	PM3
15/09/2017	5.M T meru dn 50 pvc	-1.912371	30.082721	PM1
17/09/2017	1.kagugu dn 40 hdpe	-1.916973	30.078179	PM2?
21/09/2017	1.kagugu mt meru dn 50 hdpe	-1.912796	30.083612	PM2?
23/09/2017	3.kagugu dn 90 pvc	-1.915293	30.086643	PM3
25/09/2017	1. Kagugu mt meru dn 50 hdpe	-1.912488	30.082819	PM2?
28/09/2017	4. Kagugu dn 25 hdpe	-1.915088	30.083178	PM3

- R5: Any information about leakage rate (large or small)?

Thanks for attention

Sample Customer Data Processing by Excel Spreadsheet

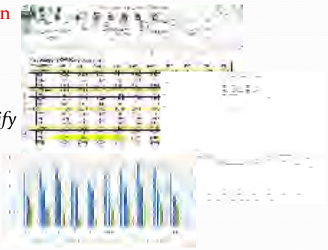
From the standpoints of water consumption, meter calibration, replacement, connection status, billing, etc.

Monthly water consumption

- Monthly water consumption: *monthly fluctuation*
- Zero consumption : *possible illegal use*
- More than 100 m3/month: *big customers*
- Graph: *fluctuation*
- POC not seen in National Customer Database: *terminated or not*

Unit consumption and NRW

- Total consumption by zone:
- Average water consumption by zone/connection: *to compare in terms of user category*
- Input volume by zone/connection: *to identify extreme cases*
- NRW by zone: *to identify zones*
- NRW rate by zone : *to identify zones*



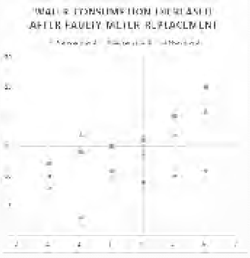
Meter replacement (1)

- List of replaced meters: *1) Cread and Pread, 2) simple input error, 3) normal meters replaced, 4) POC of assumed consumption*
- Month of replacement: *1) Month, 2) meters to be replaced*

Meter replacement (2)

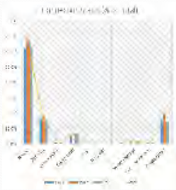
- Water consumption before and after: *1) contribution to water consumption, 2) trend of water consumption*

POC	No	Previous month	Current month	Next month
202216584	5	10	20	17
203511534	2	3	14	17
203512623	4	9	16	14
202211274	1	10	12	8
204712515	6	11	25	21
203514534	3	11	15	11
	Average	54	102	88
	Ave Increase Rate	1.76		
	Ave Water Consump	357	L/day/connection	

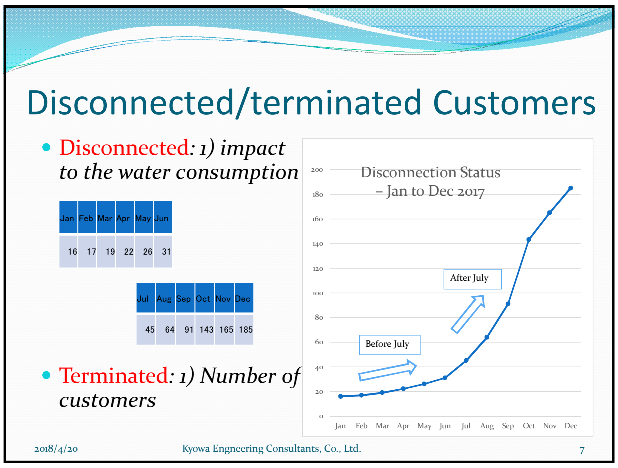


On-site meter calibration

- Observation: *1) number of faulty meters, 2) faulty meters vs. meter brand, 3) faulty meters vs. year of installation*
- Meter error: *1) more than 5%, 2) less than -5%*



	Normal	Error>5%	Meter blocked	Faulty meter	Illegal	No meter	Leak	Water shortage	Stop valve blocked	Disconnected
PM1	428	117	9	40	3	2	2	13	1	107
PM2	34	9	0	0	0	0	0	0	0	10
PM3	319	80	3	35	2	0	1	10	6	71
Total	781	206	12	75	5	2	3	23	7	188



Disconnected/terminated Customers

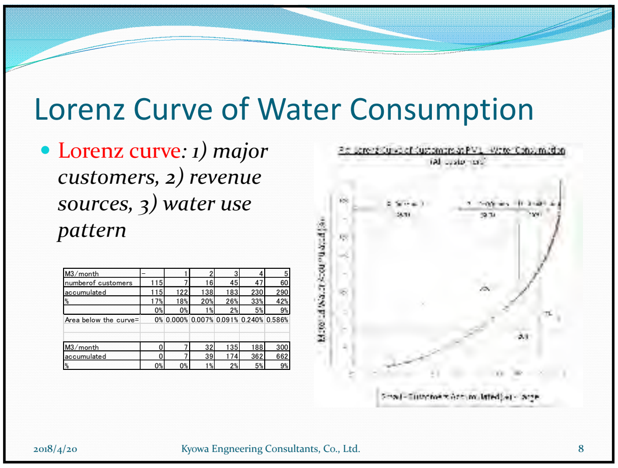
- Disconnected: *1) impact to the water consumption*

Jan	Feb	Mar	Apr	May	Jun
16	17	19	22	26	31

Jul	Aug	Sep	Oct	Nov	Dec
45	64	91	143	165	185

- Terminated: *1) Number of customers*

Disconnection Status – Jan to Dec 2017

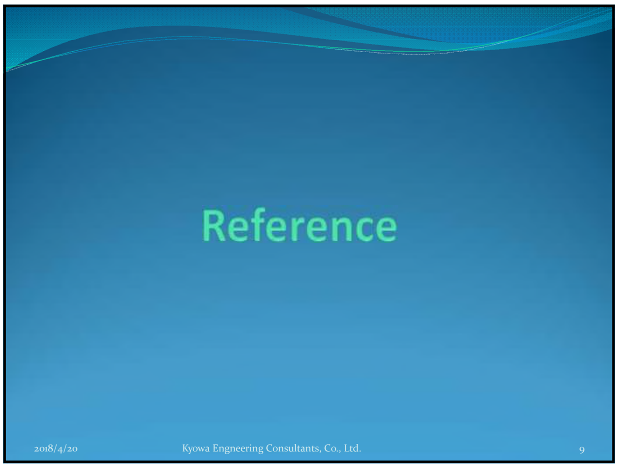


Lorenz Curve of Water Consumption

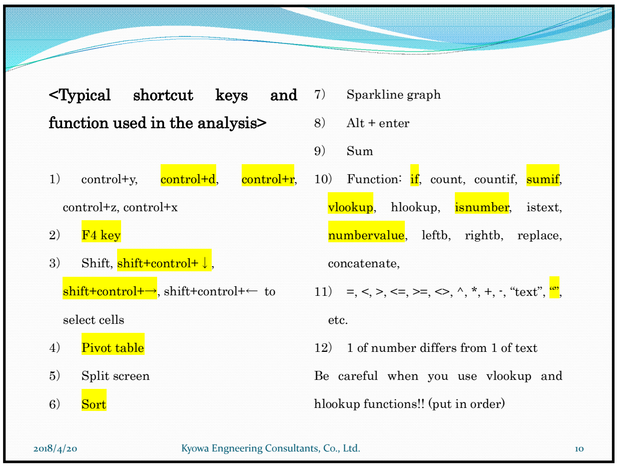
- Lorenz curve: *1) major customers, 2) revenue sources, 3) water use pattern*

M3/month	-	1	2	3	4	5
numberof customers	115	7	16	45	47	60
accumulated	115	122	138	183	230	290
%	17%	18%	20%	26%	33%	42%
	0%	0%	1%	2%	5%	9%
Area below the curve=	0%	0.000%	0.007%	0.091%	0.240%	0.586%

M3/month	0	7	32	135	188	300
accumulated	0	7	39	174	362	662
%	0%	0%	1%	2%	5%	9%



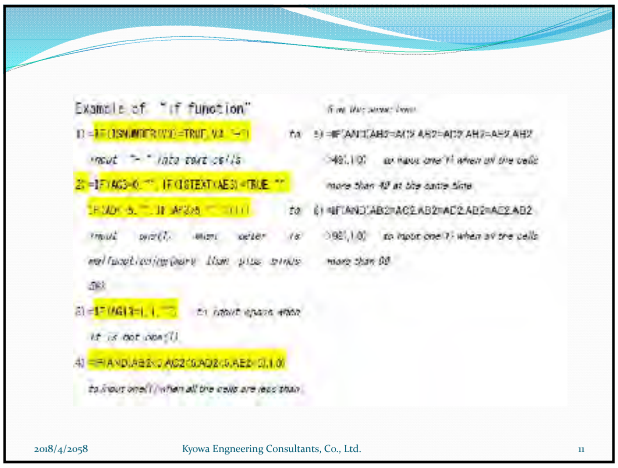
Reference



<Typical shortcut keys and function used in the analysis>

1) control+y, control+d, control+r, control+z, control+x
2) F4 key
3) Shift, shift+control+↓, shift+control+→, shift+control+← to select cells
4) Pivot table
5) Split screen
6) Sort
7) Sparkline graph
8) Alt + enter
9) Sum
10) Function: if, count, countif, sumif, vlookup, hlookup, isnumber, istext, numbervalue, leftb, rightb, replace, concatenate,
11) =, <, >, <=, >=, <>, ^, *, +, -, "text", "", etc.
12) 1 of number differs from 1 of text

Be careful when you use vlookup and hlookup functions!! (put in order)



Example of "if function"

1) =IF(ISNUMBER(V2)=TRUE,V2,"-") to input "-" into text cells

2) =IF(AC3=0,"",IF(ISTEXT(AE3)=TRUE,"",IF(AD3<5,"",IF(AF3>5,"","1")))) to input one(1) when water is not functioning(more than plus minus 5%)

3) =IF(AG13=1,1,"") to input space when it is not one(1)

4) =IF(AND(AB2<5,AC2<5,AD2<5,AE2<5),1,0) to input one(1) when all the cells are less than 5 at the same time

5) =IF(AND(AB2=AC2,AB2=AD2,AB2=AE2,AB2>40),1,0) to input one(1) when all the cells more than 40 at the same time

6) =IF(AND(AB2=AC2,AB2=AD2,AB2=AE2,AB2>90),1,0) to input one(1) when all the cells more than 90

Thanks for attention!

Kyowa Engineering Consultants, Co., Ltd.

TOPIC-H8: PILOT AREA NRW & REDUCTION ACTIVITIES

METER REPLACEMENT (MAY.2018)

-Before-

- Customer Survey :1,237 customers
- Meter to be Replaced:370 meters (incl: 25 non-errors)
- Replaced meter :298 meters (incl : 25 non-errors)
- Remaining meter:42 meters

-After-

- Customer Survey :1,183customers (NA:57)
- Meter to be Replaced:351 meters (incl : 25 non-errors)
- Replaced meter :301 meters (P:295+K:6=301)
- -Remaining meter:16 meters

-Not Available Replace : 34 meters

WHY DEFERENCE OCCURRED ?

- Many original and/or final files existing
- Many sheets and files exist for using control
- Not exist the file which is everyone recognize complete
- Duplicates of POC & Serial, no GIS data
- Two different teams surveyed same customer

⇒

- *Organize files and sheets to make them simply*
  (in this case, it can be managed with 3 sheets)
- *Create file step by step with considering next step.*
- *Double check when making a new sheet*
- *GIS and CSM data should be complete on time with DMA code*

RESULT OF CUSTOMER SURVEY 1

	POC No.on CSM Dec.2017	No. on List Aug-Dec.2017	Not Available	**Total Surveyed**
PM1	644	697	37	**660**
PM2	44	51	1	**50**
PM3	582	492	19	**473**
TOTAL	**1,270**	**1,240**	**57**	**1,183**
				95%

Not Available: Gate Closed, Water Shortage, Valve Broken, Meter Stolen, etc.

	Meter Error		Defected etc,	Meter to be Replaced	Good condition	Disconnected	**Total Surveyed**
	<-5%	>5%					
PM1	82	52	49	183	467	10	660
PM2	5	5	1	11	39	0	50
PM3	61	33	38	132	339	2	473
TOTAL	**148**	**90**	**88**	**326**	**845**	**12**	**1183**
	12.5%	7.6%	7.4%	27.6%	71.4%	1.0%	100%

Defected : Visually broken, Invisible meter index

RESULT OF CUSTOMER SURVEY 2

	No. Customer	Defected	Meter Error	Total Meter to be Replaced
		X 7.4%	X 20.1%	
Kigali City	87,367	6,465	17,561	24,026
Upcountry	110,058	8,144	22,122	30,266
TOTAL	197,425	14,609	39,682	54,292

More than 50,000 meters should be replaced !!

INDICATORS FOR MONTHLY ON NRW SPECIFIC ACTIVITIES AS MONITORING

- NRW Ratio by Branch :%
- NRW Ratio by DMA :%
- Number of Replaced Meters : meter
- Number of Repairing Leakage : points
- Length of Replaced Pipe :m
- Number of Invisible Leakage Detection: points
- Number of Meter Calibration : meters
- Number of DMA : DMAs
- etc.

NRW Analysis Manuals and Reporting Format

Methodology

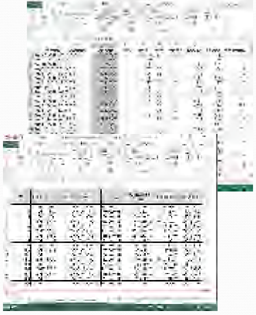
- Programming by GIS section for NRW analysis
- Excel sheet analysis by Branch Manager/Billing Officer for Monthly Report

NRW Analysis

- Responsible Person: Branch manager, billing officers and DWOs
- Base data: Monthly billing data, leak repair records, customer status, meter replacement, disconnection, etc.
- Submission within: ten (10) calendar days after the current month
- Methodology: using by Programs developed by GIS section or Excel software

Sample Procedures (1)

- National/Branch Billing Database (Month A, Year B)
- Sort of billing data by Customer ID
- List of POC of the survey area
- Confirm DMA code or XY coordinate of new customers
- Updated the list of POC with new customers

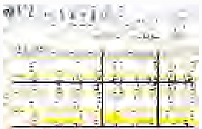


Sample Procedures (2)

- Refer to National/Branch Billing Database to obtain monthly water consumption of each POC, using 'vlookup' function
- Numerical copy of the result to another column and replace '#N/A' to "-", using 'if" and 'isnumber' function
- Sum up monthly water consumption and count total customers by user category

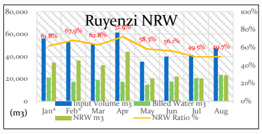
Sample Procedures (3)

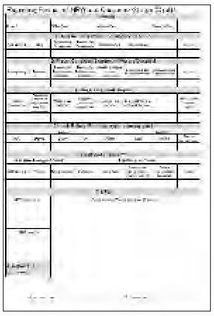
- Prepare tables in a new worksheet of NRW analysis
- Sum up monthly water consumption (billed water) by DMA code, using 'sumif' function
- Pay a special attention to 'absolute and relative reference' of $ sign
- Estimate monthly input volume by reading the Bulk Meters
- Compute NRW and its rate from the billed water and the input volume by DMA
- Prepare graphs for presentation



Sample Procedures (4)

- Fill out all columns of the reporting format for submission to NRW unit, WASAC HQs





1.6 Physical Loss

Attachment 12. Results of flow rate and
water pressure measurement

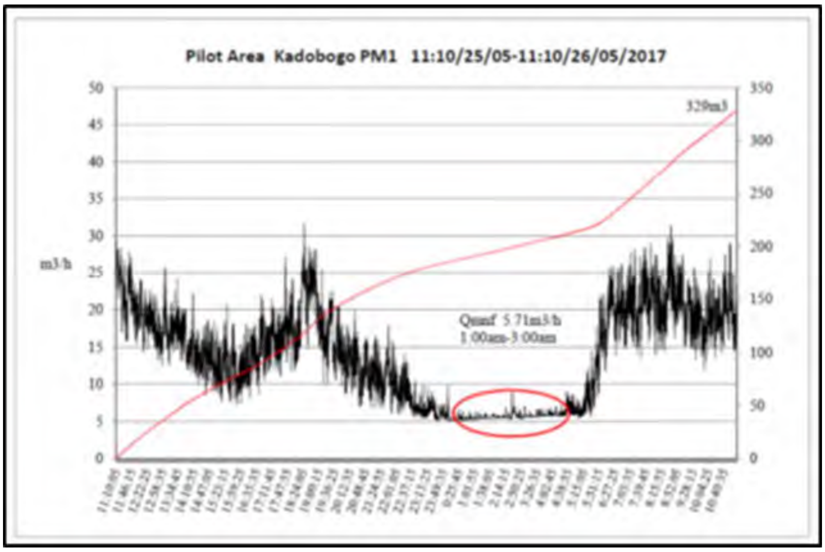
PM1

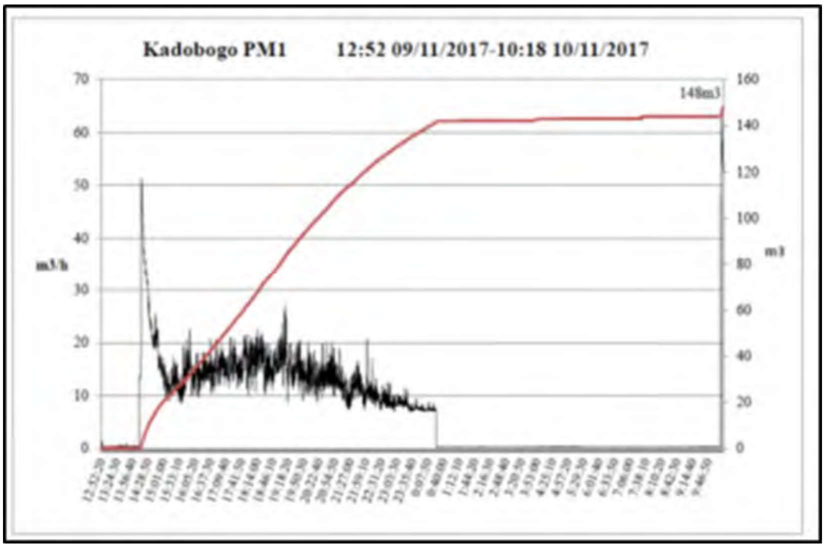
1. Qmnf

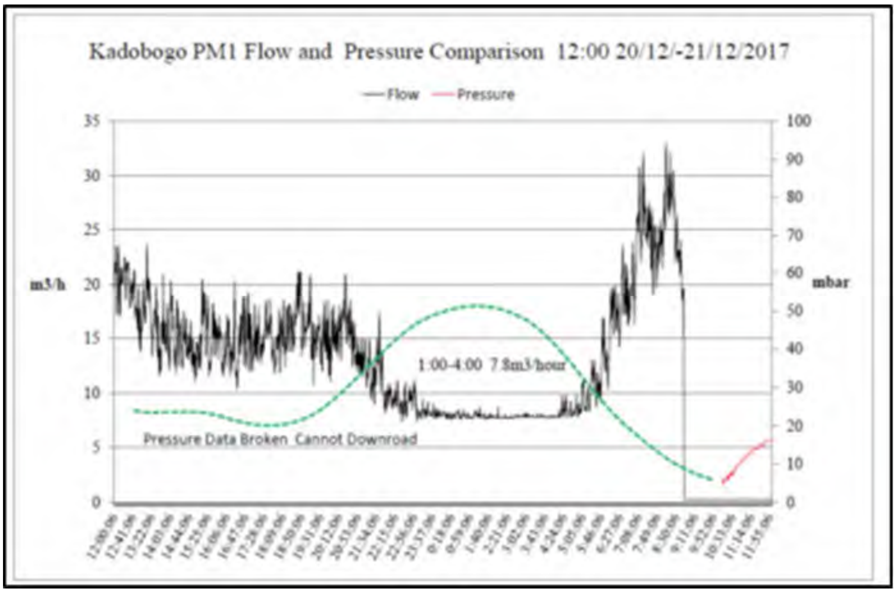
① Changes in flow rate and water pressure measurements in PM1

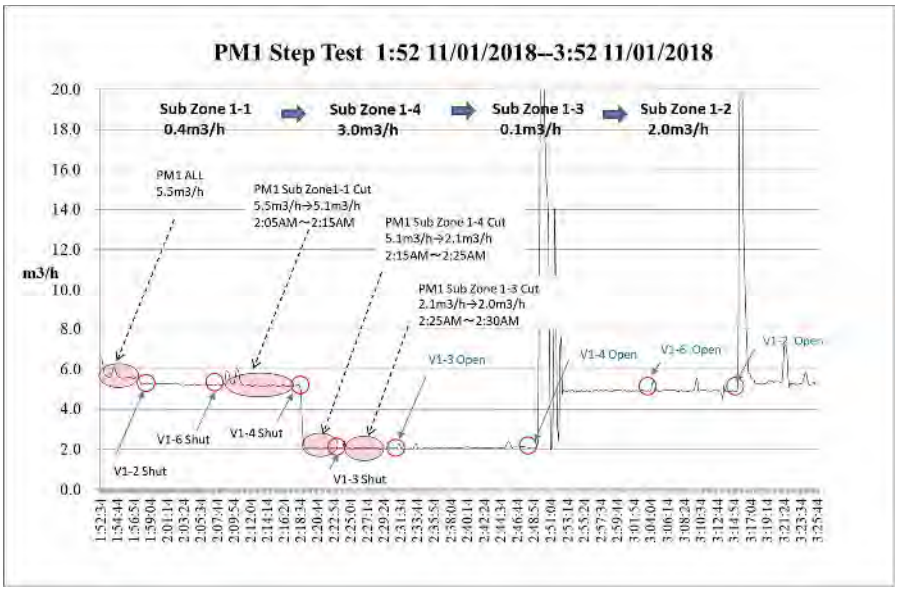
Date	Flow /Pressure	Summary of measurement
May 25 - 26, 2017	Flow 1 day	Qmnf was 5.71 m3/h.
Nov. 9 - 10, 2017	Flow 1 day (Failure)	Qmnf could not be measured because of a water outage.
Nov. 22 - 23, 2017	Pressure	23:00-5:00 = 10 bsr, 7:00-8:00 =7bsr
Dec. 20 - 21, 2017	Flow 1day	Qmnf was 7.8 m3/h.
Jan. 11, 2018	Qmnf step test	PM1 was divided into four subzones and Qmnf was measured while water distribution to each subzone was shut off in turn. Qmnf was 5.5 m3/h at 10.5 bars: A water leak (of approx. 1.5 m3/h), which was difficult to be detected in the daytime, was detected during the Qmnf measurement.
Jul. 19 - 20, 2018	Qmnf step test	Qmnf increased from 5.5 m3/h in the previous measurement to 9.23 m3/h. Qmnf increased in subzones 1-2 and 1-4 compared with the result of the Qmnf step test conducted in January 2018.
Oct. 23 - 24, 2018	Qmnf measurement	The leakage survey and repair in PM1 was completed by the end of August. Qmnf was 7.70 m3/h at 10 bars.
Nov. 26 - 27, 2018	Qmnf measurement	Qmnf was 10.22 m3/h at 10 bars. Water supply and distribution pipes were to be replaced and PRV1 was to be installed to reduce Qmnf in PM1.
Jan. 2019		PM1 has an area above the Fawe Reservoir that supplies water to PM1 (the elevation of the surface of the water in the reservoir is EL 1,468 m, while the ground elevation in PM1 is between EL 1,435 m and 1,485 m). Because this high elevation area is located near Fawe, the reservoir cannot be used for controlling water pressure and water has to be supplied through a bypass pipeline, as is done currently. Because of the use of the bypass pipeline, the water pressure in the water supply pipeline from the Ntora Reservoir was directly applied to the distribution pipeline and had raised the water pressure in the distribution pipeline, which should have been adjusted at approx. 5.5 bars, to 10 bars. This high pressure was a cause of new water leaks. It was decided that a PRV should be installed in the manhole located immediately downstream of the reservoir to reduce the water pressure in the distribution pipeline.

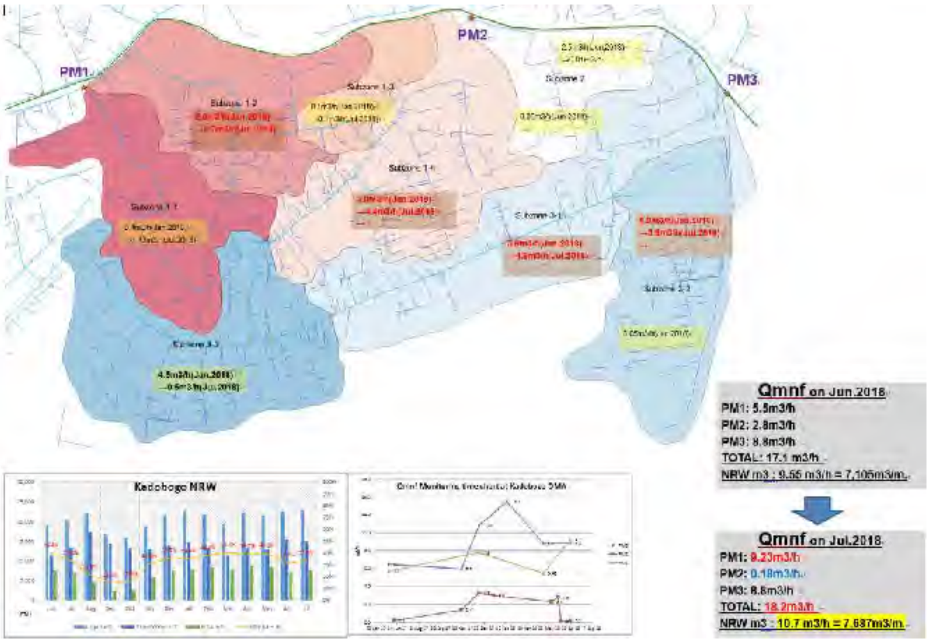
❶ Time-series Qmnf data in PM1




Kadobogo PM1 12:52 09/11/2017-10:18 10/11/2017
m3/h
70
60
50
40
30
20
10
0
m3
160
140
120
100
80
60
40
20
0
148m3


Kadobogo PM1 Flow and Pressure Comparison 12:00 20/12/-21/12/2017
Flow
Pressure
m3/h
35
30
25
20
15
10
5
0
mbar
100
90
80
70
60
50
40
30
20
10
0
1:00-4:00 7.8m3/hour
Pressure Data Broken Cannot Downroad

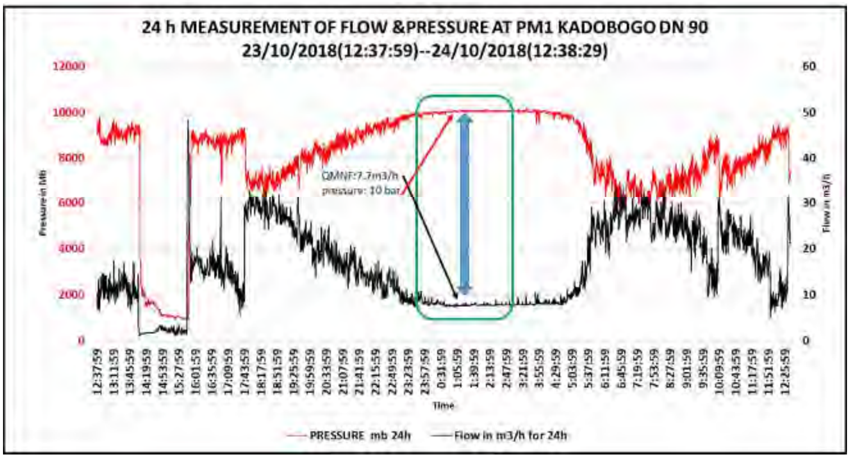

PM1 Step Test 1:52 11/01/2018--3:52 11/01/2018
Sub Zone 1-1
0.4m3/h
Sub Zone 1-4
3.0m3/h
Sub Zone 1-3
0.1m3/h
Sub Zone 1-2
2.0m3/h
PM1 ALL
5.5m3/h
PM1 Sub Zone1-1 Cut
5.5m3/h→5.1m3/h
2:05AM～2:15AM
PM1 Sub Zone 1-4 Cut
5.1m3/h→2.1m3/h
2:15AM～2:25AM
PM1 Sub Zone 1-3 Cut
2.1m3/h→2.0m3/h
2:25AM～2:30AM
V1-3 Open
V1-4 Open
V1-6 Open
V1-2 Open
V1-6 Shut
V1-4 Shut
V1-2 Shut
V1-3 Shut
m3/h
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1:52:34
1:54:44
1:56:54
1:59:04
2:01:14
2:03:24
2:05:34
2:07:44
2:09:54
2:12:04
2:14:14
2:16:24
2:18:34
2:20:44
2:22:54
2:25:04
2:27:14
2:29:24
2:31:34
2:33:44
2:35:54
2:38:04
2:40:14
2:42:24
2:44:34
2:46:44
2:48:54
2:51:04
2:53:14
2:55:24
2:57:34
2:59:44
3:01:54
3:04:04
3:06:14
3:08:24
3:10:34
3:12:44
3:14:54
3:17:04
3:19:14
3:21:24
3:23:34
3:25:44

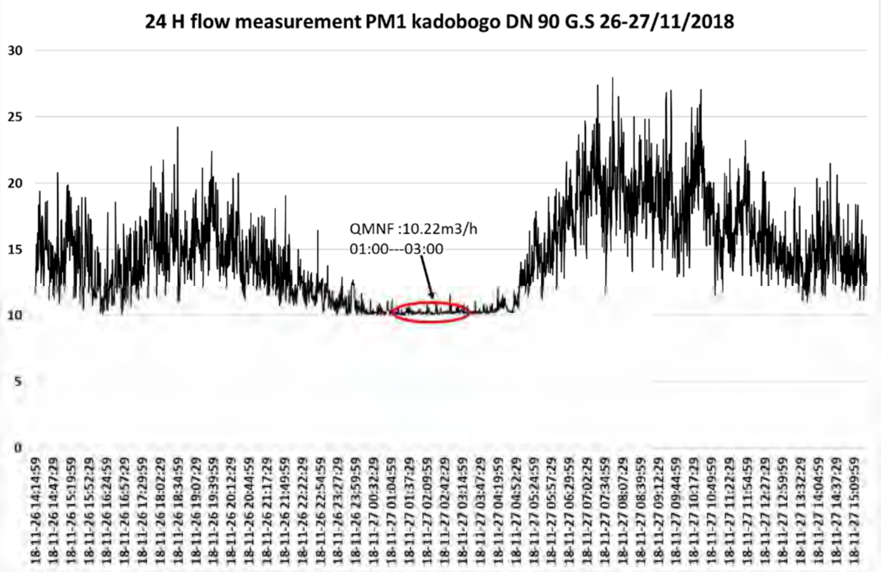


Qmnf on Jun.2018
PM1: 5.5m3/h
PM2: 2.8m3/h
PM3: 8.8m3/h
TOTAL: 17.1 m3/h
NRW m3 : 9.55 m3/h = 7,105m3/m.

Qmnf on Jul.2018
PM1: 9.23m3/h
PM2: 0.18m3/h
PM3: 8.8m3/h
TOTAL: 18.2m3/h
NRW m3 : 10.7 m3/h = 7,687m3/m.

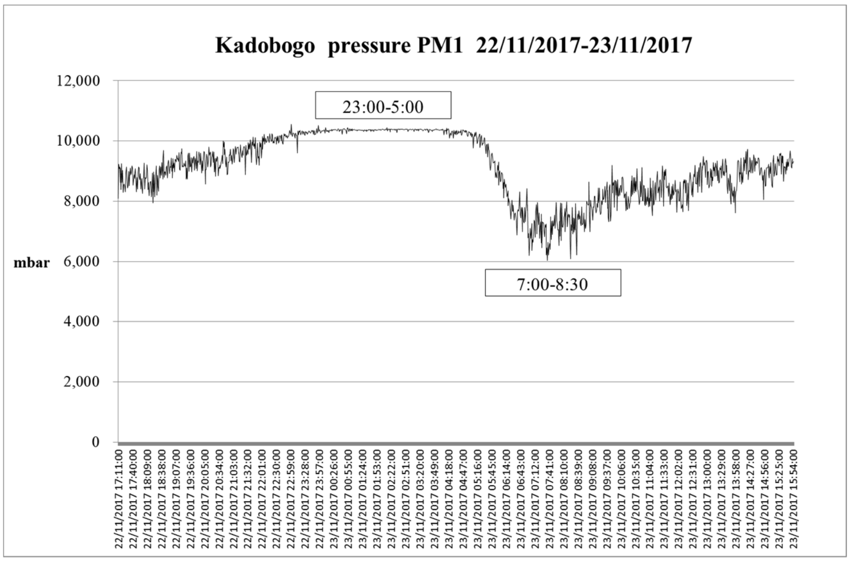
PM1

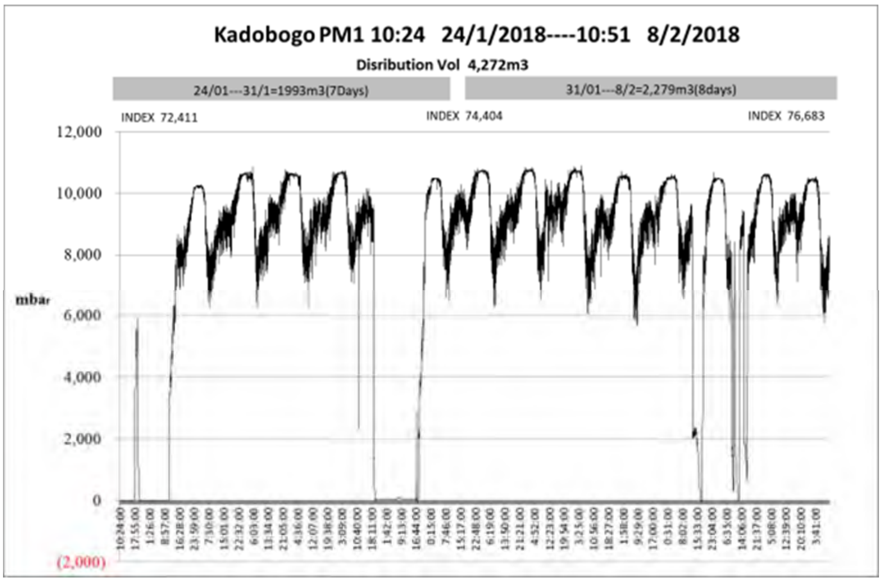

24 h MEASUREMENT OF FLOW &PRESSURE AT PM1 KADOBOGO DN 90
23/10/2018(12:37:59)--24/10/2018(12:38:29)


24 H flow measurement PM1 kadobogo DN 90 G.S 26-27/11/2018

2. Water pressure data

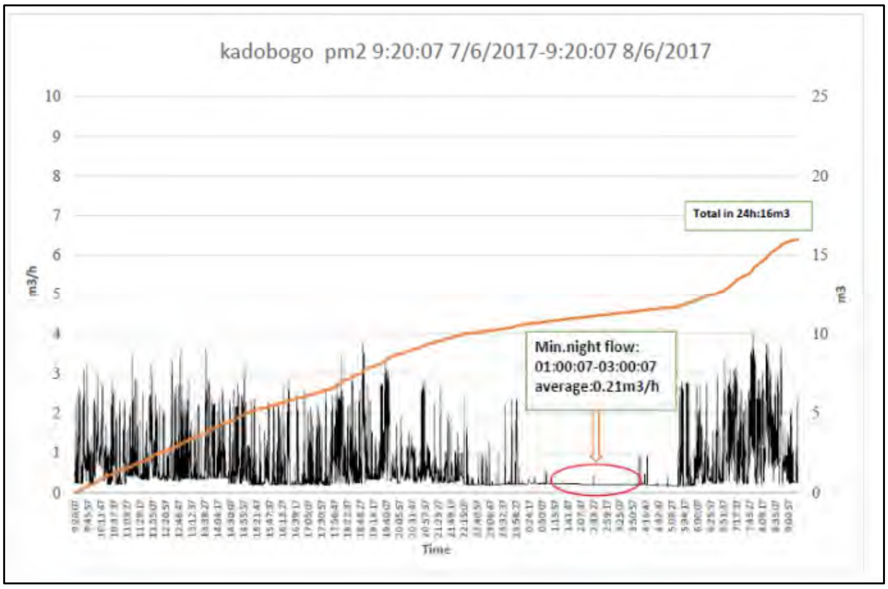
Date of installation	Condition
Nov. 22 - 23, 2017	
Jan. 24 - Feb. 8, 2018	The water pressure at the inflow point exceeded 10 bars in the night. It was approx. 6 bars when water consumption was high. The maximum and average pressures were 10.9 bars and 9.16 bars, respectively. The water supply was suspended (or the water pressure was less than 2.0 bars) for 15 % of the measurement period. Water outages occurred frequently in the Kodobogo Pilot Area because of the leakage repair and power outages. Such water outages shortened the water distribution time and reduced the volume of water distribution. However, when water consumption is far smaller than the volume of distribution, the increase in the duration and frequency of water outages does not directly cause the decrease in water consumption. Monthly water distribution volume often changes with no relation to water consumption.

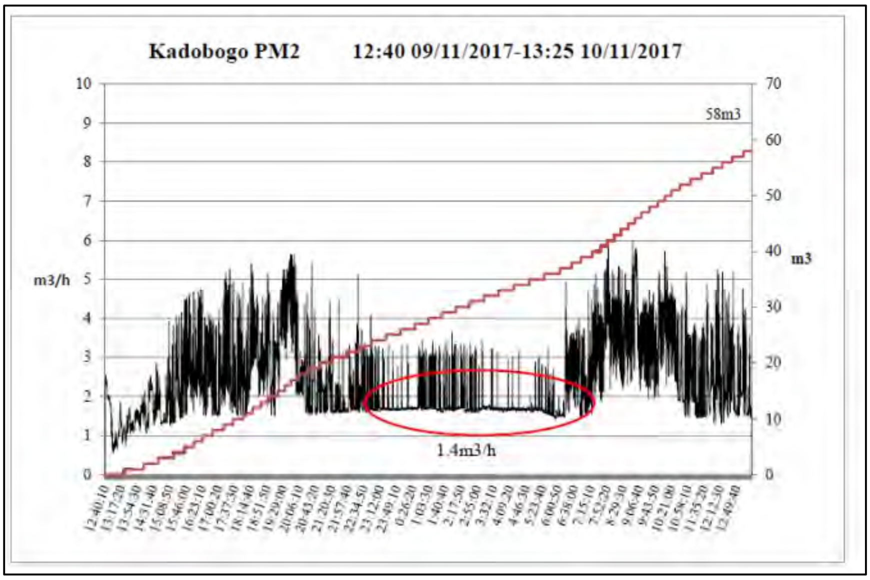


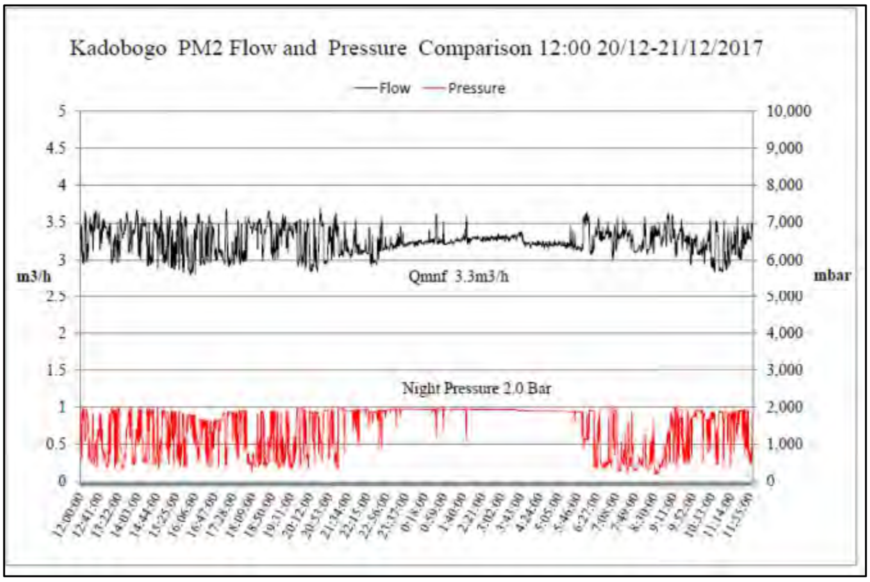


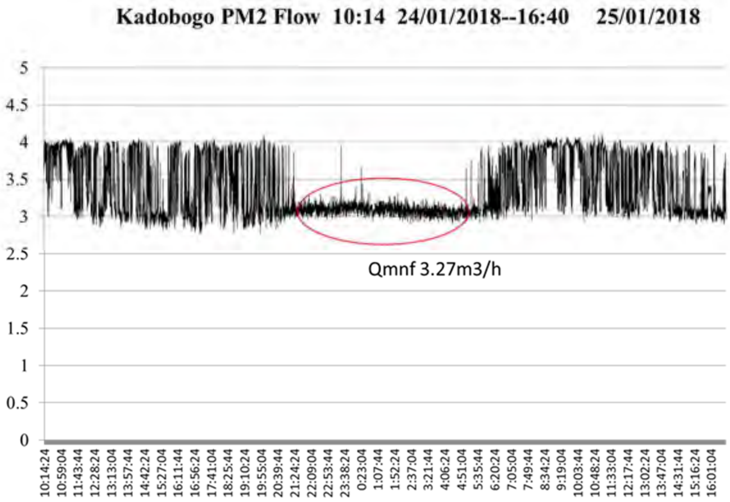
1.2 PM2

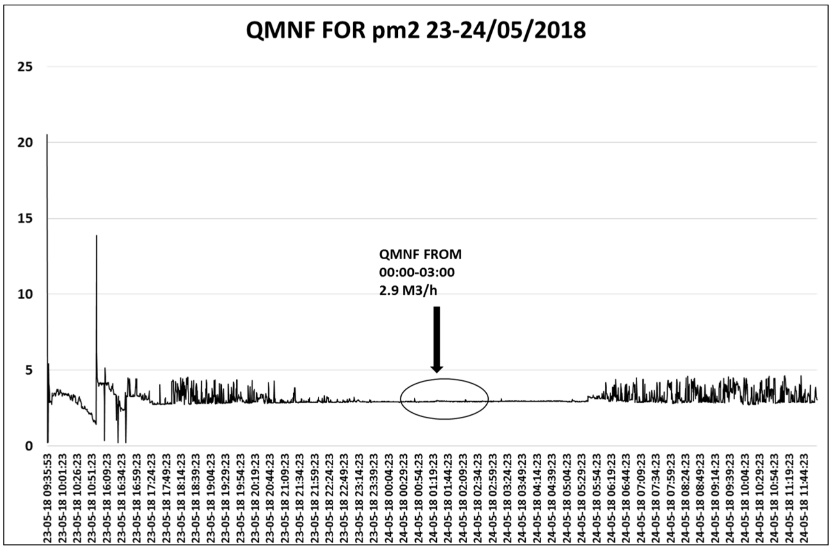
Date	Flow /Pressure	Summary of measurement
May 25 - 26, 2017	Flow 1 day (Failure)	Qmnf monitoring failed.
Jun. 7 - 8, 2017	Flow 1 day	C/Ps voluntarily monitored the Qmnf data. Qmnf in June 2017 was 0.21 m3/h.
Nov. 9 - 10, 2017	Flow 1 day	C/Ps were requested to carry out the Qmnf data monitoring before the training in Japan. The measured Qmnf was 1.4 m3/h.
Nov. 30 - Dec. 7, 2017	Pressure	The water pressure was monitored between November 30 and December 7. The pressure fluctuated sharply during this period.
Dec. 20 - 21, 2017	Flow 1 day	Qmnf was 3.3 m3/h. There was little difference between Qmnf and the flow rate in the daytime (2 bars).
Jan. 24 - 25, 2018	Flow 1 day	This monitoring was conducted in place of the one that should have been conducted on January 11. Qmnf was 3.27 m3/h.
May 23 - 24, 2018		Qmnf was 2.9 m3/h.
Jun. 12 - 14, 2018		The pressure measurement was carried out to examine the operating condition of the PRV reinstalled in the early May. The flow rate was also measured. The measurement revealed that P2 had been stable at approx. 4 bars. Qmnf was 2.31 m3/h.
Jun. 21, 2018	Qmnf, Step Test	Qmnf was 2.81 m3/h. After the step test, a leakage survey was carried out. A leakage point was identified on June 24th and the point was repaired.
Jun. 25 - 27, 2018	Measurement of Qmnf and leakage reduction effect	After the Qmnf measurement on June 14, the step test was carried out on June 21 and a leakage point was identified on June 24. The average Qmnf of the two days was 91.545 L/h (= (112.19 L/h + 70.9 L/h)/2). As Qmnf before the repair was 2.31 m3/h, the repair reduced water leakage by 2.218 m3/h (= 2.31 – 0.092 m3/h).
Jul. 19 - 20, 2018	Qmnf, Step Test	Qmnf was 0.2 m3/h. The leakage survey conducted in June reduced Qmnf significantly from 2.9 m3/h in May to 0.2 m3/h. The pressure control enabled by the installation of the PRV also contributed to this reduction.
Oct. 5, 2018	Staged measurement of water pressure – Qmnf and verification of the effect of PRVs	The baseline Qmnf value for the verification of the effect of the PRV was set at 0.74 m3/h (7.0 bars), the Qmnf value when the valve was fully open. Qmnf continuously decreased as the water pressure on the secondary side of the PRV (P2) was reduced stepwise. This finding verified the leakage reduction effect of the PRV. The P2 was set at 2.5 bars.
Oct. 23 - 24, 2018	Measurement of Qmnf and leakage reduction effect	Qmnf was 0.31 m3/h. This measurement revealed the reduction effect of 0.43 m3/h from (or 58 % of) the baseline value of 0.74 m3/h.
Nov. 26 - 27, 2018	Measurement of Qmnf	Qmnf was 0.31 m3/h, which suggested the continuation of the effect observed in October.

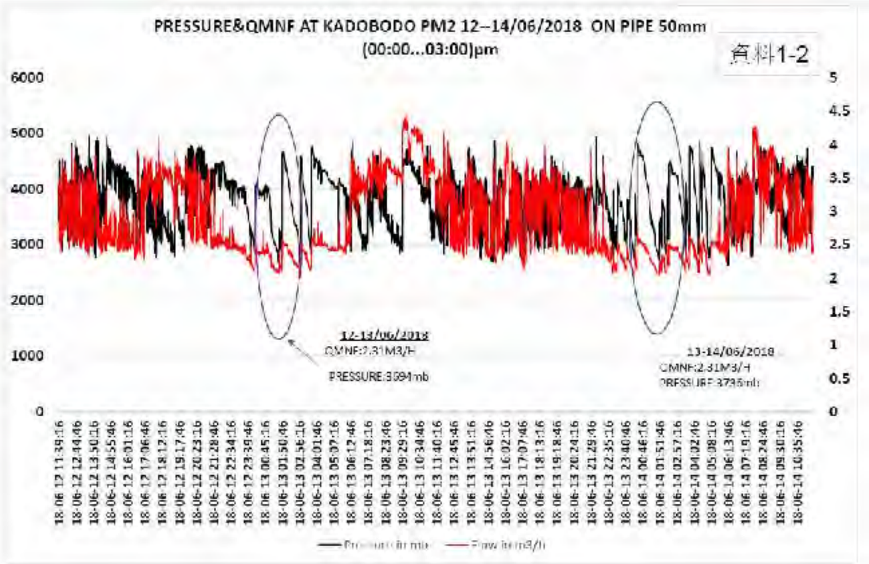

kadobogo pm2 9:20:07 7/6/2017-9:20:07 8/6/2017
m3/h
m3
Time
Total in 24h:16m3
Min.night flow:
01:00:07-03:00:07
average:0.21m3/h
10
9
8
7
6
5
4
3
2
1
0
25
20
15
10
5
0

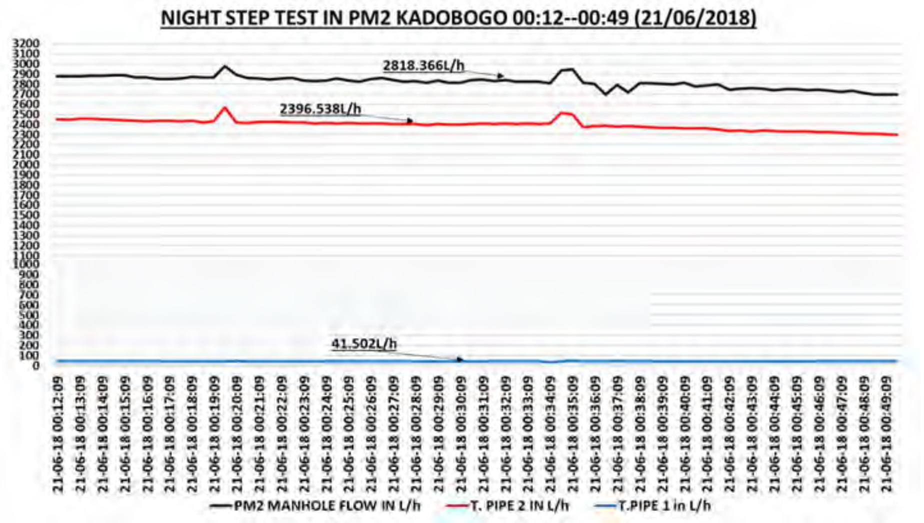

Kadobogo PM2 12:40 09/11/2017-13:25 10/11/2017
m3/h
m3
58m3
1.4m3/h
10
9
8
7
6
5
4
3
2
1
0
70
60
50
40
30
20
10
0
12:40:10
13:17:20
13:54:30
14:31:40
15:08:50
15:46:00
16:23:10
17:00:20
17:37:30
18:14:40
18:51:50
19:29:00
20:06:10
20:43:20
21:20:30
21:57:40
22:34:50
23:12:00
23:49:10
0:26:20
1:03:30
1:40:40
2:17:50
2:55:00
3:32:10
4:09:20
4:46:30
5:23:40
6:00:50
6:38:00
7:15:10
7:52:20
8:29:30
9:06:40
9:43:50
10:21:00
10:58:10
11:35:20
12:12:30
12:49:40

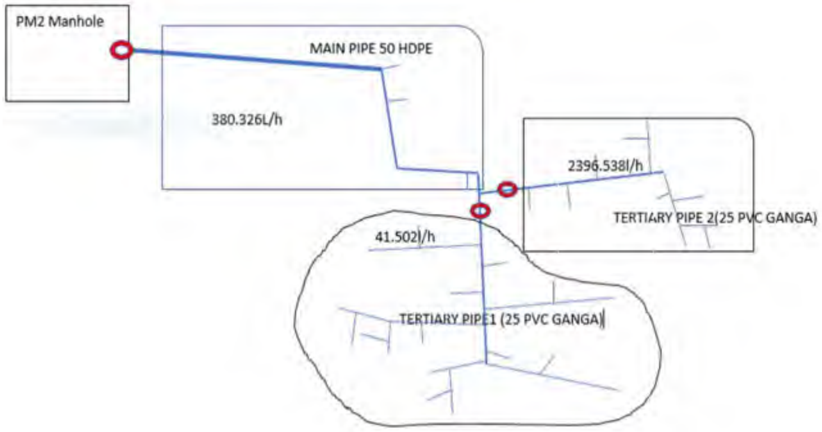

Kadobogo PM2 Flow and Pressure Comparison 12:00 20/12-21/12/2017
Flow
Pressure
m3/h
mbar
Qmnf 3.3m3/h
Night Pressure 2.0 Bar
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
12:00:00
12:41:00
13:22:00
14:03:00
14:44:00
15:25:00
16:06:00
16:47:00
17:28:00
18:09:00
18:50:00
19:31:00
20:12:00
20:53:00
21:34:00
22:15:00
22:56:00
23:37:00
0:18:00
0:59:00
1:40:00
2:21:00
3:02:00
3:43:00
4:24:00
5:05:00
5:46:00
6:27:00
7:08:00
7:49:00
8:30:00
9:11:00
9:52:00
10:33:00
11:14:00
11:55:00

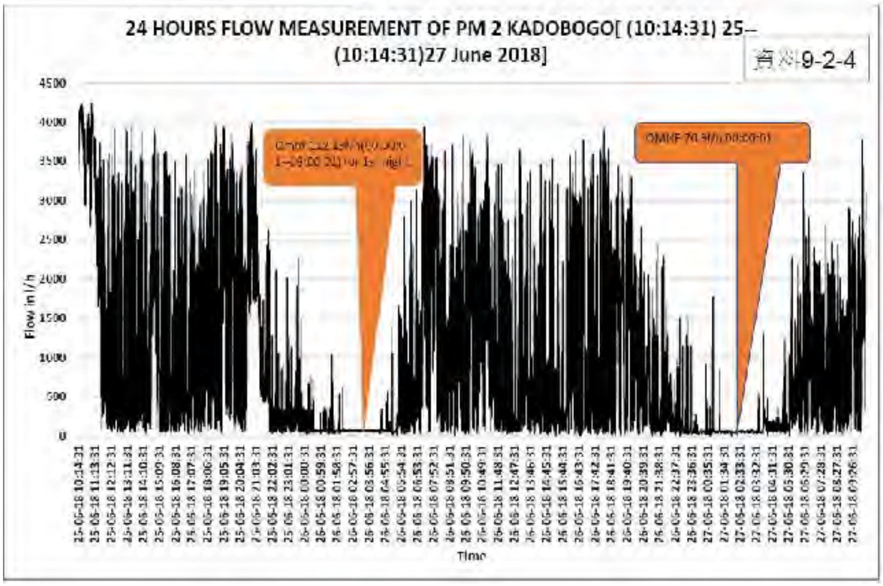

Kadobogo PM2 Flow 10:14 24/01/2018--16:40 25/01/2018
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Qmnf 3.27m3/h
10:14:24
10:59:04
11:43:44
12:28:24
13:13:04
13:57:44
14:42:24
15:27:04
16:11:44
16:56:24
17:41:04
18:25:44
19:10:24
19:55:04
20:39:44
21:24:24
22:09:04
22:53:44
23:38:24
0:23:04
1:07:44
1:52:24
2:37:04
3:21:44
4:06:24
4:51:04
5:35:44
6:20:24
7:05:04
7:49:44
8:34:24
9:19:04
10:03:44
10:48:24
11:33:04
12:17:44
13:02:24
13:47:04
14:31:44
15:16:24
16:01:04


QMNF FOR pm2 23-24/05/2018
25
20
15
10
5
0
QMNF FROM
00:00-03:00
2.9 M3/h
23-05-18 09:35:53
23-05-18 10:01:23
23-05-18 10:26:23
23-05-18 10:51:23
23-05-18 16:09:23
23-05-18 16:34:23
23-05-18 16:59:23
23-05-18 17:24:23
23-05-18 17:49:23
23-05-18 18:14:23
23-05-18 18:39:23
23-05-18 19:04:23
23-05-18 19:29:23
23-05-18 19:54:23
23-05-18 20:19:23
23-05-18 20:44:23
23-05-18 21:09:23
23-05-18 21:34:23
23-05-18 21:59:23
23-05-18 22:24:23
23-05-18 22:49:23
23-05-18 23:14:23
23-05-18 23:39:23
24-05-18 00:04:23
24-05-18 00:29:23
24-05-18 00:54:23
24-05-18 01:19:23
24-05-18 01:44:23
24-05-18 02:09:23
24-05-18 02:34:23
24-05-18 02:59:23
24-05-18 03:24:23
24-05-18 03:49:23
24-05-18 04:14:23
24-05-18 04:39:23
24-05-18 05:04:23
24-05-18 05:29:23
24-05-18 05:54:23
24-05-18 06:19:23
24-05-18 06:44:23
24-05-18 07:09:23
24-05-18 07:34:23
24-05-18 07:59:23
24-05-18 08:24:23
24-05-18 08:49:23
24-05-18 09:14:23
24-05-18 09:39:23
24-05-18 10:04:23
24-05-18 10:29:23
24-05-18 10:54:23
24-05-18 11:19:23
24-05-18 11:44:23

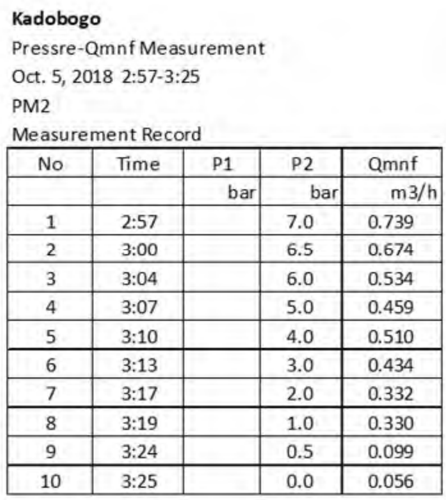

PRESSURE&QMNF AT KADOBODO PM2 12--14/06/2018 ON PIPE 50mm
(00:00...03:00)pm
資料1-2
6000
5000
4000
3000
2000
1000
0
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12-13/06/2018
QMNF:2.31M3/H
PRESSURE:3594mb
13-14/06/2018
QMNF:2.31M3/H
PRESSURE:3736mb
18-06-12 11:39:16
18-06-12 12:44:46
18-06-12 13:50:16
18-06-12 14:55:46
18-06-12 16:01:16
18-06-12 17:06:46
18-06-12 18:12:16
18-06-12 19:17:46
18-06-12 20:23:16
18-06-12 21:28:46
18-06-12 22:34:16
18-06-12 23:39:46
18-06-13 00:45:16
18-06-13 01:50:46
18-06-13 02:56:16
18-06-13 04:01:46
18-06-13 05:07:16
18-06-13 06:12:46
18-06-13 07:18:16
18-06-13 08:23:46
18-06-13 09:29:16
18-06-13 10:34:46
18-06-13 11:40:16
18-06-13 12:45:46
18-06-13 13:51:16
18-06-13 14:56:46
18-06-13 16:02:16
18-06-13 17:07:46
18-06-13 18:13:16
18-06-13 19:18:46
18-06-13 20:24:16
18-06-13 21:29:46
18-06-13 22:35:16
18-06-13 23:40:46
18-06-14 00:46:16
18-06-14 01:51:46
18-06-14 02:57:16
18-06-14 04:02:46
18-06-14 05:08:16
18-06-14 06:13:46
18-06-14 07:19:16
18-06-14 08:24:46
18-06-14 09:30:16
18-06-14 10:35:46
Pressure in mb
Flow in m3/h


NIGHT STEP TEST IN PM2 KADOBOGO 00:12--00:49 (21/06/2018)
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2818.366L/h
2396.538L/h
41.502L/h
21-06-18 00:12:09
21-06-18 00:13:09
21-06-18 00:14:09
21-06-18 00:15:09
21-06-18 00:16:09
21-06-18 00:17:09
21-06-18 00:18:09
21-06-18 00:19:09
21-06-18 00:20:09
21-06-18 00:21:09
21-06-18 00:22:09
21-06-18 00:23:09
21-06-18 00:24:09
21-06-18 00:25:09
21-06-18 00:26:09
21-06-18 00:27:09
21-06-18 00:28:09
21-06-18 00:29:09
21-06-18 00:30:09
21-06-18 00:31:09
21-06-18 00:32:09
21-06-18 00:33:09
21-06-18 00:34:09
21-06-18 00:35:09
21-06-18 00:36:09
21-06-18 00:37:09
21-06-18 00:38:09
21-06-18 00:39:09
21-06-18 00:40:09
21-06-18 00:41:09
21-06-18 00:42:09
21-06-18 00:43:09
21-06-18 00:44:09
21-06-18 00:45:09
21-06-18 00:46:09
21-06-18 00:47:09
21-06-18 00:48:09
21-06-18 00:49:09
PM2 MANHOLE FLOW IN L/h
T. PIPE 2 IN L/h
T.PIPE 1 in L/h


PM2 Manhole
MAIN PIPE 50 HDPE
380.326L/h
2396.538l/h
TERTIARY PIPE 2(25 PVC GANGA)
41.502l/h
TERTIARY PIPE1 (25 PVC GANGA)

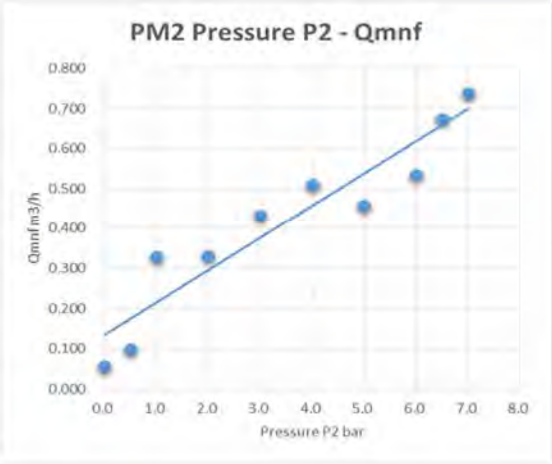

24 HOURS FLOW MEASUREMENT OF PM 2 KADOBOGO[(10:14:31) 25–(10:14:31)27 June 2018]
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Flow in l/h
QMNF 70.9l/h,00:00:01
25-06-18 10:14:31
25-06-18 11:13:31
25-06-18 12:12:31
25-06-18 13:11:31
25-06-18 14:10:31
25-06-18 15:09:31
25-06-18 16:08:31
25-06-18 17:07:31
25-06-18 18:06:31
25-06-18 19:05:31
25-06-18 20:04:31
25-06-18 21:03:31
25-06-18 22:02:31
25-06-18 23:01:31
26-06-18 00:00:31
26-06-18 00:59:31
26-06-18 01:58:31
26-06-18 02:57:31
26-06-18 03:56:31
26-06-18 04:55:31
26-06-18 05:54:31
26-06-18 06:53:31
26-06-18 07:52:31
26-06-18 08:51:31
26-06-18 09:50:31
26-06-18 10:49:31
26-06-18 11:48:31
26-06-18 12:47:31
26-06-18 13:46:31
26-06-18 14:45:31
26-06-18 15:44:31
26-06-18 16:43:31
26-06-18 17:42:31
26-06-18 18:41:31
26-06-18 19:40:31
26-06-18 20:39:31
26-06-18 21:38:31
26-06-18 22:37:31
26-06-18 23:36:31
27-06-18 00:35:31
27-06-18 01:34:31
27-06-18 02:33:31
27-06-18 03:32:31
27-06-18 04:31:31
27-06-18 05:30:31
27-06-18 06:29:31
27-06-18 07:28:31
27-06-18 08:27:31
27-06-18 09:26:31
Time

資料9-2-4

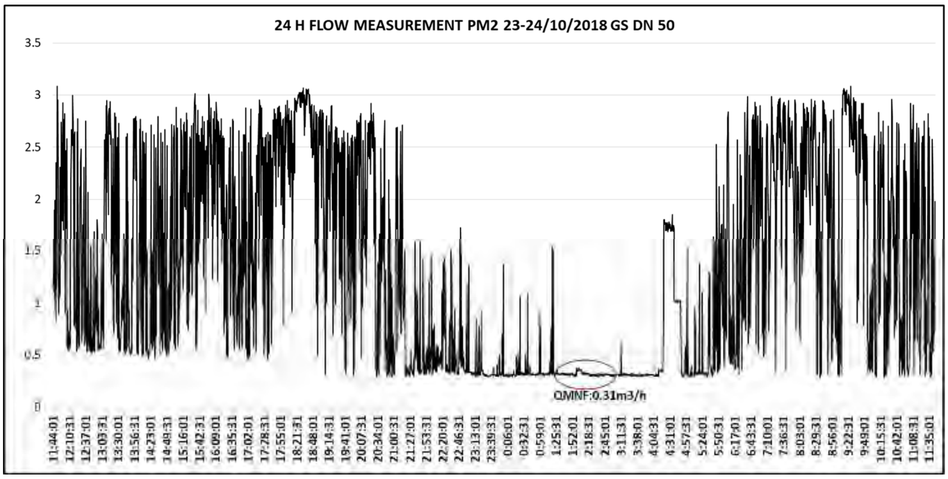


Kadobogo
Pressre-Qmnf Measurement
Oct. 5, 2018 2:57-3:25
PM2
Measurement Record

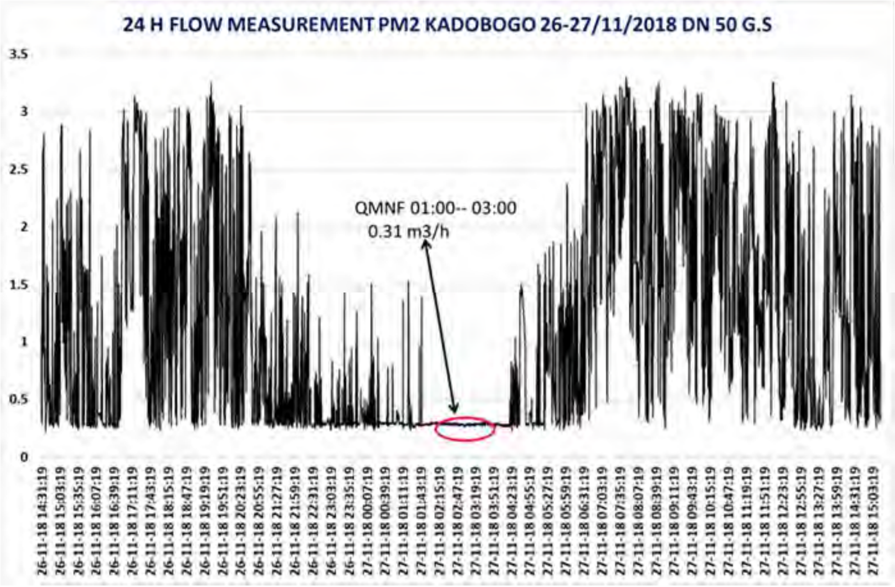
No	Time	P1	P2	Qmnf
		bar	bar	m3/h
1	2:57		7.0	0.739
2	3:00		6.5	0.674
3	3:04		6.0	0.534
4	3:07		5.0	0.459
5	3:10		4.0	0.510
6	3:13		3.0	0.434
7	3:17		2.0	0.332
8	3:19		1.0	0.330
9	3:24		0.5	0.099
10	3:25		0.0	0.056



Result of the measurement of the effect of PRV (staged measurement of P2 – Qmnf)

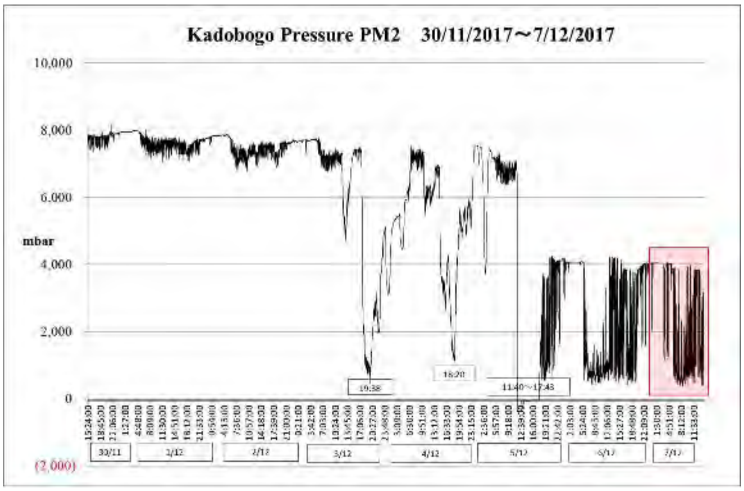


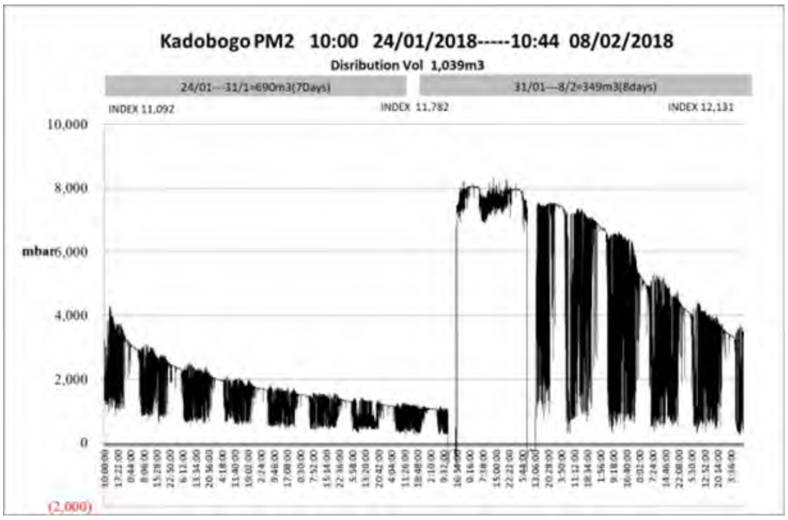
Result of the measurement of the effect of PRV (in PM2)



❷ Data of water pressure in PM2

Date of removal	Characteristics of monitoring data collected up to the date
Nov. 30 - Dec. 7, 2017	The water pressure curve shows that the operating water pressure was at approx. 8 bars for the first two to three days, the pressure went up and down sharply for the next two to three days and the distribution pressure dropped for the last two to three days. This curve suggests that the PRV installed in PM2 was not functioning well at all.
Jan. 24 - Feb. 8, 2018	Although a PRV was installed in PM2, it was not functioning normally. Average water pressure: 5.34 bars (an average of the data above 2.0 bars), Maximum water pressure: 8.3 bars, water outage rate: 8.6 %
May 31, 2018	The PRV was inspected for its installation condition and the direction of its installation was corrected.

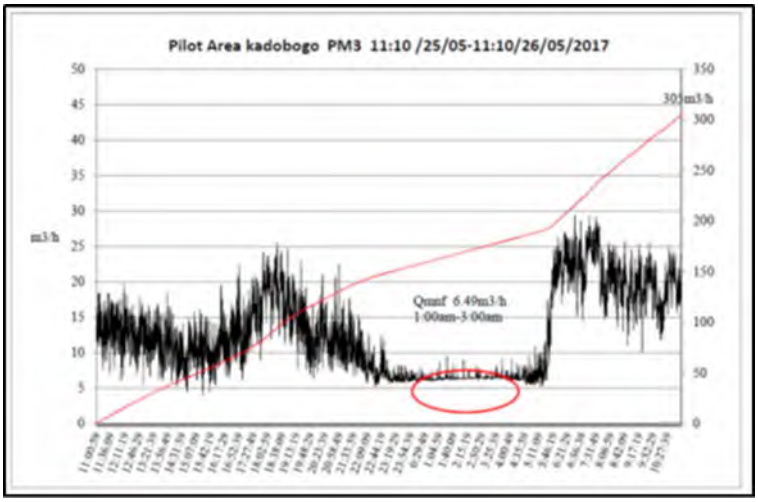


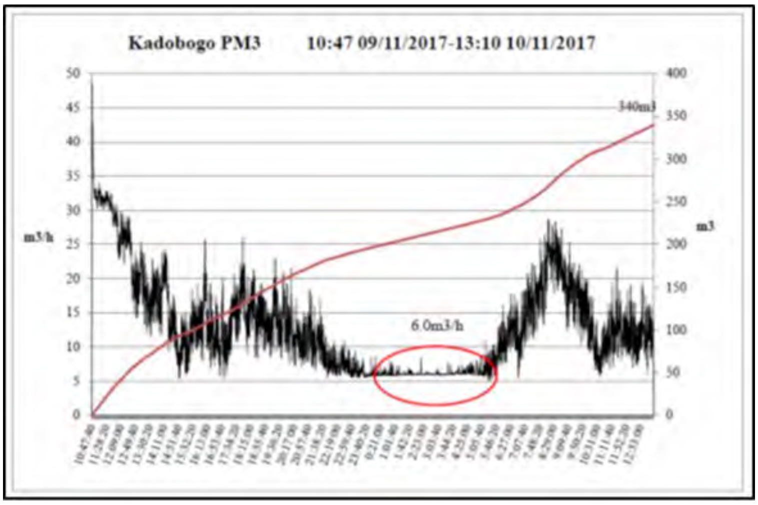


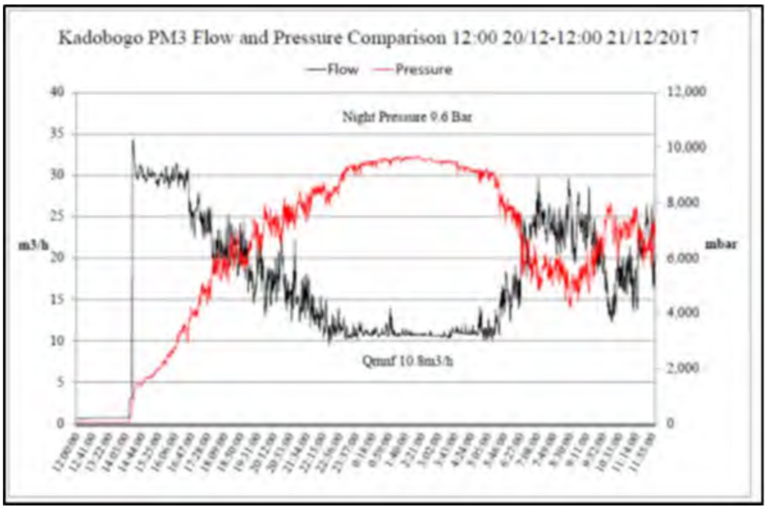
1.3 PM3

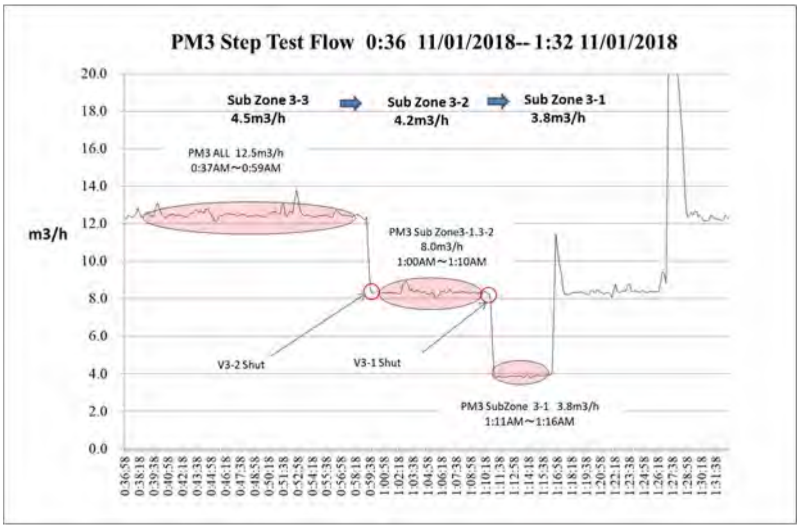
Date	Flow /Pressure	Summary of measurement
May 25 – 26, 2017	Flow 1 day	Qmnf was 6.49 m3/h.
Nov. 9 – 10, 2017	Flow 1 day	C/Ps were requested to monitor the flow rate data before the training in Japan. Qmnf was 6.0 m3/h.
Nov. 30 – Dec. 7, 2017	Pressure	The water pressure was monitored between Nov. 30 and Dec. 7 At around 2:00: 6 - 9 bars, at around 9:00: 0.5 - 1.0 bar
Dec. 20 – 21, 2017	Flow 1 day Pressure	Qmnf was 10.8 m3/h. The water pressure between 0:00 and 5:00 a.m. was 9.6 bars. Water supply was suspended until 14:00.
Dec. 29, 2017	Step test with valve test Pressure	The functions of the valve were examined in the step test. The flow rate at 11:00 a.m. was 20.0 m3/h. The change in water pressure during the step test conducted in the daytime was monitored.
Jan. 5, 2018	Training on the step test	As part of the training program, the step test was conducted in the daytime. The flow rate at 11:00 a.m. was 22.5 m3/h.
Jan. 11, 2018	Qmnf step test	Qmnf was 12.5 m3/h. PM3 was divided into three subzones and Qmnf was measured while water distribution to each subzone was shut off in turn. The Qmnf values in Subzones 3-1, 3-2 and 3-3 were 3.8, 4.2 and 4.5 m3/h, respectively. The method of subdividing a subzone into sub-subzones and examining the volume of water leakage in each sub-subzone thoroughly is a useful method to detect water leakage. Therefore, it was decided that Subzone 3-2 was to be subdivided into sub-subzones and Qmnf in each sub-subzone was to be measured.
Jan. 25, 2018	Subdivision of Subzone 3-2	Subzone 3-2 was divided into two sub-subzones and Qmnf in each sub-subzone was measured. The Qmnf values measured in the two sub-subzones were 4.8 m3/h and 0.06 m3/h, respectively. The leakage survey in the upper reaches of PM3-2 began on January 30. The survey detected a leak (estimated at more than 2.0 m3/h) on a pipe branching from a 25 mm water supply pipeline that distributed water to approx. 15 households.
Feb. 23-24, 2018	Qmnf measurement	Qmnf was 13.5 m3/h and the water pressure was 7.8 bars.
Jul. 19-20, 2018	Qmnf step test	Qmnf in PM3 was 9.3 m3/h
Sep. 18, 2018		The construction of a PRV chamber and the installation of a PRV in PM3 was completed on September 18. Since then, the high pressure on the primary side of the valve (P1) had been reduced to 3 - 3.5 bars on the secondary side (P2) and this adjusted pressure had been used for distributing water in PM3. The pressure setting of the valve was readjusted to reduce P2 to 2.5 bars on October 24.
Oct. 5, 2018	Staged measurement of water pressure – Qmnf, verification of the effect of PRV Setting a baseline value	The baseline Qmnf for the verification of the effect of the PRV was set at 9.44 m3/h (at 7.5 bars), which was Qmnf when PRV was fully opened. As P2 was reduced stepwise by the PRV, Qmnf continuously decreased. This finding proved the leakage reduction effect of the PRV.
Oct. 23-24, 2018	Measurement of the effect of PRV	Qmnf was 5.8 m3/h (at 2.5 - 3.0 bars). This value indicated the reduction of Qmnf of 3.64 m3/h or 39 %.
Nov. 26-27, 2018	Qmnf measurement	Qmnf was 3.32 m3/h at 2.5 - 3.0 bars.

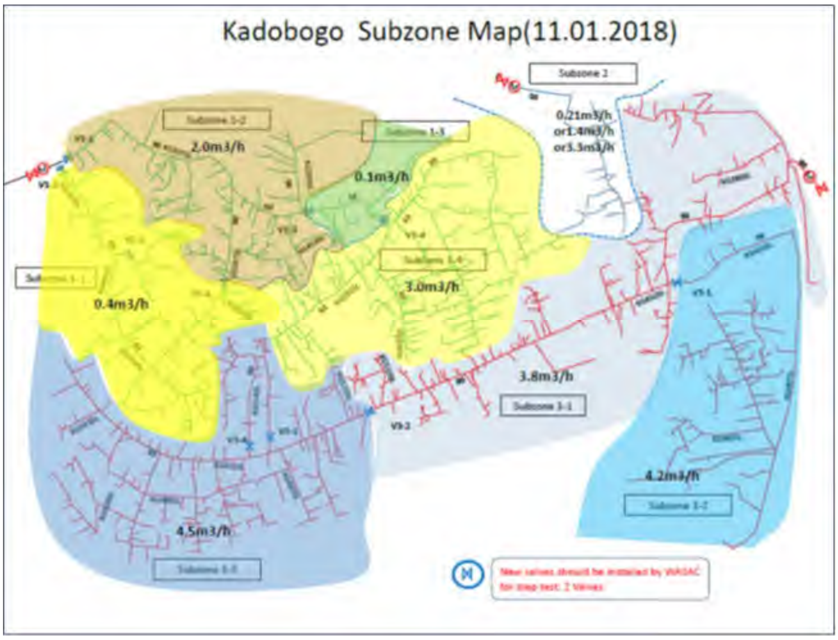
Dec. 20, 2018	Qmnf step test	Qmnf was 2.91 m3/h. The test revealed that Qmnf was 1.73 m3/h in Subzone 3-2, which indicated large water leakage in the subzone.
Jan. 28-29, 2019	Qmnf measurement	Qmnf was 4.71 m3/h.
Feb. 5-6, 2019	Qmnf step test	Qmnf was 3.53 m3/h. After the pressure had been adjusted with the PRV, no increase in the water leakage was observed as the values of Qmnf measured on November 27, 2018, December 20, 2018 and January 5-6, 2019 were 3.32 m3/h, 2.91 m3/h and 3.53 m3/h, respectively.



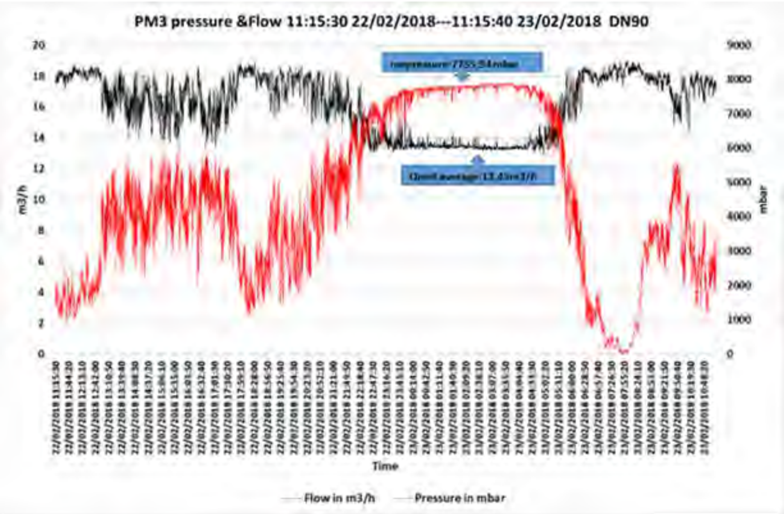






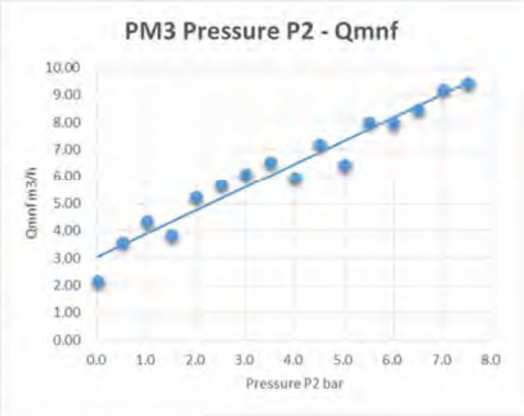


Map showing the result of the Qmnf measurement in sub-subzones of PM3-2

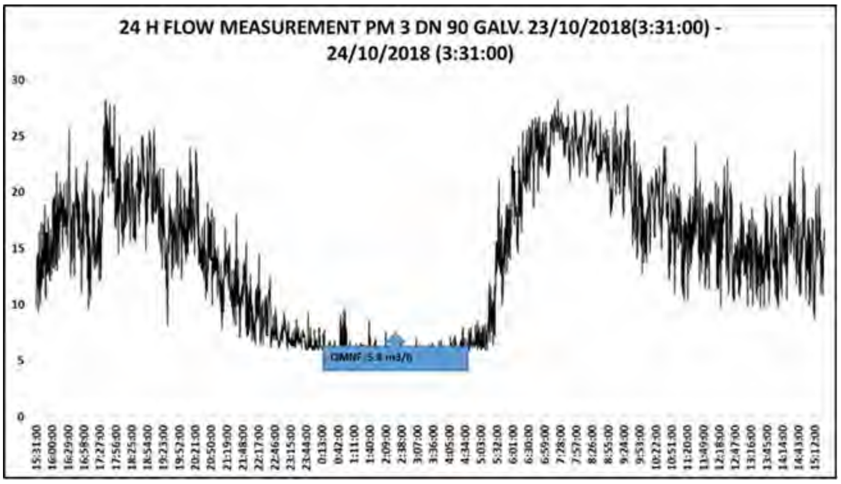


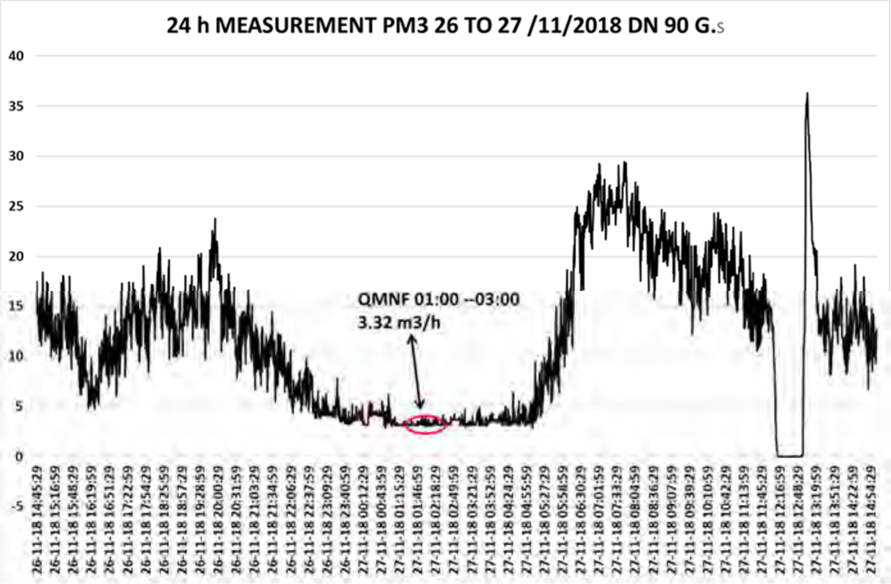
Kadobogo
Pressre-Qmnf Measurement
Oct. 5, 2018 1:18-2:03
PM3
Measurement Record

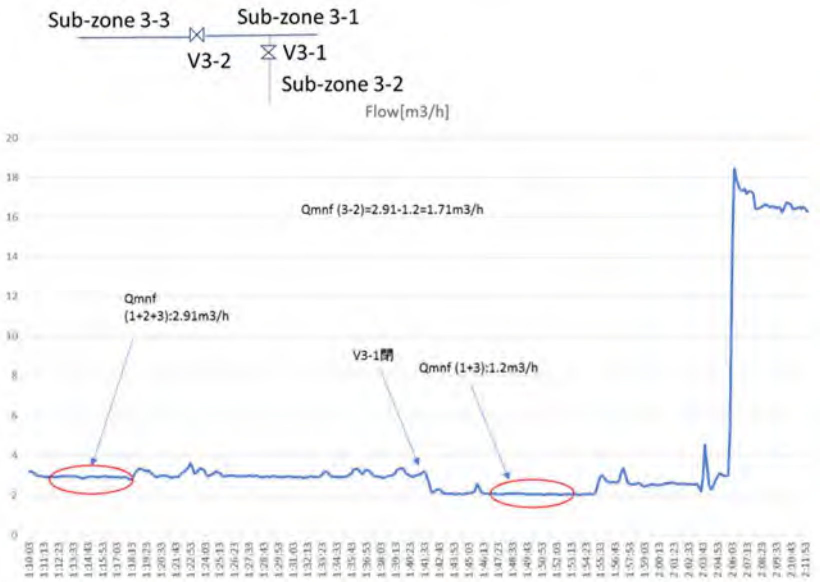
No	Time	P1	P2	Qmnf
		bar	bar	m3/h
1	1:18		7.5	9.44
2	1:21		7.0	9.19
3	1:25		6.5	8.48
4	1:28		6.0	7.98
5	1:31		5.5	8.01
6	1:35		5.0	6.43
7	1:37		4.5	7.19
8	1:41		4.0	5.95
9	1:43		3.5	6.54
10	1:46		3.0	6.08
11	1:49		2.5	5.70
12	1:52		2.0	5.25
13	1:55		1.5	3.85
14	1:58		1.0	4.36
15	2:01		0.5	3.57
16	2:03		0.0	2.16

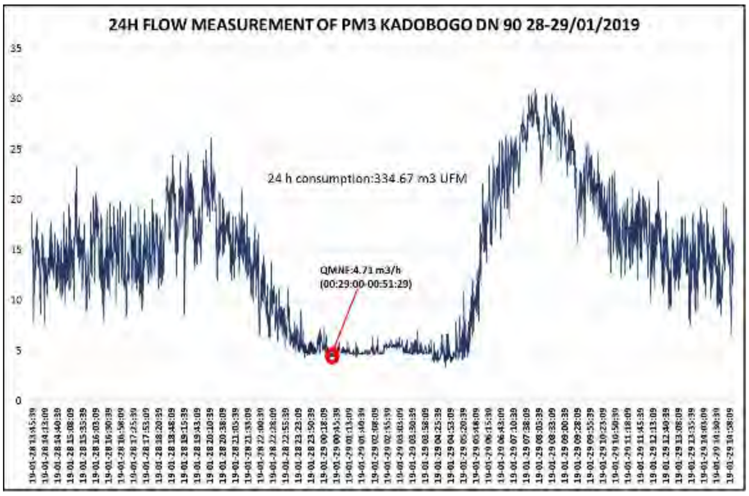


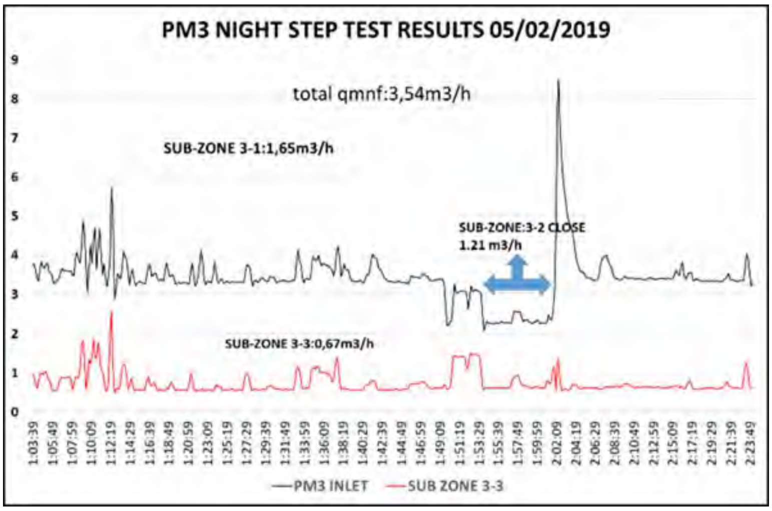
Result of the measurement of the effect of PRV (staged measurement of P2 – Qmnf)

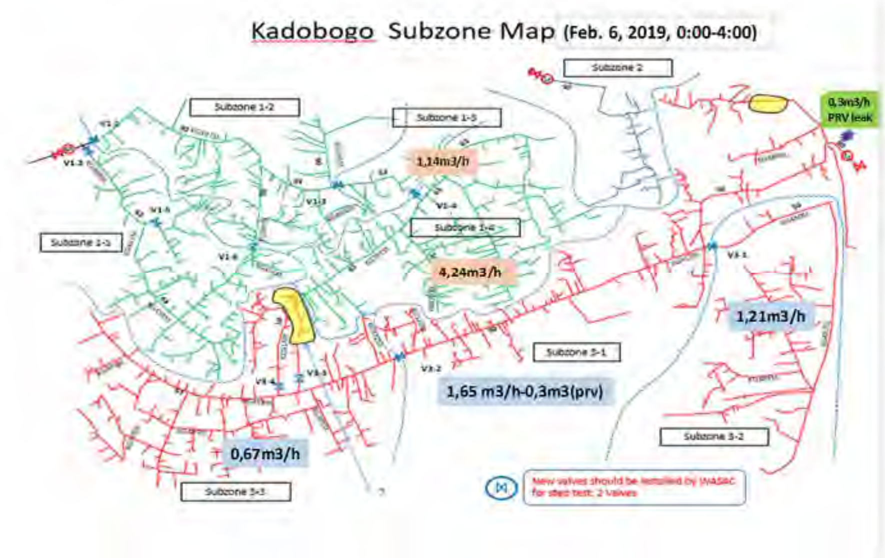



24 h MEASUREMENT PM3 26 TO 27 /11/2018 DN 90 G.S
40
35
30
25
20
15
10
5
0
-5
QMNF 01:00 --03:00
3.32 m3/h
26-11-18 14:45:29
26-11-18 15:16:59
26-11-18 15:48:29
26-11-18 16:19:59
26-11-18 16:51:29
26-11-18 17:22:59
26-11-18 17:54:29
26-11-18 18:25:59
26-11-18 18:57:29
26-11-18 19:28:59
26-11-18 20:00:29
26-11-18 20:31:59
26-11-18 21:03:29
26-11-18 21:34:59
26-11-18 22:06:29
26-11-18 22:37:59
26-11-18 23:09:29
26-11-18 23:40:59
27-11-18 00:12:29
27-11-18 00:43:59
27-11-18 01:15:29
27-11-18 01:46:59
27-11-18 02:18:29
27-11-18 02:49:59
27-11-18 03:21:29
27-11-18 03:52:59
27-11-18 04:24:29
27-11-18 04:55:59
27-11-18 05:27:29
27-11-18 05:58:59
27-11-18 06:30:29
27-11-18 07:01:59
27-11-18 07:33:29
27-11-18 08:04:59
27-11-18 08:36:29
27-11-18 09:07:59
27-11-18 09:39:29
27-11-18 10:10:59
27-11-18 10:42:29
27-11-18 11:13:59
27-11-18 11:45:29
27-11-18 12:16:59
27-11-18 12:48:29
27-11-18 13:19:59
27-11-18 13:51:29
27-11-18 14:22:59
27-11-18 14:54:29


Sub-zone 3-3
Sub-zone 3-1
V3-2
V3-1
Sub-zone 3-2
Flow[m3/h]
20
18
16
14
12
10
8
6
4
2
0
Qmnf (3-2)=2.91-1.2=1.71m3/h
Qmnf
(1+2+3):2.91m3/h
V3-1閉
Qmnf (1+3):1.2m3/h

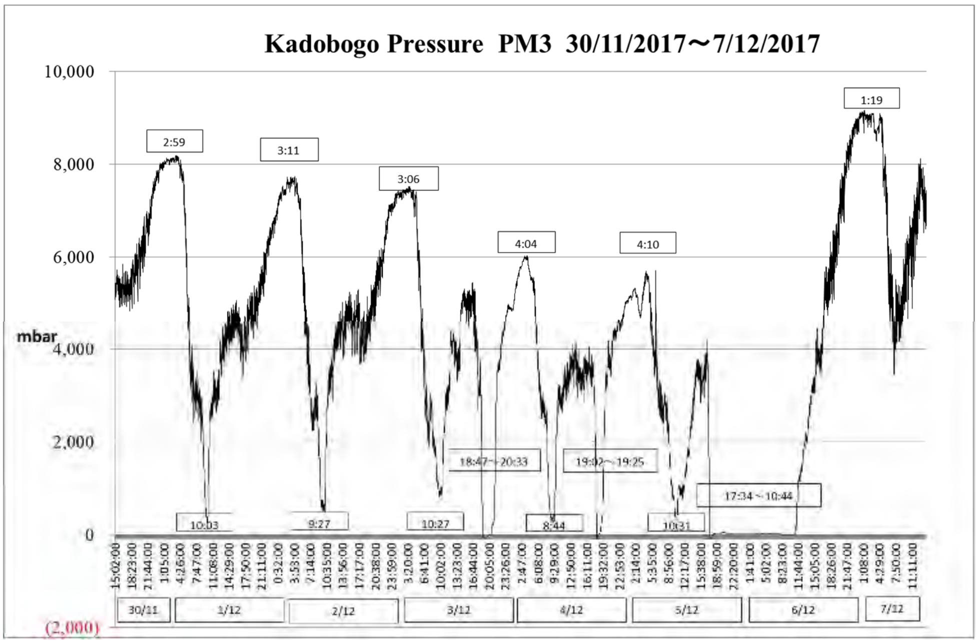

24H FLOW MEASUREMENT OF PM3 KADOBOGO DN 90 28-29/01/2019
35
30
25
20
15
10
5
0
24 h consumption:334.67 m3 UFM
QMNF:4.71 m3/h
(00:29:00-00:51:29)


PM3 NIGHT STEP TEST RESULTS 05/02/2019
total qmnf:3,54m3/h
SUB-ZONE 3-1:1,65m3/h
SUB-ZONE:3-2 CLOSE
1.21 m3/h
SUB-ZONE 3-3:0,67m3/h
9
8
7
6
5
4
3
2
1
0
1:03:39
1:05:49
1:07:59
1:10:09
1:12:19
1:14:29
1:16:39
1:18:49
1:20:59
1:23:09
1:25:19
1:27:29
1:29:39
1:31:49
1:33:59
1:36:09
1:38:19
1:40:29
1:42:39
1:44:49
1:46:59
1:49:09
1:51:19
1:53:29
1:55:39
1:57:49
1:59:59
2:02:09
2:04:19
2:06:29
2:08:39
2:10:49
2:12:59
2:15:09
2:17:19
2:19:29
2:21:39
2:23:49
PM3 INLET
SUB ZONE 3-3

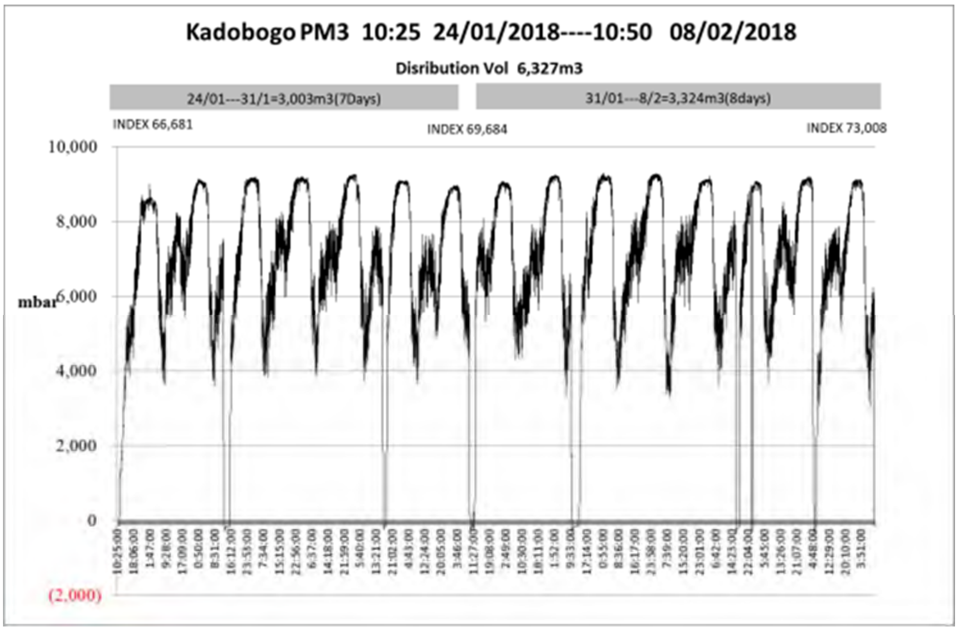

Kadobogo Subzone Map (Feb. 6, 2019, 0:00-4:00)
Subzone 2
Subzone 1-2
Subzone 1-5
0,3m3/h
PRV leak
1,14m3/h
V1-2
V1-3
V1-5
V1-3
V1-4
Subzone 1-4
Subzone 1-1
V1-6
4,24m3/h
V3-1
1,21m3/h
Subzone 3-1
V3-2
V3-4
V3-3
1,65 m3/h-0,3m3(prv)
Subzone 3-2
0,67m3/h
Subzone 3-3
New valves should be installed by WASAC for step test: 2 Valves

Data of water pressure in PM3

Date of installation	Characteristics of monitoring data collected up to the date
Nov. 30 - Dec. 7, 2017	The maximum pressure was unstable, fluctuating between 6 bars and 8 bars. It was necessary to monitor water pressure appropriately and study a way to control the pressure by adjusting the opening of the PRV and other valves.
Jan 24 - Feb.8, 2018	The water pressure at the inflow point reached close to 10 bar in the night. The pressure fluctuated sharply. The pressure changed in inverse proportion to the flow rate with a regular diurnal rhythm. Power outages and leakage repair were assumed to be the causes of the water outages (or water pressure of 0) recorded during the measurement period. The water pressure curve revealed that, although the water consumption changed largely, the water pressure in the pipes was always positive and it fluctuated between 4 bars and 9 bars in the normal operation. The average water pressure was 7.2 bars (an average of the data above 2.0 bars), maximum water pressure was 9.3 bars and the proportion of time of water outage/water outage rate was 5.0 %.



Kadobogo Pressure PM3

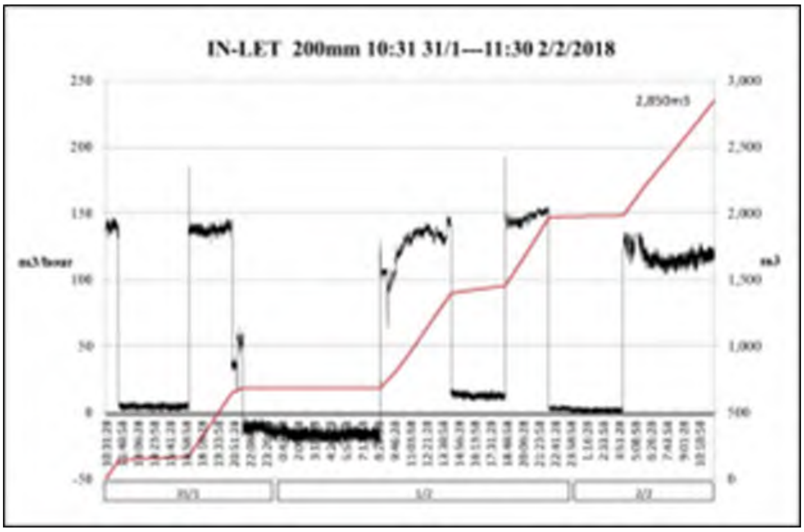


Outline survey of the volume of water distribution in Ruyenzi

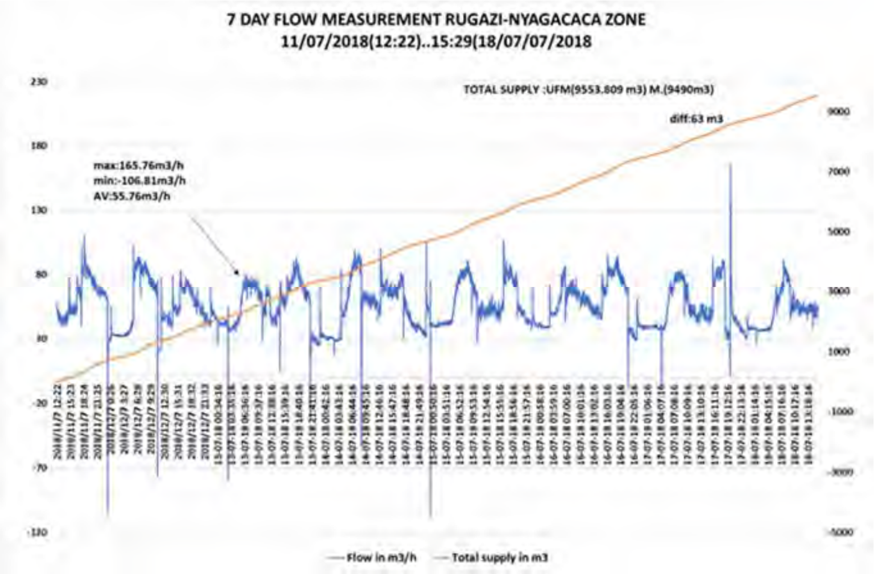
1.RUNDA InLet 200mm	
Jan. 31 – Feb. 2, 2018	As the water distribution was artificially controlled, it is difficult to obtain data of continuous water distribution curve.
2.RY1 (Bypass Line) RUYNYAGACA200mm	
Jan. 31 – Feb. 2, 2018	The distribution data were monitored for two days. Data “jumps,” which were presumably caused by valve adjustment, were recorded.
Jul. 11-18, 2018	An outline survey of Qmnf was conducted with attention paid to the water outflow from RY1 to outside the area.
Dec. 3-4, 2018	Ultrasonic flow meters installed at the inlet and outlet were used for 24-hour flow rate measurement for the measurement of Qmnf. Based on the measurement results, the water leakage was estimated at 27.9 m3/h (Fig. 14).
Feb. 13, 2019	The leakage step test was conducted to identify areas with large leakage. Large leakage was observed in Zones 1-5 and 1-6. Although Zone 1-5 is an area where water pressure was regulated by PRV1, which reduced the primary pressure of 9.0 bars to the secondary pressure of 3.50 bars, a large pressure difference of 9.0 bars was observed in the area because of the elevation difference between PRV1 and the lowest part in the subzone of 55 m. This pressure difference was assumed to be related to the large leakage. Zone 1-6 is an area where water is directly distributed from the Ruyenzi Reservoir. As the water pressure at the outlet of the reservoir was 6.0 bars in the night and the elevation difference in the zone was 35 m, the maximum pressure of 9.5 bars was applied to the water pipe in the night. Although two pressure reducing valves (PRVs) had been installed in RY1, the zones in which PRV had not been installed including Zone 1-6 occupied 70 % of the total area of RY1. A pressure reducing measure that covered the entire RY1 was required for effective leakage reduction. When water leakage was assumed to account for almost 100 % of NRW, the water leakage per unit time in the daytime was estimated at approx. 93 % of Qmnf. Dec. 4, 2018: Qmnf 27.9 m3/h (NRW: 19,414 m3/m in November) Feb. 13, 2019: Qmnf 26.5m3/h (NRW: 19,453 m3/m in January) A x 16 + 27.9 x 8 = 19,414/30, A = 26.5, 26.5/27.9 = 0.95 A x 16 + 29.4 x 8 = 19,453/31, A = 24.5, 24.5/26.5 = 0.92
3. RY2 (Gravity Line) KAMUHANDA200mm	
Jan. 31 - Jan. 31, 2018	It was only possible to monitor the data for less than a day. Because of the limited power supply, the water distribution through KAMUHANDA 200mm was monitored only for approx. 10 hours. It was preferable to obtain water distribution data for two to three days in the next monitoring.
Jul. 11-18, 2018	An outline survey of Qmnf was conducted.
Dec. 3-4, 2018	Qmnf was measured. The water leakage was estimated at 7.3 m3/h.
Feb. 19-20, 2019	The step test was conducted to identify areas with large leakage. As NRW in RY2 was 3,402 m3/m in February, it was assumed that the water leakage per unit time in the daytime was almost the same as Qmnf. Qmnf immediately downstream of the Ruyenzi Reservoir: Dec. 4, 2019: Qmnf 7.3 m3/h (NRW: 6,881 m3/m in November) Feb. 19, 2019: Qmnf 4.71m3/h (NRW: 2,665m3/m in January) A x 16 + 7.3 x 8 = 6,881/30, A = 10.7, 10.7/7.3 = 1.46 A x 16 + 4.71 x 8 = 2,665/31, A = 3.0, 3.0/4.71 = 0.64 Qmnf at PRV2:

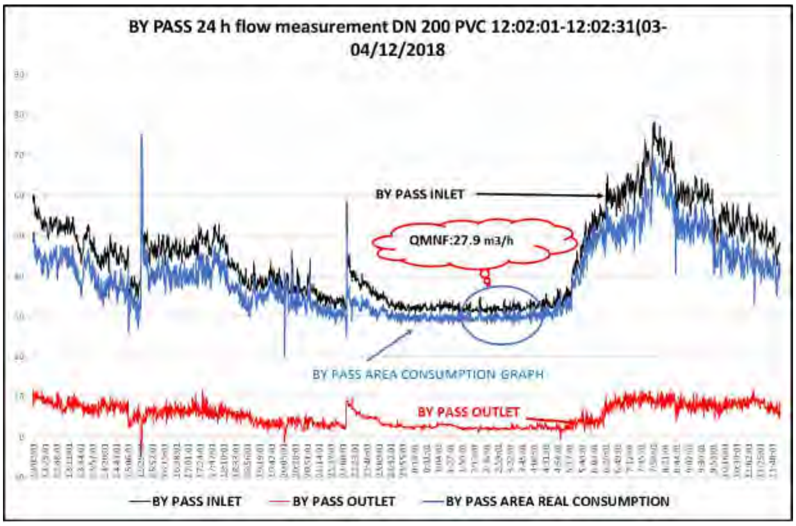
	Nov. 15, 2018: 2.70 m3/h Feb. 19, 2019: 2.84 m3/h (2,045 m3/m)
4. RY3 PM4(Pilot Manhole)160mm	
Jan.31 – Jan. 31, 2018	Because of the limited power supply, the water distribution in PM4 160mm was monitored only for approx. 10 hours. No data were obtained after 23:00. Attention should be paid to the fact that the water distribution curve went up toward the night.
Jul. 11-18, 2018	An outline survey of Qmnf was conducted with attention paid to the fact that water supply was continuously rationed in RY3.
Dec. 3-4, 2018	There were three sharp drops of flow rate during the 24-hour period. The water distribution from the Gihara Reservoir to the other distribution areas was a possible cause of these sharp drops. As this distribution to the other areas caused the shortage of water distribution in RY3, water outages occurred frequently. Because of the water outages, water consumption in the night was large. The measurement of the flow rate in the late night was 27 m3/h. Because of this large flow rate, it was not possible to measure Qmnf. The establishment of stable water supply was the priority in RY3.

1. Reservoir Inlet

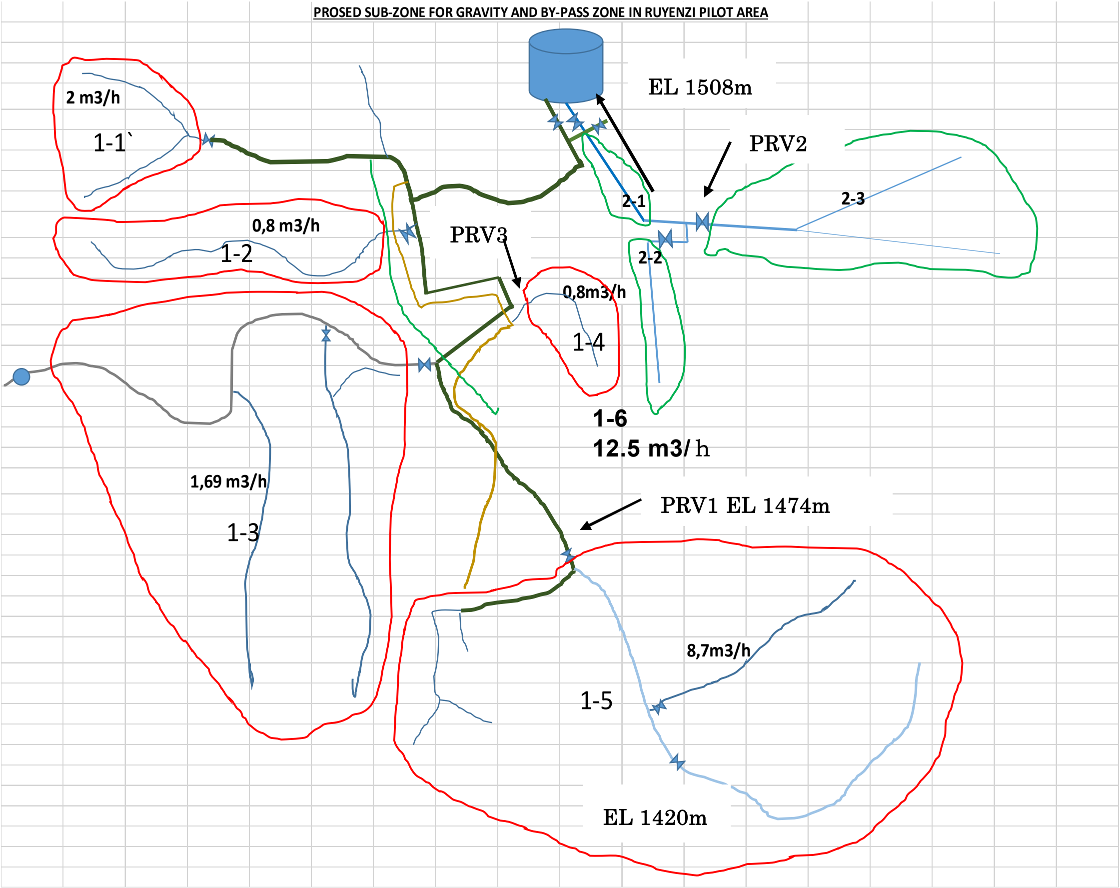


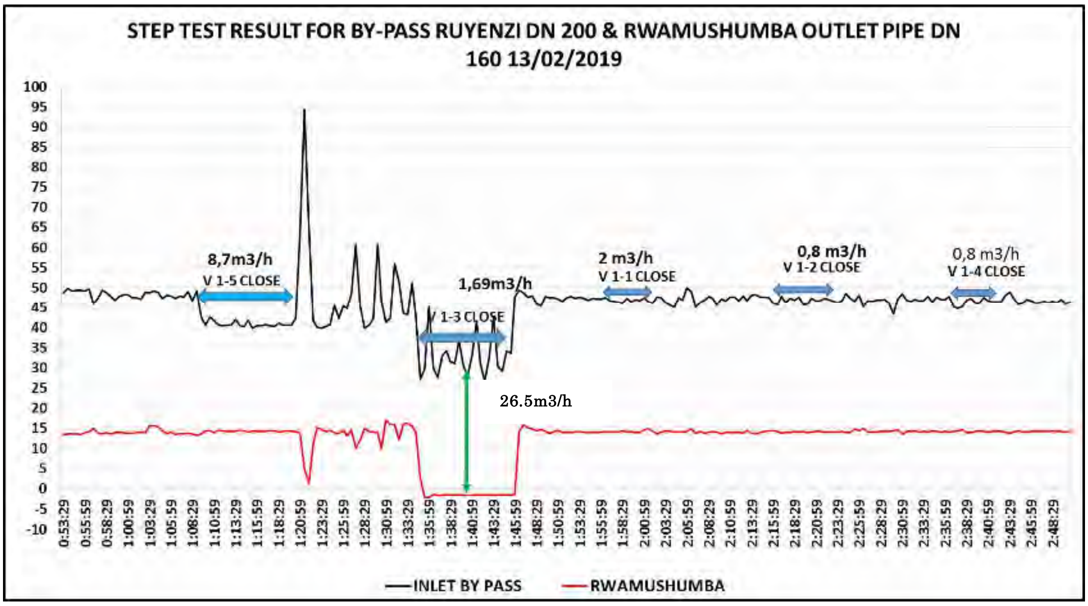
2. RY1 (pipeline that bypasses the Ruyenzi Reservoir)





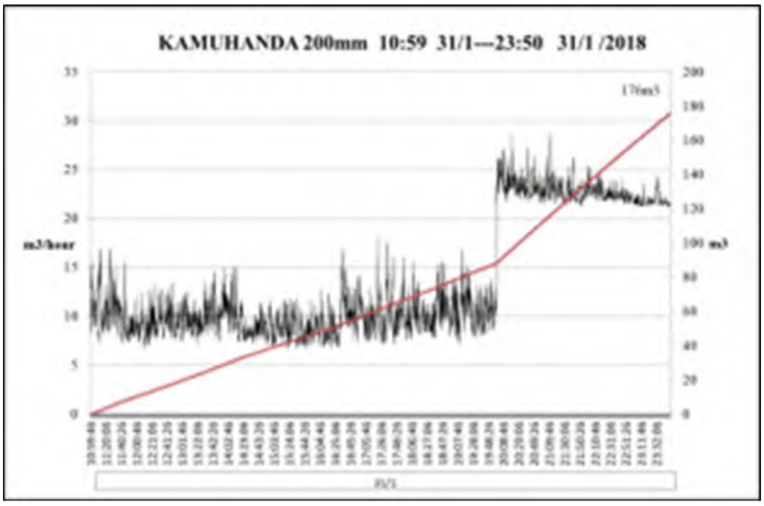
Result of the Qmnf measurement in RY1 (December 3-4)

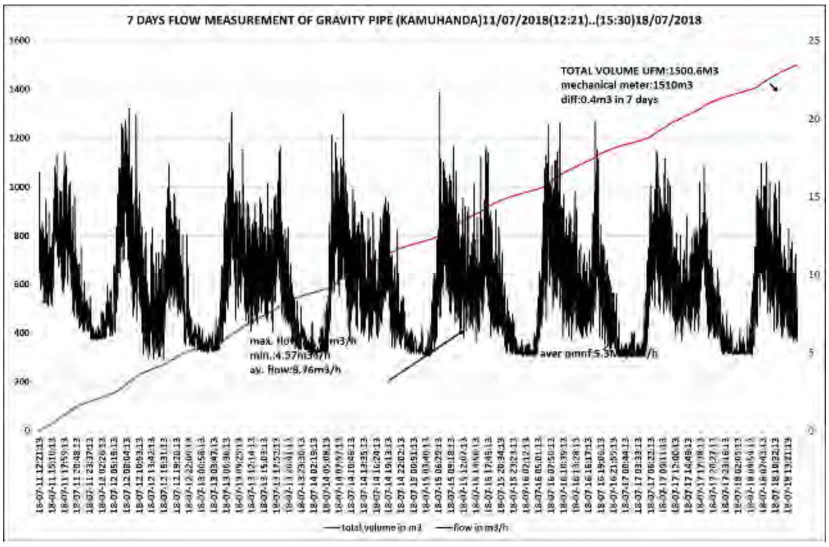


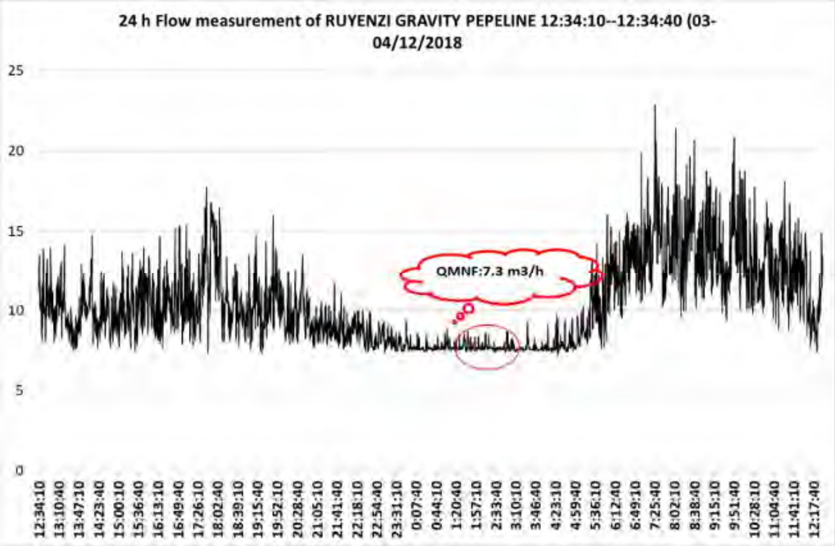


Result of the step test in RY1

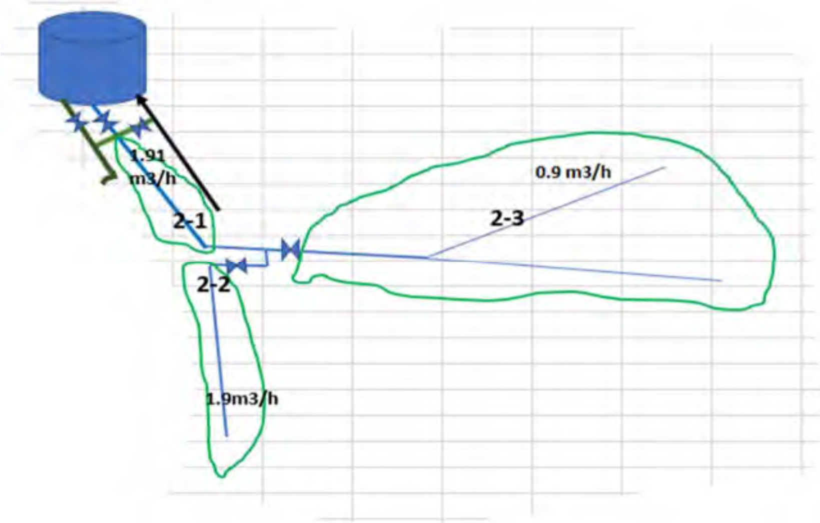
3. RY2

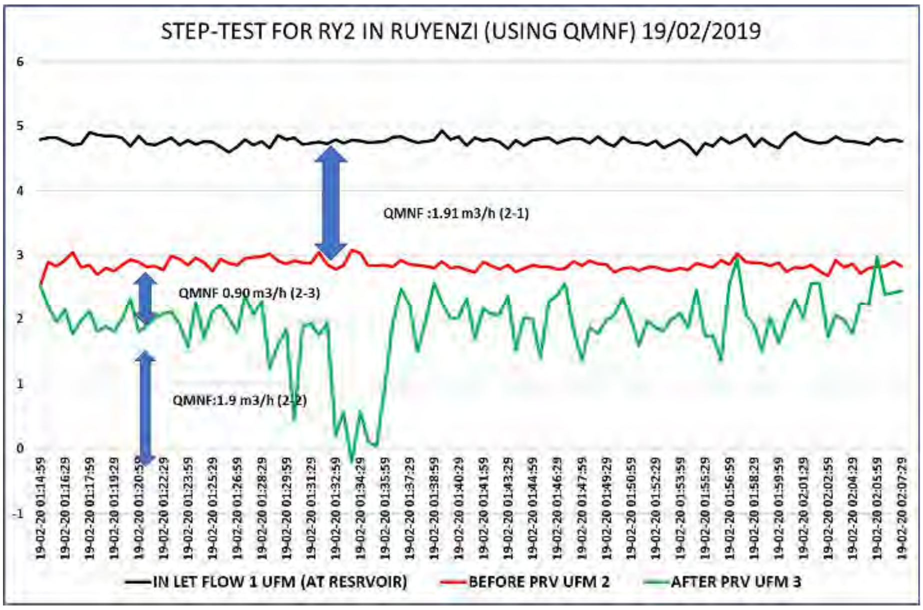




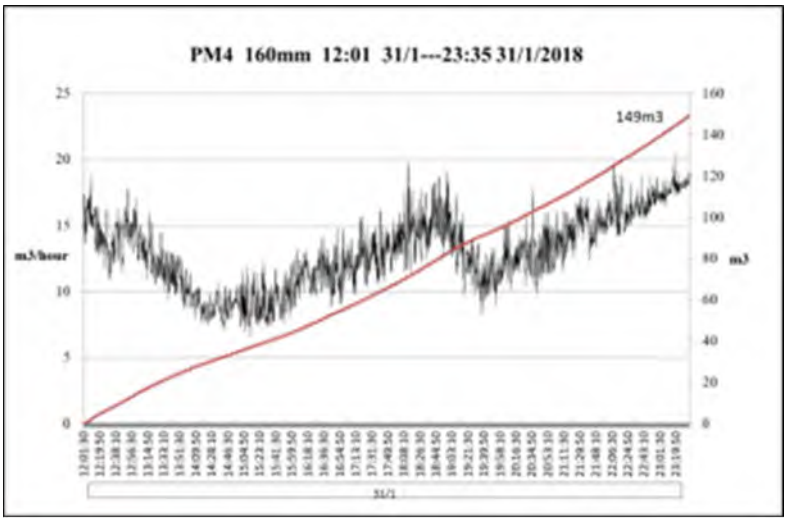


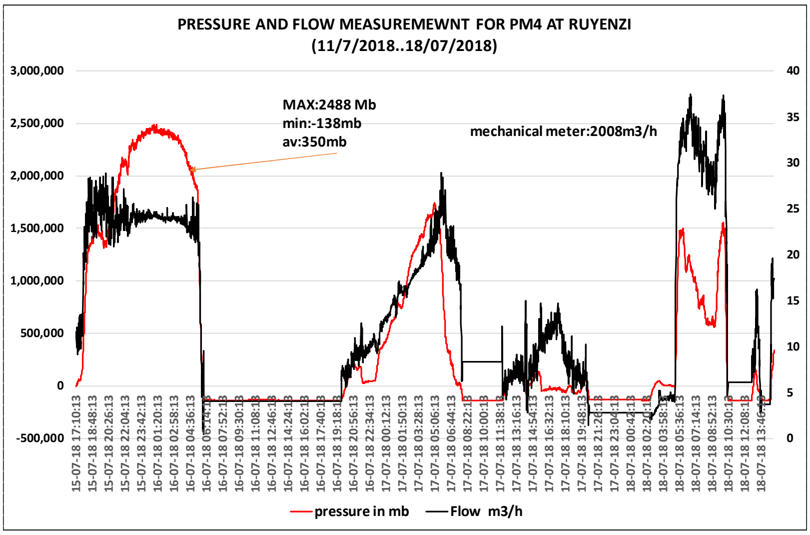
Result of the Qmnf measurement in RY2 (Gravity line) (December 3-4)

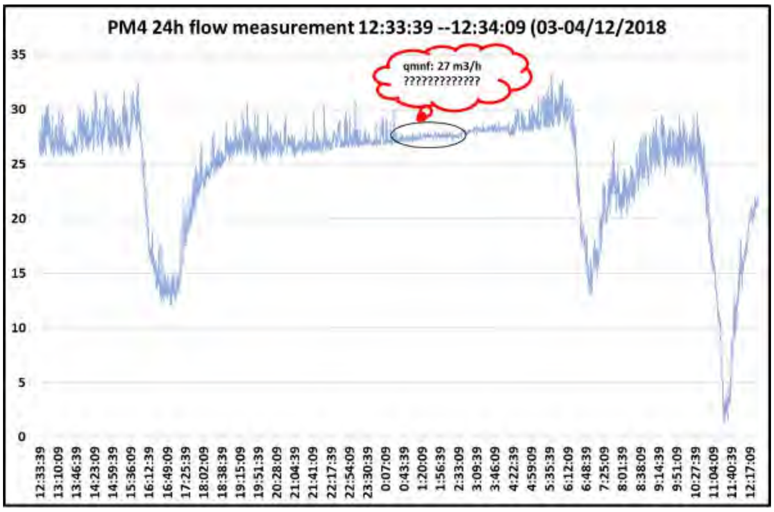

1.91
m3/h
0.9 m3/h
2-1
2-3
2-2
1.9m3/h


STEP-TEST FOR RY2 IN RUYENZI (USING QMNF) 19/02/2019
6
5
4
3
2
1
0
-1
QMNF :1.91 m3/h (2-1)
QMNF 0.90 m3/h (2-3)
QMNF:1.9 m3/h (2-2)
19-02-20 01:14:59
19-02-20 01:16:29
19-02-20 01:17:59
19-02-20 01:19:29
19-02-20 01:20:59
19-02-20 01:22:29
19-02-20 01:23:59
19-02-20 01:25:29
19-02-20 01:26:59
19-02-20 01:28:29
19-02-20 01:29:59
19-02-20 01:31:29
19-02-20 01:32:59
19-02-20 01:34:29
19-02-20 01:35:59
19-02-20 01:37:29
19-02-20 01:38:59
19-02-20 01:40:29
19-02-20 01:41:59
19-02-20 01:43:29
19-02-20 01:44:59
19-02-20 01:46:29
19-02-20 01:47:59
19-02-20 01:49:29
19-02-20 01:50:59
19-02-20 01:52:29
19-02-20 01:53:59
19-02-20 01:55:29
19-02-20 01:56:59
19-02-20 01:58:29
19-02-20 01:59:59
19-02-20 02:01:29
19-02-20 02:02:59
19-02-20 02:04:29
19-02-20 02:05:59
19-02-20 02:07:29
IN LET FLOW 1 UFM (AT RESRVOIR)
BEFORE PRV UFM 2
AFTER PRV UFM 3

4. RY3


PM4 160mm 12:01 31/1---23:35 31/1/2018
149m3
m3/hour
m3
0
5
10
15
20
25
0
20
40
60
80
100
120
140
160
31/1


PRESSURE AND FLOW MEASUREMEWNT FOR PM4 AT RUYENZI
(11/7/2018..18/07/2018)
MAX:2488 Mb
min:-138mb
av:350mb
mechanical meter:2008m3/h
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
-500,000
40
35
30
25
20
15
10
5
0
pressure in mb
Flow m3/h

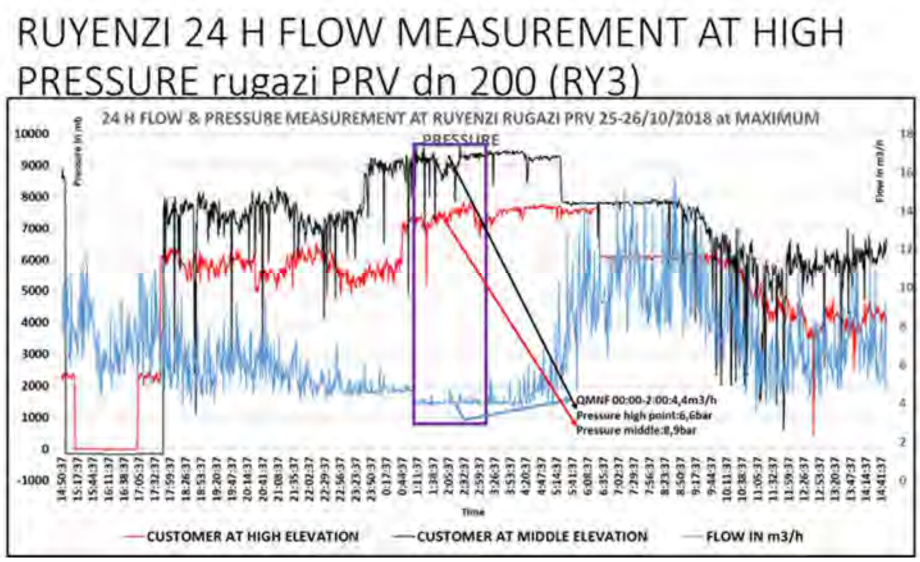

PM4 24h flow measurement 12:33:39 --12:34:09 (03-04/12/2018
qmnf: 27 m3/h
?????????????
35
30
25
20
15
10
5
0
12:33:39
13:10:09
13:46:39
14:23:09
14:59:39
15:36:09
16:12:39
16:49:09
17:25:39
18:02:09
18:38:39
19:15:09
19:51:39
20:28:09
21:04:39
21:41:09
22:17:39
22:54:09
23:30:39
0:07:09
0:43:39
1:20:09
1:56:39
2:33:09
3:09:39
3:46:09
4:22:39
4:59:09
5:35:39
6:12:09
6:48:39
7:25:09
8:01:39
8:38:09
9:14:39
9:51:09
10:27:39
11:04:09
11:40:39
12:17:09

Measurement of the effect of PRVs

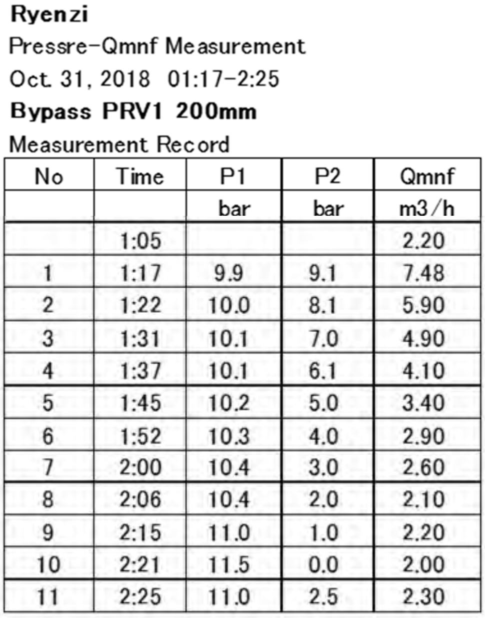
1） PRV1

Measurement of the effect of PRV1 (in Ruyenzi)

Date	Activity	Description and result
Oct. 25-26, 2018	Measurement of baseline Qmnf	As there was not an appropriate location to install an ultrasonic flow meter just downstream of PRV1, one of the two diverging pipelines (HDPE 110) further downstream was excavated and the meter was installed on the pipeline. Qmnf was measured at 4.4. m3/h (P2: 6.6 bars). (These values of P2 and Qmnf were almost the same as those measured in the staged measurement conducted on the 31st.) However, because the valve could not be opened fully in the measurement conducted on the 26th, Qmnf of 7.48 m3/h recorded in the beginning of the measurement on the 31st with PRV1 fully open (P2: 9.1 bars) was adopted as the baseline Qmnf.
Oct. 31, 2018	Staged measurement	Qmnf was measured while P2 was reduced stepwise from the condition that the valve was fully open (the condition simulating that without PRV) to measure the Qmnf reduction effect of the valve. The measurement revealed a correlation between P2 and Qmnf: Whenever the pressure was reduced by a step, Qmnf clearly decreased. The final pressure setting: P2 at 2.5 bars (Qmnf: 2.4 m3/h)
Nov. 7-8, 2018	Measurement of Qmnf reduction effect	Qmnf was measured on the 8th. The measurement revealed a decrease of Qmnf from 7.48 m3/h in the case without PRV (P2: 9.1 bar) to 1.5 m3/h in the case that the water pressure was reduced by the installed PRV (P2: 2.2 bars) measured on the 8th, or a Qmnf reduction effect of 5.98 m3/h (or 80 %) (with the pressure reduction of 6.9 bars). The final pressure setting of P2 at 2.5 bars was adopted temporarily. Because the water pressure at water taps near PRV1 was low with this pressure setting, the setting was modified to P2 at 3.5 bars on Feb. 6, 2019.


RUYENZI 24 H FLOW MEASUREMENT AT HIGH PRESSURE rugazi PRV dn 200 (RY3)

Qmnf:4.4m3/



Ryenzi

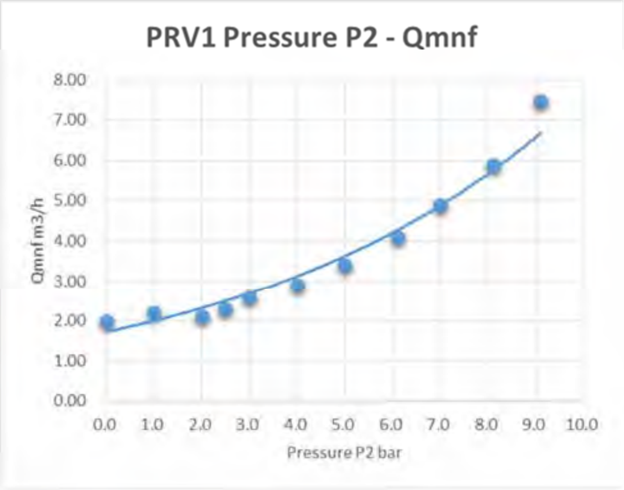
Pressre-Qmnf Measurement

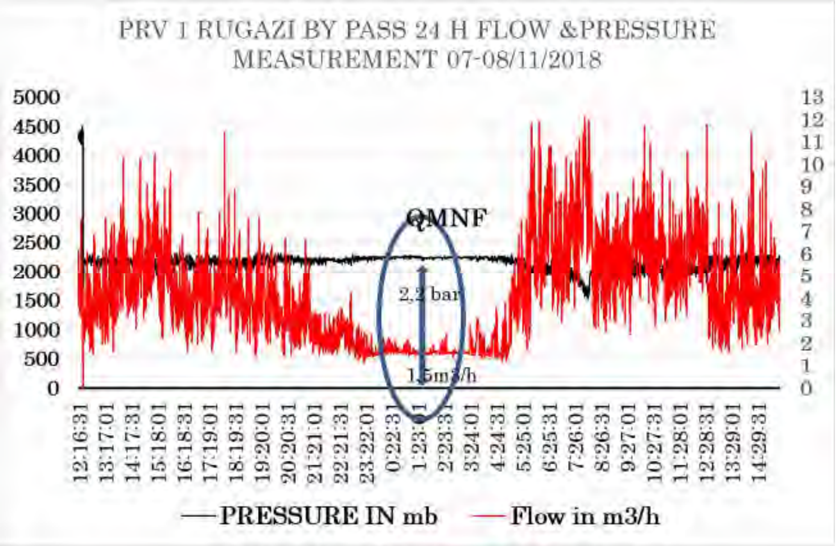
Oct. 31, 2018 01:17-2:25

Bypass PRV1 200mm

Measurement Record

No	Time	P1	P2	Qmnf
		bar	bar	m3/h
	1:05			2.20
1	1:17	9.9	9.1	7.48
2	1:22	10.0	8.1	5.90
3	1:31	10.1	7.0	4.90
4	1:37	10.1	6.1	4.10
5	1:45	10.2	5.0	3.40
6	1:52	10.3	4.0	2.90
7	2:00	10.4	3.0	2.60
8	2:06	10.4	2.0	2.10
9	2:15	11.0	1.0	2.20
10	2:21	11.5	0.0	2.00
11	2:25	11.0	2.5	2.30





Result of the Qmnf measurement downstream PRV1 (November 7-8)

Water pressure measurement at PRV1 (October 25))

PRV Survey	
Date	25th October, 2018
Place	Ruyenzi
PRV1: 200mm	1475

Pressure Reading (bar)

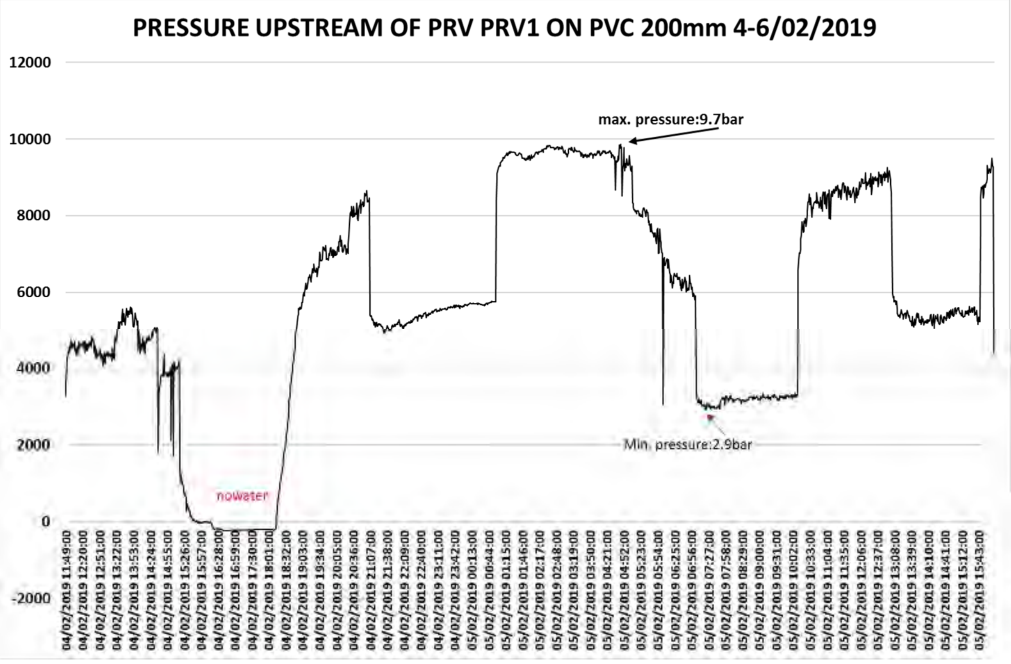
Day	Time	Flow Rate	P1	P2	Difference	Opening
		m3/h	bar	bar		
25	10:05	6.4	7.5	2.5	5.0	No touch
25	12:20	8.3	8.0	5.0	3.0	Full Open （Fail）
26	15:26	5.5	8.0	2.0	6.0	
26	15:40		8.0	8.0	0.0	Full Open （Success）
26	15:47		8.0	2.0	6.0	Adjusted to 15:26

Flowmeter (m3/h)

Day	Time		Flow Rate	For		Place
			m3/h			
25	12:10		6.4	Setting Up		Down S of PRV
25	12:05		8.3	Full Open		Down S of PRV
26	14:53		5.5	Removed		Down S of PRV

POC Pressure measurement (bar)

Day	Time		Pressure	Device		POC No
			bar			
25	11:17		–	–		~~240215084~~
25	11:33		2.5	Manometer	Data Logger	240214522
25	13:03	解放後	~~3.4~~	~~Manometer~~		~~240215065~~
25	13:36	解放後	6.9	Manometer	Data Logger	240219069
25	13:45	解放後	–	–		~~240216735~~
25	14:21	解放後	16.0	Manometer		240216098
26	14:50	解放後			Data Logger	240214522
26	13:36	解放後			Data Logger	240219069

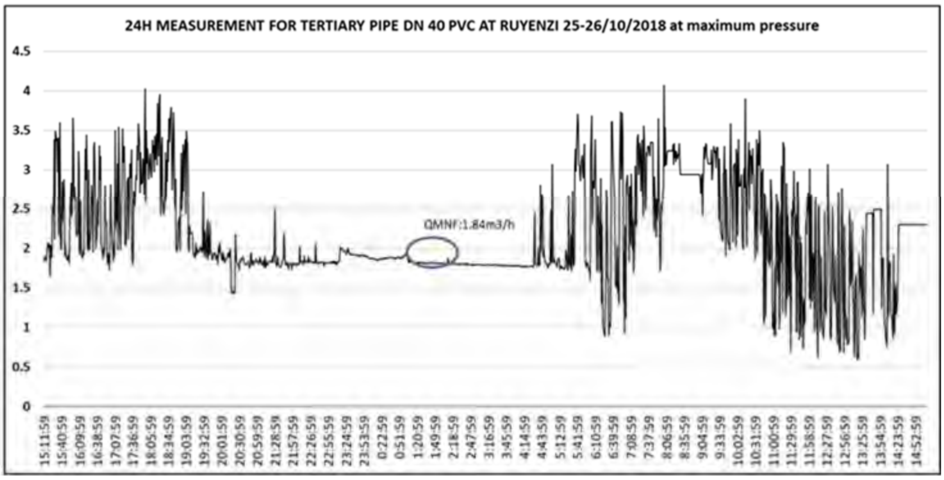


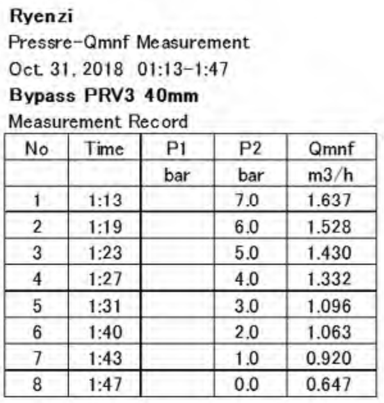
2） PRV3

Measurement of the effect of PRV3 (in Ruyenzi)

Date	Activity	Description and result
Oct. 25-26, 2018	Measurement of baseline Qmnf	The baseline Qmnf was measured with PRV installed on the bypass pipeline fully open (P1:4.0 bars, P2: 4.0 bars). Qmnf was 1.84 m3/h.
Oct. 31, 2018	Staged measurement	Qmnf was measured while P2 was reduced stepwise from the condition that the valve was fully open (the condition simulating that without PRV) to measure the Qmnf reduction effect of the valve. The measurement revealed a correlation between P2 and Qmnf: Whenever the pressure was reduced by a step, Qmnf clearly decreased. The final pressure setting: P2: 1.0 bar (Qmnf: 0.92 m3/h)
Nov. 15-16, 2018 (The measurement attempted on the 7th and 8th failed.)	Measurement of Qmnf reduction effect	Qmnf measurement was conducted. The measurement revealed a decrease of Qmnf from 1.84 m3/h in the case without PRV (P2: 4.0 bars) to 0.78 m3/h in the case that the water pressure was reduced by the installed PRV (P2: 1.0 bar), or a Qmnf reduction effect of 1.06 m3/h (or 58 %) (with the pressure reduction of 3.0 bars).

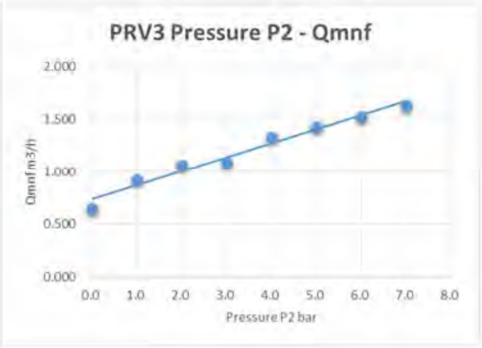
RUYENZI TRRTIARY PIPE DN 40 (RY1)



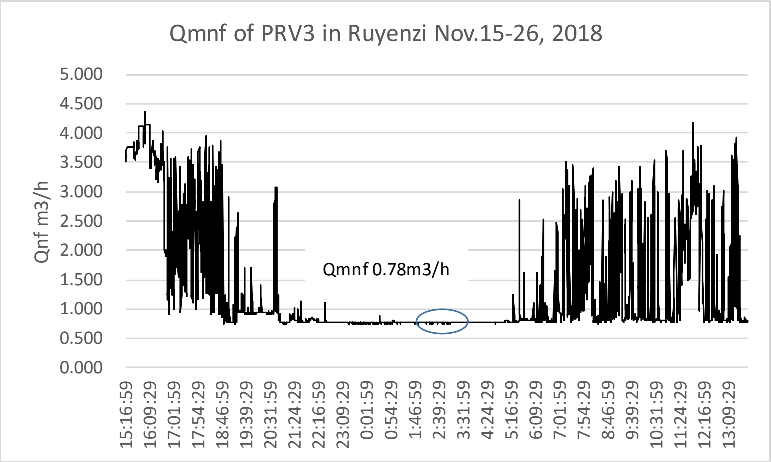


Ryenzi
Pressre-Qmnf Measurement
Oct. 31, 2018 01:13-1:47
Bypass PRV3 40mm
Measurement Record

No	Time	P1	P2	Qmnf
		bar	bar	m3/h
1	1:13		7.0	1.637
2	1:19		6.0	1.528
3	1:23		5.0	1.430
4	1:27		4.0	1.332
5	1:31		3.0	1.096
6	1:40		2.0	1.063
7	1:43		1.0	0.920
8	1:47		0.0	0.647

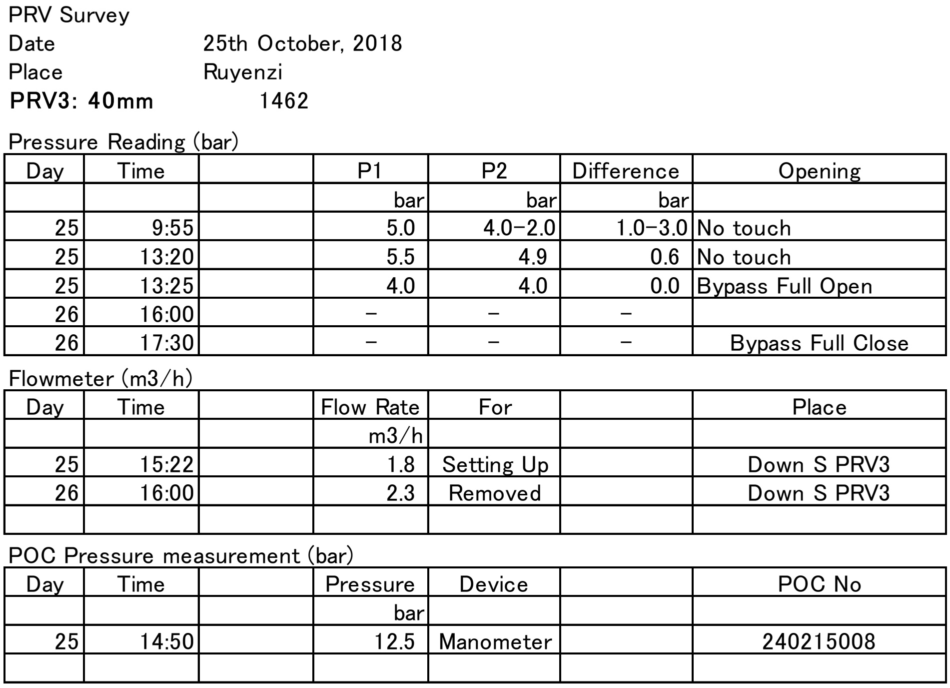


Result of the Qmnf measurement downstream of PRV1 (November 7-8)



Result of the Qmnf measurement downstream of PRV3 (November 15-16)

Water pressure measurement at PRV3 (October 25-26, 2018)



PRV Survey
Date 25th October, 2018
Place Ruyenzi
PRV3: 40mm 1462

Pressure Reading (bar)

Day	Time		P1	P2	Difference	Opening
			bar	bar	bar	
25	9:55		5.0	4.0–2.0	1.0–3.0	No touch
25	13:20		5.5	4.9	0.6	No touch
25	13:25		4.0	4.0	0.0	Bypass Full Open
26	16:00		–	–	–	
26	17:30		–	–	–	Bypass Full Close

Flowmeter (m3/h)

Day	Time		Flow Rate	For		Place
			m3/h			
25	15:22		1.8	Setting Up		Down S PRV3
26	16:00		2.3	Removed		Down S PRV3

POC Pressure measurement (bar)

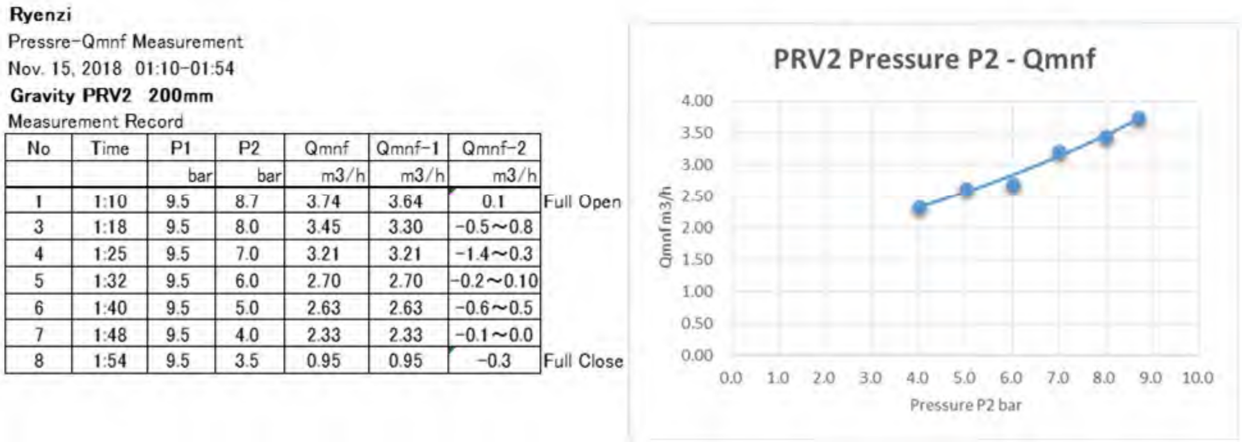
Day	Time		Pressure	Device		POC No
			bar			
25	14:50		12.5	Manometer		240215008

3） **PRV2**

Measurement of the effect of PRV2 (in Ruyenzi)

Date	Activity	Description and result
Nov. 15, 2018	Measurement of baseline Qmnf	An ultrasonic flow meter was installed just upstream of the PRV. The Qmnf measurement of 3.74 m3/h taken at the beginning of the staged measurement on the 15th while PRV was kept as open as possible (P2: 8.7 bars) was used as the baseline Qmnf.
Nov. 15, /2018	Staged measurement	Qmnf was measured while P2 was reduced stepwise from the condition that the valve was as open as possible to measure the Qmnf reduction effect of the valve. The measurement revealed a correlation between P2 and Qmnf: Whenever the pressure was reduced by a step, Qmnf clearly decreased. A sharp drop of Qmnf

		was observed when the pressure was reduced below 4 bars. However, the water flow from water taps in the high elevation area was reduced when P2 was reduced below 6.0 bars. For these reasons, the final pressure setting of P2 = 6.0 bars (Qmnf = 2.70 m3/h) was adopted.
Nov. 7, 2018	Measurement of Qmnf reduction effect	There is an area above the elevation of PRV2, EL 1,410 m, downstream of the valve. The highest point in this area is at EL 1,460 m. The measurement of the water pressure at water taps of customers in the highest area revealed that water barely reached the tap in this area (water pressure of 0.2 - 1.0 bar) when P2 was set at 5.5 bars. Therefore, P2 could only be reduced to around 6.0 bars. The Qmnf measurement taken in November 7 and 8 with P2 set at 6.0 bars was 2.6 m3/h Qmnf decreased from 3.74 m3/h in the case without PRV (P2: 8.7 bars) to 2.6 m3/h in the case that the water pressure was reduced by the installed PRV (P2: 6.0 bars), or a Qmnf reduction effect of 1.14 m3/h (or 30 %) (with the pressure reduction of 2.7 bars).



Ryenzi

Pressre-Qmnf Measurement

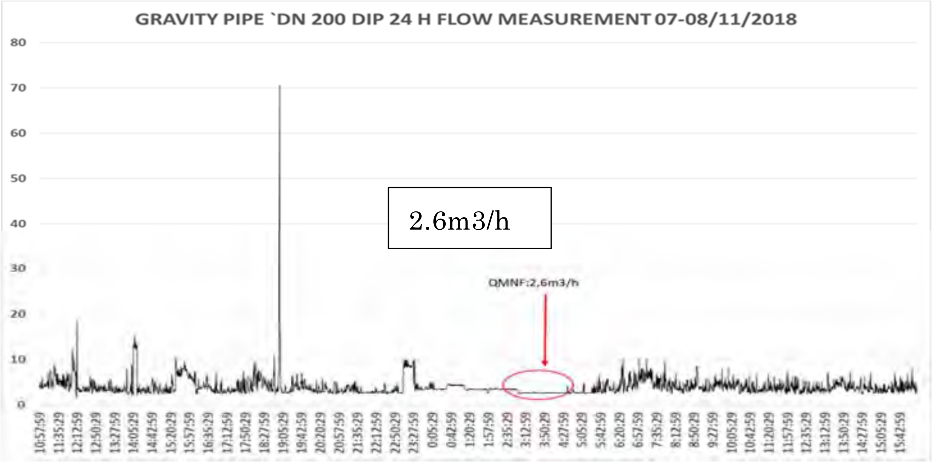
Nov. 15, 2018 01:10-01:54

Gravity PRV2 200mm

Measurement Record

No	Time	P1	P2	Qmnf	Qmnf-1	Qmnf-2	
		bar	bar	m3/h	m3/h	m3/h	
1	1:10	9.5	8.7	3.74	3.64	0.1	Full Open
3	1:18	9.5	8.0	3.45	3.30	-0.5~0.8	
4	1:25	9.5	7.0	3.21	3.21	-1.4~0.3	
5	1:32	9.5	6.0	2.70	2.70	-0.2~0.10	
6	1:40	9.5	5.0	2.63	2.63	-0.6~0.5	
7	1:48	9.5	4.0	2.33	2.33	-0.1~0.0	
8	1:54	9.5	3.5	0.95	0.95	-0.3	Full Close

Result of the measurement of the effect of PRV2 (staged measurement of P2-Qmnf)



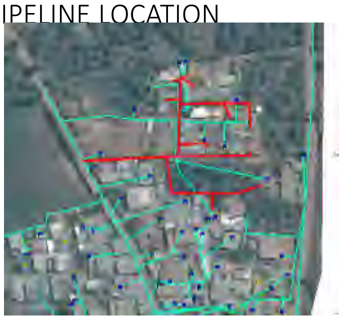
Result of the measurement of Qmnf downstream of PRV2 (in Ruyenzi) (November 7-8)

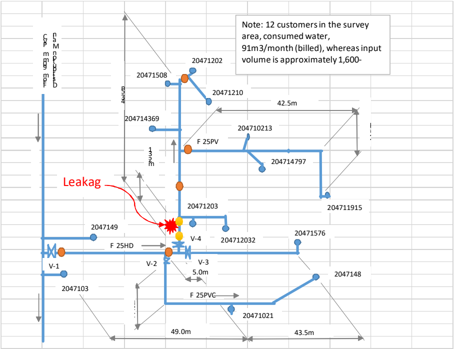
KADOBOGO PM3-2 result 21-22/03/2018

LEAKAGE SURVEY

ESRI MAP

EXACT PIPELINE LOCATION





Note: 12 customers in the survey area, consumed water, 91m3/month (billed), whereas input volume is approximately 1,600-

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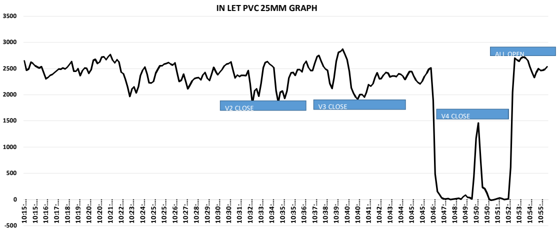
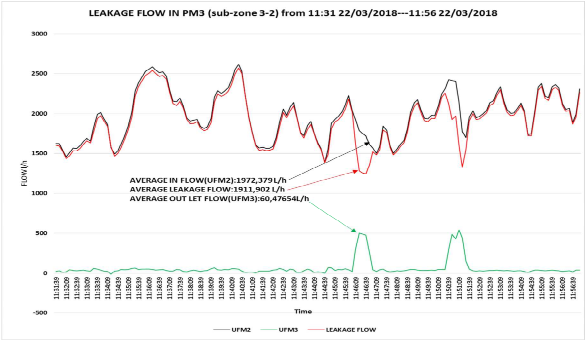
RESULTS OF LEAKAGE survey 22/03/2018

UFM1 GRAPH SHOWING THE CONSUMPTION OF 3 PIPELINE CONNECTED ON DN25 TERTIARY PIPE



Consumption of 3 pipeline supplied by dn 25 pipe

- V2 CLOSE (AVERAGE FLOW) WAS:2368 L/h
- Consumption V2=ALL-V2=160L/h
- V3 CLOSE :2331L/h
- Consumption V3=ALL-V3=197L/h
- V4 CLOSE:164L/h
- Consumption V4=ALL-V4=2364L/h
- ALL OPEN:2528L/h

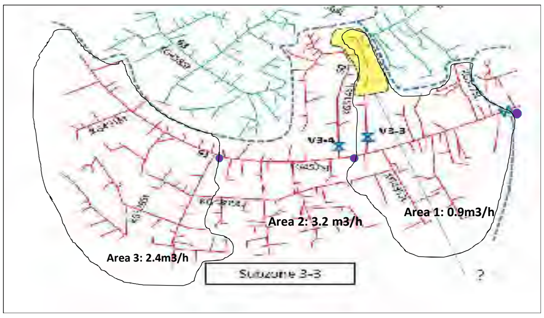


RESULTS OF LEAKAGE FOUND

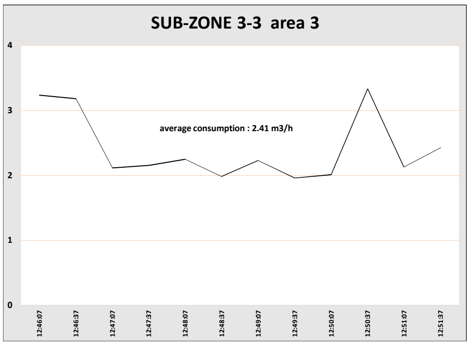
- **AVERAGE IN FLOW(UFM2):1972,379 L/h**
- **AVERAGE LEAKAGE FLOW:1911,902 L/h**
- **AVERAGE OUT LET FLOW(UFM3):60,47654L/h**

KADOBOGO leak survey progress

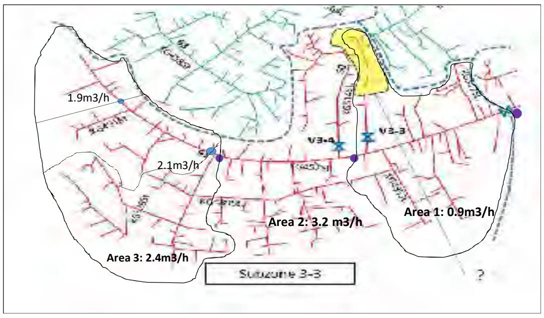
LEAKAGE SURVEY

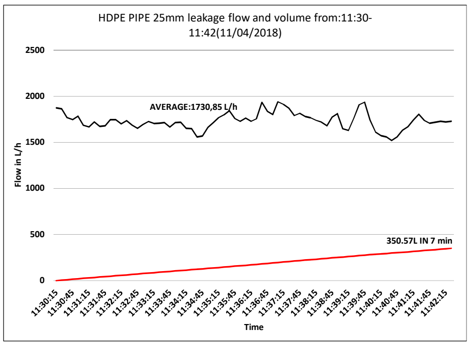


Area 3 is the first for leak survey because there have few customers and consumption is high(2.4m3/h)


SUB-ZONE 3-3 area 3

average consumption : 2.41 m3/h

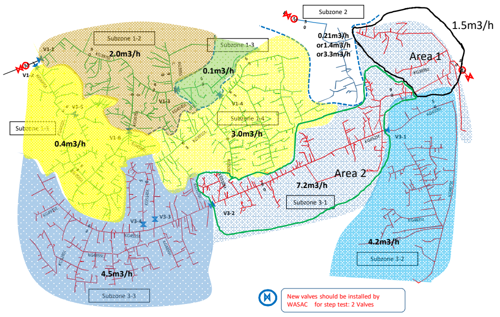


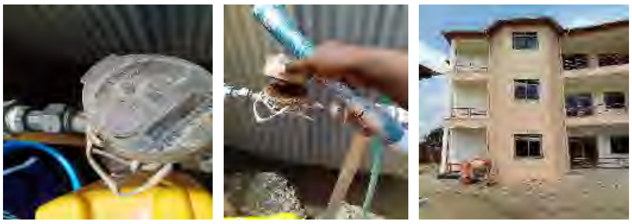

HDPE PIPE 25mm leakage flow and volume from:11:30-11:42(11/04/2018)

AVERAGE:1730,85 L/h

350.57L IN 7 min

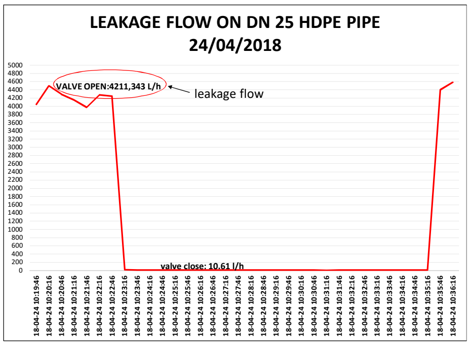
Kadobogo Subzone Map(11.01.2018)





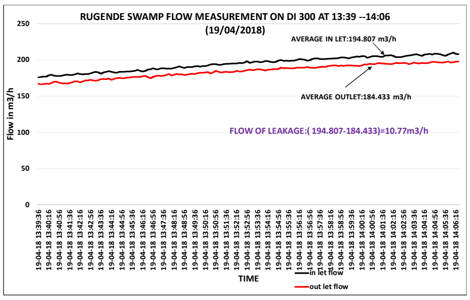
Poc: 204710983

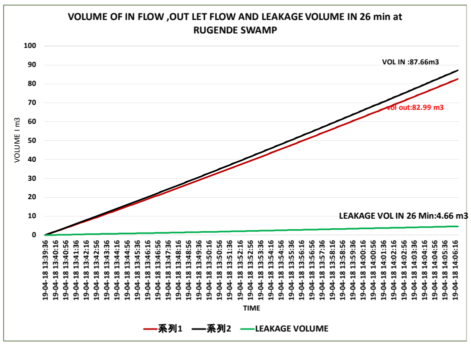
Invisible leakage on dn 25 HDPE pipe at pm 3 sub-zone 3-1



WHERE DID THAT WATER DISAPEAR???

LEAK SURVEY ON 18—20/04/2018 AT RUGENDE SWAMP dn 300 DI (KARENGE 1)

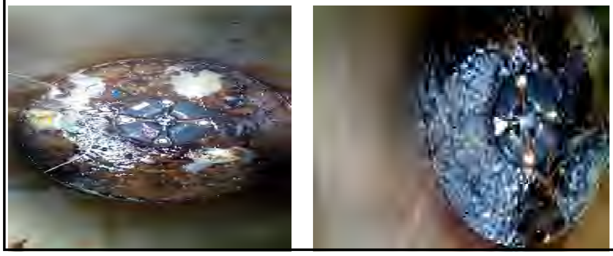




Leakage volume in rugende swamp

loss in 26 min	4.66m3
per hour(m3)	10.77m3
per day(m3)	258.55m3
per mounth (m3)	7756.573 m3

There also visible leakage at muyumbu on both AIR VALVES OF karenge 1&2

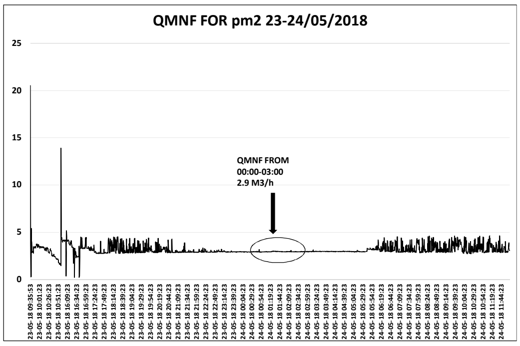


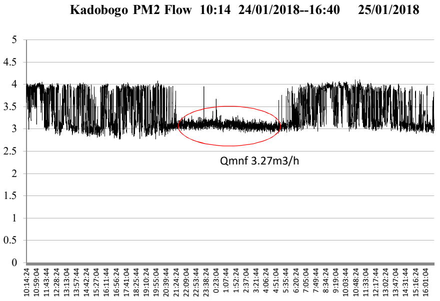
RUYENZI TERTIARY PIPE SURVEY 1

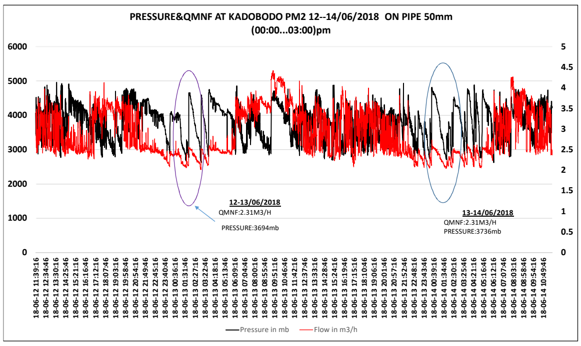
THX

KADOBOGO PM2

LEAKAGE SURVEY

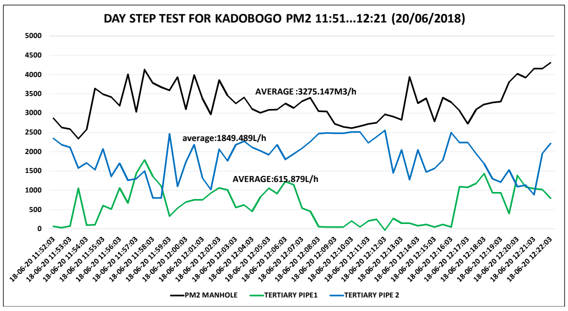


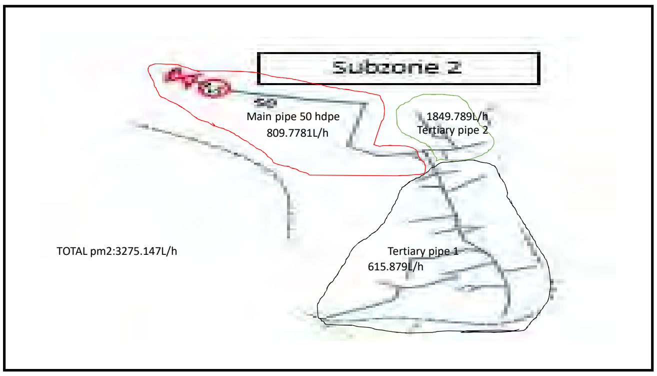




Qmnf comparison for pm2 before and after pipe replacement

- January 2018:3.27m3/h
- Pressure in manhole 7.5bar and lowest point:6bar
- June 2018:pressure 3694mb&3736mb,Flow:2.31m3/h(00:00..03:00)



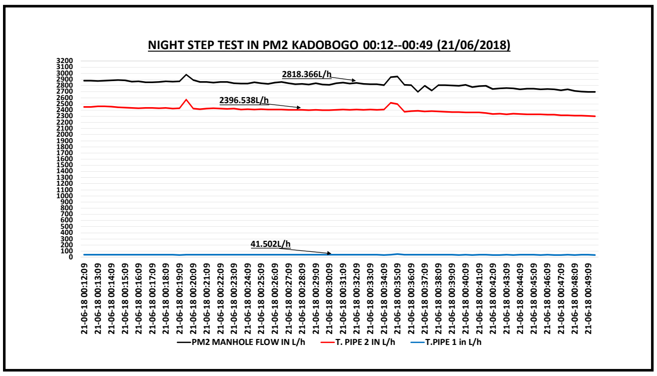

Subzone 2

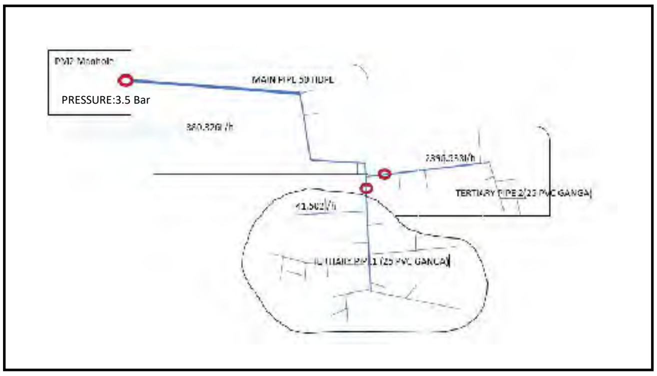
Main pipe 50 hdpe
809.7781L/h

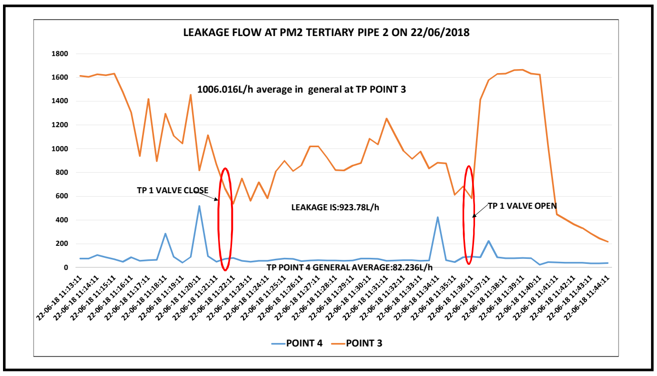
1849.789L/h
Tertiary pipe 2

TOTAL pm2:3275.147L/h

Tertiary pipe 1
615.879L/h


NIGHT STEP TEST IN PM2 KADOBOGO 00:12--00:49 (21/06/2018)


PRESSURE:3.5 Bar


LEAKAGE FLOW AT PM2 TERTIARY PIPE 2 ON 22/06/2018

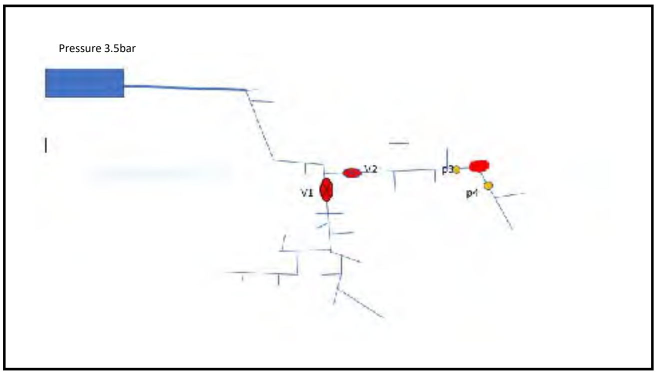
1006.016L/h average in general at TP POINT 3

TP 1 VALVE CLOSE

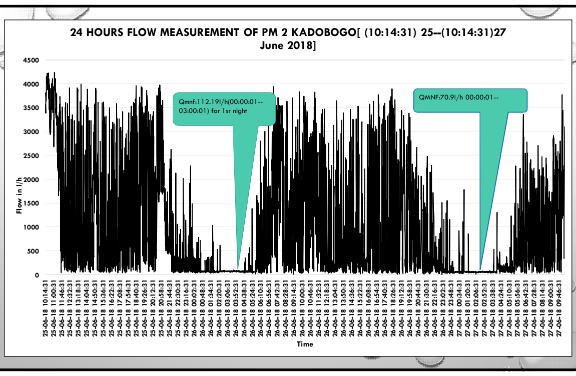
LEAKAGE IS:923.78L/h

TP 1 VALVE OPEN

TP POINT 4 GENERAL AVERAGE:82.236L/h


Pressure 3.5bar

WEEKLY REPORT
KADOBOGO&RUYENZI

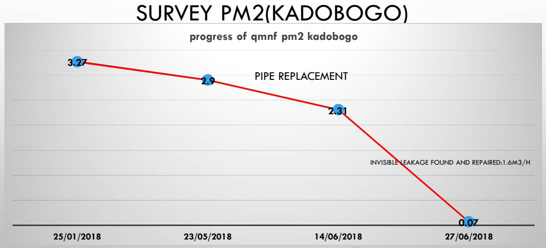


24 HOURS FLOW MEASUREMENT OF PM 2 KADOBOGO[(10:14:31) 25--(10:14:31)27 June 2018]

Qmnf:112.19l/h(00:00:01--03:00:01) for 1sr night

QMNF:70.9l/h 00:00:01--

QMNF PROGRESS BEFORE AND AFTER LEAKAGE SURVEY PM2(KADOBOGO)

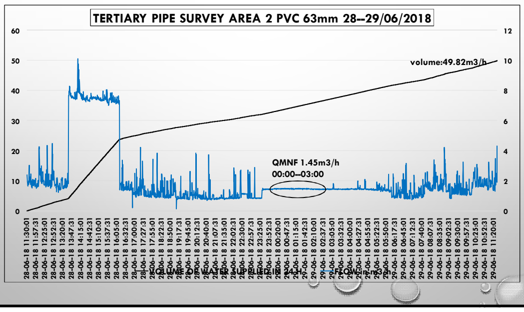


progress of qmnf pm2 kadobogo

PIPE REPLACEMENT

INVISIBLE LEAKAGE FOUND AND REPAIRED:1.6M3/H

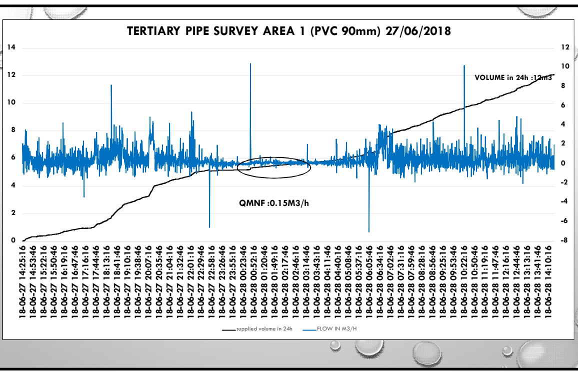
RUYENZI TERTIARY PIPE SURVEY



TERTIARY PIPE SURVEY AREA 2 PVC 63mm 28--29/06/2018

volume:49.82m3/h

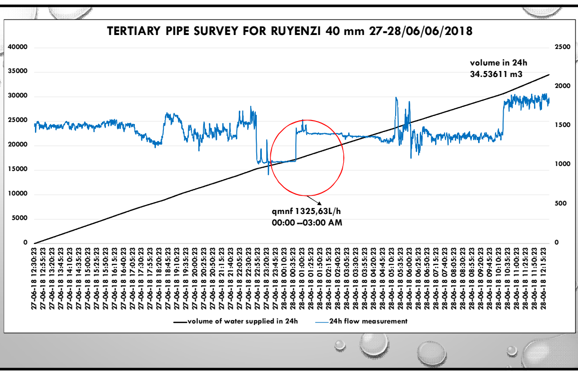
QMNF 1.45m3/h
00:00--03:00



TERTIARY PIPE SURVEY AREA 1 (PVC 90mm) 27/06/2018

VOLUME in 24h :12m3

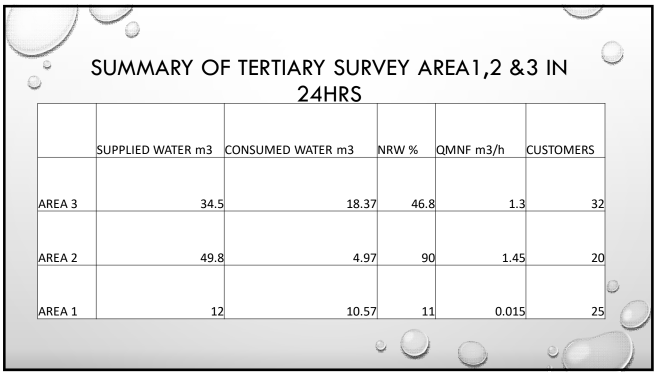
QMNF :0.15M3/h



TERTIARY PIPE SURVEY FOR RUYENZI 40 mm 27-28/06/06/2018

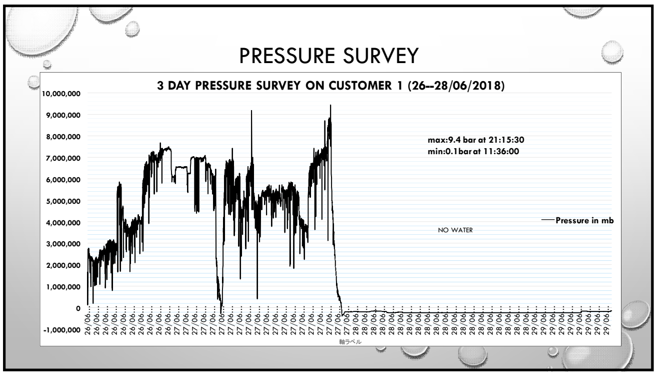
volume in 24h
34.53611 m3

qmnf 1325,63L/h
00:00 --03:00 AM



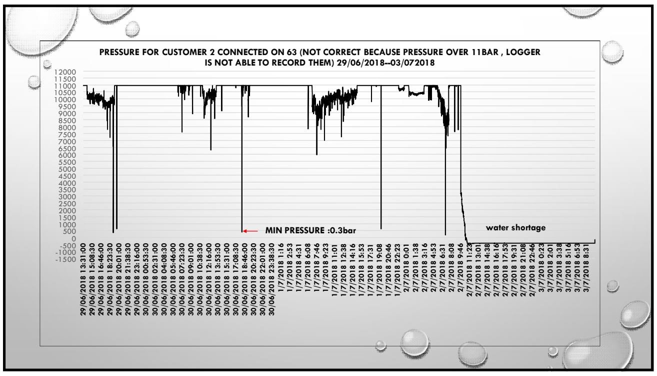
SUMMARY OF TERTIARY SURVEY AREA1,2 &3 IN 24HRS

	SUPPLIED WATER m3	CONSUMED WATER m3	NRW %	QMNF m3/h	CUSTOMERS
AREA 3	34.5	18.37	46.8	1.3	32
AREA 2	49.8	4.97	90	1.45	20
AREA 1	12	10.57	11	0.015	25

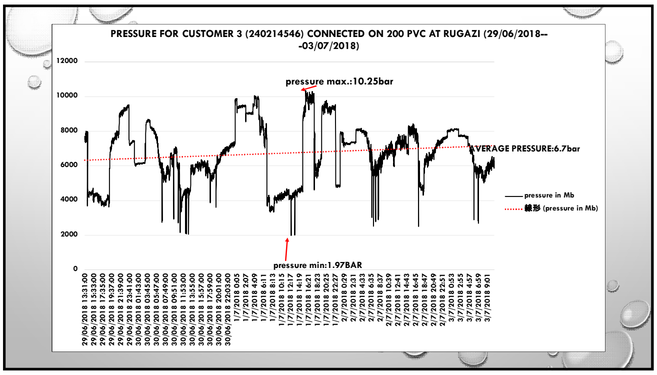


PRESSURE SURVEY

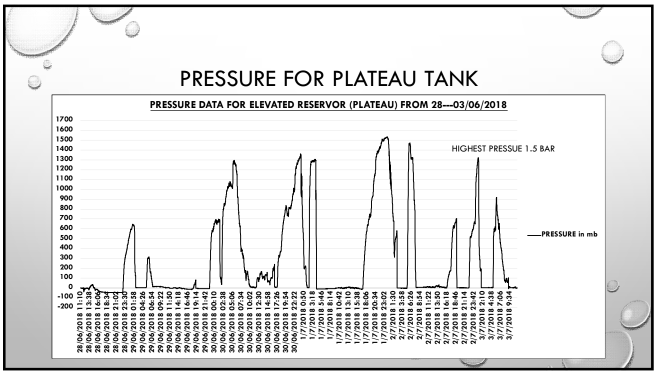
3 DAY PRESSURE SURVEY ON CUSTOMER 1 (26--28/06/2018)



PRESSURE FOR CUSTOMER 2 CONNECTED ON 63 (NOT CORRECT BECAUSE PRESSURE OVER 11BAR , LOGGER IS NOT ABLE TO RECORD THEM) 29/06/2018--03/072018

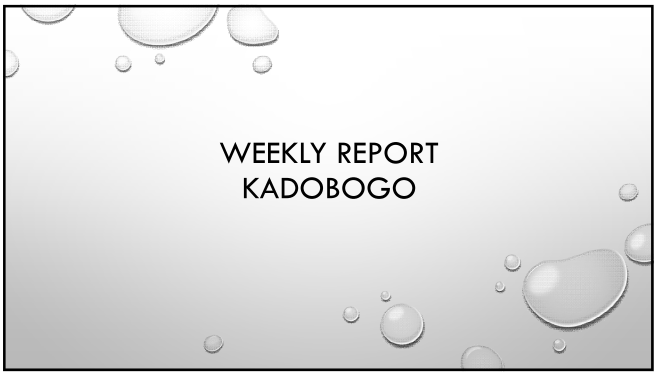


PRESSURE FOR CUSTOMER 3 (240214546) CONNECTED ON 200 PVC AT RUGAZI (29/06/2018---03/07/2018)

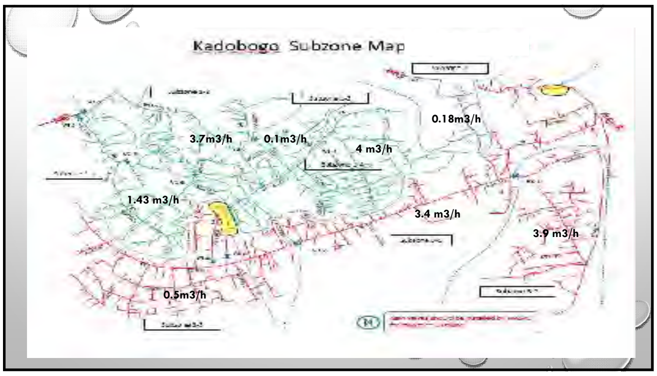


PRESSURE FOR PLATEAU TANK

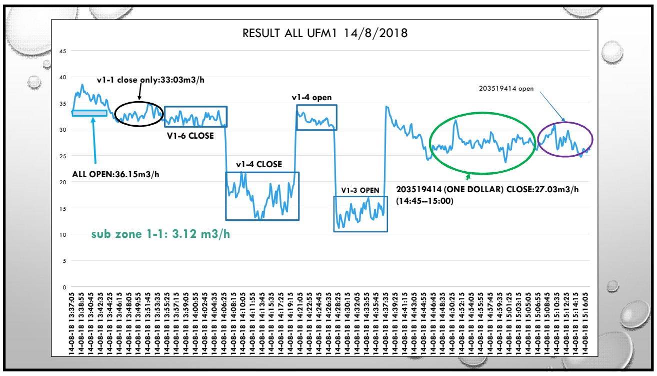
PRESSURE DATA FOR ELEVATED RESERVOR (PLATEAU) FROM 28---03/06/2018



WEEKLY REPORT
KADOBOGO



Kadobogo Subzone Map



RESULT ALL UFM1 14/8/2018

v1-1 close only:33:03m3/h

ALL OPEN:36.15m3/h

V1-6 CLOSE

v1-4 CLOSE

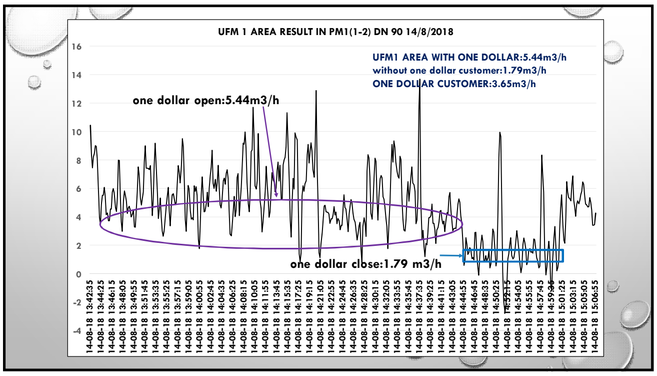
v1-4 open

V1-3 OPEN

203519414 open

203519414 (ONE DOLLAR) CLOSE:27.03m3/h (14:45--15:00)

sub zone 1-1: 3.12 m3/h

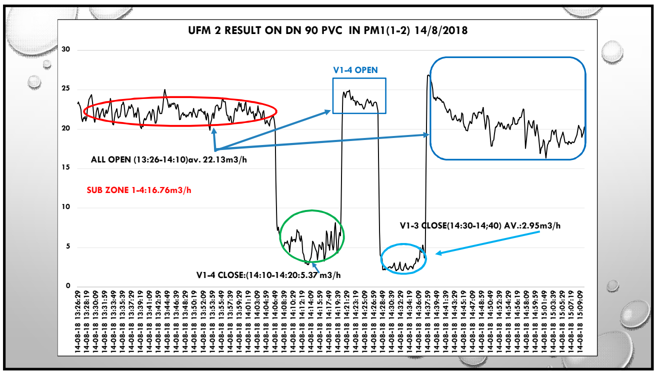


UFM 1 AREA RESULT IN PM1(1-2) DN 90 14/8/2018

UFM1 AREA WITH ONE DOLLAR:5.44m3/h
without one dollar customer:1.79m3/h
ONE DOLLAR CUSTOMER:3.65m3/h

one dollar open:5.44m3/h

one dollar close:1.79 m3/h



UFM 2 RESULT ON DN 90 PVC IN PM1(1-2) 14/8/2018

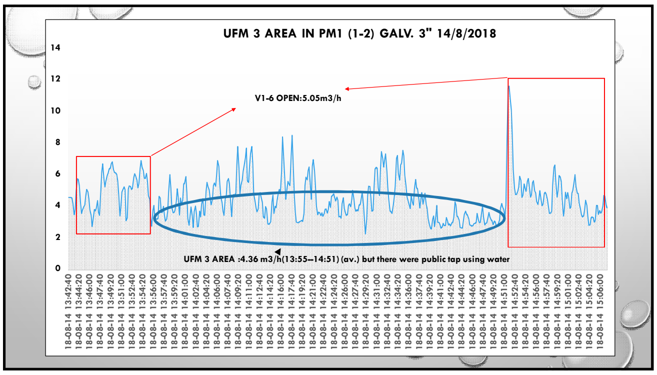
V1-4 OPEN

ALL OPEN (13:26-14:10)av. 22.13m3/h

SUB ZONE 1-4:16.76m3/h

V1-3 CLOSE(14:30-14;40) AV.:2.95m3/h

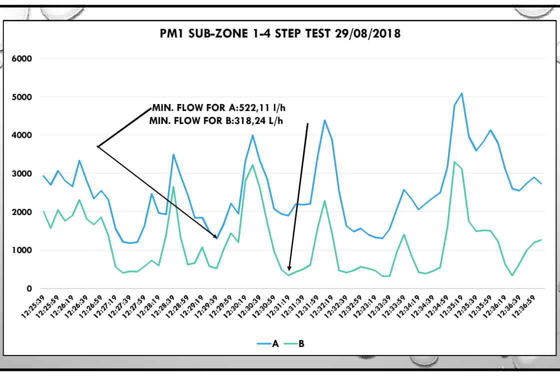
V1-4 CLOSE:(14:10-14:20:5.37 m3/h

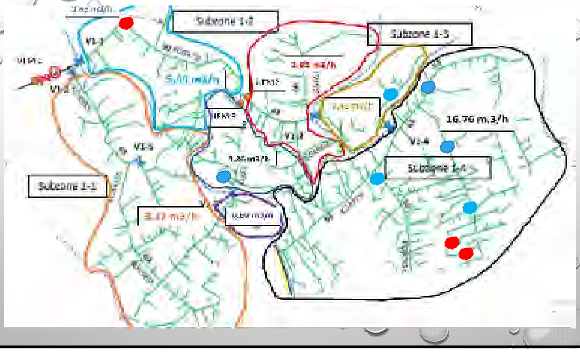


UFM 3 AREA IN PM1 (1-2) GALV. 3" 14/8/2018

V1-6 OPEN:5.05m3/h

UFM 3 AREA :4.36 m3/h(13:55--14:51) (av.) but there were public tap using water





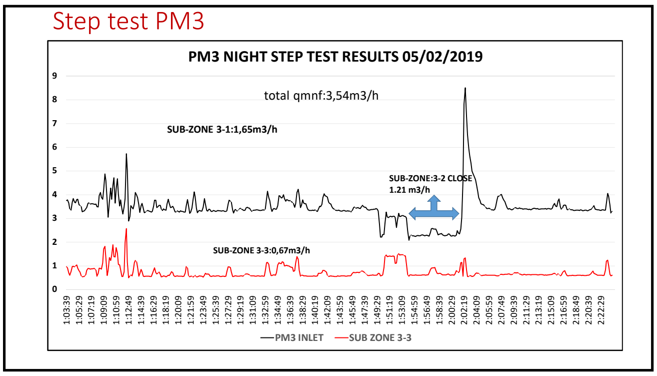
Flow Measurement at Subzone 1-4

Total Inflow: 5.8m3/h, 247 customers

THX

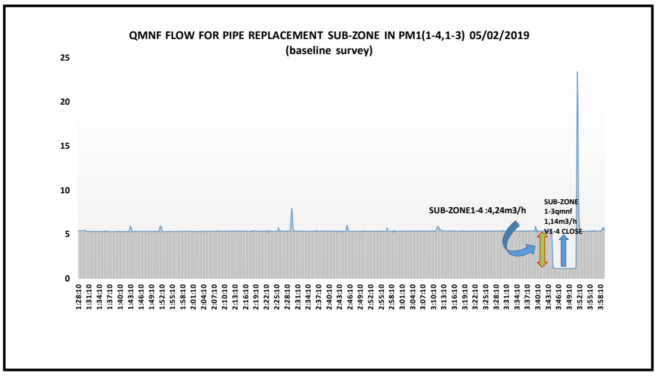
WEEKLY REPORT

STEP-TEST (RUYENZI RY1 & PM3 KADOBOGO)

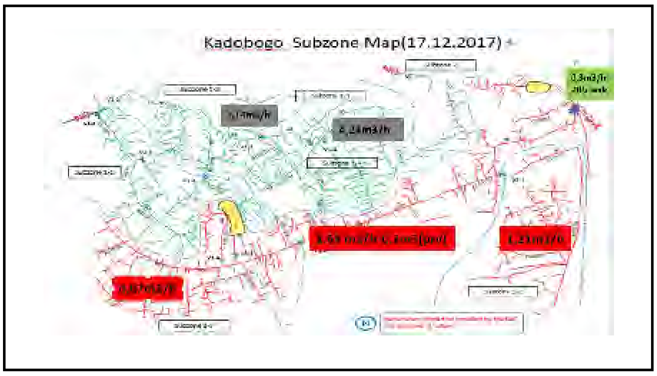


Step test PM3

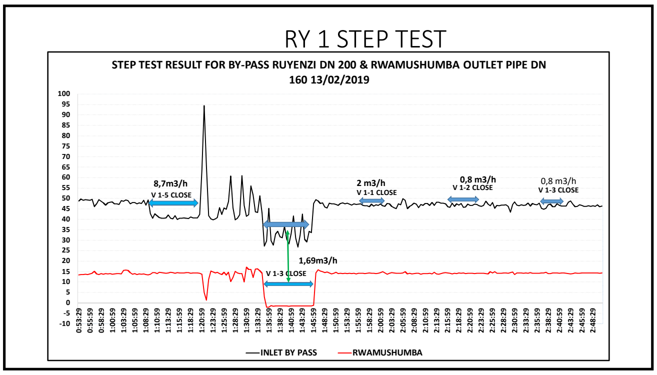
PM3 NIGHT STEP TEST RESULTS 05/02/2019



QMNF FLOW FOR PIPE REPLACEMENT SUB-ZONE IN PM1(1-4,1-3) 05/02/2019 (baseline survey)

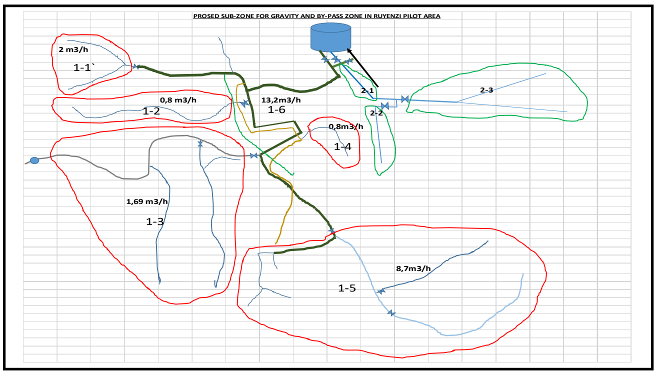


Kadobogo Subzone Map(17.12.2017)



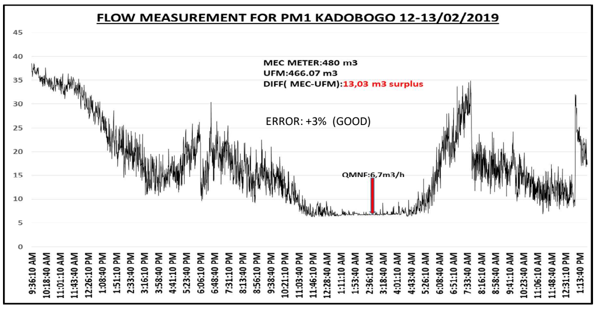
RY 1 STEP TEST

STEP TEST RESULT FOR BY-PASS RUYENZI DN 200 & RWAMUSHUMBA OUTLET PIPE DN 160 13/02/2019



PROSED SUB-ZONE FOR GRAVITY AND BY-PASS ZONE IN RUYENZI PILOT AREA

MEC. METER ACCURACY TEST (PM1 KADOBOGO



WAY FORWARD

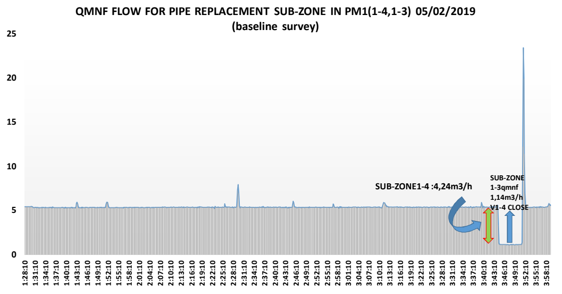
- At Pm3 there we will continue to detect leakage on (3-1 &3-2).
- Ruyenzi (1-5& 1-6) we have to conduct modified step test, then after we start leakage detection.
- For Kadobogo PM1 (1-4 &1-3) they are replacing low quality materials by the news one. So after replacement we will see if the qmnf will still high then take other measures.

THX

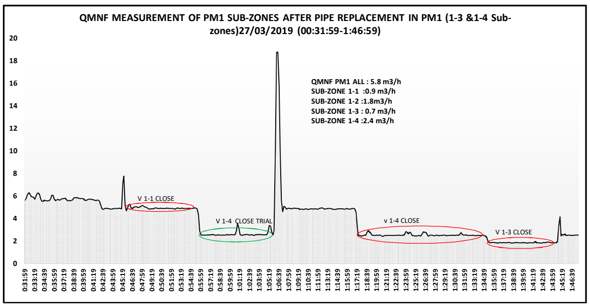
PROGRESS REPORT

PILOT AREA (KADOBOGO & RUYENZI)

KADOBOGO

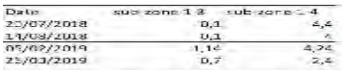


Step test PM1 AFTER PIPE REPLACEMENT



PM1 STEP TEST 26/03/2019(AFTER PIPE REPLACEMENT)

EFFECT OF PIPE REPLACEMENT IN PM1 (SUB-ZONE 1-4 & 1-3)



Date	sub-zone 1-3	sub-zone 1-4
20/07/2018	0,1	4,4
14/08/2018	0,1	4
05/02/2019	1,14	4,24
25/03/2019	0,7	2,4