REPUBLIC OF KENYA
WATER RESOURCES AUTHORITY

REPUBLIC OF KENYA
WATER RESOURCES MANAGEMENT EXPERT

COMPLETION REPORT

MAY 2019

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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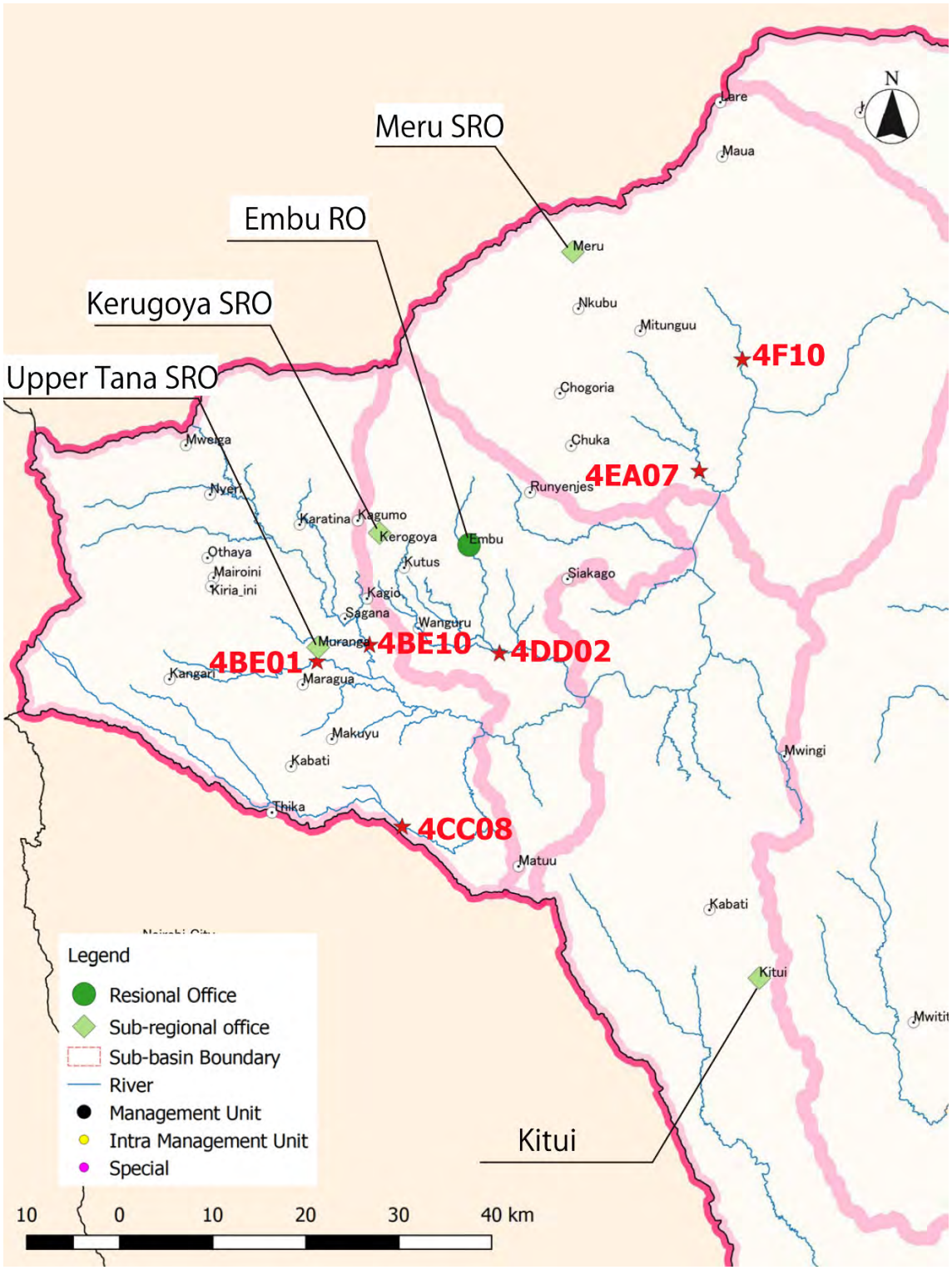
Location Map of Target Area of the Project



Location Map of Tana Catchment (Pilot Project Area)

Republic of Kenya
Water Resources Management Expert
Completion Report

Location Map of Target Area of the Project
Location Map of Tana Catchment (Pilot Project Area)

Table of Contents

List of Tables

Page

List of Figures

Page

Abbreviations

CEO	:	Chief Executive Officer
CMS	:	Catchment Management Strategy
CP	:	Counterpart Personnel
GIS	:	Geographic Information System
GIZ	:	German International Cooperation
GPRS	:	Global Packet Radio Services
GPS	:	Global Positioning System
GSM	:	Global System for Mobile Communication
HQ	:	Headquarter
IWRM	:	Integrated Water Resources Management
JICA	:	Japan International Cooperation Agency
KMD	:	Kenya Meteorological Department
KEWI	:	Kenya Water Institute
KWSCRP	:	Kenya Water Security and Climate Resilience Project
MWI	:	Ministry of Water and Irrigation
MWS	:	Ministry of Water and Sanitation
NWMP	:	National Water Master Plan
O&M	:	Operation and Maintenance
RGS	:	Regular Gauging Station
RM	:	Regional Manager
RO	:	Regional Office
SRM	:	Sub-regional Manager
SRO	:	Sub-regional Office
SWO	:	Surface Water Officer
TCA	:	Tana Catchment Area
WB	:	World Bank
WRA	:	Water Resources Authority
WRM	:	Water Resources Management
WRUA	:	Water Resources Users Association

Units

Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer

Area

ha	=	hectare
m^2	=	square meter
km^2	=	square kilometer

Volume

1, lit	=	liter
m^3	=	cubic meter
m^3/s, cms	=	cubic meter per second
CM	=	cubic meter
MCM	=	million cubic meter
BCM	=	billion cubic meter
m^3/d, cmd	=	cubic meter per day
BBL	=	Barrel

Weight

mg	=	milligram
g	=	gram
kg	=	kilogram
t	=	ton
MT	=	metric ton

Time

s	=	second
hr	=	hour
d	=	day
yr	=	year

Money

KSh	=	Kenya shilling
US$	=	U.S. dollar
¥	=	Japanese yen

Energy

kcal	=	kilocalorie
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatt-hour
GWh	=	gigawatt-hour

Others

%	=	percent
o	=	degree
'	=	minute
"	=	second
°C	=	degree Celsius
cap.	=	capital
LU	=	livestock unit
md	=	man-day
mil.	=	million
no.	=	number
pers.	=	person
mmho	=	micromho
ppm	=	parts per million
ppb	=	parts per billion
lpcd	=	liter per capita per day

1 Project Outline

1.1 Background

The Republic of Kenya has a population of approximately 43,180,000 people (Source: World Bank, 2012) and has a national territory of 583,000 km^2. Of the national territory, approximately 83% belongs to arid or semi-arid zones. In Kenya, in addition to the consistent lack of water resources, water demand is increasing due to development; thus, appropriate water resources management becomes a crucial issue. A development study for the "National Water Master Plan (NWMP) (former Master Plan prepared in 1992 and then updated for the water supply and sewerage sector in 1998)" was previously conducted. The Government of Kenya is proceeding with water sector reform after the enactment of the Water Act in 2002 and administrative framework is widely changing from the former NWMP. In 2007, the "Kenya Vision 2030" ("Vision 2030" hereinunder) was formulated as a national long-term development blueprint to create a globally competitive and prosperous nation with a high quality of life by 2030, that aims to transform Kenya into a newly industrializing middle-income country. Toward the realization of the target, a directive of actions was proclaimed under three main pillars, namely: (i) economic development (economic pillar), (ii) creation of safe society (social pillar), and (iii) political reform (political pillar).

On the other hand, the former Master Plan required the updating of meteo-hydrological information after the passage of 20 years. The Master Plan was substantially reviewed and updated to prepare a new framework of water resources development and management in accordance with the national socio-economic development activities. In order to achieve the development target, a study on the National Water Master Plan 2030 covering six catchments was conducted considering climate change, and final reports were published in October 2013.

In order to enhance water resources development and management, establishment of further efficient and effective monitoring organization for quantity and quality of water resources (surface water, groundwater, and rain water) was recommended in the new Master Plan, and then this Project was realized.

1.2 Objective

The overall goal is that the "water resources management by the Water Resources Authority (WRA[1]) is enhanced, and the Project goal is that "meteo-hydrological data management capacity of WRA is improved."

1.3 Project Area

The Project activities were mainly conducted at the Head Office of WRA. On the other hand, as for the field activities, both parties of WRA and the JICA Expert Team agreed that Tana Catchment should be selected among six catchments through a series of discussions after commencement of the Project.

[1] The name of agency was "WRMA" at the commencement of the Project, then it was reformed as "WRA" in compliance with the New Water Act 2016 in April 2017. Therefore, it is described uniformly as "WRA" in this document in principle.

1.4 Related Organization

(1) Responsible agency : Ministry of Water and Sanitation (MWS[2])

(2) Implementing agency : Water Resources Authority (WRA)

1.5 Schedule

The original schedule of the Project was set for approximately 25 months from January 10, 2017 to February 28, 2019. On the other hand, it was revealed that WRA was preparing the new Strategic Plan 2017–2022 in July 2018, which was presumed completed in March 2019, and judged necessary to confirm its contents and duly reflect them in the future cooperation direction (this work item is included in Output 3 of the Project). Therefore, the total project period has been extended for four months until June 28, 2019 considering the period required for the preparation of the completion report.

1.6 Agreement upon Commencement of the Project

(1) Counterpart Personnel

As a result of the discussions between WRA and the JICA Expert Team on the composition of counterpart personnel (CP), a total of 19 personnel mainly composed of surface water officers were nominated by the Chief Executive Officer (CEO) on April 11, 2017 (issued by WRA's Internal Memo, Ref: Appendix 1). During the Project, three personnel have been changed due to human resources management in WRA as shown in Table 1.1.

Table 1.1 Changes of Counterpart Personnel

Name of Original CP	Position	Name of New CP	Position
Mr. Geoffry Wachira	Regional Manager, Tana Catchment	Mr. Benard S. Omuya	Regional Manager, Tana Catchment
Mr. John Kinyanjui	Assistant Technical Coordination Manager, Tana Catchment	Mr. Philip K. Munyua	Assistant Technical Coordination Manager (Water Rights Assistant), Tana Catchment
Mr. Lawrence Thooko	Project Manager of WRA side/ Assistant Technical Coordination Manager (Data Management)	No substitution	Retirement (Feb. 2019)

Source: JICA Expert Team

(2) Contents of Project Activities

In proceeding with the project activities, since an agreement on the contents of the vital issues was acknowledged by both parties, the following three issues were substantially discussed. A Technical Note containing agreed key points was signed on April 12, 2017 (Ref: Appendix 2):

(a) Detailed conditions on equipment to be procured (water level sensors and current meters)
(b) Cost sharing for Project activities (by WRA, JICA, and the JICA Expert Team)
(c) Concrete contents of three sub-contract works (candidate target gauging stations and criteria for selection)

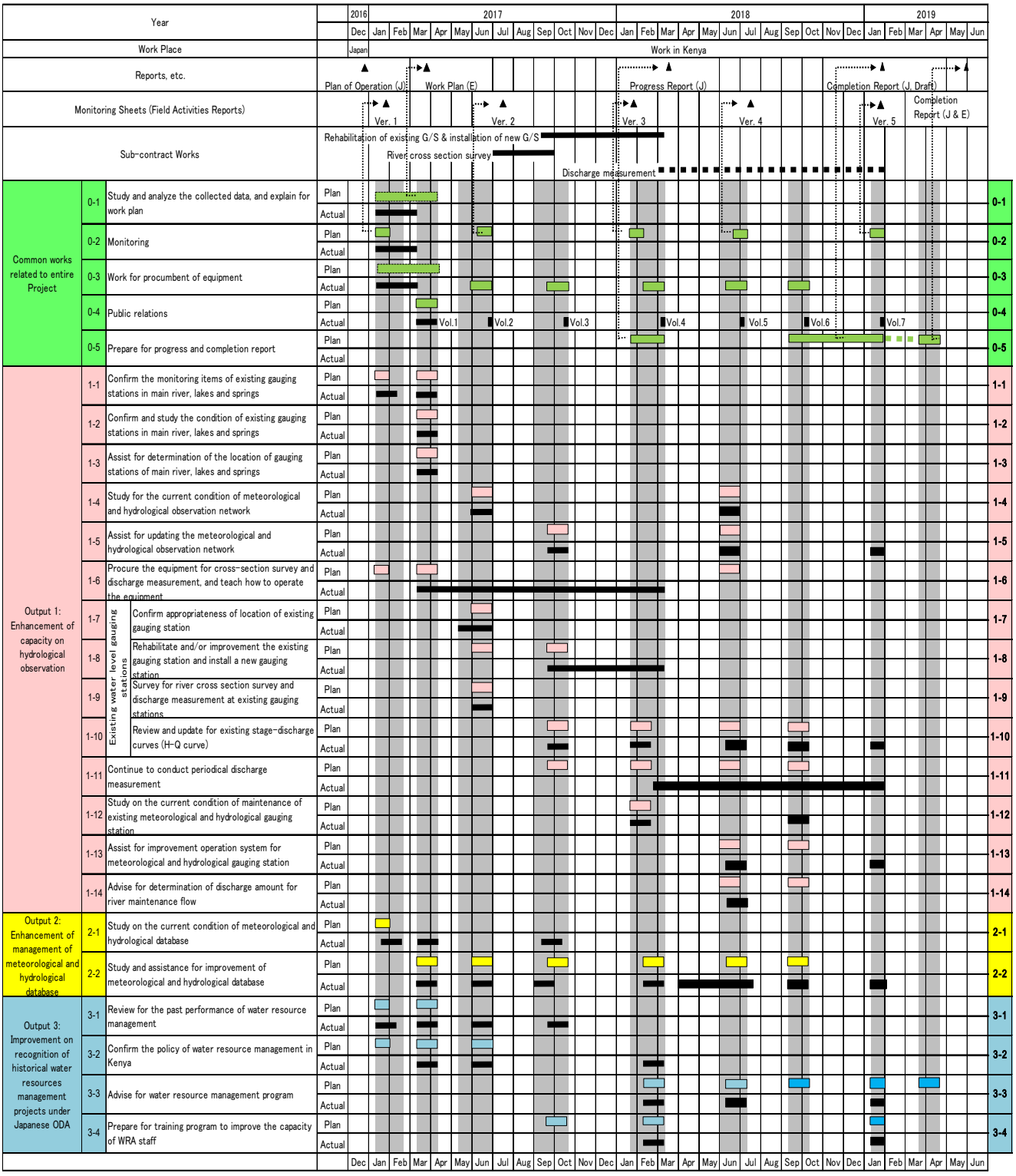
[2] The name of ministry was "MWI" at the commencement of the Project, then it was reformed as "MWS" in February2018. Therefore, it is described uniformly as "MWS" in this document in principle.

Regarding item (c) above, the Technical Note stipulates that new gauging station should be decided through joint field reconnaissance by WRA and the JICA Expert Team. Based on the statement, a joint field reconnaissance was conducted between June 13 and 15, 2017. As a result, both parties agreed that an existing Intra-management Unit Station (4F10 in the Kathita River) should be upgraded to a Management Unit Station. This adjustment was described in the Technical Note No.2, and then it was signed and exchanged on June 15, 2017 (Ref: Appendix 3). Both parties acknowledged to proceed with the sub-contract works in accordance with this agreement.

1.7 Overall Work Plan

1.7.1 Work Schedule

A flowchart of the Project is shown in Figure 1.1.



Note: Hatched in gray means the assignment period of Japanese experts in Kenya.

Source: JICA Expert Team

Figure 1.1 Overall Work Flow

1.7.2 Staffing

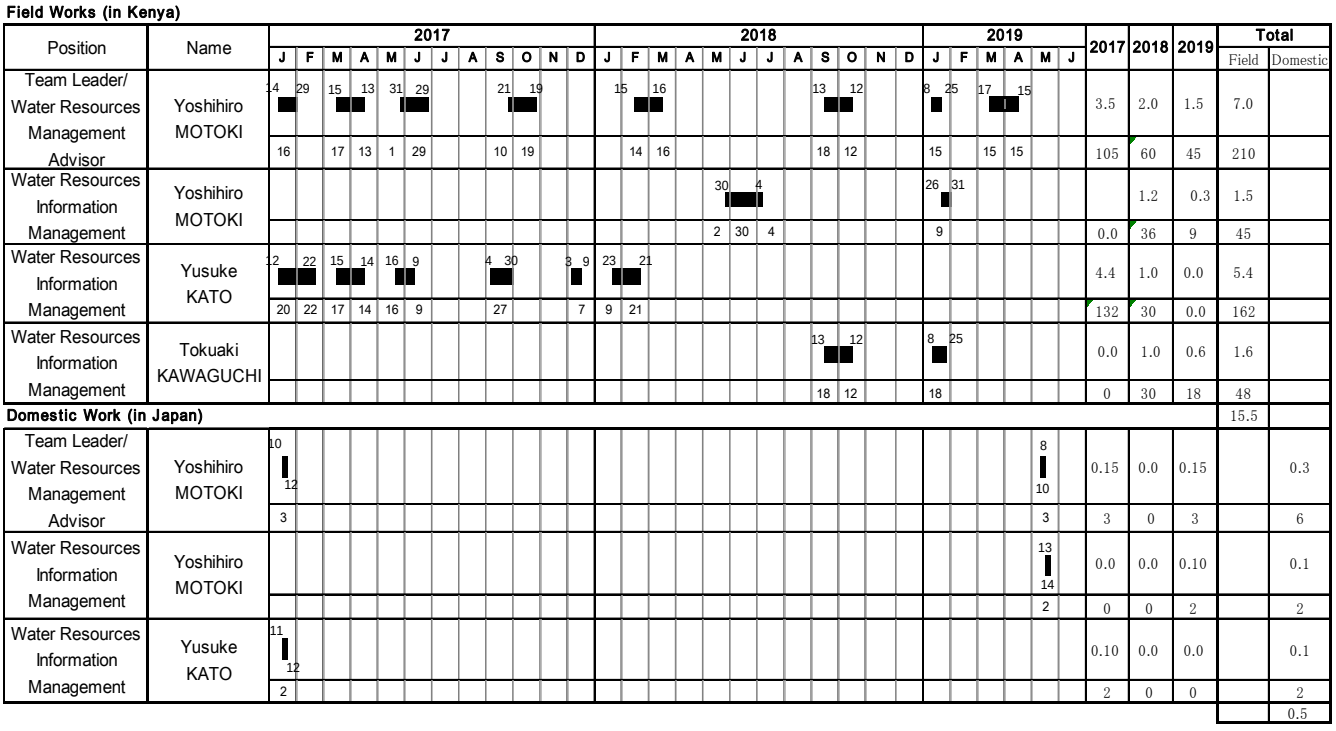
The JICA Expert Team is composed of three Japanese experts, one secretary, and four national technical assistants. Actual assignment period of the individuals is tabulated in Table 1.2.

Table 1.2 Composition of Team Members and Assignment Period

Category	Position	Name	Contract (Man-month)	Actual (Man-month)
Japanese Expert	Team Leader/ Water Resources Management Advisor	Yoshihiro MOTOKI	7.00	7.00
	Water Resources Information Management (Addition)	Yoshihiro MOTOKI	1.50	1.50
	Water Resources Information Management	Yusuke KATO	5.40	5.40
	Water Resources Information Management (Addition)	Tokuaki KAWAGUCHI	1.60	1.60
General Assistant	Secretary	Ms. Jacquiline AYUMA	19.00	19.00
Special Assistants	Assistant for Water Resources Management Advisor and Water Resources Information Management	Ms. Jokastah KALUNGU/ Mr. James NJUE	16.50	16.50
	Assistant for GIS/ Computer System	Mr. Moffat MAGONDU/ Mr. George Odhianmbo OKOTH	3.00	3.00

Note: Actual MM shows figures accumulated as of April 2019. Source: JICA Expert Team

Actual assignment periods of the Japanese experts are shown in Figure 1.2.



Source: JICA Expert Team

Figure 1.2 Assignment Schedule

2 Project Activities

2.1 Activities for Output 1

Activities of Output 1 are composed of the following six subjects:

- Activity 1.1 Assistance in determination of location of gauging stations of main river, lakes and springs
- Activity 1.2 Assistance in updating meteo-hydrological observation network
- Activity 1.3 Trainings on how to operate the equipment for discharge measurement
- Activity 1.4 Assistance for the preparation of stage-discharge curves (H-Q curves)
- Activity 1.5 Assistance for improvement of operation for meteorological and hydrological gauging stations
- Activity 1.6 Advice on determination of discharge amount for river maintenance flow

2.1.1 Assistance in Determination of Location of Gauging Stations in Main River, Lakes, and Springs【Activity 1.1】

Activity 1.1 includes three components, i.e., (1) Confirmation on monitoring items of the existing gauging stations in main rivers, lakes, and springs, (2) Confirmation and study of conditions of existing gauging stations in main rivers, lakes, and springs, and (3) Assistance for determination of location of gauging stations of main rivers, lakes, and springs.

(1) Confirmation on monitoring items of the existing gauging stations in main rivers, lakes, and springs

The location of monitoring stations in Tana Catchment by WRA is as shown in Table 2.1.

Table 2.1 Water Level Gauging Stations and Their Priority in Tana Catchment

Priority	Number of Station
National	1
Management Unit	11
Intra-management Unit Station	18
Special	24
Total	54

Source：Prepared by the JICA Expert Team based on information of WRA

WRA has a ledger note, which covers the subjects for each gauging station as tabulated in Table 2.2.

Table 2.2 Described Subjects in the Ledgers of Gauging Stations by WRA

Item	Description	Note
Type	1. Manual 2. Automatic	
Priority	1. National 2. Management Unit 3. Intra-management Unit Station 4. Special 5. Others	
Station_Ty	1. Staff gauge 2. Weir station 3. Seba 4. OTT 5. Thalimendes	
Region	1. LVN 2. LVS 3. RVCA 4. ATHI 5. TANA 6. ENNCA	
LOCDESC	Location Description	
Sub_basin	Sub-basin Code	
Last_repair	Last Rehabilitation Date	
Area	Catchment area km^2 above the location of the station	
LOGAUGE	Reduced level of Lower Gauge	
UPGAUGE	Reduced level of Upper Gauge	

Item	Description	Note
BMDIR	Type and position of the BM	Concrete, top of the right side of the bridge abutment
BMDIST	Distance of benchmark from first gauge	
BMAL	Assumed level	
GAUGERL	Reduced level	Meters above sea similar
ACSSDESC	Description of accessing the staff gauge	
CTRLDESC	Description of control (natural or artificial)	Natural control - channel or bed out rock across the river channel
Open_Year	Year Opened	
Close_Year	Year Closed	
Longitude	Coordinates in decimal degrees	
Latitude	Coordinates in decimal degrees	
Altitude	Altitude of the station (masl)	On top of the benchmark
Sediment	If a sediment station, 1; if not, 0	Station earmarked for sediment monitoring
ACTION_URG	Urgent action required	
ACTION_REQ	Action requested: Rehabilitation = 1, upgrading = 2, relocation = 3, abandonment = 4	
DATE_VISIT	Last date visited	
NO_STAFF GAUGE	No. of staff gauges (0-1.5, 1.5-3.0, 3.0-4.5, 4.5-6.0)	
Daily_Hist	Daily history file existing = 1, not = 0, with rating curve = 2, photo of station = 3, cross section = 4, longitudinal section = 5, for more information, refer to below list, if all present = 7, partial = 8, none = 9	
SUB_REGION	Indicate name	
Photo	Paste a photo of the station (best short)	
RELOCATION	Any previous relocation(s)	
REMARKS	General remarks	
GAUGE READER	WRMA staff = 1, Honoraria = 2, WRUA = 3, Others specify	

Source/Note：JICA Expert Team has prepared based on the information of WRA.

Aside from the subjects in the table above, the following subjects are recommended to be added in the ledger:

- Name of person in-charge
- Name of gauge readers
- Date when updating of the ledger was conducted
- Date when the latest river cross section survey was conducted
- Date when the latest discharge measurement was conducted
- Date when the latest H-Q curves was estimated
- Period of observed data which are stored in the database
- Existence/ non-existence of benchmarks for verification of ground elevation

Further, standard datum should be established in the respective sub-catchments to unify the elevation of Gauge “0”.

WRA has installed water level sensors (telemetric equipment) at the locations in Table 2.3 through the project for the Inter-governmental Authority on Development (IGAD) to share hydrological data in coordination with east African countries. A total of two gauging stations are involved at Tana (4G01) and Kathita (4F19) in the Tana Catchment.

Table 2.3 List of Gauging Stations Targeted by IGAD Project

No.	Station Name	Combined Humidity / Temperature at Station	Shaft Encoder at Gauge Station	Pressure Sensor at Gauge Station	Rain Sensor at Gauge Station	GSM/GPRS or METEOSAT
1	Archers Post[5ED01]	1	1		0	GSM/GPRS
2	Sio[1AH01]	1	1		1	GSM/GPRS
3	Mara[1LA04]	1	1		1	GSM/GPRS
4	Migori[1KB05]	1	1		0	GSM/GPRS
5	Nyando[1GD03]	1	1		1	GSM/GPRS
6	Sondu[1JG04]	1	1		0	GSM/GPRS
7	Tana[4G01]	1		1	0	GSM/GPRS
8	Sabaki[3HA08]	1		1	1	GMS/GPRS
9	Umba[3KG01]	1		1	1	GMS/GPRS
10	Kathita[4F19]	1		1	0	GSM/GPRS
11	Athi[3DA02]	1		1	1	GMS/GPRS
12	Kerio [2C08]	1		1	0	GSM/GPRS
13	Malewa [2GB01]	1		1	0	GSM/GPRS
14	Ewaso Ngiro South [2K10]	1		1	0	GSM/GPRS
15	Turkwel [2B21]	1		1	0	GSM/GPRS
TOTAL		15	6	9	6	

Note: GSM=Global System for Mobile Communication GPRS=General Packet Radio Services
Source: JICA Expert Team prepared the table based on the WRA's information.

(2) Confirmation and study of conditions of existing gauging stations in main rivers, lakes, and springs

The WRA classifies surface water monitoring stations (water level gauging stations) into four categories as shown in Table 2.4.

Table 2.4 Installation Criteria of the Four Types of Water Level Gauging Stations

Type of Gauging Station	Criteria of Installation	Equipment
a. National (N)	● Stations of national importance ● Data gives an overview of the national water resources status ● Located at rivers and water bodies of national importance ● Monitors water from several management units ● Monitors water resources that would indicate the extreme impact on national water resources ● To be fully automated	● Gauge plates ● Automatic water level recorder ● Data logger
a. Management Unit (MU)	● Located at the outlet of each management unit ● Gives WR status for a specific management unit (Water Quality and Quantity) ● Has long-term data available ● To be fully automated	● Gauge plates ● Automatic water level recorder ● Data logger
b. Intra Management Unit (IMU)	● Located at the outlet of each sub-management unit ● Gives WR status for a specific management sub-catchment (Water Quality and Quantity) ● Used for water allocation and demand management ● Assesses the critical catchment yields	● Gauge plates
c. Special (S)	● Monitors water resources status for selected water bodies, e.g., Wastewater sewers ● Established for specialized studies ● Established where there are disputes	● Gauge plates

Source: WRA-related documents

However, although the gauging stations have been installed in compliance with the classification in Table 2.4 in the beginning, it seems that these criteria have become emasculated recently. The "National" stations are continuously operated and managed with high priority. Further, the "Management Unit" stations are prioritized for donor's assistance in the operation and management; however, it is hard to say that the activities are normally enhanced. Regarding the "Intra Management Unit" and "Special" stations, no serious hindrance occurred even if continuous monitoring cannot be conducted at present.

For the appropriateness of the category for respective stations, it is necessary to update the objectives, since objectives how to utilize the observed water level records are not so clear. The manner of updating will be difficult to fix and becomes merely a desktop theory if the objective and utilization of water level observation are not clarified.

Although WRA owns a lot of gauging stations, there are many stations that have stopped operating in the past. In particular, "Intra Management Unit" and "Special" stations have this tendency. The main reason why these stations cannot continue doing their observation is the budget issue. Due to incomplete regular observation by RO/ SRO staff and inconsistent reports by the gauge readers, who were responsible for the maintenance of stations, robbery of staff gauge plates might occur. When damage and/or loss of staff gauges happens, the situation is left as it is and many cases of stopped observation occur. Even if maintenance is strengthened, immediate removal of core problem is not so easy. One of the very few effective countermeasures might be shifting from present steel-made staff gauges to concrete posts which are difficult to be stolen. In fact, WRA is pushing forward this countermeasure.

On the other hand, the "National" and "Management Unit" stations are continuously operated by funds coming from donors and/or the Government of Kenya. Due to numerous monitoring stations, WRA cannot conduct its observation at all stations. However, WRA is doing appropriate operation as a whole through selection and concentration of the stations.

As for Garissa G/S as a "National" station and other "Management Unit" stations, the objectives of installation are obviously set. However, due to unclear recognition on detailed utilization of observed data, the criteria for installation and actual location of the gauging stations does not match consistently. Since the "Management Unit" stations are located at the upstream side of the confluence between a tributary and the Tana mainstream, the layout of the stations might have no problem, but the policy on utilization of water level data is not clearly established. There is an issue that the objectives of observation and the policy of utilization of water level data are not clearly established. Regarding the human resources allotment and budget allocation, prioritized operation based on stations category could not be confirmed through interviews with the sub-regional managers.

(3) Assistance for determination of location of gauging stations of main rivers, lakes, and springs

As a result of the study in the previous clause, in particular on the conditions for installation of water level gauging stations, it should be suggested to shift from "maintenance point of view" to "objective point of view". Some stations recognized that objectives of observation are well acknowledged even if the current criteria are applied. Accordingly, forcible revisions of the current criteria (Table 2-4) for the six catchments in the country will bring about confusion. Meanwhile, it is advisable to maintain the current criteria while integration and abolition should be proceeded in accordance with the objectives.

2.1.2 Assistance in Updating Meteorological and Hydrological Observation Network【Activity 1.2】

Activity 1.2 includes two components, i.e., (1) Study for current conditions of meteorological and hydrological observation network, and (2) Assistance for improvement of meteorological and hydrological observation network:

(1) Study for current conditions of meteorological and hydrological observation network

Improving and updating of the meteorological and hydrological observation network are not regularly conducted by WRA. Accordingly, if drought occurs, appropriate measures are hardly conducted and usually are too late. Although a manual of water allocation exists, there is no regulation which stipulates concrete countermeasures to be undertaken when drought occurs.

In coping with floods, experiences of concrete activities (countermeasures) conducted by WRA are very limited, since flood forecasting is the responsibility of the Kenya Meteorological Department (KMD). On the other hand, since the New Water Act 2016 was enacted, measures against flood are the responsibility of WRA. WRA prioritizes to install flood monitoring networks in the crucial flood areas (21 locations, among them, two areas are located in the Tana Catchment) in the National Water Master Plan (NWMP2030). Therefore, closer coordination between WRA and KDM is demanded for water resources management.

Catchment	Target Flood Protection Areas
LVNCA	1. Yala Swamp
LVSCA	2. Kano Plain 3. Sondu Rivermouth 4. Kuja Rivermouth 5. Kisumu
RVCA	6. Middle/Lower Turkwel 7. Lower Kerio 8. Nakuru 9. Narok 10. Mogotio
ACA	11. Downmost Athi 12. Lumi Rivermouth 13. Nairobi City 14. Kwale 15. Mombasa
TCA	16. Lower Tana 17. Ijara
ENNCA	18. Middle/Lower Ewaso Ng'iro North 19. Wajir 20. Mandera 21. Isiolo

Source: NWMP2030

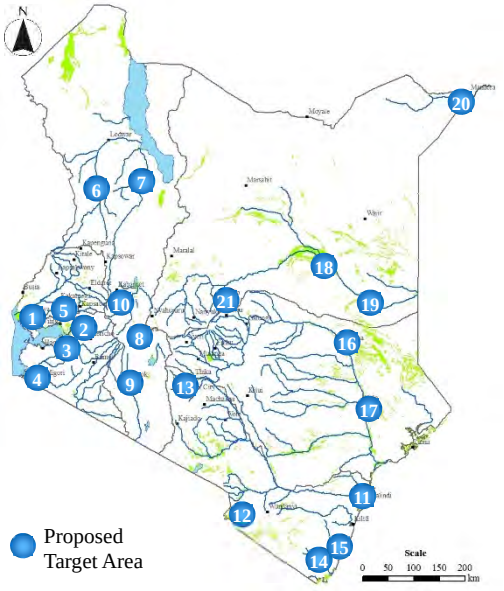


Figure 2.1 Target Flood Protection Areas Proposed in NWMP

On the other hand, large-scale flooding occurred in the Tana Catchment between March and May 2018. Inundation has occurred not only in Garissa at the downstream area but also in the Pilot Project area at the upstream. Considering the accumulated situation of population and assets, it is deemed that flood damage risk is high at the upstream area as well. In particular, having heavy downpour of rainfall in the surrounding area of Mt. Kenya, the danger of reaching flood peak discharge within few hours is anticipated. Therefore, strengthening of flood monitoring is a crucial issue. An increase in the number of monitoring stations and staff gauges at the river bank (high elevation portion) and automation of monitoring devices should be

proceeded. Further, in accordance with the conditions of telecommunication, introduction of flood forecasting system is also considerable in the future. In this case, considerations on practical countermeasures will be important on how to secure stable telecommunication networks under severe meteorological conditions from planning and system design stages.

(2) Assistance for improvement of meteorological and hydrological observation network

Based on the issues confirmed in the previous Clause 2.1.1 (2) and information and knowledge accumulated through the Project activities, an improvement of current meteorological and hydrological networks was proposed. The process of the study is presented below.

(a) Outline of monitoring system and data collection status

As of March 2019, the telemetering system in Kenya consists of a total of 29 stations, namely; 23 automated water level stations and six automated weather stations (precipitation, air temperature, humidity, radiation, and wind speed). In principle, the system is designed such that hourly data is transmitted from the field stations to the WRA Headquarter in Nairobi and automatically stored in the File Transfer Protocol (FTP) server. In addition, the system can remotely check the power supply conditions at respective stations from the headquarter. Table 2.5 shows the details of gauging stations and conditions of data collection, as of March 31, 2019. A person in-charge in the ICT Section checks the status of data storage every day in principle. A total of four telemetering gauging stations have been installed in the Tana Catchment and the three stations are under operation. At 4BE10 (Tana Rukanga), which is one of the target stations for the Project activities, the data logger has temporarily stopped operation due to the inundation in April 2018. Therefore, the data logger was once replaced and repair works were done. After then, the repaired data logger was already returned to 4BE10, but automatic data transmission to the headquarter is not yet restored by the end of March 2019.

Table 2.5 List of Telemetered Gauging Stations Operated by WRA（March 2019）

Fund Source	No.	G/S ID No.	Name of G/S	Conditions of Data Collection (as of March 28, 2019)
IGAD (WMO Fund)	1	1AH01	Sio	Yes
	2	1GD03	Nyando	Yes
	3	1JG04	Sondu-Miriu	Yes
	4	1KB05	Gucha Migoli	Yes
	5	1LA04	Mara	Yes
	6	2E07B	Perkerra	Yes
	7	2FC19	Njoro	Yes
	8	2B33	Suam	Yes
	9	2K04	Ewaso Ngiro South	Yes
	10	3DA02	Athi	Yes
	11	3HA13	Sabaki	Yes
	12	3KG01	Umba	Yes
	13	4BE10	Tana Rukanga	Data logger recorded, but data is not transmitted
	14	4G01	Tana Garissa	Yes
WRA Fund	15	1HD09	Awach Kibuon	Yes
	16	1FG02	Yala	No: network problem
	17	1LA03	Nyangores River	No: (to be confirmed)
	18	2C07	Kerio	Yes
	19	3BA29	Nairobi	No: network problem
	20	3F09	Athi Kibwezi	No: washed away by flood
	21	4DD02	Thiba	Yes
	22	4EA06	Mutonga	Yes

	23	5DA07	Isiolo	Yes
CETRAD Fund	24	856895	Naromoru	No
	25	8937059	Nyambene	No
	26	857004	Wamba	No
	27	859085	Marsabit	No
	28	49507	Nyahururu	No
	29	49417	Archers Post	No

Source: WRA In Tana Catchment

Explanation：

IGAD: The Inter-governmental Authority on Development (in Eastern Africa)

In 1996, IGAD was established by an approval of the United Nations in order to promote regional cooperation in east African countries. At present, it is composed of eight countries, i.e., Djibouti, Ethiopia, Kenya, Somalia, Sudan, Uganda, Eritrea, and South Sudan. The headquarter exists in Djibouti City, the capital of Djibouti.

CETRAD: Center for Training and Integrated Research in ASAL Development

In 2002, CETRAD was established in succession of the Laikipia Research Programme (1976–1997) by means of bilateral cooperation between the Republic of Kenya (former Ministry of Water and Irrigation in-charge) and the Swiss Confederation. The headquarter exists in Nanyuki (Laikipia County).

(b) Information on contractors engaged in system design and installation works

As for the IGAD system, WRA shared its responsibility for design, procurement, and installation of the equipment from the monitoring station in the field to the FTP server in the headquarter. On the other hand, the Graphical User's Interface (GUI) used by MIKE INFO was prepared by the engineering services of the Kenya Water Security and Climate Resilience Project (KWCRP) of the World Bank. In addition, as for the monitoring system by own fund of WRA, NARIANA Enterprises Limited (same contractor of the sub-contract works of "Rehabilitation of Existing Gauging Stations and Installation of New Gauging Station" and "Discharge Measurements" for the Project) conducted design and installation works.

(c) Status of maintenance of installed monitoring devices

Although the responsibilities of maintenance for the telemetering gauging stations should be primarily shouldered by the sub-regional offices, the officers in-charge in HQ are handling the tasks at present, since SRO staff are under training on related technologies. It is envisaged that the RO and/or SRO will take responsibilities to manage the telemetering system as well as other regular gauging stations in the future.

(d) Existing ledger of monitoring stations (surface water) and database

The details on the ledgers of WRA, which are stored and managed by the Data Management Section in HQ, are as mentioned in Clause 2.1.1 (1) and are managed by each catchment area. On the other hand, an inventory (Excel file) of the six catchments prepared by the Kenya Water Security and Climate Resilience Project (KWSCRP) was obtained through WRA in January 2019. The inventory includes the item of "Risk of Vandalism", column of evaluation by the KWSCRP (monitoring should be continued proactively or not) and related information (e.g., "Long-term records available" and "Information of the G/S location should be reconfirmed at SRO in-charge", etc.). Total of 156 and 186 stations are listed in WRA's ledger and in the inventory of KWSCRP, respectively, as registered monitoring stations (water level gauging stations) in Tana Catchment. The difference of numbers between two sources might be taken from the inventory, because it includes other agency's monitoring stations than WRA.

(e) Proposed improvement of meteorological and hydrological network in Tana Catchment

NWMP2030 proposed the numbers of monitoring stations in the Tana Catchment in the future as shown in Table 2.6 (proposed as one component of water resources management plan).

Table 2.6 Proposed Monitoring Stations by NWMP 2030 (in Tana Catchment)

Type of Monitoring Stations	Proposed Number of Stations
Surface water	26
Rainfall	47
Groundwater	18
Reference point	3

Source：NWMP 2030

As for the water level gauging stations, Appendix 4 compiles the results of evaluation by the current Project based on the recommended stations by NWMP2030 and comments extracted from the inventory of KWSCRP. Through the examination after integration of the comments from the CP (HQ and Embu RO), a total of 27 water level gauging stations are proposed as presented in Appendix 4. A breakdown of the proposed sites is tabulated in Table 2.7:

Table 2.7 Breakdown of Water Level Gauging Stations Proposed by the Project (Tana Catchment)

Proposal	Details	Reasons
Total 27 sites (Water level G/S)	25 sites are the same as proposed by NWRM2030. However, 4CC03 should be cancelled and to be represented by 4CC08 instead.	Principal monitoring sites were appropriately proposed from hydrological point of view by NWMP2030. Among them, 20 sites are in operation and 5 sites are not operational due to some reasons (as of March 2019).
	2 sites of 4CC0 and 4F10 are added.	4CC08 is a substitution of 4CC03. Although 4F10 is not working for a long time, rehabilitation works have been done by the current Project (monitoring restarted: from February 2018)

Source: JICA Expert Team (details to be referred to Appendix 4)

As far as Surface Water Officer (SWO) is concerned, respective SRO is composed of one or two personnel only. Since monitoring sites are scattered in the catchment area, efficiency of the activities is demanded for the staff. However, the activities are restricted due to budget constraint for the availability of vehicles and allowance for the staff, etc. In accordance with the interview with the SWO in Embu RO, monitored field data can be regularly collected only at 15 gauging stations at present (discussion on March 16, 2019).

The SWO explained that approximately 40 to 50 water level gauging stations should be maintained in the Tana Catchment. The JICA Expert Team requested a concrete rule of the judgement (why the number of stations is required). The SWO replied that such numbers are necessary for water right management and control of water utilization and demand/supply balance. However, the JICA Expert Team could not receive any apparent rule which can

clarify objectives of the gauging station as shown in Table 2.7 one by one. Instead, a mutual consent on the continuation of monitoring and maintenance at the proposed 27 sites in the future was secured.

On the other hand, manpower will be cut by means of automated data transmission by telemetering system which is promoted by WRA at present. However, it is anticipated that the burden of maintenance (manpower and cost) will increase due to an increase in number of monitoring stations (monitoring devices). Staffing patterns at RO and SRO will be the key. Considering current conditions where drastic improvement cannot be expected, clarification of monitoring objectives and concentration of gauging stations should be proceeded together with automation of gauging stations.

As for another aspect, monitoring in the sub-catchments is shifted to Water Resources Users Association (WRUA) in accordance with the monitoring objectives, and an alternative direction where WRA concentrates on the management of principal stations, improvement of data quality (regular collection/ check of water level data and subsequent registration to the database) and management by discharge quantity should be considered through coordination and agreement with other concerned agencies.

Further, the NWMP2030 proposed to layout rainfall gauging stations in consideration of climate classification such as arid zone lying at eastern part of the catchment, semi-arid zone in central western part, wet zone where Mt. Kenya and Aberdare Range are located, and monitoring density. Such layout plan was judged appropriate even at present. Further, three reference points were proposed. Two of those are located along the Tana mainstream (4BE10 at the upstream and 4G01 at the middle stream) and one is located at the tributary of Thika (4CC03 to be shifted to 4CC08). This is judged appropriate for water resources management. Regarding the groundwater monitoring stations, the number in Table 2.6 should be kept as it is for future plan, since additional information to judge its appropriateness could not be obtained.

2.1.3 Training on Equipment for Hydrological Measurement【Activity 1.3】

(1) Training on equipment for water level observation

In most of the gauging stations, river water level is recorded once a day through visual reading of staff gauge by a gauge reader who is residing nearby. The observed records are submitted to SRO by the gauge reader every month, then the SRO staff encodes the records into the monthly record format using an Excel file. Aiming at automated observation, the Project procured four sets of water level sensor, data logger, and data collector equipment, and provided them to WRA as listed in Table 2.8.

Table 2.8 Hydrological Monitoring Equipment Procured and Provided to WRA

No.	Equipment	Q'ty	Specification
1	Water level sensor	4	SENSEZ made, water pressure type, model- HM-910-10-20-CN (made in Japan)
2	Data logger	4	HIOKI made, model-LR5042 (made in Japan)
3	Data collector	4	HIOKI made, model-LR5092 (made in Japan)

Source: JICA Expert Team

One of the four sets of equipment was installed at 4F10, which is managed by Meru SRO, and then the JICA Expert Team provided a training for utilization of equipment. In the training, the JICA Expert Team instructed and advised on the utilization of equipment, i.e., installation of equipment, manner of data collection/ calibration of records during co-working with SRO staff as summarized in Table 2.9.

Table 2.9 Training Contents of Equipment for Water Level Observation

No.	Date	Location	Participants	Contents of Training
1	Mar.01, 2019	4F10	Meru SRO	Installation of water level sensor and data logger
2	Sep.26, 2018	4F10	Meru SRO	Data collection by means of data collector
3	Sep.27, 2018	Meru SRO	Meru SRO	Software installation of data editor to PC
4	Jan.15, 2019	Embu RO	RO, SROs	Manner of calibration of raw water level records accumulated by data logger

Source: JICA Expert Team

(2) Training on equipment for discharge measurement

There are no operations manual of equipment for discharge measurement at present, and so, transfer of knowledge is mainly traced verbally. As one of sub-contract works, discharge measurements have been commenced from March 2018. On March 8, the 1st workshop has been held with the contractor. The JICA Expert Team explained the method of measurement, manner of recording and analysis of measurement results. No manual is available in WRA for discharge measurement. Since it depends on the capability of staff, it is hard to say that certain quality is assured. In the workshop, the JICA Expert Team provided an input form of measured results and instructed recording method at the field and computation of discharge through a trial measurement at 4BE10 (Tana Rukanaga). Figure 2.2 shows some scenes of the training.

Setting of data logger

Data collection by data collector

Software installation on PC

Checking indicator of data logger

Training of data transfer from data collector to PC

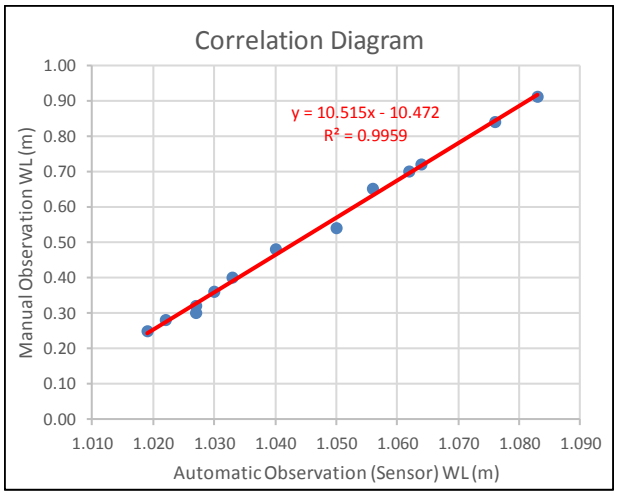
Explanation at the progress meeting

Source: JICA Expert Team

Figure 2.2 Training Scenes for Handling of Equipment

The JICA Expert Team retrieved the raw records at 4F10 from installation in February 2018 and compared with the records of gauge readings. Then, a correlation diagram between two values was prepared as shown in Figure 2.3. The correlation coefficient R^2 was estimated at 0.9959; therefore, high reliability of observed record by the equipment has been confirmed. The observed raw data by water

level sensor was converted into water level by using the regression line and was compared with the gauge readings as shown in Table 2.10. It was also confirmed that the converted water levels showed enough accuracy within a small error range of 3 cm only. Based on the results, an instruction note (Ref: Attachment 5) regarding the procedure of conversion was prepared and distributed to all attendees of the training program. The converted data of water level from February to September 2018 are drawn in Figure 2.4. In accordance with the figure, it was recognized that the maximum water level of 2.4 m had been recorded at 4F10 on April 24, 2018. In addition, the converted discharge by using the H-Q curve, which is explained in the next section, is also shown in Figure 2.4.



Source: JICA Expert Team

Figure 2.3 Correlation between Observed Record by Sensor vs. Staff Gauge Readings

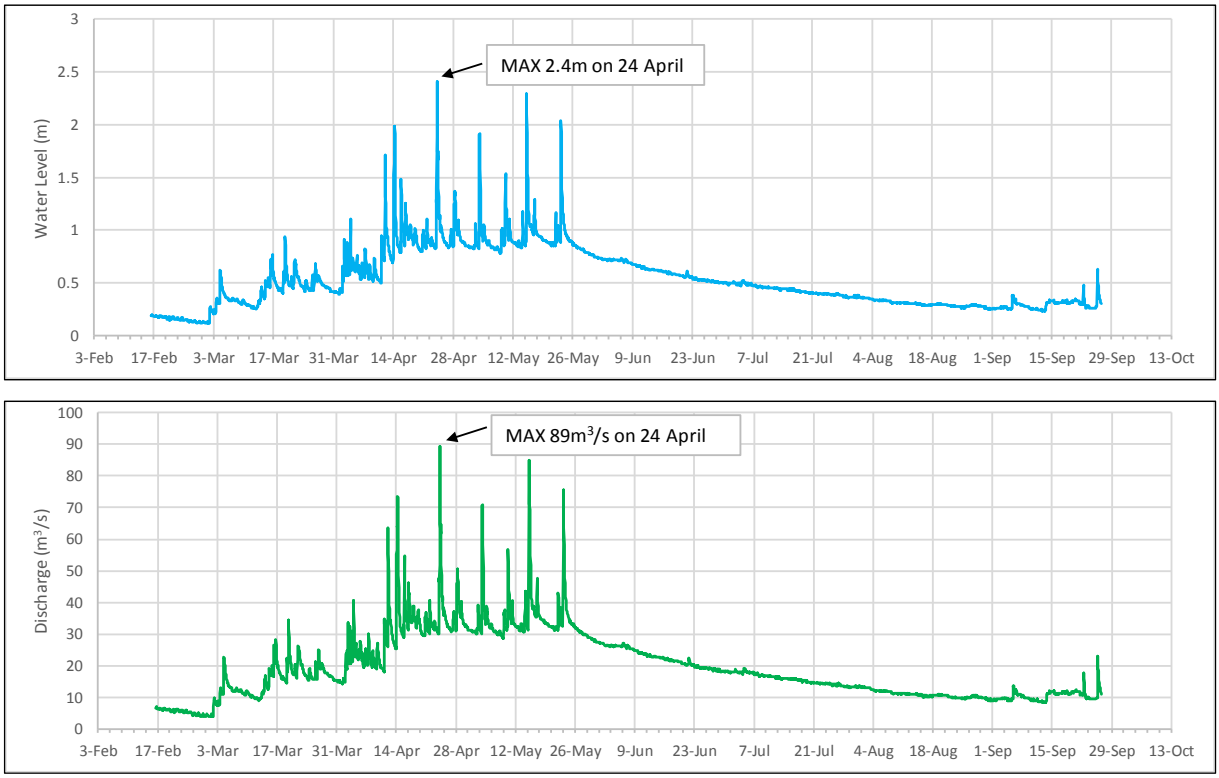
Table 2.10 Adjustment of Observed Records（RGS 4F10）

Date	Manual Obs. by Staff Gauge Reading			Automatic Obs. by Sensor				WL Difference (1)−(2)
	Time		(1) WL (m)	Original of Data logger		Converted Data		
	Start	End		Time	(2) WL (m)	Time	(3) WL (m)	
2018/3/27	9:50	11:34	0.54	10:00	1.050	10:00	0.57	−0.03
2018/4/19	9:08	9:18	0.91	9:00	1.083	9:00	0.92	−0.01
2018/5/2	14:00	15:18	0.84	14:00	1.076	14:00	0.84	−0.00
2018/6/7	11:25	13:05	0.72	12:00	1.064	12:00	0.72	0.00
2018/6/8	14:25	15:55	0.70	15:00	1.062	15:00	0.69	0.01
2018/6/12	12:38	13:47	0.65	13:00	1.056	13:00	0.63	0.02
2018/7/9	14:14	15:39	0.48	15:00	1.040	15:00	0.46	0.02
2018/7/23	9:30	10:25	0.40	10:00	1.033	10:00	0.39	0.01
2018/7/29	9:22	9:59	0.36	9:00	1.030	9:00	0.36	0.00
2018/8/25	10:35	11:15	0.28	11:00	1.022	11:00	0.27	0.01
2018/9/13	12:01	12:29	0.25	12:00	1.019	12:00	0.24	0.01
2018/9/14	9:35	10:00	0.32	10:00	1.027	10:00	0.33	−0.01
2018/9/22	9:35	10:00	0.30	9:00	1.027	9:00	0.33	−0.03

Note: Conversion Equation (3) = 10.515 ×(1) − 10.472

The column '(1) WL(m)' indicates average water level from start to end of observation

Source: JICA Expert Team



Source: JICA Expert Team

Figure 2.4 Water Level Records and Converted Discharge Data（RGS 4F10）

The Meru SRO staff who joined in the training program learned the methodology of equipment utilization such as data recording system, procedure of data collection by using equipment and calibration method of recorded data. The remaining three sets of equipment (water level sensor and data logger) will be installed and automated observation will be commenced through selection of appropriate sites for installation mainly by HQ staff. In the future, improvement of work efficiency will be realized by means of the technical skills learned, and many effects on the increase of recorded data and improvement of data reliability by automated observation are expected.

2.1.4 Assistance for Stage-Discharge Curves【Activity1.4】

Activity 1.4 includes five components, i.e., (1) Confirmation on appropriateness of existing sites of water level gauging stations, (2) Rehabilitation of existing gauging stations and installation of new gauging station, (3) River cross section survey and discharge measurements at existing gauging stations, (4) Evaluation and improvement of existing H-Q curves, and (5) Periodical discharge measurements:

(1) Confirmation on appropriateness of existing sites of water level gauging stations

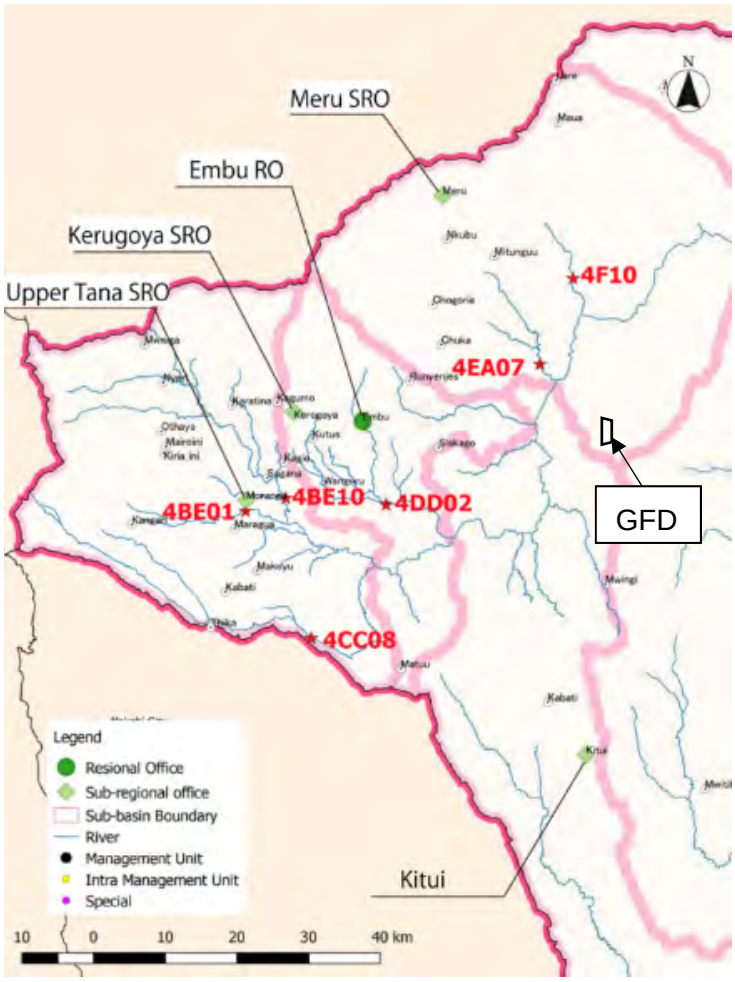
The JICA Expert Team conducted site reconnaissance twice (January and April 2017) and a joint field survey with WRA (June 2017), and inspected existing water level gauging stations, which required restoration works, in Tana Catchment. A principal rule has been set to select “Management Unit” stations, which are classified as high priority by WRA, and inspection was primarily conducted at the gauging stations along tributaries at the upstream area of the Tana River. These stations are all located at the upstream side in the tributaries (keeping certain distance from the confluence to avoid influence by backwater of the mainstream) and located within almost straight river stretches. Most of the sites did

not show channel erosion and aggressive variation of river channel sections. However, through discussions with CP, bank slope protection by gabion mattress was provided at 4F10 (Kathita) to protect from further bank erosion in front of the existing gauge house. At 4BE10 (Tana Rukanga), since the risk of erosion at the foundation of the existing gauge house by surface flow on the slope due to rainwater was confirmed, a small drainage canal (length: 15 m) was constructed by stone masonry at the back of the gauge house. This new canal can catch the rainwater on the ground surface and lead it safely to a creek nearby through the canal.

To select the target water level gauging stations, accessibility is an important requirement in assuring continuous activities. At 4F10, which was treated as the new gauging station, observation had been stopped due to the damaged staff gauges caused by flooding that occurred a long time ago. Although an intake weir is located at the downstream, it was appropriately judged as a candidate site since the village is located nearby (for observation by a gauge reader).

Further, it was confirmed that 4F10 would not be affected even after construction of the Grand Falls Dam (GFD) and the reservoir is impounded based on the related documents, since it is located higher than the planned High Water Level (HWL). Accordingly, it is very important for 4F10 to monitor and manage the discharge of the Kathita River regardless of the dam construction in the future.

The water level gauging stations, which were agreed as the target sites with WRA, are shown in Figure 2.5. At the six gauging stations, discharge measurement was conducted, and H-Q curves were created. Key related information on these stations are summarized in Table 2.11.



Source: JICA Expert Team

Figure 2.5 Location Map of Target Gauging Stations

Table 2.11 Key Information of Target Gauging Stations

No.	G/S ID No.	Name of G/S	Lowest Riverbed Elevation* (El.m)	Longitude	Latitude	Responsible SRO
1	4BE01	Maragua	1,212	0°44'59.29"S	37°09'27.91"E	Muranga
2	4BE10	Tana Rukanga	1,107	0°43'41.56"S	37°15'32.00"E	Muranga
3	4CC08	Thika	1,305	1° 4'16.90"S	37°19'18.34"E	Muranga
4	4DD02	Thiba	1,050	0°44'02.22"S	37°30'38.28"E	Kerugoya
5	4EA07	Mutonga	616	0°22'43.65"S	37°53'47.45"E	Meru
6	4F10	Kathita	567	0°09′43″S	37°58′47.00″E	Meru

Note：* From the results of the River Cross Section Survey (Sep. 2017) Source: JICA Expert Team

(2) Rehabilitation of existing gauging stations and installation of new gauging station

As one of the sub-contract works of the Project, rehabilitation of two existing gauging stations (4DD02 and 4BE10) and installation of one new gauging station (4F10) were conducted. Regarding 4F10, although it is “Intra-management Unit” station at present, an agreement was concluded that this should be upgraded as a new site as a result of discussions with WRA, since this is considered an important one as mentioned in the previous clause (1). At the time when the Project was commenced, the staff gauges were destroyed by flooding and monitoring works were not conducted.

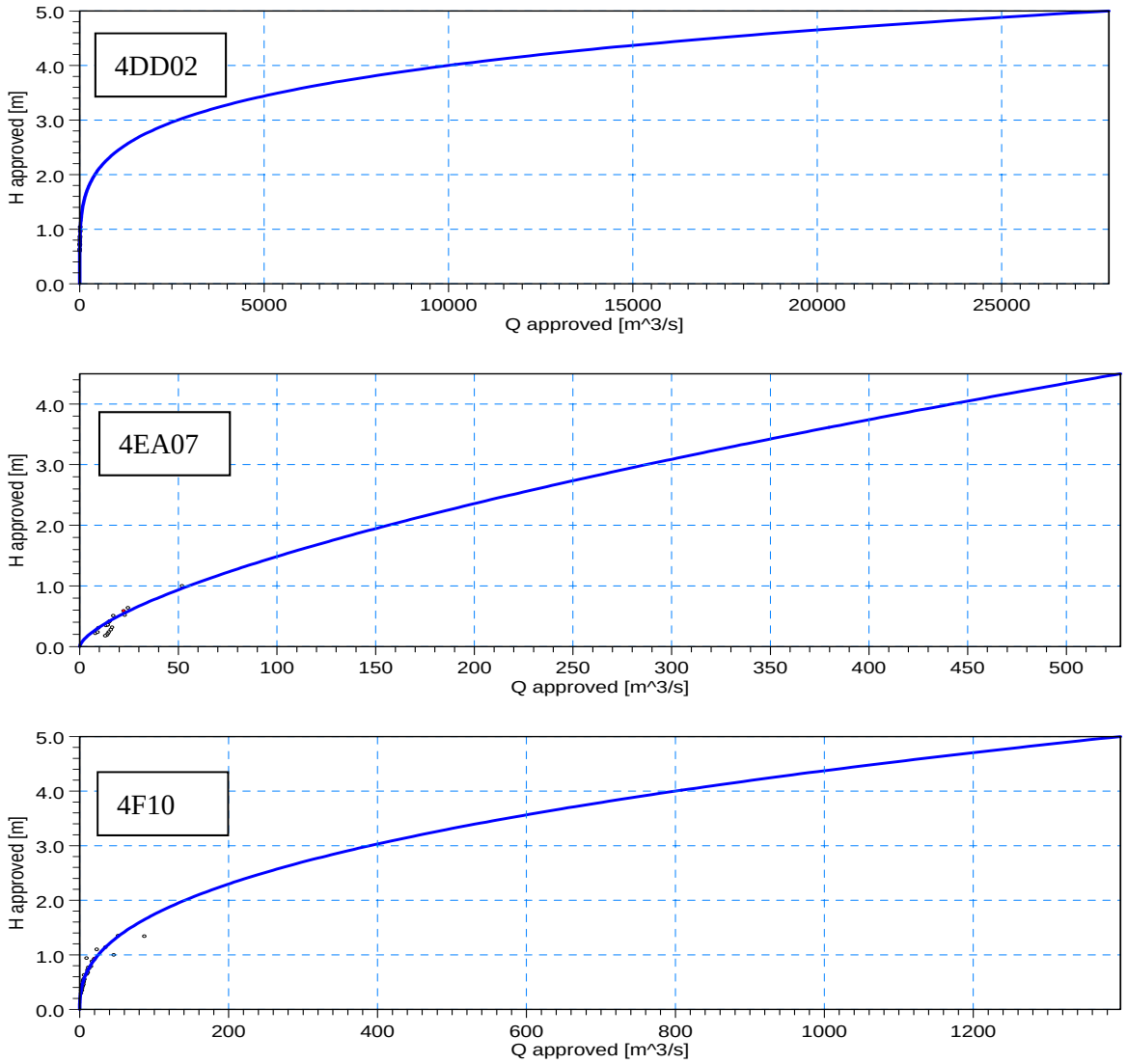
(3) River cross section survey and discharge measurements at existing gauging stations

Any river cross section survey results at existing gauging stations could not be collected. On the other hand, regarding the discharge measurements (H-Q curves), existing references at some sites could be collected. Comparison between these materials and the survey results of the Project is examined in the following Clause (4).

(4) Evaluation and improvement of existing H-Q curves

Although WRA has a rule to conduct discharge measurement once in every three months, it is not conducted consistently due to budget constraint. Respective SROs duly recognize the necessity and importance of discharge measurement, but they could not take actions properly. Further, assistance of RO such as transportation of field equipment and moving from site to site is considered indispensable. However, close coordination between RO and SROs could not be confirmed. Some H-Q curves could be collected, but fundamental information such as discharge measurement results, regression formula applied for conversion from water levels to discharges, and applied period of a curve could not be confirmed. Although such tasks should be properly shared by RO, these key information are not well organized at present.

At the three sites, i.e., 4DD01, 4EA07, and 4F10, of the target six sites, H-Q curves were collected and confirmed. These are shown in Figure 2.6.



Source：WRA's references

Figure 2.6 Existing H-Q Curves at Target Gauging Stations (WRA)

In Figure 2.6, the discharge measurement results are plotted on the graph. Therefore, it was deemed that WRA should keep the results, but these could not be confirmed as mentioned in the previous clause. The H-Q curves, which were created based on the discharge measurement results in the Project, are illustrated in Figure 2.7. Comparison and salient features between these curves are briefly described by sites as follows:

- ❒ 4DD02 : A large discrepancy (WRA: H=2.0 m, Q=500 m^3 and H=3.0 m, Q=3,000 m^3/s, Project: H=2.0 m, Q=74 m^3/s and H=3.0 m, Q=184 m^3/s)
- ❒ 4EA07 : Almost equivalent (WRA: H=1.0 m, Q=54 m^3/s, Project: H=1.0 m, Q=58 m^3/s)
- ❒ 4F10 : Almost equivalent（WRA: H=1.0 m, Q=30 m^3/s, Project: H=1.0 m, Q=36 m^3/s）

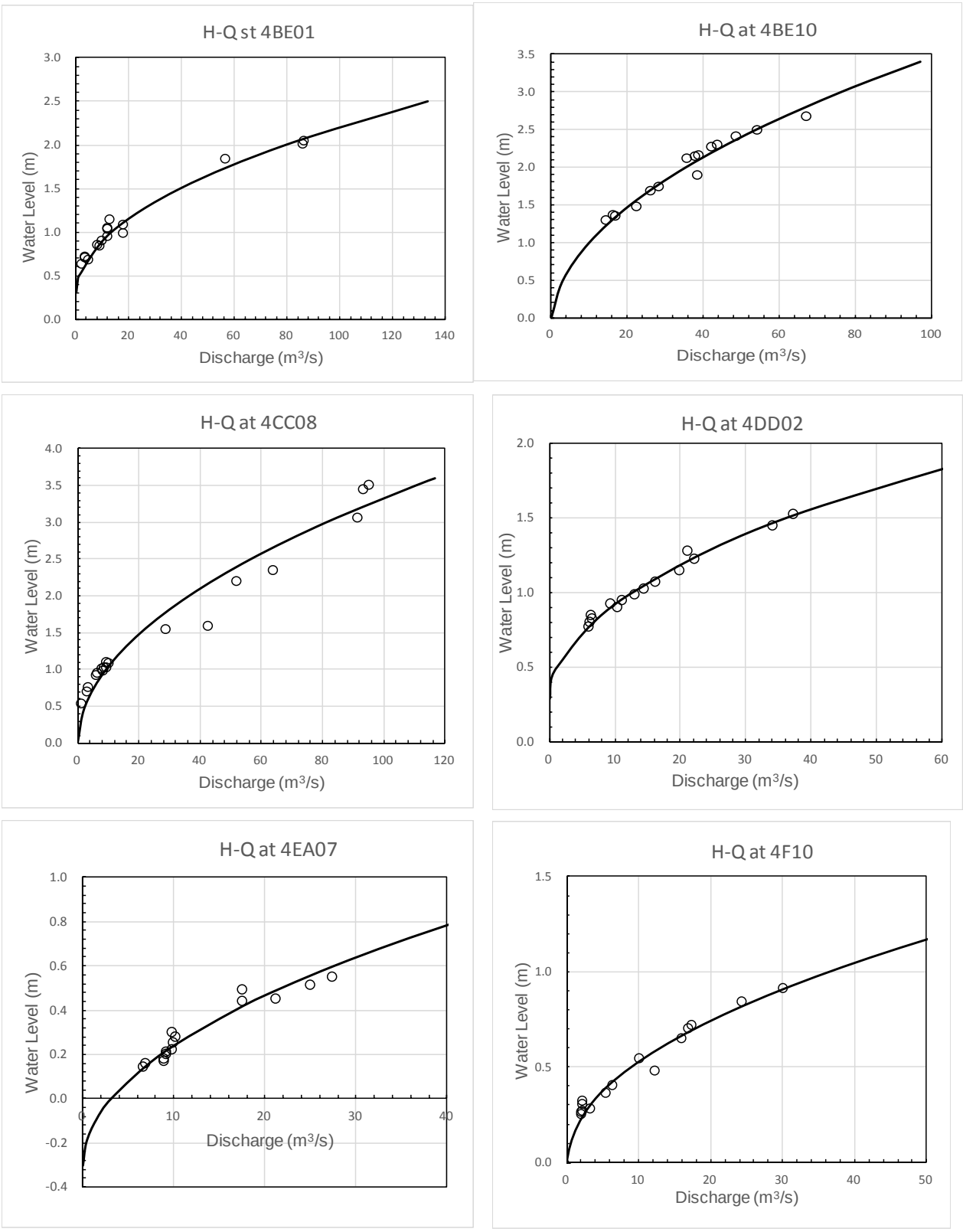
Regarding the H-Q curve at 4DD02, since there is a possible error in the magnitude of horizontal axis, the JICA Expert Team suggested to the WRA staff in-charge to check the original data of discharge measurements and take appropriate action for revision of the curve.

(5) Periodical discharge measurements

Through a sub-contract work, 90 discharge measurements were conducted (94 times actually). Detailed results of measurements are compiled in the contractor's final report (NARIANA Enterprises Limited). In this connection, while the measurements were conducted, two workshops were held to explain the detailed methodology of discharge measurement and subsequent analyses to the staff of HQ, RO, and SROs. The outline is described hereunder, and lecture materials used in the workshops are attached in Appendix 5.

- 1st Workshop
  - Date/ Venue : March 8 and 9, 2018, Conference Room, Embu RO, WRA
  - Objectives : Outline of the Project activities, methodology of discharge measurement, estimation of H-Q curve and field practice of measurement (at 4BE10)
  - Participants : 22 persons (including the JICA Expert Team and staff of the contractor)
- 2nd Workshop
  - Date/ Venue : June 26 and 27, 2018, Conference Room, Embu RO, WRA
  - Objectives : Intermediate results of the measurements, H-Q curves (tentative) and composition of the manual, etc.
  - Participants : 24 persons (including the JICA Expert Team and staff of the contractor)

Based on the results of measurements, H-Q curves at the target six gauging stations were estimated as shown in Figure 2.7.



Source: JICA Expert Team

Figure 2.7 Results of Discharge Measurement and H-Q Curves

The regression formulae of H-Q curves (Figure 2.7) at respective sites are tabulated in Table 2.12.

Table 2.12 Estimated Approximate Equations of H-Q Curves

G/S ID No.	Name	Number of Data Used	Regression Formula of H-Q Curves
4BE01	Maragua	16	$Q = 27.756 \times (H - 0.310)^2$
4BE10	Tana Rukanga	15	$Q = 7.685 \times (H + 0.152)^2$
4CC08	Thika	18	$Q = 8.889 \times (H + 0.025)^2$
4DD02	Thiba	15	$Q = 25.004 \times (H - 0.285)^2$
4EA07	Mutonga	15	$Q = 33.784 \times (H + 0.306)^2$
4F10	Kathita	15	$Q = 37.199 \times (H - 0.010)^2$

Source: JICA Expert Team

Although the number of measurements defined in the contract was 90 times in total (15 times each), around 16 and 18 times of measurement at 4BE01 and 4CC08 were performed, respectively, under an agreement with the contractor, considering the risk of less variations of water levels due to a short time interval between measurements, contrary to the intention of the technical specifications of the contract. Eventually, no change of the contract was made.

2.1.5 Assistance for Improvement of Operation of Meteorological and Hydrological Gauging Stations【Activity 1.5】

Activity 1.5 includes two components, i.e., (1) Understanding and finding issues of operation of meteorological and hydrological gauging stations, and (2) Support for improvement of operation of meteorological and hydrological gauging stations.

(1) Understanding and finding issues of operation of meteorological and hydrological gauging stations

An interview survey to clarify the current operation system of the targeted six water level gauging stations for the Project was conducted to each SRO. The survey results are summarized in Table 2.13. The number of staffs for operation and maintenance works is one or two persons at each SRO, and the staffs perform activities of data collection, inspection, and cleaning works monthly. The number of staff and frequency of activities for the rainfall gauging stations are same as for the water level gauging stations in accordance with the answers of respective SRO in the interview survey.

Table 2.13 Current Status of Operation and Maintenance of Water Level Gauging Stations

Upper Tana SRO: Two staffs for maintenance work

G/S ID No.	Measurement Method	Period	Frequency			Note
			Data Collection	Field Inspection	Cleaning Works	
4BE10	Manual/ Automatic	1979 onward	Monthly	Monthly	Monthly	Automatic recording device is not functional.
4BE01	Manual	1950 onward	Monthly	Monthly	Monthly	
4CC08	Manual/ Automatic	2010 onward	Monthly	Monthly	Monthly	Data logger installed by the Tanath Water Supply Company

Meru SRO: One staff for maintenance work

G/S ID No.	Measurement Method	Period	Frequency			Note
			Data Collection	Field Inspection	Cleaning Works	
4EA07	Manual/ Automatic	―	Monthly	Monthly	Monthly	Automatic recording device is not functional.

G/S ID No.	Measurement Method	Period	Frequency			Note
			Data Collection	Field Inspection	Cleaning Works	
4F10	Manual/ Automatic	―	Monthly	Monthly	Monthly	Data logger installed by the Project

Kerugoya SRO: Two staffs for maintenance work

G/S ID No	Measurement Method	Period	Frequency			Note
			Data Collection	Field Inspection	Cleaning Works	
4DD02	Manual/ Automatic	―	Monthly	Monthly	Monthly	Telemetering devices installed by IGAD Project

Source: JICA Expert Team

The field inspection and cleaning works of the facilities and equipment are conducted in compliance with the manners described in the following documents:

(i) Guide to Hydrological Practices, WMO-No.168

(ii) ISO 1100-1, Measurement of Liquid Flows in Open Channels

(iii) Guidelines for Assessment of River Gauging Stations

The guideline (i), which is published by the World Meteorological Organization (WMO), presents detailed methodology for inspection of gauging stations including technical particulars. It was confirmed that the operation and maintenance activities were conducted by referring to an appropriate guideline.

However, it was found that automatic equipment at two water level gauging stations did not properly function and SRO had no specific plan to repair as described in the column of "Note" in Table 2.13. Also, it was confirmed that there was no description of the latest information such as malfunction, etc., on the ledger of RGSs at SRO. The rapid sharing of field information is a crucial issue, since unless the latest information is accurately recorded, proper maintenance becomes difficult. Although the budget for maintenance works has a certain limitation, it is essential to perform consistent operation and maintenance of RGSs by regularly updating information on such malfunction and issues of the equipment and preparing a maintenance plan for priority RGSs strategically.

(2) Support for improvement of operation of meteorological and hydrological gauging stations

As for sharing information between RO and HQ, a guideline was prepared including suggestions to record the latest information of RGSs collected through operation and maintenance works. The guideline describes the roles of SRO, RO, and HQ for operation and maintenance works and the procedure for sharing the checklist in detail. The structure is shown below, and the guideline is presented in Attachment 7.

Title: GUIDELINE FOR MAINTENANCE OF REGULAR GAUGING STATION

Major contents

1. Objective of Guideline
2. Management of Maintenance Work
2.1 Maintenance Work
2.2 Handling of Checklist
3. Roles and the Tasks

Attachments:

- Checklist for Maintenance Work of Regular Gauging Station
- Sample of Summary Table of Checklist

A sample checklist and procedure for sharing information are shown in Table 2.14 and Figure 2.8 respectively. In the checklist, two columns for recording the confirmed issues and required countermeasures to cope with the problems are provided. The procedure was set to enable actions for appropriate countermeasures through sharing information by submission of the checklist prepared by SRO to HQ via RO.

The guideline was distributed to SRO, RO, and HQ for conducting a trial operation in October 2018 and then comments of the offices concerned were collected. One of the major comments from SRO is that the frequency of monthly submission of the checklist is too high and this will cause heavy burden for the staff. However, since data collection should be included in the maintenance activities and required monthly, it is with unanimous agreement among all personnel concerned that the frequency of monthly submission was kept eventually.

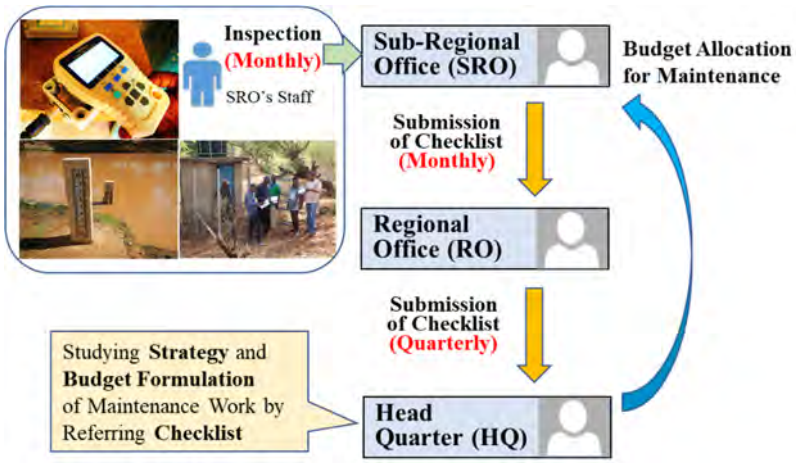
It is expected that repair and replacement of equipment will be accelerated properly by sharing the information on maintenance works by submitting the checklist continuously in the future. In this regard, since the budget for maintenance activities is limited, it is important to restore high priority gauging stations aiming at effective maintenance works as discussed in Clause 2.1.1.

Table 2.14 Sample Checklist（Operation and Maintenance）

Filled by _____ Checked by _____ **Checklist for Maintenance Work of Regular Gauging Station** TANA BASIN 2019/1/17

S/No	STATION ID	STATION NAME/ RIVER	CONSTITUENCY	COUNTY	LOCATION	REGION	SRO	CHECK ITEMS										COMMENTS	
								Facility		Device		Replacement		Calibration		Cleanup		ISSUES	REQUIREMENTS
								YES	NO	YES	NO	YES	NO	YES	NO	YES	NO		
1	4AA06	LOWER SAGANA	KIENI	NYERI	Kabaru forest station to Hombe forest station road	TANA	Upper Tana	☑	☐	☐	☑	☑	☐	☑	☐	☑	☐	Observation sensor was broken and not functioned	Observation sensor should be replaced
2	4AA07	U.SAGANA	KIENI	NYERI	Kabaru forest station to Hombe forest station road	TANA	Upper Tana	☑	☐	☑	☐	☑	☐	☑	☑	☑	☐	None	None
3	4AA1	SAGANA	MATHIRA	NYERI	Rocky	TANA	MURANGA	SAMPLE								☑	☐	None	None
4	4AA2	THEGO	KIENI	NYERI	Chaka-state lodge road	TANA	MURANGA	☐	☑	☑	☐	☑	☐	☑	☐	☑	☐	One staff gauge had been flowed out	To re-install a staff gauge is required
5	4AA4	NAIROBI	NYERI TOWN	NYERI	Chaka state lodge road	TANA	MURANGA	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	None	None
6	4AA5	SAGANA	NYERI TOWN	NYERI	Marua-Kiganjo Sagana bridge	TANA	MURANGA	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	None	None
7	4AB01	MURINGATO	NYERI TOWN	NYERI	Kiganjo-Nyeri at Muringato bridge	TANA	Upper Tana	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	None	None
8	4AB02	MWEIGA	NYERI TOWN	NYERI		TANA	Upper Tana	☐	☑	☑	☐	☑	☐	☑	☐	☑	☐	The revetment for securing observation hut had been eroded partially	To repair the revetment is required

Source: JICA Expert Team



Source: JICA Expert Team

Figure 2.8 Proposed Procedure for Sharing Information on O&M of Water Level Gauging Stations

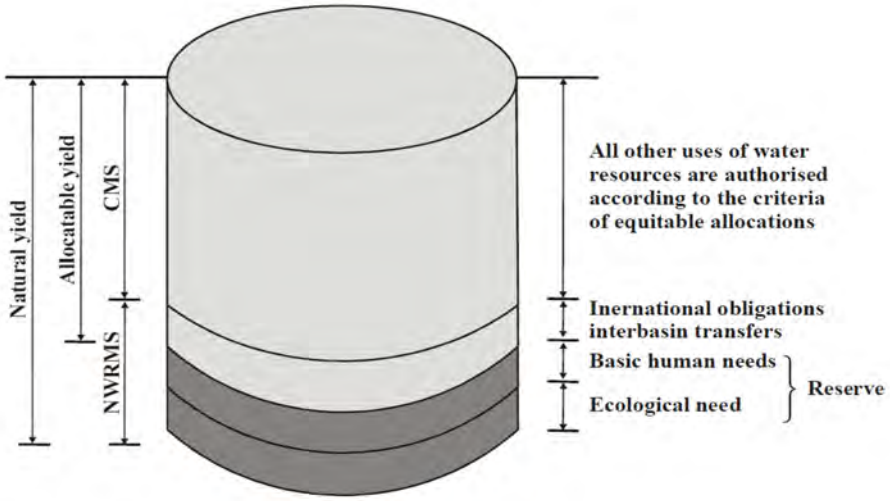
2.1.6 Guidance on Setting of River Maintenance Flow【Activity 1.6】

There is a concept of river maintenance flow in Kenya. Although the "Water Allocation Guideline (March 2010)" defines a methodology for estimation of river maintenance flow, it does not reach to show a concrete method to set appropriate discharges at arbitrary points. The major reason is the lack of hydrological data. A practical way might be to estimate maintenance flow discharge proportionally with the catchment areas and to convert to upstream points of the "National" gauging station, where relatively substantial hydrological data is accumulated.

Regarding the concept of maintenance flow discharge, the JICA Expert Team explained it comparing the normal flow discharge in Kenya with the one in Japan (Ref: Appendix 6). The explanation presented in the handout for the 2nd Workshop (June 26 to 27, 2018) is extracted and presented as follows:

>>>>>>>>>>>>>

- The Water Act 2002 Section 8 mandates WRA "to develop the principle, guidelines, and procedures for the allocation of water resources". The first edition of the "Guidelines for Water Allocation" was issued in March 2010 to set out the guidelines to be followed by WRA in decision making on the allocation of available water resources.
- The guideline generally considers allocation of four demands of (1) ecological demand, (2) basic human needs, (3) international obligation and inter-basin transfers, and (4) demand allocated for individual use by means of permit (Ref: Figure 2.9).
- The "Reserve" is the portion of the water resources which is set aside to meet demands for ecological and basic human needs. The reserve needs to be defined with respect to the quantity, reliability, and quality.



Source: Water Allocation Guidelines, March 2010, Kenya

Figure 2.9 Conceptual Graph of Water Allocation in Kenya

In NWMP 2030, the "Reserve" was specified as "95% value of the naturalized daily flow on the flow duration curve with the probability of once in ten years, based on the Water Allocation Guideline.

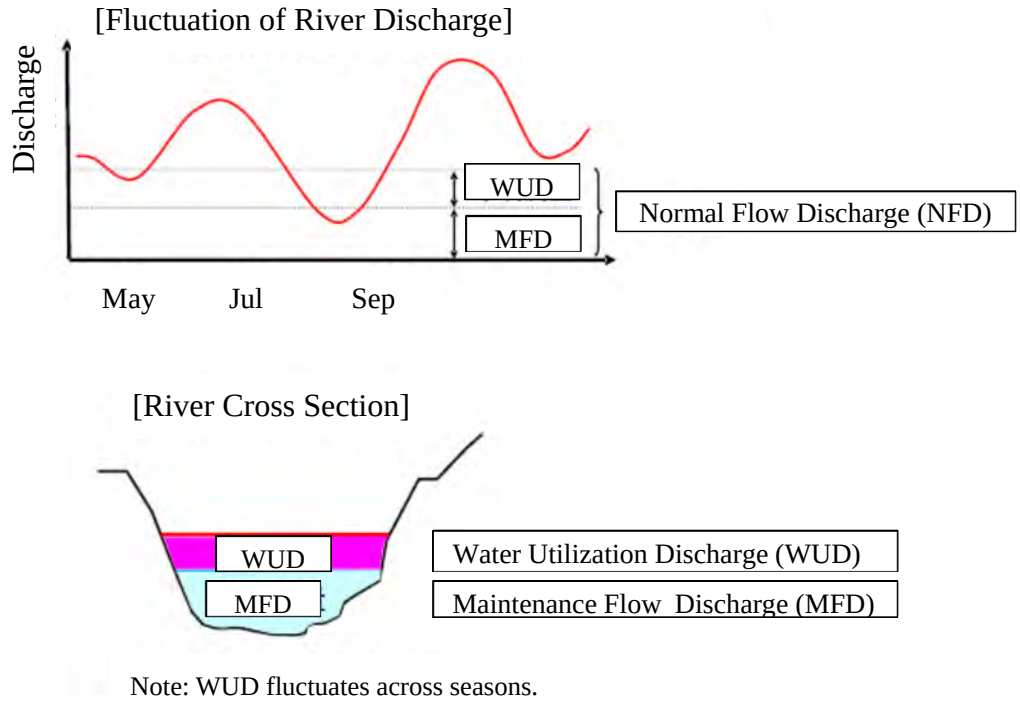
On the other hand, the definitions of the technical terms relevant in Japan are as follows:

- There are two types of flow discharges to be determined.
- The first one is the flow discharge determined in total consideration of water functions such as navigation, fisheries, tourism, maintenance of clean river water, prevention of salt water intrusion damage, prevention of river-mouth clogging, protection of river management facilities, maintenance of groundwater levels, landscape values, and ecosystems, and securing of opportunities for human interactions with the river. This discharge is hereinafter referred to as "Maintenance Flow Discharge".
- The second is the flow discharge necessary for water utilization at the downstream point for which the maintenance flow discharge has been determined (hereinafter referred to as "Water Utilization Flow Discharge"); this discharge is determined at a point that serves as the reference point for appropriate river management.
- The "Normal Flow Discharge", if necessary, should be determined for each of the river reach represented by annual fluctuations in the maintenance flow discharge and water utilization flow discharge.
- The "Normal Flow Discharge" is as follows:
  - The Normal Flow Discharge is estimated as the required discharge to satisfy both the "Maintenance Flow Discharge" and "Water Utilization Flow Discharge".

Normal Flow Discharge (NWD)	=	Maintenance Flow Discharge (MFD)	+	Water Utilization Discharge (WUD)

- Even in case of drought year, the "Normal Flow Discharge", which requires total consideration of water functions, should be secured. Therefore, the "Normal Flow Discharge" is not determined as desired for normal year ⇒ Discharge to maintain water function at the minimal level.

The relationship among the Maintenance Flow Discharge, Water Utilization Discharge, and Normal Flow Discharge is illustrated in the images in Figure 2.10.



Note: WUD fluctuates across seasons.

Source: JICA Expert Team

Figure 2.10 Conceptual Graphs of Maintenance Flow and Water Utilization Discharges

In order to set the Maintenance Flow Discharge and Water Utilization Discharge, continuous monitoring of water levels/ discharges and data analysis and management are primarily essential. It should be recognized as the highest priority issue to realize quantitative management.

2.2 Activities for Output 2

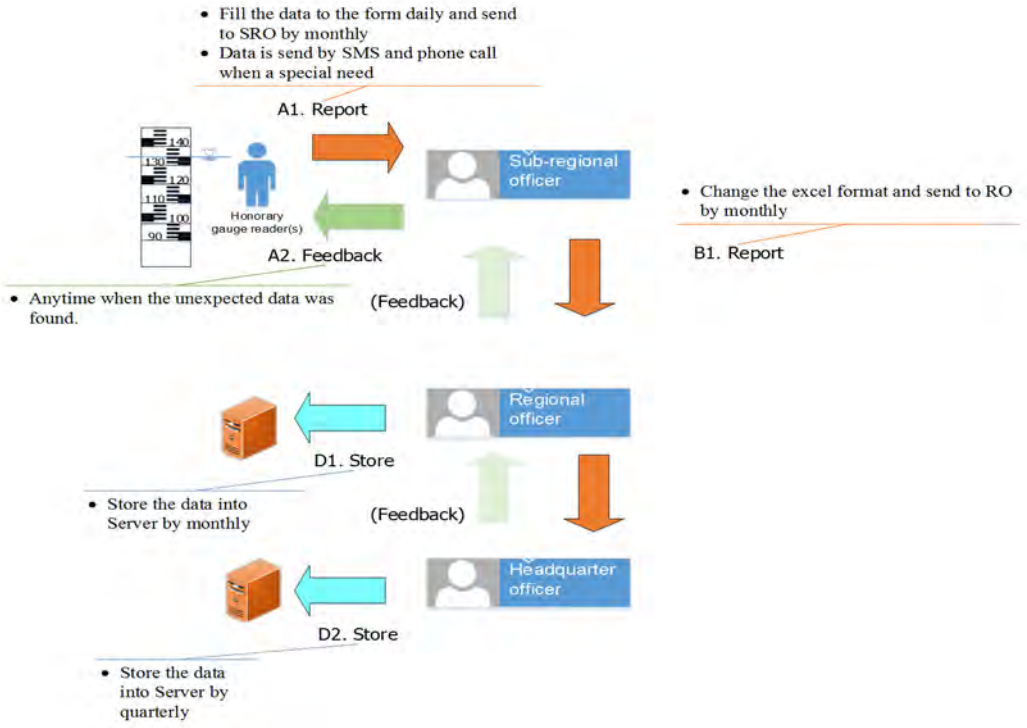
Activities of Output 2 are composed of the following two subjects:

- Activity 2.1 Confirmation on current condition of meteorological and hydrological database
- Activity 2.2 Assistance for improvement of meteorological and hydrological database

2.2.1 Confirmation on Current Condition of Meteorological and Hydrological Database 【Activity 2.1】

(1) Current registration work of meteorological and hydrological database

The WRA observes and records meteorological and hydrological data every day. The observed data are informed to the headquarter in Nairobi (HQ), Regional Office (RO), and Sub-regional Office (SRO) as shown in Figure 2.11.



A gauge reader goes to the station and records observed data every morning at 9:30 a.m.

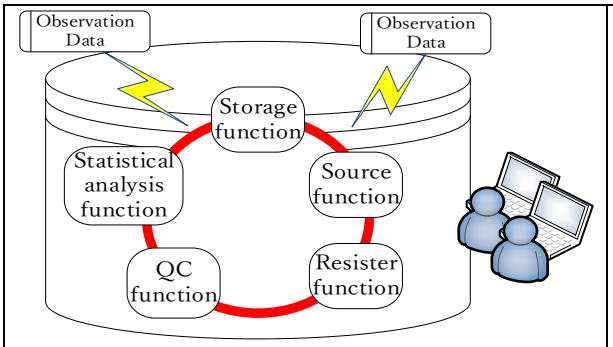
Code	Action	From	To	Manner	Timing
A1	Report	GR*1	SRO	Filled Form	Monthly
A2	Feedback	SRO	GR*1	Call	Anytime when unexpected data is found.
B1	Report	SRO	RO	Quarterly	Monthly
		SRO	RO	Excel format	Every month
B2	Feedback	RO	SRO	Call/Write email	Anytime when unexpected data is found.
C1	Report	RO	HQ	Export back-up	Quarterly
C2	Feedback			Call/Write email	Anytime when unexpected data is found.
D1/D2	Store	HQ/RO	Sever	(Mike Basin)	Quarterly

Note: *1、Gauging reader Source: JICA Expert Team

Figure 2.11 Transmission Route of Observed Records

(2) Current conditions of database system from aspect of its function

There are five functions that the database system should contain as shown in Figure 2.12.



1	Storage function	Store data on a daily /monthly basis and develop a repository.
2	Source function	Retrieve and organize the data
3	Register function	Add, amend and delete data as required
4	Quality control function	To ensure the integrity and consistency of the data
5	Statistical analysis function	Utilize the data for rationalization by statistical analysis.

Source: JICA Expert Team

Figure 2.12 Functions of Database

The responsibilities of the five functions are shared with each office as indicated in Table 2.15.

Table 2.15 Responsibilities Shared by Offices Concerned on Database Management (Initial Setting)

Function	Responsible Institution		
	Headquarter (HQ)	Regional Office (RO)	Sub-regional Office (SRO)
Storage function	○	○	△
Source function		○	○
Register function		○	○
Quality control	○	○	△
Statistical analysis	○	△	–

Note: ○：Main roles, △：Assisting roles Source: JICA Expert Team

The SRO prioritizes his tasks on observation of meteorological and hydrological data, and does not conduct the data analysis such as conversion from water levels to discharges. The work of conversion from water levels to discharges with the preparation of H-Q curves is conducted by RO.

(3) Current condition of data storage

The number of staffs in-charge of database system and the conditions of data storage (paper-based or server storage) are summarized as shown in Table 2.16. One person handles the data storage at SRO, while two persons are assigned at RO and HQ. At each SRO, the person in-charge of data storage stores the paper-based monthly report, and also saves an excel file which is an input data on the server computer. However, SROs including RO do not have any server computer (desktop computer), so they save the excel files on their personal laptop computer. It is supposed to be installed in one desktop computer at each SRO and RO under the Kenya Water Security and Climate Resilience Project (KWSCRP) by the World Bank.

Table 2.16 Current Status of Storing Data

Office	Number of Staff	Storage		Timing
		Paper	Server	
SRO Meru	1	○	○※	Monthly
SRO Kerugoya	1	○	○※	Monthly
SRO Upper Tana	1	○	○※	Monthly
RO Embu	2	―	○※	Monthly
HQ Nairobi	2	―	○	Quarterly

Note: ※ They keep the data files on their personal laptop computer instead of server computer (desktop computer) since they do not have any server system. It is scheduled that one desktop computer will be provided to each office by the World Bank Project.

Source: JICA Expert Team

The paper-based monthly reports of observed data are stored in shelves as shown in Figure 2.13 below. It was found that the drawer of shelves had been broken in some offices and confirmed degradation of the monthly report due to storage in the open-type shelves. The number of officials in-charge of database management is one staff at each SRO, and the person in-charge engages in inspection of quality, storage of monthly report, data entry, data transmission, and so on. The data transmission has been basically implemented on a monthly basis; however, according to the RO staff, some SROs sometimes miss the data transmission. SROs basically allocate one gauging reader at each station for entrusting recording of the observed data and provide them with an allowance periodically. As result of the interview with SRO staffs, they sometimes could not give the gauge readers an allowance due to budget constraint; therefore, the activities of data recording by gauge readers had been stacked up for some time. This is probably the reason why some SROs have sometimes been stacked up with the data transmission. In addition, the person in-charge of database management has a full schedule for other works depending on the season since the person is not an exclusive official for the database management. It is assumed that it is also one of the reasons for the interruption of data transmission.

Muranga SRO	Kerugoya SRO	Meru SRO

Source: JICA Expert Team

Figure 2.13 Current Status of Storing of Monthly Records

(4) Current issues on database management

It is an important goal of the database management to ensure data quality and data storage consistently. In this aspect, various problems such as shortage of workforce, budget, equipment (PC), and facilities (shelves) were found based on the current conditions of database management. It is currently difficult to make an improvement program of database system because problems are not well identified and recognized. It is deemed that the highest priority of tasks is to find and share the issues quantitatively.

2.2.2 Assistance for Improvement of Meteorological and Hydrological Database【Activity 2.2】

A guideline for hydrometeorological database management was prepared for ensuring data quality and data storage steadily (refer to Attachment 7). The guideline is composed of the chapter shown below.

Title: GUIDELINE FOR HYDROMETEOROLOGICAL DATABASE MANAGEMENT
ToC:

1. Objective of Guideline
2. Procedure of Database Management
3. Role of the Tasks
4. Handling of Documents and Data

Attachment:

- Checklist-SRO, RO and HQ
- Sample of Summary Table of Checklist

A checklist for confirming the work performance was drawn up indicating the required activities and responsibility of SRO, RO, and HQ for database management. Two columns for recording some confirmed issues and requirements against the issues were laid in case of finding any issues. By adding the columns, understanding issues quantitatively for database management will be available. The sharing of information will be enhanced by submitting the checklist from SRO to HQ via RO, then the information will be used as valuable information for accomplishing appropriate countermeasures.

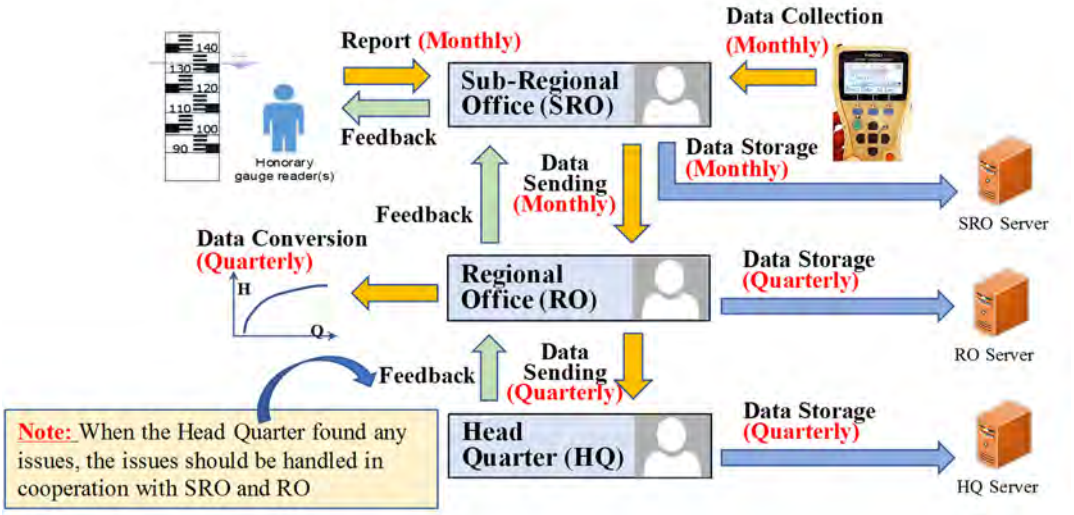
Table 2.17 Sample Checklist（for Database Management）

Filled by ____________ Checked by ____________ **Checklist for Hydrometeorological Database Management** TANA BASIN 2019/1/17

S/No	STATION ID	STATION NAME/ RIVER	CONSTITUENCY	COUNTY	LOCATION	REGION	SRO/ RO	CHECK ITEMS: SRO Data Filling YES	NO	SRO Data Matching YES	NO	SRO Exported Data YES	NO	SRO Paper Filing YES	NO	SRO e-Data Storing YES	NO	RO Data Filling YES	NO	RO Data Correction YES	NO	RO e-Data Storing YES	NO	HQ Data Filling YES	NO	HQ e-Data Storing YES	NO	COMMENTS: ISSUES	COMMENTS: REQUIREMENTS
1	4AA06	LOWER SAGANA	KIENI	NYERI	Kabaru forest station to Bombe forest station road	TANA	Upper Tana/ Embu	☑	☐	☑	☐	☑	☐	☑	☐	☐	☑	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	SRO: There is no server computer for storing e-data RO: None	SRO: The budget for purchasing one server computer is required RO: None
2	4AA07	U.SAGANA	KIENI	NYERI	Kabaru forest station to Bombe forest station road	TANA	Upper Tana/ Embu	☑	☐	☑	☐	☑	☐	☑	☐	☐	☑	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	SRO: There is no server computer for storing e-data RO: None	SRO: The budget for purchasing one server computer is required RO: None
3	4AA1	SAGANA	MATHIRA	NYERI	Rooks	TANA	MURANGA Embu	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	SRO: None RO: None	SRO: None RO: None
4	4AA2	THEGO	KIENI	NYERI	Chaka-state lodge road	TANA	MURANGA Embu	☑	☐	☑	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	☑	☐	☑	☐	☑	☐	☑	☐	SRO: None RO: None	SRO: None RO: None
5	4AA4	NAIROBI	NYERI TOWN	NYERI	Chaka state lodge road	TANA	MURANGA Embu	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☐	☑	☐	☑	☐	☑	☐	☑	SRO: None RO: No preparation of H-Q curve for converting water level into discharge	SRO: None RO: Discharge measurement for preparing H-Q curve should be conducted
6	4AA5	SAGANA	NYERI TOWN	NYERI	Mana-Kiganjo Sagana bridge	TANA	MURANGA Embu	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	SRO: None RO: None	SRO: None RO: None
7	4AB01	MURINGATO	NYERI TOWN	NYERI	Kiganjo-Nyeri at Muringato bridge	TANA	Upper Tana/ Embu	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	SRO: No budget for paying allowance to observing honorary RO: None	SRO: The budget for paying allowance to observing honorary RO: None
8	4AB03	MWEIGA	NYERI TOWN	NYERI		TANA	Upper Tana/ Embu	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☐	☑	☑	☐	SRO: None RO: None	SRO: None RO: None

SAMPLE

Source: JICA Expert Team



Source: JICA Expert Team

Figure 2.14 Schematic Diagram of Database Management

The guideline was distributed to SRO, RO, and HQ and test operation by using the checklist had been conducted in October 2018. After the test operation, an interview for collecting comments from each official was implemented. The staffs of HQ and RO made a comment regarding the responsible institution shown in Table 2.18 below. The comment was that SRO should also have a main role for quality control in addition to HQ and RO because SROs type the observed data and the inspections of primary data by SROs are important. Based on the comment, the guideline was updated adding the main role of quality control to SRO.

Table 2.18 Revised Responsibilities Shared by Office Concerned for Database Management (Revised)

Function	Responsible Institution		
	HQ	RO	SRO
Storage function	○[1)]	○[2)]	△
Source function		○[1)]	○[2)]
Register function		○[1)]	○[2)]
Quality control	○[1)]	○[1)]	~~△~~⇒○[1) 2)]
Statistical analysis	○	△	

Note: ：○: Main role, △ ：Assisting role
1) Responsibility of securing quality, 2) Responsibility of work implementation
Source: JICA Expert Team

Currently, SROs and RO do not have any server computer (desktop computer); therefore, they use their own personal laptop computer for data storage. After the installation of one desktop computer in each SRO and RO by the World Bank project, they will use them for data storage. Although there are some risks of data loss since the personal laptop computer can be easily and freely carried out, the risks will be reduced after installation of server computer (desktop computer).

It is expected to ensure the data storage steadily by using the checklist and confirming the data recording and storing. On the other hand, with regard to no recording and storing stations, it is available to find the issues easily from the columns of checklist which describe the reasons and issues. Through the sharing of information, it is expected that appropriate countermeasures will be available and the facilities and organization will be improved accurately.

2.3 Activity for Output 3

Activities of Output 3 are composed of the following two subjects:

- Activity 3.1 Provision of guidance on future water resources management program in Kenya through the support of the Government of Japan
- Activity 3.2 Identification of required training subjects and preparation of training program

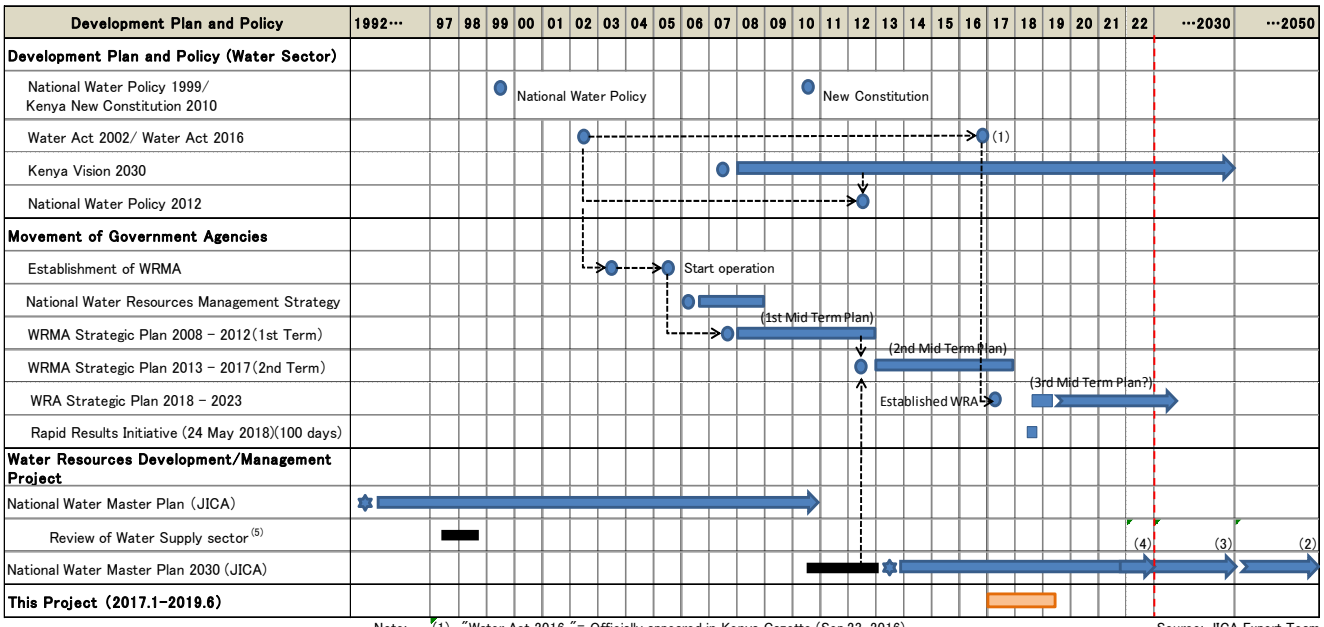
2.3.1 Provision of Guidance on Future Water Resources Management Program in Kenya through the Support of the Government of Japan【Activity 3.1】

The Activitiy 3.1 includes three compoenets, i.e. (1) Review for the past performance of water resources management, (2) Confirmation of the policy of water resources management in Kenya, and (3) Advice for water resources management program.

(1) Review for the past performance of water resources management (Activity 3.1)

1) Outline of the water sector in Kenya

The transition of the constitution, national development policy and plans and water acts (2002/ 2016) in Kenya is shown in Figure 2.15 together with the progress of the national water resources development and management plans.



Note: (1) "Water Act 2016 "= Officially appeared in Kenya Gazette (Sep.23, 2016)
(2) Targeted Year 2050 for water resources vulnerability and evaluation of water resources potential affected by climate change
(3) Targeted Year 2030 formulation of sustainable integrated master plan of water resources development, utilization and management for respective catchments
(4) Targeted Year 2022 for preparation of action plans for enhancement of water resources management at WRMA regional offices
(5) "The Aftercare Study on the National Water Master Plan, Nov. 1998, JICA"
Source: JICA Expert Team

Figure 2.15 Relationship between National Develoment Plans and Water Resources Development/ Management Plans

Major policies, plans and guidelines prepared by MWS and WRA as seen in Figure 2.15 were reviewed. The results are tabulated in Table 2.19:

Table 2.19 Related Plans and Guidelines of Water Resources Management Sector

Name of Documents	Agency	Publishment	Major Contents
1. The National Water Resources Management Strategy (NWRMS) (2006-2008)	Ministry of Water and Irrigation	January 2006	Based on the former Water Act, the structure of water resources administration was initially regulated. In 2005, WRMA has been lauched. It is recognized that this provided a framework of the Catchment Management Strategy (CMS), which would have been prepared subsequently in Catchment.
2. WRMA Strategic Plan 2012-2017	WRMA	2012	This is a medium-term strategic plan of WRMA (2nd term) and composed of six plans as below: (1) Strengthen monitoring networks to enhance data collection and improve information management system (2) Improve the use of water resources management tools for effective water resources planning and allocation (3) Strengthen use of water resources management tools and collaboration for effective catchment protection and conservation (4) Strengthen stakeholder collaboration to enhance water storage and adaptation to climate change impacts (5) Build staff capacity and improve working environment (6) Enhance resource mobilization and effective use of finances
3. National Water Master Plan 2030	JICA	2014	This is a water resources development and management master plan covering the respective six catchments with development target of 2030. Whenever preparing policies in water sector is required, the master plan is always referred to and abstracted. It is composed of five development plans, three management plans and an institutional strengthening plan. At present, the Kenya Water Security and Climate Resilience Project (KWSCRP) supported the WB utilizes the output and collected data by the NWRM2030 in many subjects.
4. Tana Catchment, Catchment Management Strategy (2014-2022)	WRA	Oct. 2014	This is the CMS for Tana Catchment. There are six CMSs. The time of preparation and its framework are complied with the NWRMS (2006) almost in parallel for all six CMSs.
5. Water Act 2014	WRA	2016	The new Water Act was enacted to revise the former Water Act (2002) and to embody decentralization in the water sector. By the enactment, the WRMA was renamed as the WRA and responsibilities of all water resources related agencies were reviewed.
6. A Report on the Evaluation of the WRMA Strategic Plan 2012-2017	WRA	April 2017	This is an evaluation report of the WRMA Strategic Plan (2012-2017). This report wrapped-up the results of discussions in workshop-style meetings of 5 days, which were organizaed and attended by WRA staff.

7. Rapid Results Initiative	Ministry of Water and Sanitation	24 May 2018	The present government has been established on January 28, 2018. Rapid development of principal activities defined by new Water Act 2016 is demanded. In particular, a 100-day action plan was prepared through selection of items for earlier implementation with priority.
8. Draft Sessional Paper No.** of 2018 on National Water Policy, Version of 21 June 2018	Ministry of Water and Sanitation	June 2018	A draft document for deliberation in the Session. The present National Water Policy was enacted in 1999. The concept was succeeded to the former Water Act 2002, and then continued to the its revision in 2016. In particular, this paper indicates three issues, which is facing in water sector, i.e., (1) Low-level water supply and sewerage treatment services, (2) Vulenerability of water resources management, and (3) Security of water resources and lack of storage capacity. With this fundamental recognition, eight policy objectives are presented.。
9. Development of A New Strategic Plan 2018-2023, Terms of Reference for the Consultants	WRA	June 2018	A draft specification prepared to outsource formulation of new WRA medium-term strategic plan. Based on this document, a consultant firm was procured, and the specified works are on-going. (information by CEO Mr. Shurie)
10. Capacity Development and Institutional Strengthening for WRA, A Concept for Support to JICA	WRA	July 2018	A concept paper prepared by WRA requesting cooperation of JICA for next year onward. Basically, the requested items are composed of three subjects, i.e., (1) Capacity development of WRA staff, (2) Installation, improvement and automation of monitoring stations, (3) Strengthening of dam safety assurance.
11. WRA Strategic Plan 2019-2023	WRA	Mar. 2019	Under preparation. In March 2019, the 1st Draft was submitted to WRA by the consultant in charge.

Source: JICA Expert Team

The point to be focused is that the National Water Master Plan (NWMP 2030) was formulated in 2013 after 20 years past from submission of the original master plan in 1992 assisted by JICA and those are closely related with enactment of the Water Act, establishment of WRMA and preparation of the strategic plans (medium-term plans), etc. Fruther, it should be paid attention that NWMP 2030 has been formulated before enactment of the new Water Act 2016. At presnt, WRA is preparing new WRA Strategic Plan 2018-2023 in compliance with the new Water Act 2016.

2) NWMP 2030 (National Water Master Plan 2030)

In 2007, “Kenya Vision 2030” was contemplated targeted at 2030 for the development goal. The water was defined as indispensable resources to realize the proposed development activities in the Vision. In order to achieve the goals, it was acknowledged that appropriate implementation systems and plans of the water resources development and management are prerequisite to meet the increasing water demand in municipal, irrigation and industrial uses in consideration of environmental conservation

On the other hand, the climate change over the world is recognized as a crucial issue in Kenya as well and the perception on the increasing risks of flood and drought is heightened. Under such significant

changes of circumstances in the water sector, updating of the the former Master Plan (in 2002) became necessary, and then the master plan study was conducted with an assistance of JICA.

The study period was 37 months from October 2010 to October 2013. The final reports were compiled in 7 volumes containing the water resources master plan with target year of 2030 for the six catchments. Basic composition is listed as follows:

Development Plan

(a) Water Supply Development Plan, (b) Sanitation Development Plan, (c) Irrigation Development Plan, (d) Hydropower Development Plan, (e) Water Resources Development Plan

Management Plan

(f) Water Resources Management Plan, (g) Flood and Drought Disaster Management Plan,
(h) Environmental Management Plan

Another Plan

(i) Instituinal Strengthening Plan

The current Project focused, in particular, the water rsources management plan and flood and drought disaster management plan among the Master Plan (for 6 Catchments). The JICA Expert Team explained the contents of recommendations in the plans to the management staff of WRA at the presentation for the purposes of information sharing and follow-up activities (at WRA Board Room, April 7, 2017).

3) Catchment Management Strategy

In compliance with the stipulation in the former Water Act in 2002 (Section 15: Catchment Management Strategy), the Catchment Management Strategies (CMSs) were prepared between 2014 and 2015. The implementation periods were set for 7 to 8 years from 2014 (or 2015) to 2022.

The concept of Integarated Water Resources Management (IWRM) was applied as the principle concept and it showed the guidelines for management, utilization, development, conservation, and protection of water resources in the catchments. Although the time frame and the contents of plans were fundamentally contemplated in conformity with the NWMP2030, which was prepared ahead of CMSs, the overall structures of CMSs are composed from different perspective. For instance, the Tana Catchment Area CMS has a plan composition as follows:

(a) Management approaches
(b) Water balance and demand mangament
(c) Water allocation and use management
(d) Water resources protection
(e) Catchment consevation and protection
(f) Flood and drought management
(g) Climate change adaption
(h) Water resources infrastructure development
(i) Rights based approaches
(j) Livelihood enhancement
(k) Institutional stregthening
(l) Monitroing and information management
(m) Financing the CMS

At the regional office of the Tana Catchment in Embu, the JICA Expert Team interviewed to the Regional Manager about the current status of the CMS as abovementioned. It was found that the CMS is principally utilized as a guide for the activities. However, actually the contents of activities and priority are mofified and implemented at the level of respective offices because of budget restrictions. On the other hand, since the new Water Act 2016 was enacted, it is presumed that the CMSs will be reviewed and updated on the detailed contents at all Catchments after preparation of the WRA Strategic Plan 2017-2022.

4) Kenya Water Security and Climate Resiliance Project (KWCRP, World Bank)

This is on-going project conducted by WRA as main executing agency by receiving assistance from the Workd Bank. The Nzoia River baisn in the Lake Victoria North Catchment was selected as the pilot river basin and various activities are undertaken. The sub-projects in charge of WRA are as follows:

(a) Nzoia Watershed Management
(b) Lower Nzoia Flood Early Warning System
(c) Strengtheining Water Management and Planning
- Activity 1: Water Resources Knowledge Base
- Activity 2: Water Resources Planning and Allocation
- Activity 3: Institutional Capacity Strengthening and Partnership

As for for the sub-project of item (a) above, since the river basin has significantly abundant sediment yield, an importance of the watershed conservation plan is indicated and the plan formulation is proceeded in conformity with the concept of IWRM. In addition, as for item (b), the construction works for installation of 16 automated gauging stations at the flood prone areas across the country (designated by the NWMP2030) is on-going by means of a grant-aid (Approximately US 3.5mil.) from the Government of Kerea. As the target area of the Nozoia River basin, an agreement of cooperation was exchanged between WRA and Kenya Meteorological Department (KMD) to make smooth sharing of required meteohydrological data each other.

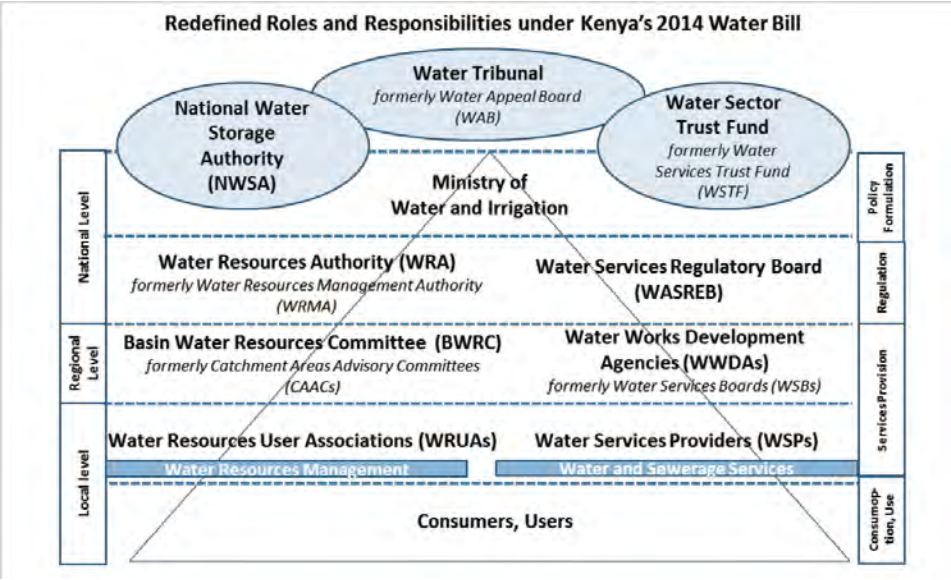
(2) Confirmation of the policy of water resources management in Kenya (Activity 3.1)

1) New Water Act 2016

In order to embody the decentralization in the water sector, which was adopted in the new Consitution enacted in 2010, the new Water Act was proclaimed in 2016. By the new law, the Water Resources Management Authority (WRMA) was changed to the Water Resources Authority (WRA), and some changes can ben seen in the responsible functions as well. Further, the names of other related governmental organizations have been changed as follows:

Former Water Act	New Water Act
● Catchment Area Advisory Committees (CAACs)	Basin Water Resources Committees (BWRCs)
● Water Services Board (WSBs)	Water Works Developmenet Agencies (WWDAs)

The outline on the changes of organization during preparation of the Bill in 2014 is illustrated in Figure 2.16[3].



Source: https://www.2030wrg.org/wp-content/uploads/2016/12/...

Figure 2.16 Re-definition and Allocated Responsibilities of Government Agencies by New Water Act in 2014

Regarding the difference between WRMA and WRA, the points identified from the former and new Water Acts are summarized in Table 2.20:

Table 2.20 Different Points on the Function between WRMA and WRA（Old and New Water Acts）

	WRMA（Old Water Act）	WRA（New Water Act）
1	・Catchment Area Advisory Committees (CAACs) have coordinating functions in the region.	・The Basin Water Resources Committees (BWRCs) will succeed the roles of the CAACs. Fruther, the BWRCs should have the functions of basin water resources management, assistance for establishment of WRUA and advisory agency for WRA. ・The county government can dispatch his representatives to the concerned BWRC geopolitically. ・Be responsible to establish WRUA. ・WRA can make a contract with BWRC to accomplish certain particular tasks.
2	・The roles of the regional government for water supply and water resources management are not clear.	・Regardless of the public agencies or the private companies for water supply, they can participate in the public-private-partnership contract after securing permission from the responsible coordinating agency.
3	・The roles of flood risk reduction are limited.	・The roles for flood mitigation function were added.
4	・No regulation exists for permission of trans-basin water resources development	・WRA is responsible to handle permissions on transboundary water resources development.
5	・Water resources management is the role of the central government. Transboundary water resources development should be also implemented by a national budget.	・Regional governments have responsibilities for water supply and sewage treatment services.
6	・There is no clear guideline of fund raising for project implementation.	・WRA can receive subsidies from the government for activities.

[3] "Ministry of Water and Irrigation" is reformed as "Ministry of Water and Sanitation".

	WRMA（Old Water Act）	WRA（New Water Act）
7	・To cope with illegalities, relief measures can be provided in compliance with permission of the Attorney Generals.	・No description exists like those in the former Act.

Source: JICA Expert Team

In Part III- "Regulation of the Management and Use of Water Resources" of establishment of WRA of the new Water Act 2016, the Acticle 11 declared establishment of WRA and the Article 12 clearly specified nine functions of WRA as follows:

(a) Formulate and enforce standards, procedures and regulations for the management and use of water resources and flood mitigation;

(b) Regulate the management and use of water resources;

(c) Enforce regulations made under this Act;

(d) Receive water permit applications for water abstraction, water use and recharge and determine, issue, vary water permits; and enforce the conditions of those permits;

(e) Collect water permit fees and water use charge;

(f) Determine and set prmit and water use fees;

(g) Provide information and advice to the Cabinet Secretary for formulation of policy on national water resource management, water storage and flood control strategfies;

(h) Coordinate with other original, national water international bodies for the better regulation of the management and use of water resources, and,

(i) Advise the Cabinet Secretary generally on the management and use of water resources

It is recognized that above stipulations are the bacic principles to regulate all policies and activities of WRA. Further, flood mitigation was clearly defined as the responsibilities of WRA.

2) Hearing with GIZ

The international donor agency of the Government of Germany, the *Gesellschaftfür Internationale Zusammenarbeit GmbH* (GIZ), has continued activities of development programs in broad fields including economic development, water resources development and management, clean energy, governance, food security, peace and security, etc., from 1964 in Kenya. Particularly for the water sector, the history of assistance is quite long and GIZ has joined in the formulation of the WRA (former WRMA) Performance Report and Catchment Management Strategy. At WRA Headquarter, a Technical Advisor (Kenyan) is stationed and assisted in making computer programs for water allocation and GIS-driven data management.

As part of the activities in this Project, interview with the GIZ staff in Nairobi was conducted twice on March 21 and March 30, 2017 (at GIZ Office in Nairobi). The opinion of GIZ regarding the new Water Act is summarized as follows:

- On the part of water resources management, no major change might be done from the former.
- On the new Water Act, with focus on decentralization, jurisdictions of central government and regional government are clarified.
- A distinct change from the former Water Act can be seen in water supply.

- WRMA has been mandated to prepare rules and regulations (for water resources management) as well as to perform actual management in the catchments. On the contrary, new Water Act stipulates that WRA shares only the former function and Basin Water Resources Committee (BWRC) and Water Resources Utitization Association (WRUA) share the latter function.

As mentioned above, overall assistance activities of GIZ to the water sector in Kenya has stopped by December 2018 in compliance with the change of policy in the government of the home country. All outputs of the respective projects have already been transferred to WRA.

(3) Advices for water resources management programs (Activity 3.1)

1) Results of needs assessment in WRA

Based on the study results of clauses (1) and (2) as abovementioned, the WRA's way forward to be taken is realized little by little, and it will not change so much from the time of WRMA. As for the relevant information, the "Draft Session Paper on National Water Policy (Version of 21 June 2018)" was obtained. It focuses on "Water Resources Management" among the following eight principal areas.

As seen in the document, "water resources management" is still situated at the upper rank within the priority areas and exists as base flow in the policies and plans in the water sector. The necessity of enhancement and improvement seems not to change so far. Further, in the Water Resources Management of the "Draft Implementation Matrix" attached as Annex, policies and actions are included in two directions among 12 policy directions related to "Monitoring and Data Management" (extract from the original document).

Table 2.21 Extract from Draft Session Paper on National Water Policy in 2018

Policy	Contents of Activities	Implementation
6. Put in place water resources systems for continuous and coordinated surveillance, assessment and monitoring of basin areas, aquifers, and water bodies	a) Develop and implement a national water resource assessment and monitoring framework for surface and groundwater resources, and water quality b) Establish a water resources systems coordination framework among sector actors	3 years 3 years
12. Establish national system for acquisition, management and sharing of water resources information and data	a) Establish an integrated geo-referenced water resources database b) Develop and implement a framework on data and information sharing system	4 years 1 year

Source: "Draft Session Paper No.** of 2018 on the National Water Policy, Version of 21 June 2018, Ministry of Water and Sanitation"

Further, the "Concept Paper (September 2018)", which was received during the discussions with CEO Mr. Shurie, noted three issues as required areas for assistance as follows:

(a) Strengthening and building institutional capacity for water resources management through capacity development and technology transfer with focus on the regional and sub-regional offices;

(b) Enhancement of monitoring network through installation of telemetering system in line

with NWMP2030; and

(c) Development of dam safety regulation.

The original sentences are extracted as follows:

……

1. Strengthening and building institutional capacity for water resources management through capacity development and technology transfer with focus on the regional and sub-regional offices.

2. Enhancement of monitoring network through installation of telemetric and other monitoring equipment in order to improve water resources management by WRA in line with the National Water Master Plan 2030
   - Acquisition, installation and calibration of automatic water level sensors, automatic river gauges to provide telemetric automated hydrometeorological and water quality monitoring stations in target counties in Athi Catchment.
   - Provision of telemetric automated groundwater monitoring stations (drill and equip with data loggers and telemetric system for ten groundwater monitoring stations in:
     - Kiambu (Thika-Delmonte-Kakuzi, Kikuyu Escarpment Forest)
     - Nairobi (Upper Hill)
     - Mombasa Town
     - Kwale (Ukunda)
     - Kilifi (Malindi)
     - Taita Taveta (Mzima Springs)
     - Makueni (Kibwezi Spring area)
     - Machakos
     - Kajiado (Ongata Rongai)
   - Acquisition of Acoustic Doppler Current Meter (ADCP) and Acoustic Doppler Velocimeter (AVP).
   - Civil works which will include: Construction of automatic water level data logger housing, construction of perimeter fence for automatic water level data logger housing and rainfall stations, construction of ARG data logger stations, onsite construction of reinforced concrete posts and struts for erecting staff gauge.

3. Development of dam safety regulations which will involve:
   i. Development of guidelines and standards for dam safety;
   ii. Development of dam safety manuals;
   iii. Assessment in all existing dams; and
   iv. Mapping and inventory of all existing dams in the country.

……

2) Future cooperation direction (Draft)

Since the National Water Policy and revised Water Act (new Water Act 2016) have not yet been prepared in accordance with the new Constitution, which was enacted in 2010, the Institutional Strengthening Plan of NWMP2030 was formulated based on the National Water Policy in 1999 and former Water Act 2002.

In the Institutional Strengthening Plan, the following eight strategic actions are proposed:

(a) Action 1: Define concrete framework of water resources management
(b) Action 2: Establish monopolistic and unified regulation of water resources at the national level and regional level
(c) Action 3: Unitary management of water rights and basin resources development plans
(d) Action 4: Establish scientific and quantitative management of water resources
(e) Action 5: Enhance supply side management and demand side management
(f) Action 6: Capacity development of the WRMA Regional Office
(g) Action 7: Enhance the establishment and strengthening of Water Resources Users Association (WRUAs)
(h) Action 8: Improvement of financial capacity for the water resources management

In the Master Plan, to avoid disputes for water rights and impacts to the environment, earlier implementation of the actions abovementioned was proposed. In particular, it was recommended to execute a trial study for Actions 3 and 4 as part of institutional strengthening of WRA headquarter and regional offices, and recommended that the trial can be implemented with the use of the water resources development and management plans of NWMP2030.

It was confirmed that the contents of the respective actions included many aspects, which could contribute to the development of the water sector in light of the policies and plans relevant to water resources development and management, such as new Water Act 2016 after formulation of the master plan. On the other hand, as for the water resources management at the regional level and river basin level, new issues are identified such as: how WRA regional offices can collaborate with BWRCs concretely, what are the tasks of WRA, can the present staff of the regional office cope or not, etc.

3) WRA Strategic Plan 2018-2023（First Draft）

In February 2019, the first draft of the WRA Strategic Plan 2018-2023 based on the Water Act 2016 was submitted by the consulting firm in charge to WRA. The outline is presented as follows:

(a) Entire structure and outline

The plan is composed of an executive summary and eight chapters. Titles and described contents of each chapter are summarized in Table 2.22.

Table 2.22 Contents and Salient Features of WRA Strategic Plan 2018-2023

Title of Chapter	Major Contents	Features and Supplemental Note
Summary	❒The Govermnet of Kenya is committed to ensure the realization of the right to water as guaranteed under Article 43 of the Constitution of Kenya. ❒Under the Millenium Development Goals, an integrated approach towards water resources management, the Government has embraced through adoption of the Integrated Water Resources Management (IWRM) ❒The WRMA has now been replaced to WRA by the new Water Act 2016. The purpose of the Water Act 2016 is to make provision for the regulation management and development of water resources, water and sewerage services in line with the Constitution of Kenya. ❒Under the Act, WRA is designated as an agency of the national	Overall outline of the Plan is presented.

	government responsible for regulating the management and use of water resources. ❒ Although water resources are controlled under the central government through evaluation of the WRA Strategic Plan 2012-2017, the new Strategic Plan 2017-2022 should show the roles during plan implementation for the county government. ❒ Key to the Big Four Agenda is "Water". ❒ WRA's activities will become very important and will be expected to undertake deliberately some key interventions to supporting roles. ❒ In formulating this Strategic Plan, the methodology of participatory approach involving internal and expertnal stakeholder cinsultations and the SWOT (Strength, Weakness, Opportunity and Threats) analysis method was adopted. ❒ The new Strategic Plan contains the activities to achieve its initiatives, clear time lines and deliverables. ❒ The new Strategic Plan proposed the appropriate organizational structure and the financial, operational human resources and risk management strategy to deliver the expected results in every financial year. ❒ The new Strategic Plan contains integrated monitoring and evaluation framework for assessment of progress during its implementation.	
1. Introduction	❒ WRA is a state corporation established under the Ministry of Water and Sanitation by the Water Act 2016 and operationalized by the Gazette on April 21, 2017. The authority has been in experience for 12 years as WRMA, and then WRA has been officially launched. ❒ WRA is mandated to implement the Integrated Water Resources Management (IWRM) principles anchored in the Dublin Principles with WRUA and other stakeholders. ❒ WRA has developed six Catchment Management Strategies (CMS) in accordance with the National Water Management Strategy. The CMS are implemented at community levels through development of Sub-catchment Management Plans for local communities by WRUA with support from WRA. ❒ Under Part III Section 12 of the new Water Act 2016, WRA is mandated nine functions. In order to achieve this, WRA has overall responsibilities for regulating the management and use of water resources in the territory. ❒ Under Section 13 of the new Act, WRA has the power as follows: ● Source and receive funding for the activities of WRA ● Collect, analyse and disseminate information on water resources ● Monitor compliance by water users with the conditions of permits and the requirements of the law ● Inssue permits inter-basin water transfer, and ● Delegate regulatory functions to the basin water resources committee provided for under Section 25 of the Water Act.	This Chapter describes the background of establishment of WRA, responsibility, authority and jurisdiction. Also the visions, missions and values to be shared are shown. Those coincide with the information disclosed to the public on the homepage of WRA. The nine functions defined by the new Water Act are shown in Page 2-40.
2. The Role of WRA in National Development Agenda	❒ Kenya Constitution 2010 The Constitution of Kenya (21010) recognizes water as a human right, while under Kenya Vision 2030, water is defined as an essential resource to support country's development agenda. ❒ Kenya Vision 2030 and Big Four Agenda Kenya Vision 2030 is the country's new development blue print covering the period from 2008 to 2030 with an aim of transforming the country into an industrialized economy. The implementation of the	

	Vision is based on five-year Medium-Term Plans (2008-2012, 2012-2017 and so forth till 2030). WRA has five Vision 2030 flagship projects related to water resources management as follows: (1) Establishing, rehabilitating and up-grading the hydrometeorological monitoring networks (2) Ground water hydro-geological assessment (3) Review of Catchment Management Strategies (4) Development od Sub-catchment Management Plans (5) Offering technical support in the construction of earth/ sand dams Further, WRA will be expected to undertake deliberately some key interventions as follows: (1) Provision of dta and information for planning (2) Securing water resources in order to provide sustainable water in good quality and quantity (3) Regulation and enforcement of water resources management rules for sustainable management and use of water resources ❒ Water Resources Management Policy The direction of water resources management is mentioned in six aspects as below, and then, 12 expected areas in which WRA can contribute, are presented. (a) Importance of national water resources in a context of water scarcety, (b) Roles of BWRCs (Basin Water Resource Committee) established under Water Act 2016 and absence of integarated basin management, (c) fair distribution of water resources and appropriate water rights management, (d) Water quality and pollution control and management, (e) Community participation in water resources management, (f) Regular water quality surveillance and continuous monitoring ❒ Contribution to Other Sectors WRA can contribute directly and indirectly to other sectors such as energy, agriculture, industrialization, health, education and training, and tourism.	
3. Situational Analysis of the WRA	The review results of the WRA Strategic Plan 2012-2017 are described. The description is extracted from "A Report on the Evaluation of the WRMA Strategic Plan 2012-2017", which was prepared by WRA in April 2017. ❒ In Table 1, contents of activities (achievement) and evaluation are presented for each mandate area. ❒ The current organization of WRA (WRMA) and staff numbers (including breakdown of each office) in conformity with the former Water Act 2002 are shown. Among a total of 756 staff, approximately 40% (290 persons) is technical and other 60% (466 persons) is clerical staff (administration and support staff). ❒ In order to formulate this Strategic Plan, SWOT analysis nad PESTLEG analysis were executed (Table 5). ❒ A summary of customers and stakeholder information and needs and resistance issues are tabulated (Table 6). ❒ The new Water Act 2016 defnes that WRA is a regulatory authority and seven functions are presented again. ❒ WRA's roles to be accomplished are arranged from points of "regulation", "protection" and "dissemination" and concluded.	As conclusion, WRA has dual purpose as water resources management regulator and implementer. PESTLEG: A sort of methodology for assessment and analysis of micoro-economy **(P**lotical, **E**conomic, **S**ocial, **T**echnological, **L**egislative, **E**nvironmentl and **G**overnance)

4. Strategic Direction of WRA	❒ Corporate strategic objectives WRA will promote an inclusive and integrated approach to the regulation of the management and use of water resources by ensuring measures are put in place for water quality management, catchment protection, and conservation, exploration and application of appropriate technology, and monitoring and information systems. It will also sustainable use of water. ❒ Regarding the water resources in Kenya, severe current situation requiring improvement is pointed out from the points of surface water, groundwater, integrated land use, trans-boundary water resources, water rights, water quality and pollution control, surveillance and monitoring, community and stakeholder participation. ❒ Seven strategic obejectives and results are presented. ❒ The strategic objectives are rearranged from four focal points, i.e., customer/ stakeholder, financial, internal processes, organizational capacity (For Balanced Score). A "Strategic objectives, strategy map and implementation matrix" is presented with numerical targets and preliminary budget in 5 years.	It is recognized that this Chapter shows the core recommendations in this document.
5. Regulation and Management Capacity	❒ Functions and responsibilities of institutions for water resources sub-sector with five grade organization (WRA Board, Headquarter, Catchment, Basin Water Resources Committee (BWRC), Sub-catchment) are mentioned. ❒ Four grade implementation organization is proposed under WRA. WRA⇒BWRD⇒WRA Basin Office⇒Sub-Basin Office⇒Regional Government (County), WRUA, Civil Society Organization, etc. ❒ The Counties consisting of six Catchments are listed.	It is not clear for the role demarcation between WRA Regional Offices (RO) and BWRC. "WRA Basin Office" might be recognized as WRA Regional Office.
6. Resources Required	❒ Proposed new organization of WRA has 797 staff instead of 756 at present. ❒ New organization of WRA with three grades, i.e., Section, Division and Department is proposed. The CEO should communicate with responsible staff of six offices every day and supervise. ❒ To implement this Strategic Plan, approximately Ksh. 5.0 billion will be necessary (3.0 billion for reccurent budget and 2.0 billion for development budget) ❒ The means and target funding partners are mentioned. ❒ Form the point of institutional requirement, roles and functions of the central and county governments are pointed out. Although national territory of Kenya is divided by the catchment, integrated management plan by the unit of river basin does not exist. Watershed conservation plan and Sub-catchment management plans are not comprehensively integrated. BWRCs will be function in enhancing basin-level water resources governance.	The hierarchy of "Section", "Division" and "Department" is not clear. (The expressions might cause the unclearness)
7. Monitoring and Evaluation Strategy	❒ As for the national level, the Kenya Vision 2030 is implemented through five-year Medium-term Plans (MTP) and the progress of achievement will be evaluated. ❒ In water sector, evaluation of laws and policies are totally mandated to the Ministry of Water and Sanitation (MWS). Evaluation of the progress of implementation of the National Water Resources Management Strategies will be conducted for board level, management level and function level. ❒ As for monitoring and evaluation, tools and indicators for measuring performance is proposed.	

8. Risk Management Strategy	❒To cope with the seven kinds of risks, a risk management strategy composed of, risk level, risk rating, control measure, mitigating action, responsible agency and time frame, etc. is proposed.	
Annex	❒Following six annexes are presented in the list: (1) Overall Instituional Status of WRA against WA 2002 Mandates (2) WRA Development Themes and Sub-themes (3) Map of Kenya showing Regionas and Sub-regions (4) Contacts from HQ, Regional and Sub-regional Offices (5) Logical Framework Matrix (6) Results and Implementation Matrix in Balanced Scored Format	

Source: JICA Expert Team

(b) Focal points

Although this WRA Strategic Plan 2017-2022 is still first draft, no major change in the overall framework is expected in the final version. However, quantitative goals and implementation schedule may change in the course of the finalization of the details. Accordingly, as for the study materials for cooperation directions after grasping the entire outline, seven strategic objectives presented in Chapter 4 are focused:

- Strengthen water resources information gathering management systems⇒Actions 2 and 4
- Improve water resources planning, allocation and compliance to regulation⇒Actions 1, 3 and 4
- Improve the protection of water resources ⇒Action 1
- Strengthen stakeholder collaboration in water resources management ⇒Actions 6 and 7
- Build institutional capacity and improve working environment ⇒Actions 1 and 5
- Enhance resource mobilization and effective use of the finances ⇒Action 8
- Enhance stakeholder participation in water resources management ⇒Action 5

Relationship between the WRA Strategic Plan 2017-2022 and strategic actions recommended by the Institutional Strengthening Plan of NWMP2030 was analyzed and presented the results above. As a result of the review of the contents of the seven strategic objectives, it was clarified that the Strategic Plan is related closely with the Institutional Strengthening Plan of NWMP2030 and with the recommended action plans although there are differences to some extent.

4) Priority areas in medium and long terms for enhancement of water management sector

Based on the analyses from the previous clauses, four criteria (basic conditions) were set up to select the areas for continuous cooperation in water resources management sector in Kenya with the assistance of the Government of Japan as follows:

(a) To comply with the policy as stipulated in the new Water Act 2016 (nine functions required of WRA);
(b) To contribute to realization of NWMP2030;
(c) To link with the current requirements of WRA and solution of issues (referring to new WRA Strategic Plan); and
(d) To effectively utilize technologies, knowledge, and experiences in water resources sector in Japan.

As priority areas qualified by the above four criteria, which WRA continuously needs to enhance in the medium and long terms, the following five areas are selected:

Table 2.23 Priority Fields in Medium and Long Terms for Enhancement of Water Resources Management Sector

Areas for Cooperation	Background and Needs	Major Study Contents and Remarks for Implementation
(1) Strengthening of meteo-hydrological monitoring networks and data management	❒ Strengthening of meteo-hydrological monitoring network is required in all aspects of the facilities, technical skills and maintenance organization, etc. ❒ Although WRA is promoting automated data transmission (installation of telemetering system) at monitoring stations in all catchments by KWSCRP, this is still insufficient in light of WRA's target. ❒ Realization of functioning telemetering system requires the section in charge to cope with various works such as planning, design, installation, and maintenance works of monitoring and telecommunication facilities as well as outsourcing/ maintenance contract, securing frequency range (for radio), assuring database security and redundancy, procurement of spare parts and their management, staff management and human resources development, etc. Setting of obvious objectives for data use and assessment on applicability of related technologies are required. ❒ Aside from promoting telemetering system, the activities conducted in the Project such as those enhancing reliability and sustainability of water resources data and supporting quantitative and qualitative management in the respective catchments should be continued. ❒ Human resources development, education, and training in and out of the organization in order to improve lack of engineers in hydrology and technical skills are crucial issues currently.	Major Outputs: ● Review of monitoring networks recommended by NWMP2030 and preparation of improvement plan ● Identification of necessary technologies and skills for the establishment, operation, and maintenance of telemetering system ● Development of standard design and specifications for conventional monitoring and telemetering facilities ● Implementation of a pilot project (planning, design, installation, and operation of facilities) ● Preparation of quality management standards for hydrological data (rainfall and water level) ● Institutional strengthening, technology transfer, and human resources development ● Study on applicability of 3L-type (low-cost, long-life and localized) water level sensors and development of standard specifications (including implementation of a pilot project) Preconditions: ● Confirmation of the results, lessons, and issues of KWSCRP ● Establishment of organizational system for maintenance should be conducted in parallel.
(2) Strengthening of issuance and management of water right	❒ In order to meet future large increase of water consumption, water resources development including intra- and trans-basin water conveyance will be necessary. A framework (legal system) to avoid dispute between regions is required to provide water right for development.	Major Outputs: ● Survey on current situation of water right issuance works in the catchments ● Arrangement and improvement of water right ledgers (database keeping of the latest version

	❒ Although the functions of BWRCs and WRUAs will be enhanced in compliance with the new Water Act 2016, WRA will still be responsible to issue and manage water right. ❒ It is required that WRA firmly establishes competence and function for monopolistic and centralized management of the water resources at the national and regional levels. To realize it, WRA should have power to regulate concerned offices of water sector and various water users to issue and restrict water rights. ❒ In order to cope with future increase of water demand and climate change and to secure reliability of water supply, fair issuance of water right from the stage of water resources development is important. Monopolistic control covering entire water rights with water resources development and establishment of implementation system will be key.	and improvement of recorded contents and updating rules, etc.) ● Revision of the Water Allocation Guideline (by WRMA, March 2010) and other regulations, etc. ● Strengthening of implementing organization (increase of staff in-charge at regional office and sub-regional offices) ● Education and training of staff in-charge <u>Preconditions:</u> In order to promote quantitative management, it will be effective not to conduct solely in this area for cooperation but conduct it together within the area (1).
(3) Assistance in the formulation of catchment management plan	❒ The Basin Water Management Councils (BWRMCs) are mandated to formulate the Basin Water Management Strategies on how catchment management for catchment level should proceed (in succession to the roles of Catchment Areas Advisory Committees: CAACs). ❒ On the other hand, existing Catchment Management Strategies (CMS) for six catchments were all prepared in accordance with the former Water Act 2002 and WRMA Strategic Plan 2012-2017. Therefore, these need to be updated based on the new Water Act and new development plans. GIZ, which has continued to assist in this field, stopped its activities in December 2018. ❒ At present, preparation of the CMS is ongoing through the assistance of KWSCRP and it is reported that a draft report will be issued within 2019 (information from WRA staff concerned). ❒ Further, WRA is mandated to formulate Sub-catchment Management Plans (SCMPs). ❒ A risk of introducing confusion lies if the issues are not clearly defined, i.e., how water resources management by the levels of regions and river basins is conducted,	<u>Major Outputs:</u> ● Clarification of responsible staff/ parties and target areas for plans (division of river basins and boundaries of counties) for respective catchment management plans, organization and responsible staff for implementation and relationships between respective plans concerned. ● Confirmation of the progress in the preparation and major contents of new Catchment Management Strategies (in coordination with KWSCRP), situation of the CMS in WRA and its importance as new policies and goals. ● As for BWRMC, assistance for the preparation of BWRMS (draft) in a pilot river basin (catchment). ● As for WRUA, assistance for the preparation of Sub-catchment Management Plans (SCMPs). ● Institutional strengthening, technology transfer, and human resources development.

	what is concrete demarcation of roles and what tasks are demanded to be shouldered by WRA regional offices, etc. ❒ In light of current accomplishment of CMS (assessment of the output), it should be focused on the importance of establishment of clear policy (demarcation of responsibilities between planners and executers), although WRA, BWRC, and WRUA succeed the former hierarchy. ❒ Formulation of effective catchment management plans is required with the establishment of water resources management system under the Water Act 2016 avoiding restriction by past development plans.	Preconditions: ● Consideration to perform efficient activities by concentrating into priority river basins (catchments) is necessary, because target agencies to extend assistance will be widely diverse.
(b) Strengthening of flood disaster management	❒ The new Water Act 2016 defines that WRA bears the functions and responsibilities of flood management. In compliance with this, concrete actions (including preparations of plans, policies and countermeasures, etc.) are necessary. ❒ Since climate and topographic conditions are broadly different in the catchments, flood characteristics cannot be discussed all together. As the directions for each catchment, the outcome of NWMP2030 should be utilized by adding the recent information of the catchments. ❒ It is required to consider the influences of future climate change in the formulation of the plans (structural and non-structural countermeasures). The lessons obtained through the serious floods that occurred in Mozambique in March 2019 should be utilized. ❒ The management plans for respective catchments should be coincided with the contents of CMS and BWRMS.	Major Outputs: ● Arrangement of the review, evaluation and lessons of past investigations related to flood disasters and implemented countermeasures in Kenya ● Arrangement of flood damage records and meteohydrological characteristics in the last 10 years ● Review of flood prone areas identified by NWMP2030 ● Study on application of 3L-type water level sensors (including trial installation in the pilot project) ● Preparation of a hazard map and an evacuation plan in the pilot area) ● Hydrological and climate change analyses Preconditions: ● Similar precedent studies in the Nzoia River basin is ongoing by KWSCRP. ● Even in the areas not designated as flood risk areas, floods occurred recently.
(c) Strengthening of management system of dam security assurance	❒ Although WRA is not the main executing agency to construct dams, WRA is responsible to assure the overall safety management of dams as the responsible entity in water resources management. ❒ In Kenya, it is said that there are 3,050 existing dams. WRA is now updating the inventory of existing dams.	Major Outputs: ● Investigations on the current status of existing dams in Kenya (salient feature, objective functions, major dimensions, responsible organizations for operation and maintenance, etc.) and

	❒ The tasks of WRA, as the "Regulator", should be clarified through substantial discussions on up to what extent WRA can do in the field of dam safety assurance, what and up to which level of actions are required, and what (technical knowledge, skilled staff, time and budget) is necessary to respond to the requirements. Based on this, a policy of staff deployment and human resources development should be established. At present, it is difficult to precisely judge up to what level of requirements can WRA's current staff meet.	arrangement of major dimensions of the dams under construction and planning/designing. ● Survey on existing regulations/ guidelines/ standards for each stage and area of coordination, planning, design, construction, supervision, bidding (procurement), and safety control for dams ● Preparation of list and location maps of salient feature of existing dams ● Preparation of safety assurance standards for dam (draft) ● Field training to check dam safety and on security maintenance works (designation of pilot dam) <u>Preconditions:</u> ● Confirmation on work progress of Dam Safety Task Force and the study outputs ● Confirmation on progress of the related works in WRA ● A seminar for dam security assurance was conducted by WB (at WB Nairobi Office, Oct.1, 2018)

Source: JICA Expert Team

2.3.2 Identification of Required Training Subjects and Preparation of Training Program 【Activity 3.2】

(1) Confirmation of current situation of staff training in WRA

In order to confirm the current situation of staff training (in and out of WRA) by WRA, an interview survey with questionnaire was conducted to the responsible office (Human Resources Management Office). Then, the following references were collected:

(a) Training needs assessment

Contents: A summary list of past training courses participated and requested by WRA staff (responded by all staff in principle) (name, position and grade, etc.)

(b) Training plan for the financial year 2017/ 2018

Contents: A summary list of the subjects and periods for overseas studies, training courses and seminars, and international conferences, which are scheduled in 2017 (July 2017 to

June 2018) (for technical and clerical staff), scheduled participants, and their positions

(c) General training requirements

Contents: A summary list of subjects of the external trainings in the past, including themes, obtained licenses/ diplomas and required training areas, themes and individual technical skills, etc. which are divided into those for technical and clerical staff

The reference of item (a) above was filled and submitted by the respective staff in the designated form (Staff Application Form) in 2016. In principle, the forms are distributed and collected annually, then the information is duly updated. However, since it is a declaration system, some existing staffs may not submit it. In such case, the information is omitted in the form.

In addition, in accordance with the references of item (b), Kenya Water Institute (KEWI), under MWS, organizes 3- to 4-day training courses in hydrology and water resources fields in the following subjects. Four to five WRA staff participated in the respective courses (actual participants should be further confirmed).

- Installation, operation and maintenance of hydrometric station training;
- Hydrometric and hydrological data processing (a staff of the Tana Catchment attended);
- Hydrological forecasting and time series analysis; and
- Hydrological modeling and GIS applications.

In these references, the training courses of the “Integrated Water Resources Management” and the “Strategic Utilization of Hydro-meteorological Data Observation” assisted by JICA are included as well.

(2) Training needs in hydrology and water resources field

Although it is deemed that personal attributes, academic background, and/or current tasks in their position influence the results of the above reference (a), the following training needs and issues can be generally identified and confirmed as specific subjects:

- Senior manager level
  Strategic management of organizations, leadership as managers, project management and financial management, etc.
- Surface water officers (SWO)
  Skills on internet and computer, skills on management and analyses of hydrological data, GIS, operation and maintenance of modern field measuring devices (ADCP/ADV, etc.), skills of software operation (MIKE Basin), etc.
- Flood management officers
  Flood prevention and disaster management, early warning system, integrated flood management, operation and maintenance of field measuring devices such as current meters, GIS and internet related technologies, etc.
- Water right officers
  Management of hydrological data, GIS, management and solving public disputes, integrated water resources management, and skills for keeping records, etc.

(3) Assistance for dispatching WRA staff to JICA training programs

The two training programs supported by JICA, i.e., the "Integrated Water Resources Management" and the "Strategic Utilization of Hydro-meteorological Data Observation" were held consecutively in 2018 and 2019, and the JICA Expert Team assisted WRA to dispatch a staff to the courses. In particular, they advised WRA in the selection of the candidates, supplemented explanation on the requirement and timeline set by JICA, assisted and advised for the preparation of application forms, and advised on the living circumstances during training, etc.

(4) Recommended training programs

In Kenya, the candidate training courses supported by KEWI are as mentioned in the previous Clause (1). KEWI has been established in 2001. It is one of the governmental agencies which is partially supported by the government for finance, and provides services for training, investigation, and consulting services related to water resources. Although the training programs of KEWI widely cover the water resources sector, many courses target water supply, water quality management, water quality test and assessment, and sewerage treatment among the short-term (about one week) programs. However, since there are courses, which WRA staff experienced to take, as seen in the previous Clause (1), it is recommended to encourage participation of junior and middle-aged staff consecutively.

On the other hand, two training courses by JICA as mentioned in Clause (3) include training elements which are the closest to WRA's activities. Therefore, it is recommended to continue dispatching staff to those courses. Further, there is another knowledge co-creation program of JICA, which is titled as "Water-related Disaster Management (Preparedness, Mitigation and Reconstruction)". Considering that WRA should share jurisdiction of flood disaster management from now on, sending middle-aged and senior staff including management staff to the program should be considered.

Further, needs on IT and computer-related subjects and learning of analyses by software, etc., were confirmed. In this field, technical seminars on MIKE series organized by DHI, etc., are the candidates. These courses should be examined based on future policy in such software and required technologies for analyses in WRA.

2.4 Common Activities in All Outputs

2.4.1 Sub-contract Works

In the Project, three sub-contract works for field survey were planned and completed.

Table 2.24 List of Sub-contracts Conducted by the Project

No.	Sub-contract Works	Major Contents	Completion
1	River cross-section survey (including plane table survey)	River cross section survey at six sites and plane table survey at one site	September 2017
2	Rehabilitation of existing gauging stations and installation of new gauging station	Rehabilitation of staff gauges at two gauging stations and installation of one new gauging station	March 2018
3	Discharge measurements	Each 15 times of measurements at six sites (total 90 times)	January 2019

Source: JICA Expert Team

(1) Outline of river cross section survey

1. Name of contract	River cross section survey
2. Name of contractor	RAMANI LAND Services Limited Address: P.O Box 15353, Langata, Nairobi, 00509, Kenya
3. Contract period	・June 23, 2017 - August 31, 2017 (Original) ・June 23, 2017 - October 13, 2017 (Amendment 1: August 21, 2017)
4. Major contents of works	River cross section survey at 6 gauging stations (total 18 sections)
5.Method of procurement	Selection by least cost (comparison of submitted price quotations)

Source: JICA Expert Team

(2) Outline of the rehabilitation of existing gauging stations and installation of new gauging station

1. Name of contract	Rehabilitation of existing gauging stations and installation of new gauging station (G/S)
2. Name of contractor	NARIANA Enterprises Limited Address: P.O Box 15353, Langata, Nairobi, 00509, Kenya
3. Contract period	・June 27, 2017 - November 15, 2017 (Original) ・June 27, 2017 - January 31, 2018 (Amendment 1: November 10, 2017) ・June 27, 2017 - March 9, 2018 (Amendment 2: January 30, 2018)
4.Major contents of works	・Plane table survey at 3 sites ・Rehabilitation at 2 water level G/S ・Installation of new gauging station at 1 water level G/S ・Construction of a drain canal ・Installation of gabion mattress
5.Method of procurement	Selection by least cost (comparison of submitted price quotations)

Source: JICA Expert Team

(3) Outline of discharge measurements

1. Name of contract	Discharge measurements
2. Name of contractor	NARIANA Enterprises Limited Address: P.O Box 15353, Langata, Nairobi, 00509, Kenya
3. Contract period	・March 2, 2018 - October 31, 2018 (Original) ・March 6, 2018 - January 25, 2019 (Amendment 1: October 3, 2018)
4. Major contents of works	15 times of discharge measurements in each of the 6 sites of water level G/S (total 90 times) and 2 workshops
5. Method of procurement	Selection by least cost (comparison of submitted price quotations)

Source: JICA Expert Team

2.4.2 Procurement of Equipment

The equipment procured by the Project are listed in Table 2.25. All equipment has been officially transferred to WRA. Part of the equipment (pressure-type water level sensor and staff gauges, etc.) have already been installed through sub-contract works and/ or lent to the contractor from WRA to effectively utilize for Project activities (current meter, etc.):

Table 2.25 List of Procured Equipment by the Project

No.	Kind	Type	Q'ty	Details
1	Current meter	Propeller type	3	Used one unit for discharge measurements (sub-contract). Remaining three units are kept by WRA HQ.
2	Pressure-type water level sensors	Pressure type	4	One set was installed at new gauging station (4F10)
3	Staff gauges	L=1.0 m	50	Some were installed for rehabilitation and installation of gauging stations.
4	Desktop PC	Windows 10	2	HP ELITEDESK
5	Printer	Color laser	1	HP Color LaserJe Pro MFPM277dw
6	GIS software	ArcGIS	1	Spatial Analyst included
7	Microsoft Office		2	
8	GPS	Handy type	1	GARMIN eTrex 30X
9	UPS		1	

Source: JICA Expert Team

2.4.3 Newsletter

As one of the public relations activities, seven volumes (2 pages each in A4 size) of newsletter were prepared and published on the information board at WRA HQ and RO in Embu (Tana Catchment). In addition, it was uploaded on the WRA's website and the Project information was disclosed through internet to common citizens in Kenya. The time of issuance and major contents of each volume are summarized in Table 2.26.

Table 2.26 Outline of the Newsletters

No.	Time of Issuance	Major Contents
No.1	March 2017	Outline of the Project, objectives, period, output and activities, target areas, results of field reconnaissance, way forward
No.2	June 2017	Summary of activities, selection of target water level gauging stations, progress of sub-contract works, outline of CMS for Tana Catchment, way forward
No.3	October 2017	Summary of activities, progress of activities for each output, progress of river cross section survey (sub-contract), way forward
No.4	March 2018	Summary of activities, progress of activities for each output, progress of rehabilitation and installation of gauging stations (sub-contract), way forward
No.5	July 2018	Summary of activities, progress of activities for each output, progress of discharge measurements (sub-contract), way forward
No.6	November 2018	Summary of activities, progress of activities for each output, Guidelines for Maintenance of RGS and Management of Hydro-meteorological Database, way forward
No.7	January 2019	Summary of activities, progress of activities for each output, follow-up meeting at Embu (closing activities), way forward

Source：JICA Expert Team

3 Issues, Elaborations, and Lessons for Project Implementation

Throughout the Project operations, counterpart personnel and the JICA Expert Team shared crucial issues, elaborations, and lessons. Table 3.1 tabulates major subjects and contents concerning this aspect.

Table 3.1 Major Issues, Elaborations, and Lessons Identified through Project Operation

Subjects	Items	Contents
1.Selection of the Counterpart Personnel (CP) who are closely related to the Project purpose	Issues	In the beginning of the Project, only five CPs were nominated including the Chief Executive Officer (CEO). However, there was uncertainty whether they could efficiently take part in the Project and anticipated activities.
	Elaborations	In order to accomplish efficient technology transfer and firmly establish it, the JICA Expert Team recommended to nominate the staff from RO and SRO staffs in the pilot area not only from the HQ. As a result, some 19 staffs were officially selected to participate in the Project activities. Therefore, the nomination of CP could create a foundation to more firmly establish the activities in the pilot area. (Ref: Section 1.6 (1))
	Lessons	Selection and deployment of the CP should be conducted taking into consideration the earlier accomplishment of the Project effects and its establishment.
2.Selection of the pilot catchment (area) for the Project activities	Issues	Before commencement of the Project, the Lake Victoria North Catchment had been selected as the pilot area (at the time of selection of the consultant firm). However, CEO requested to change it to the Tana Catchment[4] in the Kick-off Meeting (Jan.18, 2017), and then, it became necessary to immediately change.
	Elaborations	The JICA Expert Team responded to WRA that they wished to inspect the Tana Catchment by themselves and to discuss with the staff of RO concerned, and then to decide finally. The idea was duly accepted. Then, the team conducted site reconnaissance (from January 23 to 25, 2017) and reached a conclusion that it would be possible to conduct the Project activities as envisaged in the Tana Catchment as well. After that, they prepared a concrete work plan and it was accepted by WRA through discussions.
	Lessons	The detailed contents of the Project activities should be flexibly planned avoiding interference with the ongoing and other project activities, etc. Consideration should be given to keep the motivation of the CP throughout the Project.
3.Selection of equipment considering WRA's intention	Issues	As for the equipment to be procured in the Consultant's contract (to be transferred to WRA upon completion of the Project), there was a risk or concern on having problem with their applicability to the local conditions, usability, and versatility in the future, because of too many types of water level sensors, current meters, and staff gauges depending on objectives, if they were simply selected due to easy access for procurement and durability.
	Elaborations	With respect to each equipment, not only the products in Japan but also those in other countries were compared. The JICA Expert Team extended efforts to make repeated discussions patiently and withdrew their preferences. In particular, they tried to obtain pamphlets and detailed specifications from manufacturers and discussed with CP from

[4] There was a background reason that the precedent project of the "Kenya Water Security and Climate Resilience Project", supported by the World Bank, has already appointed the Nzoia River basin located in the Lake Victoria North as the Pilot Area, and so, the activities would overlap with the JICA Project.

		the beginning. As a result, it became possible to procure the equipment with mutual agreement, to install them at the field, and to effectively utilize them in the subsequent sub-contract works such as discharge measurements.
	Lessons	The equipment which are transferred to the Client after the project completion should be selected considering not only capacity and durability among Japanese made products but also the local conditions and CP's skill level as well.
4.Selection of target sites of water level gauging stations for Project activities	Issues	Certain concepts for rehabilitation of the existing and installation of new gauging stations and criteria (scenario) for selection of target sites of water level gauging stations in the Tana Catchment (pilot area) were necessary to be established.
	Elaborations	The selected target six water level gauging stations for the Project activities were all Management Unit stations except for one site at 4F10. To observe discharges in major tributaries before joining to the Tana mainstream, the sites were selected. Also, to contribute to improvement of the accuracy in water resources management by accumulation of more hydrological data through river cross section survey and discharge measurements was considered.
	Lessons	Project resources should be concentrated considering effectiveness and impact of the Project outcome in the future.
5. Review and verification of the importance of recommendations (NWMP2030)	Issues	The required roles and functions of WRA will be detailed and formed in compliance with the interpretation and its ideology. On the other hand, NWMP2030 was formulated under the former Water Act 2002. Therefore, the recommended programs, projects, and strategic actions in M/P were needed to be reconfirmed whether these are situated with equivalent priority or not and to verify the needs in light of the new Water Act 2016.
	Elaborations	WRA Strategic Plan 2017-2022 is under preparation to be completed until May 2019 (A consultant was externally procured for the works). The relationship was confirmed in comparison with the contents in NWMP2030 with above Strategic Plan. This work was aimed earlier in building consensus in WRA and securing budget smoothly in the future.
	Lessons	In case that precedent plan or program exists (NWMP2030 is the one this time), the relationship and position of the subsequent plan and guideline should be confirmed.
6.Close coordination with WB Project	Issues	The WB-assisted "Kenya Water Security and Climate Resilience Project" is composed of several components and includes similar activities (e.g., improvement of monitoring networks and enhancement of data management). Under the same executing agency, outcome and lessons obtained should be duly shared between both project teams, and accelerating transfer of technical knowledge to WRA and efficient institutional strengthening are expected.
	Elaborations	The JICA Expert Team often shared project information with the responsible staff of WRA and the Team Leader of the Consultant Team. The three parties conducted a joint meeting on October 6, 2017 to discuss the progress and current crucial issues to deal with (staff of JICA Kenya Office attended as well). After that, information sharing was continued and utilized in the Project activities and recommendations as required.
	Lessons	In the course of the Project implementation, coordination with other projects, which are undertaken by the executing agency, should be encouraged seeking more project effects.

7. Training on equipment for hydrological measurement	Issues	At most of the gauging stations, villagers, who are entrusted by WRA, keep water level records by manual staff gauge reading once a day. To secure data quality, to increase hourly data, and to improve work efficiency, promoting automatization of water level monitoring is crucial
	Elaborations	The field equipment (water level sensor and data logger, etc.) to automatically observe and store the river water level records were provided and installed. The JICA Expert Team conducted a training including trial operation such as installation of equipment, recording, collection, and calibration of the observed records with the WRA staff. Through the training, the staff cultivated better understanding in the operation of the equipment with the instructions/guidance of the team. One set of equipment, out of the four sets that were provided to WRA, was utilized in the training. By using the remaining three sets, it is expected to facilitate automatic observation through installation in other stations by the staff, who had experienced skills of operation of the equipment from now on.
	Lessons	In order to effectively utilize the equipment provided, to properly understand the purpose of automated observation by CP, and to appropriately maintain the equipment, it is important to incorporate transferring basic technical knowledge and field exercise for operation and maintenance through a training program.
8. Assistance for improvement of operation system of meteorological and hydrological gauging stations	Issues	Interruption of observation at many meteorological and hydrological gauging stations was confirmed due to breakdown of equipment or washing away of staff gauges by floods, etc. There is no record of the latest information of these problems in the ledger of RGSs, and the problems have remained without any action for repair works. As for the improvement of the O&M system, an urgent task that needs to record the issues identified and duly share the information remains.
	Elaborations	A form of checklist for recording the inspection results of gauging stations and a guideline for instructing the operation methodology of the checklist were prepared and distributed to all staff concerned. Two columns to record some confirmed issues and required countermeasures to cope with the said issues were inserted in the checklist. A flow of appropriate actions by sharing information through submission of the checklist, which is prepared by SRO, to HQ via RO was set. The guideline was distributed to SRO, RO and HQ to conduct trial operation in October 2018, then the identified issues of operation system were summarized, and the importance of data sharing was duly recognized by CP toward further improvement of current operation system of meteorological and hydrological gauging stations. Since the budget has a limitation for O&M activities, the JICA Expert Team advised the importance to operate and maintain by restoring the gauging stations, based on the priority, which were selected as high priority in the Project.
	Lessons	In order to formulate an improvement plan of meteorological and hydrological gauging stations, it is necessary to understand and share the current conditions of RGSs by the staff in-charge of O&M. In this regard, a simple supporting tool, which enables to record the minimal required information in daily routines, will be very effective.
9. Assistance for improvement of meteorological and hydrological database	Issues	An important goal in the database management is to ensure data quality and to store data steadily as well. Various issues such as shortage of workforce, budget, equipment (PC), and facilities (book shelves, etc.) were confirmed in the current conditions of database management. It is currently difficult to examine countermeasures to improve the database management because the issues are not properly recognized. Firstly, most crucial issue is to quantitatively assess the issues and share the information among the staff concerned.

	Elaborations	The guideline and checklist for hydrometeorological database management were prepared for ensuring data quality and data storage steadily. This checklist for confirming the work performance will indicate the required activities and responsibility of SRO, RO and HQ for database management. Two columns for recording some confirmed issues and requirements against the issues were laid in case of finding any issues. A trial operation by using the checklist was conducted in October 2018. Then, the JICA Expert Team encouraged CP to understand the use of checklist as an important supporting tool, which can enable the identification of organizational issues toward the improvement of database management.
	Lessons	In order to enhance data quality assurance and effective utilization of hydrometeorological data, the latest conditions of data storing should be checked and the database shall be updated periodically. In this regard, a simple supporting tool is very effective.

4 Accomplishment of Project Purpose

The Project purpose is "to enhance the capacity of Water Resources Authority on hydrological information management". In order to assess it, the following three verifiable indicators are set:

(1) Latest status at surface water monitoring stations in the Pilot Area is appropriately updated and shared among the Headquarter (HQ), Regional Office (RO), and Sub-regional Office (SRO).

(2) Daily records at surface water monitoring stations in the Pilot Area are firmly transferred from SRO to RO/HQ and duly stored in the database.

(3) Crucial issues for water resources management are identified and a cooperation project/ program is recommended.

Regarding Verifiable Indicator (1)

As a means to judge the achievement of the target, rehabilitation of existing water level gauging stations and installation of new gauging station can be applied. Through the Project, rehabilitation of existing stations at two sites (4BE10: Tana Rukanga and 4DD02: Thiba) and installation of a new station at one site (4F10: Kathita) was conducted through a sub-contract work. The details of "Rehabilitation" are restoration of staff gauges which were aged and/or lost and small-scale civil works (construction of a drain canal for rain water drainage: 4BE10). The details of "Installation" include setting of a water level sensor and a data logger as well as staff gauge plates for automatic data recording. In addition, a gabion mattress with approximately 20 m long was placed at the river side to protect existing gauge house from further erosion at the river bank.

A series of these improvement works were executed in coordination with the CP of RO in Embu and SROs (Muranga and Meru). Further, to enhance recognition of regular inspection of monitoring facilities and importance of maintenance and to promote technology transfer, the workshops were conducted twice in March and June 2018 (in connection with "discharge measurements"). The workshop involved an opportunity to present the latest status and crucial issues in the monitoring stations in the territory of each SRO (Ref: Appendix 6) and to facilitate sharing of information among the HQ/RO/ SROs and expected outcome could be confirmed to some extent.

Furthermore, the Guideline for Maintenance of Regular Gauging Station was prepared to periodically check the status of water level gauging stations in the Tana Catchment and to share the latest information among the staff concerned. A trial usage has started from October 2018. The current conditions were recorded in the checklist (a designated form was attached to the guideline) and the information was shared among the three parties. From now on, it is expected that these supporting tools will contribute to improve the monitoring stations through the conduct of continuous monitoring and accumulation of information.

Regarding Verifiable Indicator (2)

Throughout the period of project implementation, sharing of monitored data and its management at each SRO/RO were confirmed by means of direct interviews with the staff and by reference materials.

A data server (PC) and MIKE INFO (a database software) were provided and installed by the WB Project presently to enhance the capacity of WRA in nationwide data management. On the other hand, apart from

such direction to contribute to water resources management in the Tana Catchment, the JICA Project was conducted with focus on qualitative improvement of the monitoring data at the field after confirmation of the current crucial issues. Concretely, it involves the improvement of staff gauge reading and automatic data (data loggers) at water level gauging stations, which is the responsibility of the SROs (connected with the activities for installation of staff gauges, water level sensor, and data logger). The importance of the manual data was considered still unchanged based on the current monitoring network and automated data communication links, which are supported by vulnerable and unstable telecommunication infrastructure.

However, although the importance of monitored data was duly recognized, the problem of the delay of more than half year for relay of field data from SRO to RO and submission of the same to the HQ should be solved. The JICA Expert Team reiterated at every opportunity that the many rooms for improvement lay against limitations of budget and accessibility, etc., and tried to find effective means with continuous promotion activities to the CP.

In such process, the JICA Expert Team concentrated activities in solving the delay and inconsistent manners of data transfer (SRO⇒RO and RO⇒HQ), and non-adjustment of measured results of data loggers due to lack of knowledge. As for a concrete countermeasure, the Guideline for Management of Hydrometeorological Database was prepared and started trial utilization with the Guideline for Maintenance of Regular Gauging Station as aforementioned. Further, a training for data acquisition at the field (by data collector), data storing into PC, conversion of data file type (Excel form), and calibration was organized and conducted.

Through the training, it is conceivable that the CP's skill was firmly improved and a foundation to consistently transfer daily data at the monitoring stations from SRO to RO/HQ was created.

Regarding Verifiable Indicator (3)

In order to identify the issues for water resources management in Kenya, related documents and information were widely collected and a series of interviews with the concerned officials of the mother agency, namely, the Ministry of Water and Sanitation (formerly Ministry of Water and Irrigation), and donors such as WB and GIZ were conducted. The current situation was analyzed. In such process, differences of WRA's position and functions between the previous and the latest Water Acts, overall trend of water resources administration, and present issues of WRA were confirmed.

On the other hand, in the beginning stage of the Project, the JICA Expert Team extended efforts to collect information through interview sheets on the current accomplishments in the water resources management plan and the flood management plan recommended by NWMP2030 in 2014 to HQ and ROs at respective catchments. Unfortunately, however, there was no feedback from all six catchments, and therefore, any details on the accomplishment of the recommended actions and to what extent the recommended actions have been achieved were not confirmed.

Although the trial was not successful, it should be noted that NWMP2030 was widely acknowledged in the agency and referred to the WRA's mid-term plans and other related official documents. In fact, WRA's intention to continuously realize the recommended plans as the responsible agency could be reconfirmed. In other words, the recommendation of NWMP2030 is not yet obsolete although related information need to be updated.

In addition, the JICA Expert Team received the evaluation report on the WRMA Strategic Plan 2012-2017 in October 2017 (i.e., "A Report on the Evaluation of the WRMA Strategic Plan 2012-2017, April 2017" which was prepared in the one-week workshop participated by 17 staff). The report concluded relatively high rate of accomplishment in the six targets. Then, the first draft of the subsequent plan of the new WRA Strategic Plan (medium-term plan) 2017-2022 was obtained in March 2019 and then reviewed and analyzed to confirm the future direction of the strategic objectives of WRA. Based on the results and comparison with the details of recommendations of NWMP2030 concerned, future possible cooperation field in water resources management sector was recommended and a draft cooperation program was prepared.

As a whole, the Project purpose, which was set in the commencement of the Project, was accomplished up to the envisaged target at a certain level, even though some hindrances existed such as restriction of the pilot area to only upstream area (Tana Catchment) due to security consideration, and tentatively stagnant participation by the CP in the Project activities due to insufficient budget allocated by WRA.

5 Recommendation

5.1 Recommendation to the Government of Kenya

Upon completion of the Project, the JICA Expert Team would like to make the following recommendations to WRA to succeed the activities conducted through the "Water Resources Management Expert" Project:

(1) Securing of required budget for continuation of activities

A series of activities conducted through the Project such as water level gauge readings, discharge measurements, H-Q curves creation and data management, etc. are the most fundamental and important tasks for water resources management. In order to continue these activities, it is crucial for WRA to establish the structure to enable securing required annual budget.

(2) Effective utilization of Project output (guidelines, etc.)

As one of the Project outputs, guidelines with checklists for i) maintenance of water level gauging stations and for ii) data management were prepared and submitted to WRA. These were duly elaborated based on the comments of WRA during trial activities. However, it is expected that these activities will become a routine work although further improvement and utilization for easier use by WRA without idling should be done. Although the Project selected the Tana Catchment as the pilot area, it is expected that the Project output shall be expanded to other catchments.

(3) Effective utilization and appropriate allocation of procured equipment

Various equipment for field measurements as well as for office works have been procured and transferred to WRA by the JICA Expert Team. As for the field measurement equipment, it was reported by WRA that these will be transferred to the pilot area, Tana Catchment (Regional Office in Embu). It is expected that necessary actions will be undertaken for earlier utilization of the equipment at the field by the Regional Office. Three water level gauging stations with water level sensor and data loggers should be selected considering future operation and maintenance.

(4) Implementation of recommended program

Among the "Potential Areas of Further Elaboration in Water Resources Management" which was prepared based on a series of discussions between C/Ps of WRA and the JICA Expert Team, strengthening of monitoring network and data management is recognized as the urgent and most crucial issue. It is expected that WRA will expedite the finalization of the New Strategic Plan 2017-2022 and conclude discussions, coordination and integration of opinions within WRA to prioritize the potential area(s) for implementation.

(5) Strengthening of human resources development and education and effective utilization of training opportunity

Recruiting young staff and human resources development should be recognized as crucial issue for institutional strengthening and sustainable development. Although it is deemed that budget restriction can be a challenge in the organization, capacity development of young staff is required by dispatching them to technical trainings within Kenya and/or various opportunities such as JICA's training courses.

5.2 Recommendation to JICA

(1) Assistance to infiltrate understandings on cooperation scheme by the executing agency

Unfortunately, almost nobody among the staff concerned could understand, even a bit, about the technical cooperation project. The JICA Expert Team deeply recognized the necessity to extend the activities in promoting the understanding of the framework of technical and financial cooperation of Japan, and the salient features and focal points of the respective cooperation schemes. It is deemed that if CP has a preliminary knowledge about the schemes, their understanding on the project and proactive participation will be enhanced during implementation of the project.

(2) Creation of continuous cooperation relationship in water resources management sector

The Government of Kenya is now standing to accelerate the implementation of its development plans such as Kenya Vision 2030, new Water Act 2016, NWMP2030, and new strategies. In fact, MWS and WRA are preparing new strategic plans (medium-term plan) envisioning the next five years and these agencies will likely publish them within one or two months officially. Further, the JICA Expert Team reconfirmed that NWMP2030 is still quoted and referred to by other various planning documents and infiltrated into the personnel concerned as a compass to aim at water resources development and management sectors. Assistance from Japan in this development sector is steadily expected.

(3) Strengthening of information sharing and cooperation with other donors

In parallel with the Project, the KWSCRP is being undertaken by WRA with the assistance of WB envisaging completion up to May 2020. Considering the scale of the program and extent of the targets, continuous monitoring of the outcomes in order to reach the direction of cooperation and its concrete contents is important for the Government of Japan. The GIZ, which is an international agency of the Government of Germany, has stopped cooperation activities in the water sector in Kenya in December 2018. On the other hand, some information sources reported that the Government of Germany would continue assistance to WRA in other forms. Such information on direction and movement of other donors should be periodically updated to enhance effectiveness of future cooperation programs.

(4) Possibility of applicable related Japanese technology

The Internet of Things (IoT) in the field of meteorology and flood monitoring, applied technologies in telecommunication, and topographic survey technologies using LIDAR and drones are widely expanding their applicability not only in Japan but also overseas. Application to water resources engineering and disaster management sectors is progressing, and it is now recognized that active deployment of these technologies should be accelerated through coordination between public and private sectors (e.g., the 3L-type: Low-cost, Long-life and Localized water level sensors promoted by the Ministry of Land, Infrastructure and Transport and Tourism, Japan). In the case of Kenya, since the related infrastructure still stands at low standard, these technologies will not be directly applied. However, some of them might be likely applicable with certain reliability and durability, if improvement and/or reinforcement can be provided somehow. It is recommended that formulation of cooperation programs which will yield benefits for both sides by using such advanced technologies should be promoted.

Appendix 1

List of Counterpart Personnel

WRMA INTERNAL MEMO

TO: Chief executive Officer
THRO' Technical Coordination manager
FROM: ATCM- SW
REF: WRMA/HQ/EXP/23/2 VOL.2
DATE: 3rd March 2017

NAMES PROPOSED FOR JICA PROJECT COUNTERPART

Please find the proposed Line-ups and names for the above project in Tana Catchment Area for your approval.

OFFICE	MANAGER	WRM OFFICER	SW OFFICERS	DATA MAN OFFICERS	TOTAL
Headquarter		Lawrence Thooko	1.Julia M. kiruri 2.Margaret Muthiani	1.Eunice ochieng 2. Pauline Nyamu	4
Embu RO	Geoffry Wachira		1.John Kinyanjui 2. Agustus Wanjiku		
Garissa SRO	Abdi Omar		Daniel Gathima		
Meru SRO	Antony Ndungu		Alex Kimotho		
Kerugoya SRO	James Maina		1.Lucy Fundi 2. Jane njuguna		
Muranga SRO	Jackqueline Mboroki		1.Faith mbathi 2. Jane Wairimu		
Kitui SRO	Joseph Munyoki				
Total	**6**	**1**	**10**	**2**	**19**

Julia M. Kiruri
ATCM-SW

Appendix 2

Technical Note

TECHNICAL NOTE
ON
TECHNICAL COOPERATION PROJECT
ON
WATER RESOURCES MANAGEMENT EXPERT
IN
THE REPUBLIC OF KENYA

AGREED UPON
BETWEEN
WATER RESOURCES MANAGEMENT AUTHORITY (WRMA)
AND
THE JICA EXPERT TEAM

Nairobi, 12 April 2017

Mr.Lawrence Thooko
Project Manager
Water Resources Management Authority,
Republic of Kenya

Mr. Yoshihiro Motoki
Team Leader/ Water Resources Management
JICA Expert Team

The Project is the technical cooperation project and objective is to enhance capacity of water resources management in the Water Resources Management Authority of Kenya (hereinafter referred to as "WRMA") through the dispatching two Japanese experts. The project period is for 26 months from January 2017 till February 2019.

WRMA and the Expert Team dispatched by Japan International Cooperation Agency (hereinafter referred to as "JICA Experts Team") have had a series of discussions in order to decide equipment to be procured and other crucial issues such as cost sharing and target locations for the Project activities to be deployed to allow the smooth implementation of the Project. This Technical Note presents key topics on which both parties mutually recognized and agreed at the beginning stage of the Project hereinafter. Further, the detailed scope of work for the Project with demarcation between WRMA's Counterpart personnel and the JICA Experts Team is compiled in the Work Plan, which has been mutually accepted at the meeting between WRMA and JICA Experts Team on April 7. Then, the Work Plan was officially submitted to WRMA on April 12, 2017 after duly integrating the comments of WRMA.

1. Procurement of Equipment

In accordance with the results of discussions and agreement with WRMA, the equipment to be procured through the Project was mutually accepted by WRMA. JICA Experts Team will procure all the equipment by the Project budget. In particular, in regards to the current meter and water level sensor, comparison of several types was examined and its results are tabulated in Appendixes 1 and 2 respectively. Table 1 shows the selected type and number of units to be procured through the Project. Upon completion of the project, the equipment will be transferred to WRMA when JICA accepts the official request on transfer from WRMA :

Table 1 Selected Type and Number of Units to be Procured through the Project

Kind of Equipment	Selected Type	Number of Unit to be Procured
Current meter	Propeller type	3 units (1
Water level sensor	Pressure type	4 units (1

Note: (1, Depending on the actual price per unit for purchase since total budget is fixed.

2. Budget for the Project

(1) WRMA mutually accepted that required budget for participation to the Project activities by WRMA counterpart personnel should be principally shouldered by WRMA.

(2) JICA shoulders the cost for activities of the JICA Experts Team in Kenya including procurement of equipment and subcontract works.

(3) JICA Experts Team agreed to covey the WRMA's request to JICA Kenya Office to disclose the total project cost.

3. Candidate Monitoring Sites for Project Activities (Output 1 & Output 2)

As the results of discussions, priority sites for the Project activities were tentatively decided in accordance with the provisions in the Work Plan, which had been accepted by WRMA. However, those sites as tabulated in Table 2 might be subject to change due to further unforeseeable factors arising in the course of the Project. A location map of the monitoring stations is shown in Appendix 3.

Table 2 List of Monitoring Sites for Project Activities (Field Measurement and Installation)

Planned Activities	Selected Sites	Concept for Selection
1. River cross section survey	● Existing five sites ➢ 4BE01, 4BE10, 4CC07 (Muranga SRO) ➢ 4 DD02(1 (Kerugoya SRO) ➢ 4EA07 (1 (Meru SRO) (Five (5) sites) ● One candidate new site at d/s of High Grand Falls dam site (proposed) along the Tana mainstream near 4F13 or farther d/S site (2. **A total of six (6) sites**	● Considering the importance of surface flow monitoring in river channel, Management Unit G/S located near the confluence with the Tana mainstream should be prioritized. ● Discharge amount released from High Grand Falls dam will become very important for future low flow and flood management at Garissa and farther downstream areas.
2. Discharge Measurement	● Same sites at existing and newly installed stations for river cross section survey (Item 1 above) **A total of six (6) sites**	● H~Q curves will be created based in the results of discharge measurements at theses stations in the Project.
3. Repair of existing surface water gauging stations and installation of new gauging station	● Two sites subject to repair (3 among Item 1 ➢ 4 BE10 and 4DD02 ● One site for new installation (4 ➢ d/s of High Grand Falls dam site (to be examined further) **A total of three (3) sites**	● Existing gauge plates are obsolete, damaged and/or invisible due to rust and debris. ● Same reason as described in Item 1.

Note: (1, H~Q curves are available at these stations.
(2, Site reconnaissance will be jointly conducted by WRMA and JICA Experts Team to determine the appropriate site between June and July 2017.
(3, Only re-installation of staff gauges are envisaged.
(4, Installation of pressure type water level sensor with construction of logger house is presumed.

Appendixes

Appendix 1: Comparison of Type of Current Meters

Appendix 2: Comparison of Type of Water level Sensors

Appendix 3: Location Map of Target Monitoring Stations for Project Activities

Table -1 Comparison Type of Current Meters

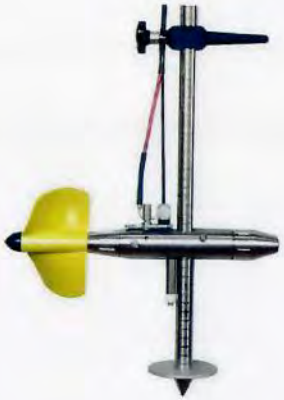
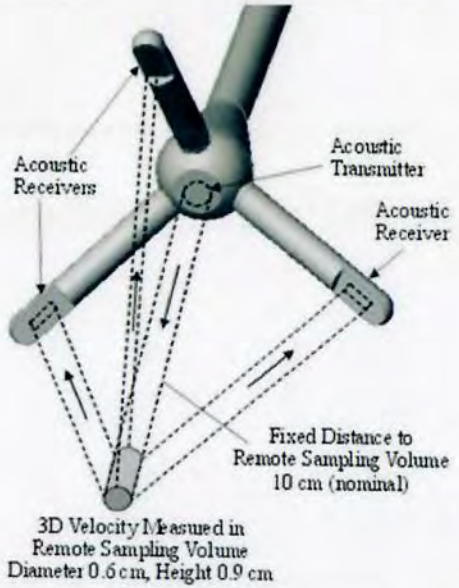
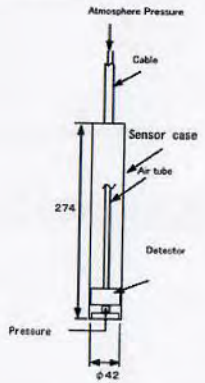
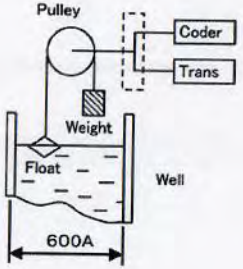
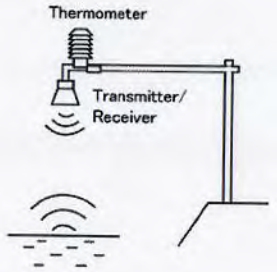
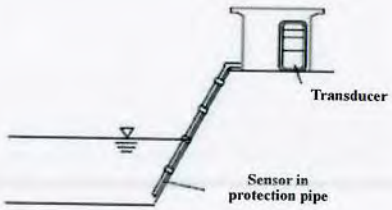
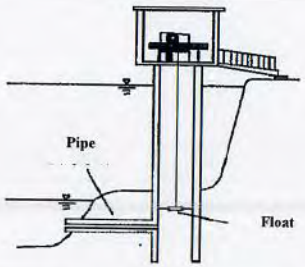
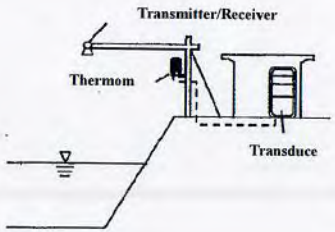
	Current Meter with propeller	Electromagnetic current meter	Acoustic Doppler Velocimeter (ADV)
Image			
Description	The theory is based on the placing a mechanical current meter at a point in a stream and counting the number of revolutions of the rotor during a measured interval of time.	The theory is based on the principle that a conductor (water) moving through a magnetic field will produce an electrical current directly proportional to the speed of movement (Faraday's law).	The theory is based on the Doppler principle to determine point velocities of flowing water as well as complete vertical velocity profiles. Acoustic Doppler velocimeters (ADVs) are a class of acoustic meter that measures a point velocity and can thus be used to make measurements with a wading rod.
Maintenance	A Current meter requires calibration to maintain accuracy. Interval for calibration should not be more than one/two years must be valid for.	A Current meter requires e calibration to maintain accuracy. Interval for calibration should not be more than one/two years must be valid for. Low flow, less than 0.15 m/s is less accurate.	It is only necessary to confirm the transmission / reception performance of radio waves. (It does not require the calibration.)
Experience in WRMA	SEBA Current Meter in SRO.	(---)	Some in the other catchment area
Price	Moderate	High	Very High
Judgment	○	×	△

Table -2 Comparison Type of Water Level Sensors

Item \ Type	Pressure Sensor	Shaft Encoder (Well)	Ultrasonic Type Sensor
Diagram			
			
Gauging Theory	Sensor in the water gauges' variation of water pressure which reflects the water level. The sensor consists of a robust ceramic material.	Water level is gauged by measuring rotation of a pulley which, a wire with float and weight on its both ends hangs on.	Ultrasonic type sensor is set above water surface. The sensor transmits supersonic waves vertically, and receives reflection waves. Water level can be estimated with a time lag from the transmission to receiving waves. This type of sensor is used in mountainous areas where river flow including sediment and bed load so much to install sensor in river water like pressure type.
Maintenance	Removal of sedimentation or deposits on the sensor is required. Titanium is prefferable for installation in estuarine or sea water.	Float type sensor is easy to maintain, though comparatively a lot of maintenance is needed to keep intake pipes clean.	Maintenance of sensors mounted on a pole requires scaffoldings such as stages or cranes.
Experience in WRMA	Existing have utilized this type. Garissa Station [4G01] utilizes this type.	Existing RGSs utilize this type.	Will be installed at Nzoia river in LVNCA.
Price	Reasonable	A large-scale civil work is required.	---
Judgment	○	△	---

Appendix - 3

Location Map of Target Monitoring Stations for Project Activities

Appendix 3

Technical Note No.2

Technical Note No.2

This Technical Note No.2 prescribes to supplement to the former Technical Note, which was exchanged between WRMA and JICA Experts Team on 12 April 2017, in order to clarify the unfixed issues in the Technical Note.

Repair of Existing Gauging Stations and Installation of New Gauging Station

As one of sub-contract works and subsequent project activities, one site for installation of new gauging station was pending till date. Under such circumstances, representatives of WRMA Headquarter and the Regional Office in Embu conducted field reconnaissance with a JICA Expert on 14 June 2017. Considering reinforcement of monitoring works of surface water in the future, the Kathita River was preliminarily selected for the site of new gauging station.

On the other hand, the proposed High Grand Falls (HGF) Dam, which is planned on the Tana mainstream at around 4 km downstream from the confluence of the Kathita River, will be submerged in downstream part of the Kathita River upon its completion. Therefore, new station should be installed at farther upstream avoiding backwater of the proposed HGF reservoir.

As the result of the reconnaissance, both parties mutually agreed on the followings:

(1) Location of new gauging station : Same location of 4F10 (near Marimanti)
(Lat: S 0°09′43″, Long: E 37°58′47″, El. 580 m approx.)

(2) Equipment to be installed : New water level sensor (pressure type) and new staff gauges (L=5.0m , 1.0m/unit)
(Existing gauge house will be utilized as it is.)

(3) Upgrading of priority
Although 4F10 is currently Intra-management Unit Station, it will be upgraded to the Management Unit station after the installation works of equipment.

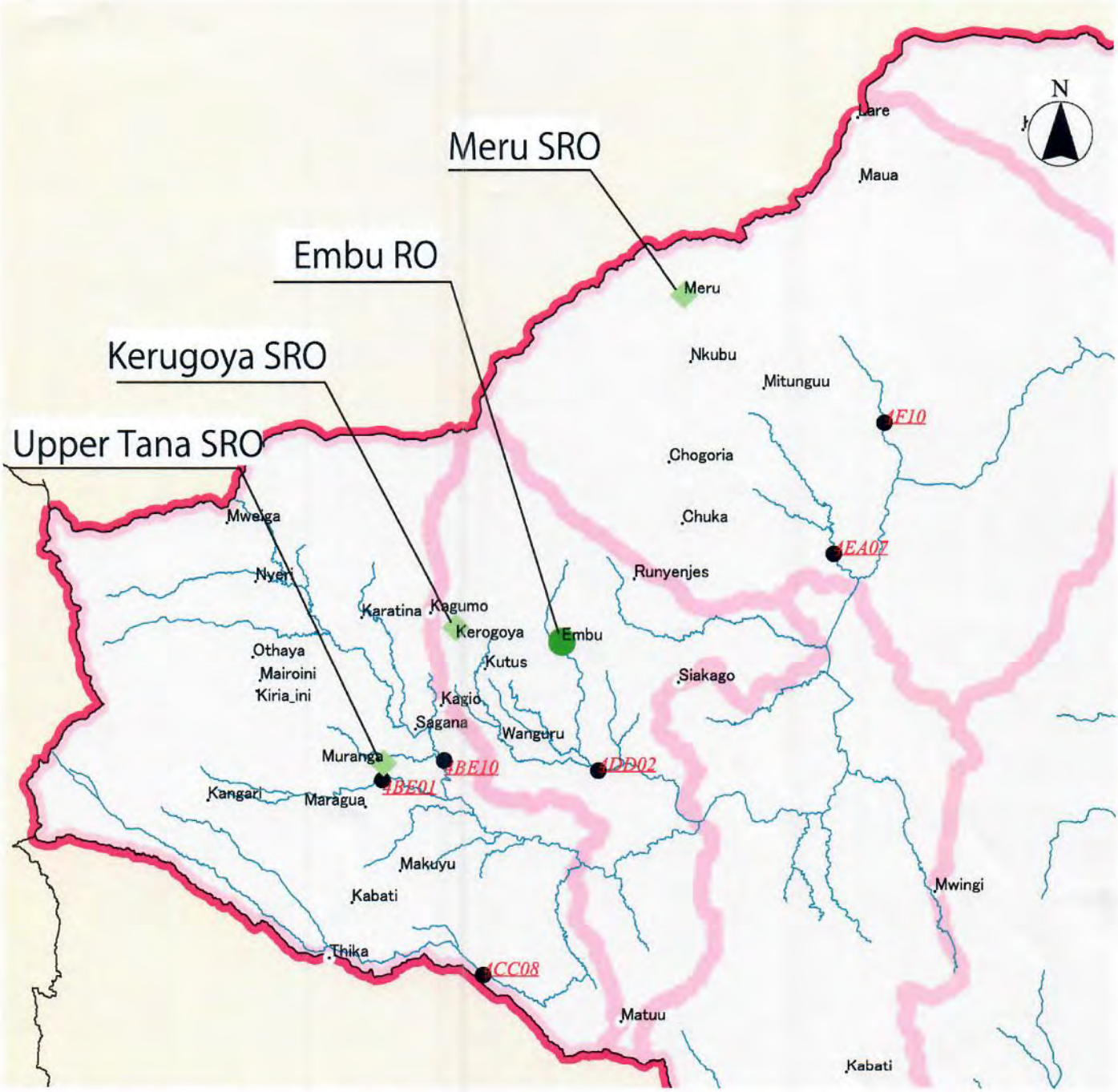
Further, as for the target sites for river cross section survey, 4CC07 (Thika River) was changed to 4CC08 (Thika River) because of unfavorable site conditions for the survey and subsequent measurement of river discharge due to existing domestic water intake structure nearby.
A location map is shown in Appendix 1.

Appendix 1: Location Map of Target Gauging Stations

Nairobi, 27 June 2017

Mr. Lawrence Thooko	**Mr. Yoshihiro Motoki**
Project Manager	Team Leader/ Water Resources Management
Water Resources Management Authority, Republic of Kenya	JICA Expert Team

Appendix 1



Location of River gauging stations (for the Project activities concerned)

No	RGS Name	Latitude	Longitude	SRO*	Remarks
1	4EA07	0°22'43.65"S	37°53'47.45"E	Meru	
2	**4DD02**	**0°44'2.22"S**	**37°30'38.28"E**	**Kerugoya**	**Rehabilitation**
3	**4BE10**	**0°43'41.56"S**	**37°15'32.00"E**	**Upper Tana**	**Rehabilitation**
4	4BE01	0°44'59.29"S	37° 9'27.91"E	Upper Tana	
5	4CC08	1° 4'16.90"S	37°19'18.34"E	Upper Tana	
6	**4F10**	**0°09′43″S**	**37°58′47″E**	**Meru**	**(new)**

Note: *, SRO: Sub Regional Office (WRMA) RO: Regional Office

Location Map of Target Gauging Stations for Rehabilitation and Newly Installation

Appendix 4

Evaluation of Network for Water Level Gauging Stations in Tana Catchment Area (Recommendation by the Project)

Evaluation of Water Level Gauging Stations in Tana Catchment (Recommendaiton by the Project)

(based on the recommendation by NWRM 2030 and related infromation collected)

A	B	C	D	E	F	G	H	I
No.	ID No.	Station Name	Location	Responsible SRO	Operational Status	Data Recording System	Evaluation and Comments by JICA Expert Team	Evaluation and Comments by WB Kenya Water Security and Climate Resilience Project (as of January 2019)
1	4AA05	Sagana	Tributary of Sagana R.	Muranga	Operational	Automatic	To keep as it is to continue monitoring. It is important to monitor discharge at most upstream areas of Tana Catchment with maintaining this site.	Station upgraded according to WRA. Coordinates require verification. Current coordinates have been upgraded from their original version via Google Earth. Listed as automatic and operational, so continue to monitor.
2	4AB06	Amboni	Sagana R.	Muranga	Operational	Manual	To keep as it is to continue monitoring for same purposes as 4AA05.	Station coordinates need verification. Station appears to be near major roads, so access should be relatively easy. Discuss this station with WRA to add to design. Station is also downstream of minor tributary confluence, so could have delineation benefits. Station listed as operational, so continue to monitor manually.
3	4AC04	New Chania	Chania R.	Muranga	Operational	Manual	To keep as it is to continue monitoring. The site is closed to Nyeri City proper. So, monitoring flood water levels is also important for flood risk assessment and preparedness.	This is a questionable station. If it is needed in the town of Nyeri, then it could be beneficial. Otherwise, 4AA05 captures that tributary and more. Better basin delineation size with 4AA05. Station is listed as operational, so continue to monitor.
4	4AD01	Gura	Gura R.	Muranga	Operational	Automatic	To keep as it is to continue monitoring. This is one of key stations at upper reaches of Tana Catchment.	Coordinates are most likely invalid for this station. Coordinates require verification with WRA. High priority and long history of data, so keep it in initial design.
5	4BB01	Ragati	Tributary of Sagana R.	Muranga	Operational	Manual	To keep as it is to continue monitoring.	Coordinates require verification for this station. Flow is captured further downstream by station 4BC04. This could be a station to potentially add to the hydromet design, but station would create a small basin.
6	4BC04	Rwamutham bi	Tributary of Sagana R.	Muranga	Operational	Manual	To keep as it is to continue monitoring. Together with 4BB01, these two stations will help to monitor flood water levels at surrounding of Muranga.	Coordinates need verification. Station appears to be on a minor tributary. Station would delineate too small of a basin to use for the hydromet network design. Station is in heavy agricultural area, so could be a good potential candidate for water quality. Located ~0.5km off Baricho-Kagio Rd (Google Earth road name) and southeast of Kiandai Village. However, station listed as operational by sub-region, so continue to monitor manually.
7	4BD01	Mathioya	Mathioya R.	Muranga	Non-Operational	Manual	To keep as it is to continue monitoring.	Coordinates require verification. Located on bridge along C71 downstream of Muranga Town/Fort Hall. Station is listed as operational, so continue to monitor manually. (not operational from Oct.2018, Re: information of Embu RO)
8	4BE01	Maragua	Maragua R.	Muranga	Not-Operational	Telemetric	Target G/S of JICA Project. ・3 river cross sections are available (measured in Aug.2017). ・DM conducted and H-Q curve newly established. Two bridges are located and suitable for discharge measurement. Need to renew the staff gauge posts and plates at right bank.	This station is listed as one that will be automated by WRA. 0 - 4.5 m gauges that are all in place. The third gauge needs to be rehabilitated. Automatic HOBO data logger and automatic water quality multiparameter installed in 2015. There is also a SEBA hydrometric MDS which is not operational. There is a benchmark at the right bank old bridge crest. Installation of 2 extra concrete posts for anchoring the boat during the high flow discharge measurements is recommended. (Not operational by vandalization)

9	4BE10	Tana Rukanga	Tana R.	Muranga	Operational	Automatic	One of the most important G/S in upstream area and target G/S of JICA Project. ・3 river cross sections are available (measured in Aug.2017). ・Staff gauge posts and plates were renewed. Bench marks connected with national grid are available. ・DM conducted and H-Q curve newly established. A ditch for protection of gauge house was constructed.	This station is a HYCOS installed station so already has an automatic data logger that is listed as operational. This station could be used as a sub-regional pilot station (Phase B) that is upgraded to full telemetric.
10	4BF01	Saba Saba	Saba Saba R.	Muranga	Operational	Manual	To keep as it is to continue monitoring. This site will monitor the incremental discharge along Saba Saba R. flowing into Tana Rukanga (4BE10).	This station does not add any value hydrologically. If WRA wants to include it as a phase C or D station, then coordinates need to be verified to ensure accuracy.
11	4CA02	Chania	Chania R.	Muranga	Operational	Automatic	To keep as it is to continue monitoring. The station is located near Thika City. Since a series of dam is planned and designed in the Chania R. and Thika R., to monitor the discharge at this site is important.	Station is too high in watershed to provide value hydrologically. Station coordinates need verification. Potential discussion point with WRA to see if station has other unknown benefits. Station is listed as automatic and operational, so continue to monitor.
12	4CC03	Yatta Furrow	Thika R.	Muranga	Operational	Manual	To cancel this site and substitute with 4CC08 after verification of accurate location of both, since those are closed each other.	Station is captured by 4CC08 downstream. However, station is marked as operational, so continue to monitor, but only as a Phase D station (meaning all sub-region Phase A-C stations must be managed sustainably first).
*	4CC08	Thika	Thika R.	Muranga	Operational	Manual	Target G/S of JICA Project. ・3 river cross sections are available (measured in Aug.2017). ・DM conducted and H-Q curve newly established. ・A bridge is located at upstream of G/S and suitable for discharge measurement. It is recommended to integrate in the network for long-term monitoring to assess discharge of Thika R. flowing into Masinga Dam.	Station located on canal next to river according to subregion. 4CC08 is on the uninhibited river. See 4CC08 as the station referenced in design.
13	4DA10	Thiba	Thiba R.	Kerugoya	Operational	Manual	To keep as it is to continue monitoring. This site will monitor the discharge from a tributary of the Thiba R.	Too small of a catchment basin size to add value? Unless there is another purpose for this station. The flow this station is measuring is captured further downstream by station 4DA07 and 4BE04. However, this station is marked as operational, so continue to monitor manually.
14	4DB04	Nyamindi	Nyamindi R.	Kerugoya	Operational	Manual	To keep as it is to continue monitoring. Discharge through three gauging stations of 4DA10, 4DB04 and 4DC06 flows and meet together into 4DD02. So, all important to know the discharge at tributaries.	Coordinates need verification. Station is too far upstream in watershed to add value hydrologically. Station is next to town of Kimbimbi, so could be a potential candidate based for water quality monitoring. Station is also located within 0.5 KM of station 4DB04 and 4DA05, so all coordinates need verification. If station is indeed operational, can continue to monitor manually, but leave as a phase D (lower priority) station for Thiba sub-region.
15	4DC06	Kapingazi	Kapingazi R.	Kerugoya	Operational	Manual	To keep as it is to continue monitoring as same reason at 4DB04.	Station closed according to WRA sub-regional staff. Information collected November-December 2017 on ISC regional office visit.

16	4DD02	Thiba	Thiba R.	Kerugoya	Operational	Automatic	Target G/S of JICA Project. ・3 river cross sections are available (measured in Aug.2017). ・Staff gauge posts and plates were renewed. Bench marks connected with national grid are available. ・DM conducted and H-Q curve newly established. It is recommended to integrate in the network for long-term monitoring to assess discharge of Thiba R. flowing between Kamburu and Gitaru Dams.	Data logger at site is not working currently and needs rehabilitation (battery replacement might be the only issue). The station has 1 - 4.5 m gauges that are all in place. Flood mark is approximately 3 m away from the 3rd gauge (3-4.5) is bent. This level is above the last staff gauge. An additional 4th gauge to capture flood flow should be installed. The benchmark is next to third gauge and should be re-established at higher grounds. Station to be upgraded to telemetric according to WRA.
17	4EA07	Mutonga	Mutonga R.	Meru	Operational	Telemetric	Target G/S of JICA Project. ・3 river cross sections are available (measured in Aug.2017). ・DM conducted and H-Q curve newly established. It is recommended to integrate in the network for long-term monitoring to assess discharge of Mutonga R. flowing into tana mainstream at u/s of High Grand Fall Dam reservoir.	Coordinates need verification. Station is very close to station 4EA05 according to current coordinates. Station could be beneficial to capture tributaries originating from Mt. Kenya on the eastern slope. Station appears to be ~1KM from major road C93, but access to exact coordinates looks challenging. Minimal roads to river from C93. The station has 0-4.5m gauges that are all in place. The benchmark was found at the old steel housing. The station has a recorder housing in good order (4ft x 4ft x 6ft with wash back tank installed on the roof). Station is listed by WRA as one that will upgraded to telemetric.
18	4EB07	Thuchi	Thuchi R.	Meru	Operational	Manual	To keep as it is to continue monitoring.	Station could be used to further delineate above station 4EA07 (which is included in design). However, station is upstream in watershed and would create a smaller basin. Discussion point with WRA. Station is listed as operational so continue to monitor manually as long as all other Phase A-C stations are sustainably managed.
19	4EC04	N/A	Ena R.	-	Non-operational	-	This site is not included in the WRA's ledger sheet. Need to verification.	<No description>
20	4F09	Ura	Thanantu R.	Meru	Operational	Manual	To keep as it is to continue monitoring.	Station is upstream in watershed, so does not provide much value hydrologically for the hydromet network design. However, station is operational so continue monitoring as a Phase D station as long as Phase A-C stations are managed sustainably.
*	4F10	Kazita	Kazita (Kathita) R.	Meru	Operational	Manual	Target G/S of JICA Project. ・3 river cross sections are available (measured in Aug.2017). ・Staff gauge posts and plates were renewed. Bench marks connected with national grid are available. ・Gabion mattress installed to protect existing gauge house against bank erosion. ・DM conducted and H-Q curve newly established. It is recommended to integrate in the network for long-term monitoring to assess discharge of Kathita R. flowing into future High Grand Fall Dam, since 4F19 will be submerged by back water of the reservoir. Need to further verification.	Coordinates need verification. If station is located on river upstream of 4F11, then could be a good candidate for hydromet network design. Need to verify location before including in design. However, station is marked as operational so continue to monitor manually as long as all other Phase A-C stations are managed sustainably.

21	4F13	Tana Grand Falls	Tana mainstream	Meru	Non-operational	Manual	A cableway across of the Tana mainstream and supporting tower at both banks still exist. It is recommended to restore the facility and to restart discharge measurement again, though this station can be utilized untill completion of High Grand Fall dam. Staff gauges cover an enough range of river water fluctuation, but needs to be rehabilitated.	Stilling well. Verify that this is a surface water station because coordinates are not on any river and not near Kibuka. Grand falls are approximately 3KM northwest of current station coordinates. No time series data provided for this station. Discuss this station with WRA. Station is marked as operational, so continue to monitor manually as long as other Phase A-C stations are managed sustainably.
22	4F19	Kazita	Kazita R.	Meru	Operational	Manual	To keep as it is to continue monitoring. It is better to continue monitoring at this site together with 4F10 until completion of High Grand Fall dam.	Station would capture other major set of tributaries off eastern slopes of Mt. Kenya. Station is downstream of Gaungu and Marimanti, so could be a good candidate for water quality before it drains to the Tana River. However, station appears to be in a remote area, so access to this station might be challenging. This station is recommended as a Phase B station because its significance in the sub-region - this station captures a large area of runoff before the confluence with the Tana.
23	4F28	Rujiweru	Bisanadi R. (right tributary)	Meru	Non-operational	-	Gauge swept away. Need to rehabilitate. Better to restore and resume monitoring works, since this is only one gauge site along the tributary.	No description to match, but coordinates put station on river.
24	4G01	Tana Garissa	Tana mainstream	Garissa	Operational	Automatic	Only one National Station in the Tana Catchment and very important to monitor low and high flow including water quality. To keep monitoring.	Station closed according to WRA sub-regional staff. Information collected November-December 2017 on ISC regional office visit.
25	4G02	Tana Garsen	Tana mainstream	Garissa	Operational	Manual	This is only the station to monitor at lowest stretches of the Tana mainstream. Need to upgrade and connect with telemetering system to cover low and high flow. To keep monitoring.	Station is located along Tana River in town of Garissa. Station is crucial for flood forecasting and ISC recommends this station be upgraded to full telemetric. Sub-regional noted that the data logger is not always functional, but there is a consistent gauge reader to obtain manual readings.
26	4G04	Tana Hola	Tana mainstream	Garissa	Operational	Manual	An important location to monitor at middle of the lower stretches of the Tana in terms of both low and high flow. It is recommended to rehabilitate and upgrade into the telemetering system. To keep monitoring.	Coordinates need verification. Coordinates were updated from original versions via Google Earth. Station appears to be along major road C112. Station appears to be downstream of town of Garsen. Station could be used for flood forecasting purposed if WRA identifies this area of the lower Tana as one of top concern. Station would need to be fully upgraded to telemetric - gauge plates washed away in flood several years ago and have not been replaced.

Note: Source of information and further explanation

Column A: Total 26 sites were recommended by NWRM 2030. Two sites marked "*" are added by current Project, but No.12 is recommended to cancel. **Total 27 sites are recommended by the Project.**

B: Master List (Ledger) of WRA

C: Master List (Ledger) of WRA

D: Confirmed by the current Project

E: Confirmed by the current Project

F: Master List (Ledger) of WRA

G: Master List (Ledger) of WRA

H: Evaluation by JICA Expert Team

I: Extracted from the master inventory sheets prepared by KWSCR Project (shared by WRA)

Color coding: Recommended by NWRM2030 | Target sites for pilot activities of the Project | Non-operational | Recommended to cancel

Appendix 5

Instruction for
Data Adjustment of Data Logger

Instruction for Data Adjustment of Data-Logger

The process of data adjustment for converting the record of Data-Logger to exact water level is explained as below.

(1) The record of Data-Logger can be converted to exact water level by using utility software program provided with the CD of Data-Logger

(2) The procedure of conversion is illustrated in the page 67 of instruction manual as shown in the figure below.

(3) The operation of conversion is just to input two information A (slope) and B (offset) in accordance with the guide as illustrated in the manual below.

(4) In the case of 4F10 station shown in the table 1 and figure 1 below, input 10.515 and -10.472 as A (slope) and B (offset) individually.

(5) The converted data can be shown graphically by graphing editor of the utility program.

Note: You have also another way for conversion. The orijinal record of Data-Logger can be output as a CSV file. Then the CSV file can be edited on Excel software. It is also easy way to convert the record.

Table 1 Data Conversion of Data-Logger ST. 4F10

Date	Manual Obs. by Staff Gauge Reading			Automatic Obs. by Sensor				WL Difference (1)-(2)
	Time		(1) WL (m)	Original of Data logger		Converted Data		
	Start	End		Time	(2) WL (m)	Time	(3) WL (m)	
2018/3/27	9:50	11:34	0.54	10:00	1.050	10:00	0.57	−0.03
2018/4/19	9:08	9:18	0.91	9:00	1.083	9:00	0.92	−0.01
2018/5/2	14:00	15:18	0.84	14:00	1.076	14:00	0.84	−0.00
2018/6/7	11:25	13:05	0.72	12:00	1.064	12:00	0.72	0.00
2018/6/8	14:25	15:55	0.70	15:00	1.062	15:00	0.69	0.01
2018/6/12	12:38	13:47	0.65	13:00	1.056	13:00	0.63	0.02
2018/7/9	14:14	15:39	0.48	15:00	1.040	15:00	0.46	0.02
2018/7/23	9:30	10:25	0.40	10:00	1.033	10:00	0.39	0.01
2018/7/29	9:22	9:59	0.36	9:00	1.030	9:00	0.36	0.00
2018/8/25	10:35	11:15	0.28	11:00	1.022	11:00	0.27	0.01
2018/9/13	12:01	12:29	0.25	12:00	1.019	12:00	0.24	0.01
2018/9/14	9:35	10:00	0.32	10:00	1.027	10:00	0.33	−0.01
2018/9/22	9:35	10:00	0.30	9:00	1.027	9:00	0.33	−0.03

Note: Conversion Equation (3) = 10.515 ×(1) − 10.472

slope 10.515
offset −10.472

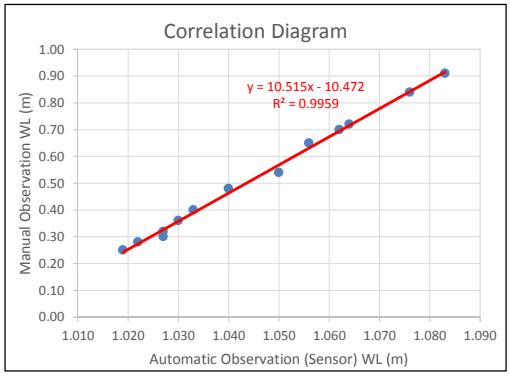
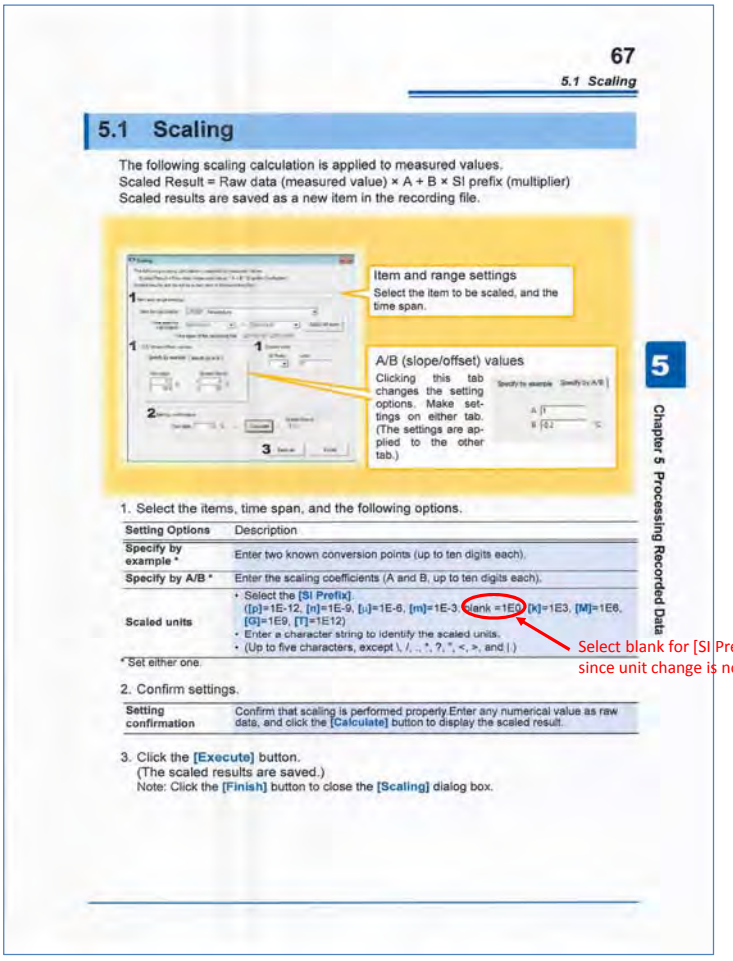


Figure 1 Correlation Diagram



Available to be Downloaded:
https://www.hioki.com/en/products/detail/?product_key=5687

Appendix 6

Handout Material for Workshops

Japan International Cooperation Agency (JICA)

Water Resources Authority (WRA)

Water Resources Management Expert

1st Workshop

--- Methodology of Discharge Measurement ---

March 8 to 9, 2018
Regional Office in Tana Catchment, Embu

JICA Experts Team
(Nippon Koei Co., Ltd.)

Contents of Workshop

Part 1. Project Briefing

1. Project Briefing
(1) Project Outline (1/2)

- Objective

  To enhance capacity of water resources management in WRA with the following three expected outputs :
- Output
  - Output 1: Enhancement of surface water monitoring to improve water resources management by WRA in line with the National Water Master Plan 2030 (NWMP)
  - Output 2: Establishment of appropriate hydro meteorological network and its management
  - Output 3: Guidance to WRA on future support for water resources management through Japan's ODA or from any other organizations

1. Project Briefing
(1) Project Outline (2/2)

- Pilot area:
  Tana Catchment
- Project period
  From Jan. 2017 to Feb. 2019
- Japanese experts
  Two personnel (Mr. Motoki (TL) and Mr. Kato)
- Sub-contract Works
  - River cross section survey (6 sites)(completed)
  - Rehabilitation of existing gauging stations and installation of new gauging stations (3 sites) (completed)
  - Discharge measurement (15 times @ 6 sites)

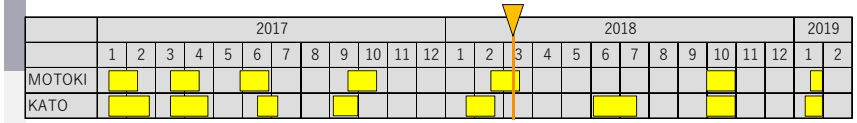
1. Project Briefing
(2) Pilot area for project activities

Upper Tana Catchment was selected as the Pilot Area at commencement of the Project. In particular, six river gauging stations RGS) were selected as target the sites for discharge measurement.

No	RGS Name	Latitude	Longitude	SRO
1	4EA07	0° 22'43.65"S	37° 53'47.45"E	Meru
2	4DD02	0° 44'2.22"S	37° 30'38.28"E	Kerugoya
3	4BE10	0° 43'41.56"S	37° 15'32.00"E	Upper Tana
4	4BE01	0° 44'59.29"S	37° 9'27.91"E	Upper Tana
5	4CC08	1° 4'16.90"S	37° 19'18.34"E	Upper Tana
6	4F10	0° 09'43"S	37° 58'47"E	Meru

1. Project Briefing (3) Work Schedule

1. Project Briefing
(4) Assignment Schedule of Experts



Mr.Motoki: Total 180 working days, and 7 trips
(Year 2017: 108 days, Year 2018: 60 days, and Year 2019: 12 days)

Mr.Kato: Total 255 working days, and 8 trips
(Year 2017: 132 days, Year 2018: 105 days, and Year 2019: 18 days)

1. Project Briefing
(5) Schedule of discharge measurement (tentative)

SRO	Remarks	3				4					5				6				7		
		05	12	19	26	02	09	16	23	30	07	14	21	28	04	11	18	25	02	09	16
Meru				1		1		1		1		1		1		1		1		1	
Kerugoya	(rehabilitation)		1		1		1		1		1		1		1		1		1		1
Upper Tana	(rehabilitation)		1		1		1		1		1		1		1		1		1		1
Upper Tana			1		1		1		1		1		1		1		1		1		1
Upper Tana				1		1		1		1		1		1		1		1		1	
Meru	(New)			1		1		1		1		1		1		1		1		1	

Rainy reason

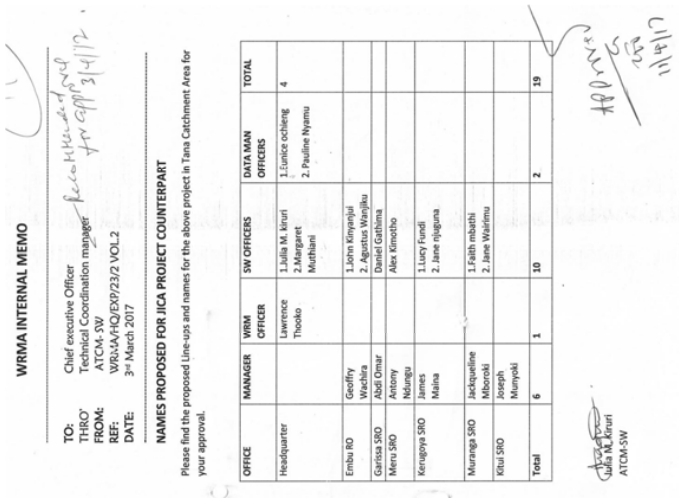
Expets (-3/15) Ramadan(5/14- 6/14)

SRO	Remarks	6	7					8				9				10					
Meru		25	02	09	16	23	30	06	13	20	27	03	10	17	24	01	08	15	22	29	Total
Kerugoya	(rehabilitation)	1		1		1		1		1		1		1		1					15
Upper Tana	(rehabilitation)		1		1		1		1		1		1		1						15
Upper Tana			1		1		1		1		1		1		1						15
Upper Tana			1		1		1		1		1		1		1						15
Meru	(New)		1		1		1		1		1		1		1						15
		1		1		1		1		1		1		1							15

Rainy reason

Expets (45 days) Expets (30 days)

1. Project Briefing
(5) Line-up of Counterpart Personnel



WRMA INTERNAL MEMO

TO: Chief executive Officer
THRO' Technical Coordination manager
FROM: ATCM- SW
REF: WRA/A-HQ/EXP/23/2 VOL.2
DATE: 3rd March 2017

NAMES PROPOSED FOR JICA PROJECT COUNTERPART

Please find the proposed Line-ups and names for the above project in Tana Catchment Area for your approval.

OFFICE	MANAGER	WRM OFFICER	SW OFFICERS	DATA MAN OFFICERS	TOTAL
Headquarter		Liwrence Thooko	1.Julia M. Kiruri 2.Margaret Muthiani	1.Eunice ochieng 2. Pauline Nyamu	4
Embu RO	Geoffry Wachira		1.John Kinyanjui 2. Agustus Wanjiku		
Garissa SRO	Abdi Omar		Daniel Gathima		
Meru SRO	Antony Mbaniju		Alex Kinotho		
Kerugoya SRO	James Malina		1.Lucy Fundi 2. Jane Njagama		
Muranga SRO	Jackqueline Mboroki		1.Faith mbathi 2. Jane Wairimu		
Kitui SRO	Joseph Munyoki				
Total	6	1	10	2	19

Julia M. Kiruri
ATCM-SW

Part 2. Methodology of Discharge Measurement

2. Methodology of Discharge Measurement
(1) Five key points for discharge measurement (1/4)

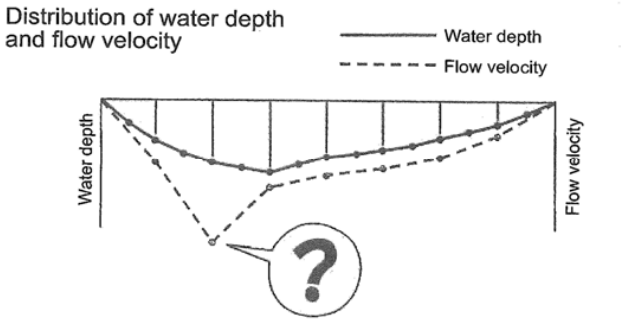
- Point 1 To select the ideal site for conducting discharge measurement
  - Reasonably straight site or 5 to 10 times the channel's width both upstream and downstream from the gauge site
  - Observations should be conducted at the sections where there is straight channel stretching long enough for observations where cross section nor river width changes substantially
  - Free from rocks, weeds, and other obstructions
  - River flow that is parallel to the bank avoiding cross flow or reverse flow
  - A stable river bed and banks - if a cross section changes over time the discharge measurement will change.

2. Methodology of Discharge Measurement
(1) Five key points for discharge measurement (2/4)

- **Point 2 To Measure the geometry of the channel cross section**
  - Determine the cross-sectional geometry – Measure width of the cross section and the depth at a certain vertical
  - Divide the river or stream into equal vertical subsections, where ideally no subsection includes more than 5 to 10 percent of the total discharge of river or stream
  - Determine the depth of river or stream for each of the verticals

2. Methodology of Discharge Measurement
(1) Five key points for discharge measurement (3/4)

- **Point 3 To apply right technology for measuring flow velocity**
  - Check the consistency of the velocities along the channel section



2. Methodology of Discharge Measurement
(1) Five key points for discharge measurement (4/4)

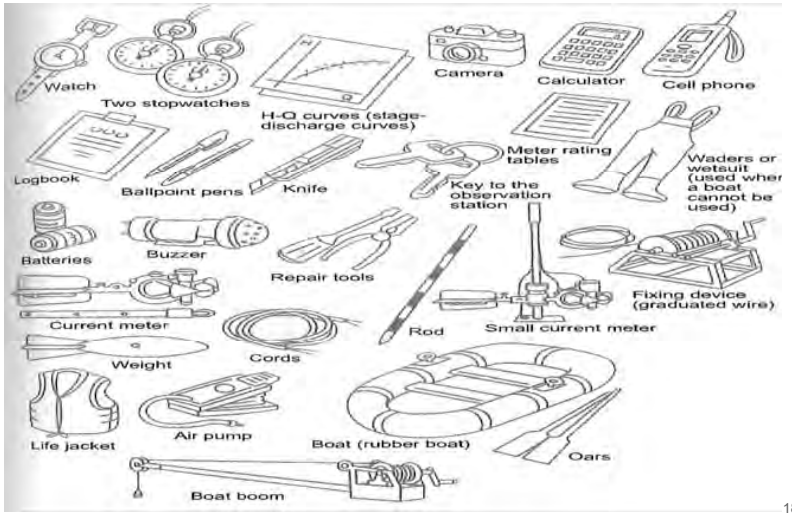
- **Point 4 To use appropriate equipment**
  - Keep instruments in good conditions (to check before mobilization to the field)
  - Clean, oil and make the instruments operational
- **Point 5 To assign qualified personnel**
  - Assign experienced hydrologists and instrument technicians who are capable enough for field measurements
  - Hire assistants from neighborhood who are familiar to the river conditions

Part 3. Field Measurement

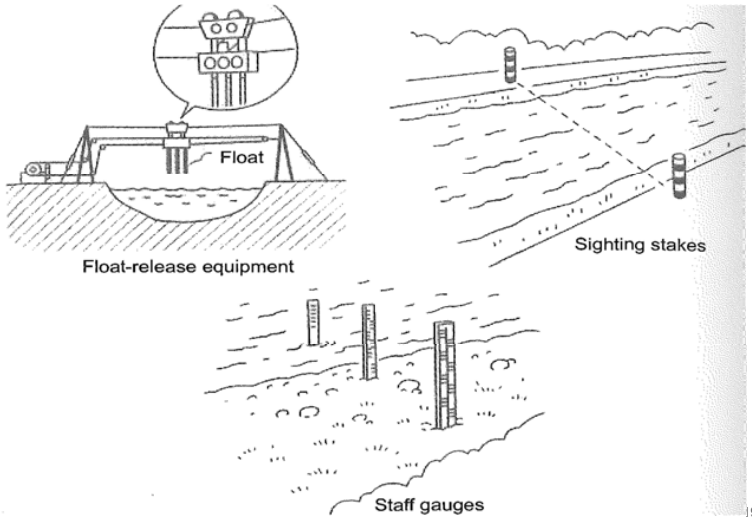
3. Field Measurement
(1) Procedure of discharge measurement

- Step 1 Record the readings of water level at staff gauges
- Step 2 Check flow conditions as discharge measurement method depends on flow conditions
  - For instance:
    - Low flow - Wading measurement using current meter or observation by boat using current meter
    - Medium flow - Observation by boat using current meter
    - High flow (flood) – Observation by float
- Step 3 Decide measurement method
- Step 4 Preparation of required equipment and setting
- Step 5 Measure water levels and flow velocities
- Step 6 Record the readings of water level at staff gauges
- Step 7 Record of the results and data analyses

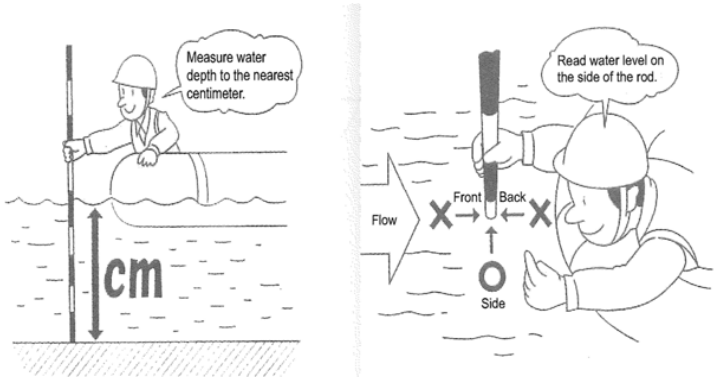
3. Field Measurement
(2) Required equipment (1/2)



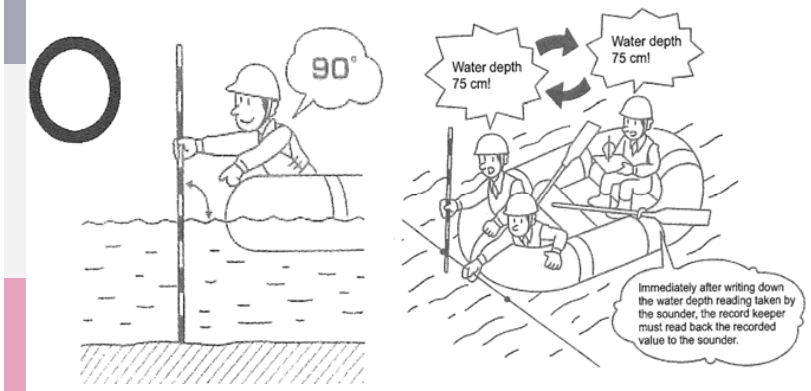
3. Field Measurement
(2) Required equipment (2/2)



3. Field Measurement
(3) Measurement of water depth (1/2)

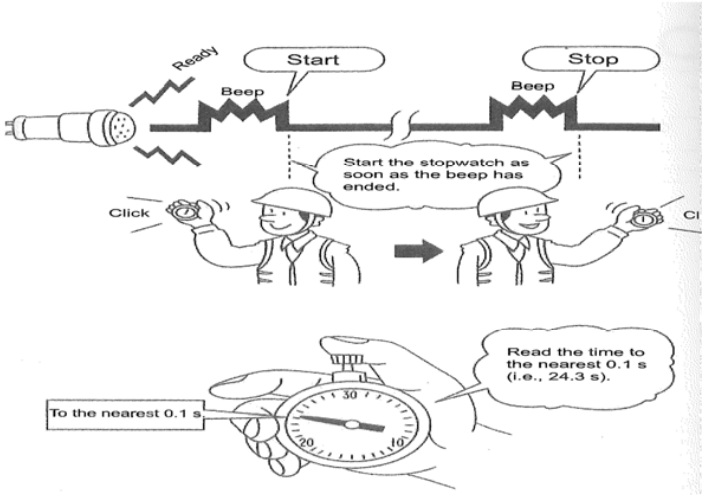


3. Field Measurement
(3) Measurement of water depth (2/2)



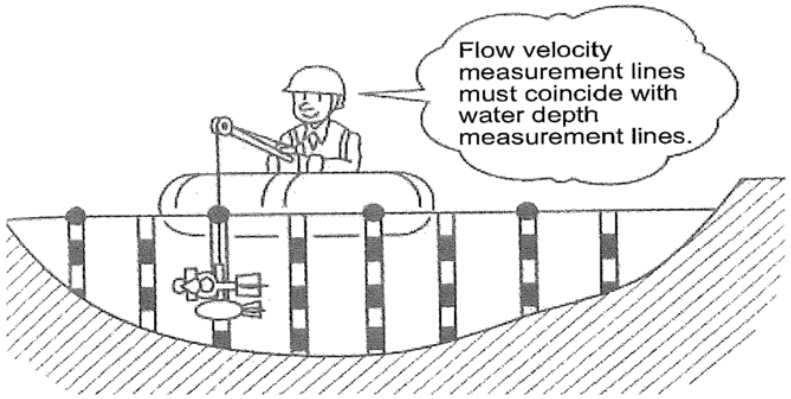
21

3. Field Measurement
(4)Time keeping (float measurement)



22

3. Field Measurement
(5) Setting of measurement lines



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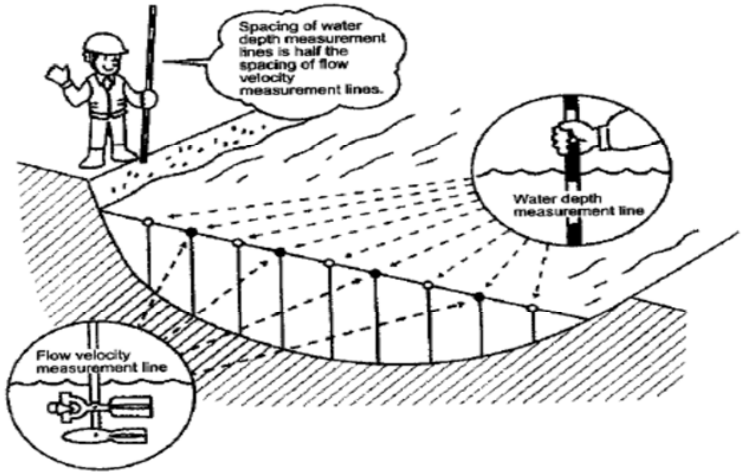
3. Field Measurement
(6) Spacing between measurement lines (1/2)



24

A6-6

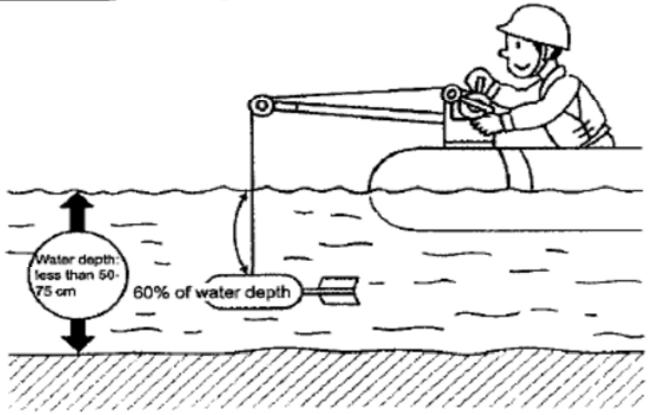
3. Field Measurement
(6) Spacing between measurement lines (2/2)

Water surface width (m)	Spacing between water depth measurement lines (m)	Spacing between flow velocity measurement lines (m)
Less than 10	10~15% of water surface width	10~15% of water surface width
10 ~ 20	1	2
20 ~ 40	2	4
40 ~ 60	3	6
60 ~ 80	4	8
80 ~ 100	5	10
100 ~ 150	6	12
150 ~ 200	10	20
More than 200	15	30

3. Field Measurement
(7) Flow velocity measurement points (1/2)

One-point method

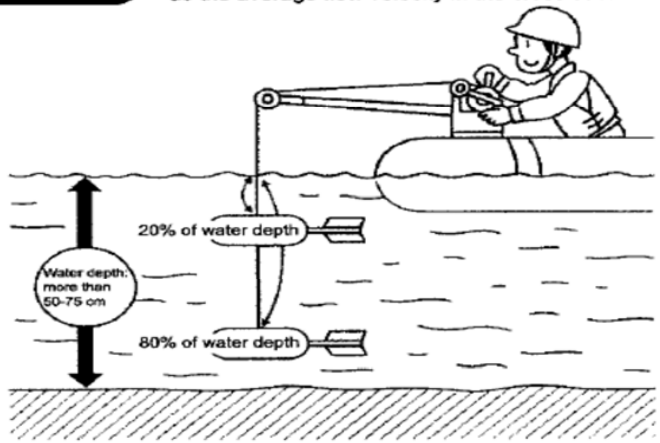
Take the flow velocity at a measurement point at 60% of water depth from the water surface as the average flow velocity in the cross section.



3. Field Measurement
(7) Flow velocity measurement points (2/2)

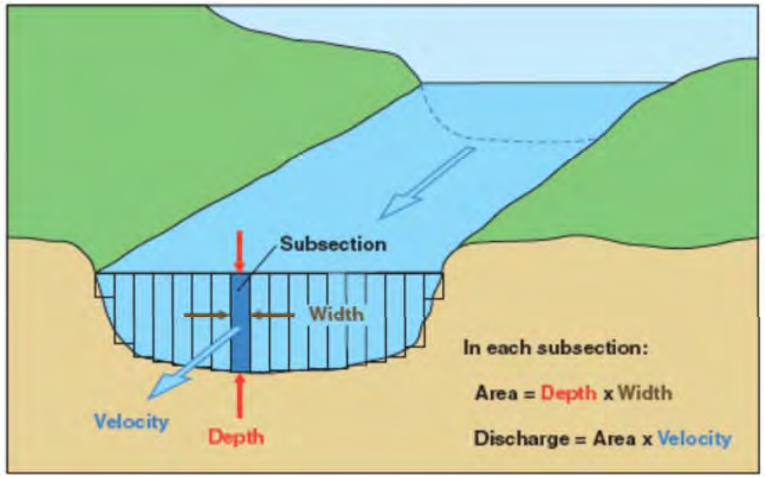
Two-point method

Take the average of the flow velocities at 20% and 80% of water depth from the water surface as the average flow velocity in the cross section.



Part 4. Record and Computation

4. Record and Computation
(1) Schematic image of discharge calculation

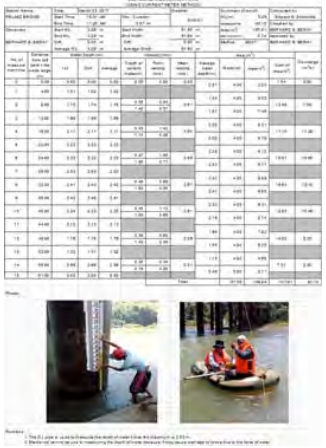


4. Record and Computation
(2) Simple theory of calculation

- The cross-section channels were already divided into a number of 'segments'.
- The edge of these segments are called 'verticals'.
- Discharge in each segment is calculated by multiplying the area of each segment by the average flow velocity representing the cross section area.
- Discharges in all segments are totaled to derive the discharge in the entire cross section.

4. Record and Computation
(3) Sample recording form (Excel)

- Calculation sheet (Current Meter, Float)



Current Meter Method

Float Method

4. Record and Computation
(4) Items to be filled in recording form

An example of records filled by actual measurements in the Philippines

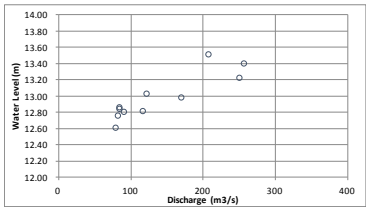
DISCHARGE CALCULATION FORM
(USING CURRENT METER METHOD)

Station Name:		Date:	1 March 2015			Weather		Summary of result:		Computed by:			
Pelaez Bridge		Start Time:	10:53	AM	Obs. Duration		Cloudy	WL(m)	6.39				
Cagayan de Oro River		End Time:	11:30	AM	0:37	hr		Discharge(m^3/s)	15.85	Checked by:			
Observers:		Start WL:	6.44	m	Start Width:		40.10	m	Area(m^2)	13.02			
		End WL:	6.34	m	End Width:		40.00	m	Mean velocity(m/s)	1.22	Approved by:		
		Diff.:	0.10	m	Diff.:		0.10	m	Method:	Wading			
		Average WL	6.39	m	Average Width:		40.05	m		Boat			

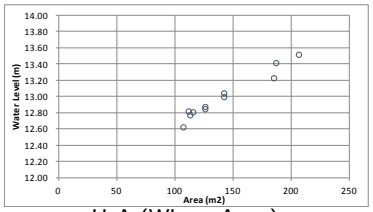
No. of measure ment line	Distance from left bank side water edge (m)	Water Depth (m)			Velocity (m/s)			Area (m^2)				Discharge (m^3/s)
		1st	2nd	Average	Depth of current meter(m)	Point velocity (m/s)	Mean velocity (m/s)	Average water depth(m)	Width(m)	Area(m^2)	Sum of Area(m^2)	

4. Record and Computation
(5) Graphical Plots

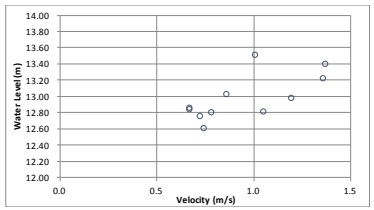
- Graphical plots are very important to grasp hydraulic characteristics.



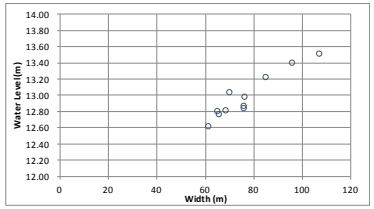
H-Q (WL vs Discharge)



H-A (WL vs Area)



H-V (WL vs Velocity)



H-B (WL vs Width)

4. Record and Computation
(6) Quality check of field records

- To check accuracy after measurements, perform discharge calculation on site/office
  - Plot stage – discharge curves and check accuracy of the plots
    - If deviation is greater than 10% - repeat calculation
    - If deviation is still 10% conduct discharge observation again

Part 5. Development of Rating Curves (H~Q Curves)

5. Development of Rating Curves (H~Q curves)
(1) Importance of rating curve

- A rating curve is established by making a number of concurrent observations of stage and discharge over a period of time covering the expected range of stages at the river gauging section.
- Periodical check of curve (fitting with the curve) and its update is necessary to accurately convert from water level to discharge.
- Quality discharge data is prerequisite for discharge quantity management for water resources management including appropriate water right control.

5. Development of Rating Curves (H~Q curves)
(2) Equation of rating curve

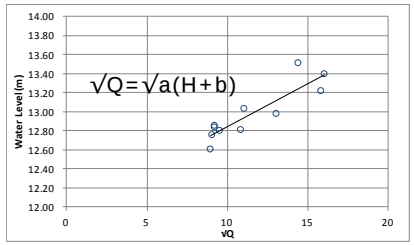
- Equation of Rating Curve

$Q=a(H+b)^n$ where Q: Discharge (m^3/s)
H: Water Level (m in MSL)
a: Multiplier (parameter)
b: Scale offset (parameter)
n : Exponent (parameter)

- Parameter Estimation

Plot H-√Q. If plots are on a straight line, n=2.

Then, a and b can be estimated by simple linear regression least squares method.

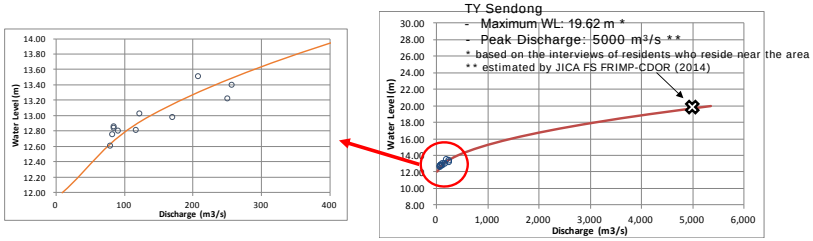


H-√Q

5. Development of Rating Curves (H~Q curves)
(3) Examples of rating curves

- Rating Curves at Six Stations

No	Station Name	River	Rating Curve
CDO1	Pelaez Bridge	CDO River	$Q=76.94(H-11.66)^2$
CDO2	Cabula Bridge	CDO River	$Q=131.49(H-39.78)^2$
CDO3	Uguiaban Bridge	CDO River	$Q=6.86(H-140.75)^2$
CDO4	Liboran	Bubunawan River	$Q=73.40(H-75.62)^2$
T1	Santa Ana	Tagoloan River	$Q=29.36(H-24.77)^2$
T2	Dalirig	Tagoloan River	$Q=205.43(H-121.13)^2$



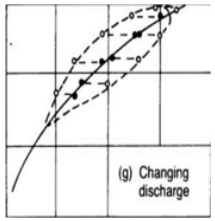
Example: Rating Curve at Pelaez Bridge

5. Development of Rating Curves (H~Q curves)
(4) Possible reasons of variations (1/2)

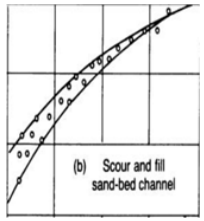
Scatters in rating curve might be due to:

- Variable backwater conditions arising due for example to tidal influences or to high flows in a tributary joining downstream
- Variation in the local acceleration due to unsteady flow
- Scouring of the bed or changes in vegetation characteristics to erosion or deposition of sediment at the stage measurement site
- Observation errors

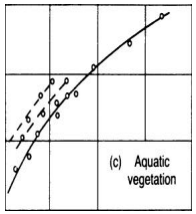
5. Development of Rating Curves (H~Q curves)
(4) Possible reasons of variations (2/2)



Rating curve affected by unsteady flow



Rating curve affected by scour and fill



Rating curve affected by aquatic vegetation

Japan International Cooperation Agency (JICA)

Water Resources Authority (WRA)

Water Resources Management Expert

2nd Workshop

--- Progress of Discharge Measurement ---

June 26 to 27, 2018
Regional Office in Tana Catchment, Embu

JICA Experts Team
(Nippon Koei Co., Ltd.)

Contents of 2nd Workshop

Part 1. Quick Review of 1st Workshop

Quick Review of 1st Workshop

Day 1 (March 8, 2018)

- Part 1. Project Briefing
- Part 2. Methodology of Discharge Measurement
- Part 3. Field Measurement
- Part 4. Record and Computation
- Part 5. Development of Rating Curves (H~Q Curves)

Day 2 (March 9, 2018)

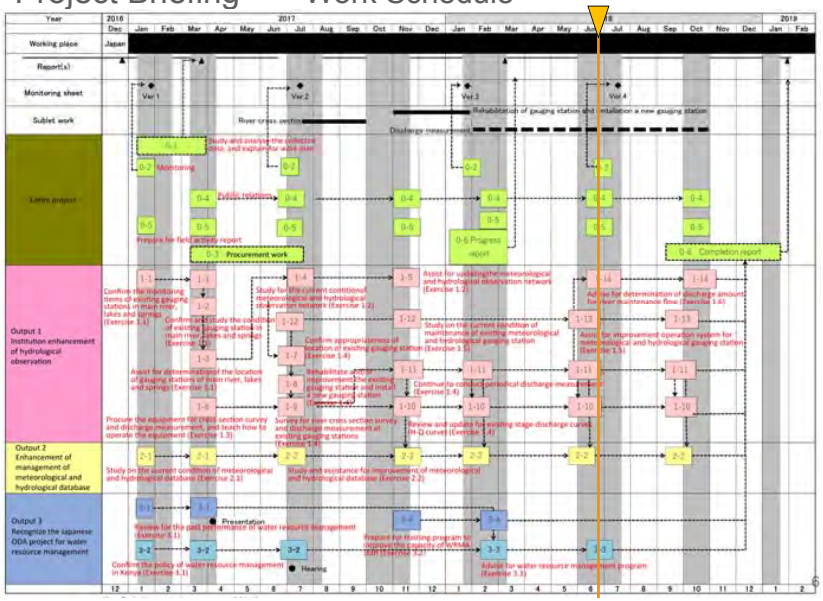
Practice: Discharge measurement (by current meter) at RGS 4BE10

Participants: Total 22 personnel from HQ, RO and SROs

Project Briefing
Project Outline

- Pilot area:
  Tana Catchment
- Project period
  From Jan. 2017 to Feb. 2019
- Japanese experts
  Two personnel (Mr. Motoki (TL) and Mr. Kato)
- Sub-contract Works
  - River cross section survey (6 sites)(completed)
  - Rehabilitation of existing gauging stations and installation of new gauging stations (3 sites) (completed)
  - Discharge measurement (15 times @ 6 sites)

Project Briefing
Work Schedule



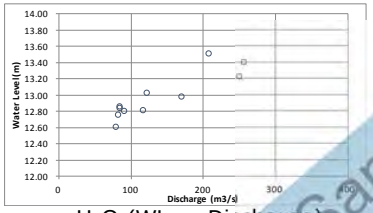
Project Briefing
Pilot area for project activities

Upper Tana Catchment was selected as the Pilot Area at commencement of the Project. In particular, six river gauging stations RGS) were selected as target the sites for discharge measurement.

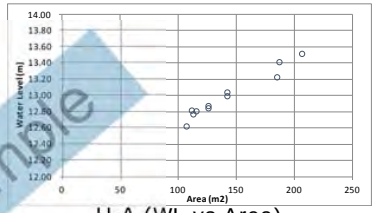
No	RGS Name	Latitude	Longitude	SRO
1	4BE01	0° 44' 59" S	37° 09' 28" E	Upper Tana
2	4BE10	0° 43' 42" S	37° 15' 32" E	Upper Tana
3	4CC08	1° 04' 17" S	37° 19' 18" E	Upper Tana
4	4DD02	0° 44' 02" S	37° 30' 38" E	Kerugoya
5	4EA07	0° 22' 43" S	37° 53' 48" E	Meru
6	4F10	0° 09' 43" S	37° 58' 47" E	Meru

Record and Computation
Graphical Plots (as sample)

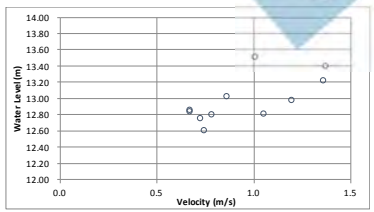
- Graphical plots are very important to grasp hydraulic characteristics.



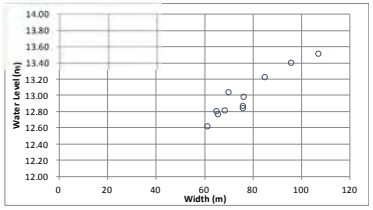
H-Q (WL vs Discharge)



H-A (WL vs Area)



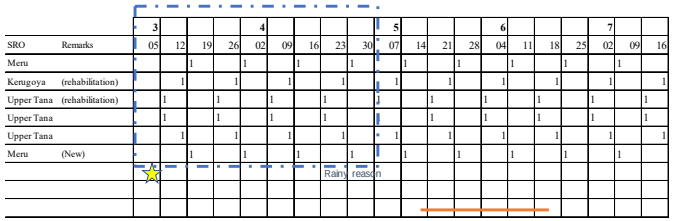
H-V (WL vs Velocity)

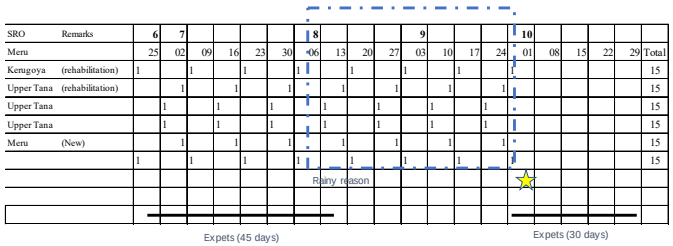


H-B (WL vs Width)

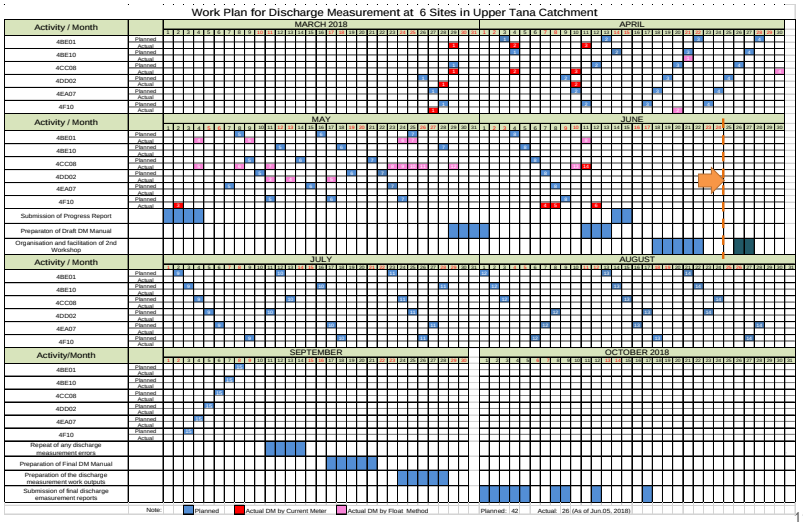
Part 2. Overall Progress of Discharge Measurement (DM)

Schedule of Discharge Measurement (set in March 2018)





Actual Progress of DM (as of June 25, 2018)



Summary of Progress of DM

Number of DM is summarized as follows:

No.	RGS No.	SRO	Current Meter Method	Float Method	Total	Progress
1	4BE01	Upper Tana	3	5	8/15	53 %
2	4BE10	Upper Tana	0	0	0/15	0 %
3	4CC08	Upper Tana	4	10	14/15	93 %
4	4DD02	Kerugoya	2	3	5/15	33 %
5	4EA07	Meru	0	0	0/15	0 %
6	4F10	Meru	5	1	6/15	40 %
Total			14	19	33/90	37 %

Initial setting of the Work Plan (in March 2018)

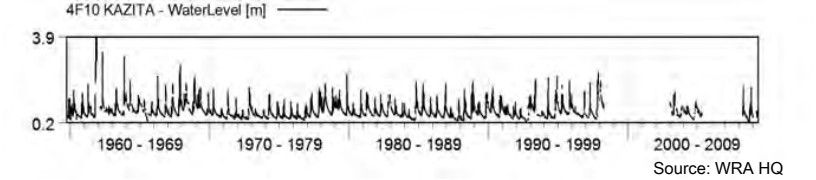
- Measurement period: From March 26 to September 8, 2018
  Total 167 days
- Number of days passed as of June 24: 91 days
- 54 % (91/167) of period has passed.

Key Observation in DM Works in 1st Half Period of the Contract (required improvement)

- Serious flooding in Tana Catchment during March to May 2018 have influenced to DM works at target sites.
  - Deteriorated access road
  - Strong current in the streams
  - Heavy downpour
- No measurement at RGS 4BE10 and 4EA07 till date
  - Need to apply more float method and reinforce more efficient measurement and appropriate discharge computation manner
  - Or, shall we shift to other RGS to complete the Contract?
- No participation to DM at sites from RO/SRO concerned
  - In 1st Workshop on 9th March, all parties agreed that SWO at RO/ SRO participate once a month at RGS in their territory.
- The Contractor did not share the result of DM sheets among CP immediately after field works by means of appropriate manner.

13

DM works at RGS 4F10 (Kathita)



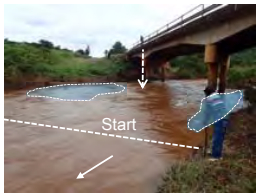
Source: WRA HQ

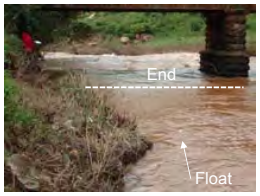
Field observation:

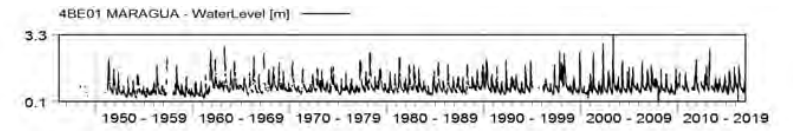
- H= 0.65m at 12:40 on Jun.12, 2018 Tuesday (by current meter method)
- No damage to the staff gauges, gauge house, steps and gabion mattress
- Bolt and nut for fixing gauge plate (1st: 0.0m – 1.0m) were taken away.
- WL of flood mark might be 1.5-2.0m at maximum by debris remained on gabion.

14

DM works at RGS 4BE01 (Maragua)







Source: WRA HQ

Field observation:

- H= 1.20m at 10:30 on Jun.11, 2018 Monday (by float method)
- 1st gauge (0.0-1.5m) has been washed away and 2nd gauge (1.5-3.0m) is tilted.
- Due to stable flow condition and straight stretches, the river section between two bridges is appropriate for both current meter and float methods.
- However, careful measurement is necessary because dead flow areas exist by influence of bridge piers.

15

River Condition at 4BE01 on 22nd May 2018

New road bridge (u/s side)

Old footpath bridge (d/s side)

Note: The 2nd gauge (1.5m-3.0m) was almost submerged under water (around H=2.7m).

16

DM works at RGS 4CC08 (Thika)



No historical water level records available.

Field observation:

- H= 1.55m at 12:30 on Jun.11, 2018
- No damage to the staff gauges installed by Tanathi Water Services Board
- It takes around 1.5 hrs. normally for preparation of boat, fixing ropes and current meter, etc. from arriving site till commencement of measurement.
- Both current meter and float methods are applicable at this site due to existence of the road bridge at upstream.
- No serious flood damage was confirmed at this site.

Part 3. Check of Recording Sheets of DM

Two steps for checking of recording sheets

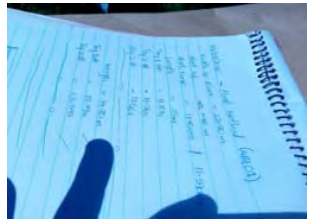
- Checking recording sheets and supervision of DM works at the site
- Suggestions of correction on errors in submitted DM recording sheets

Actions to Check DM Recording Sheets

- Ensure accurate record of information of parameters from current meter reader
- Check accuracy after measurements through discharge calculation at the site
- Recording, video taking and photographing of DM measurement for reference
- Discussing as a team as DM is being done
- Taking notes of every site situation

Checking of Recording Sheets during DM Works at Site

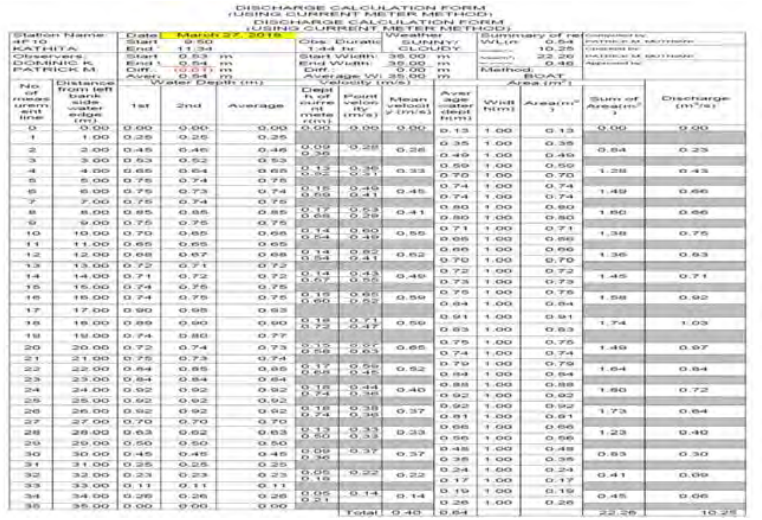


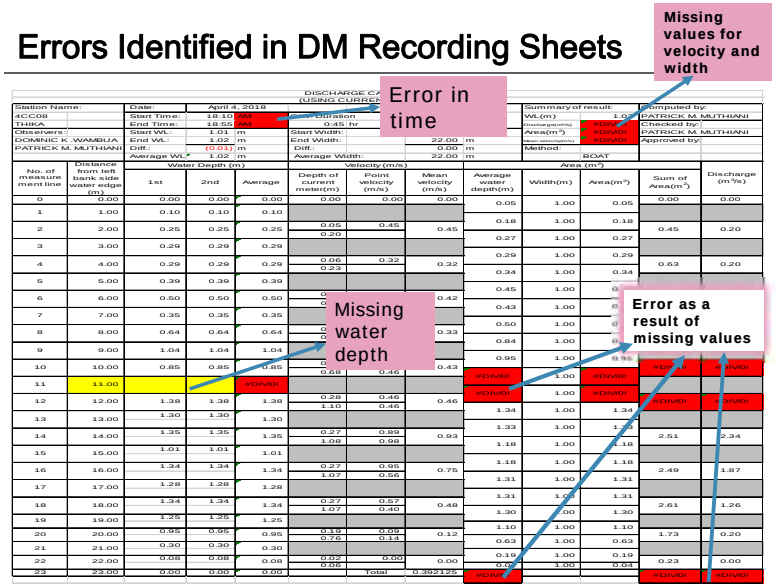
Quality Check of Field Records

- **Checking for errors of submitted DM recording sheets (items of parameters to be checked)**
  - Station name
  - Date of measurement and members of measurement party
  - Measured channel width, area, average velocity
  - Start and end of water level and time
  - Accuracy of formulas used
  - Discharge calculation done at site versus the one done in the office

Submitted DM Recording Sheets



Errors Identified in DM Recording Sheets



Summary of DM Results (as of 25th June)

Available data for H-Q curve development (by current meter method)

	RGS No.	Date	Ave. Gauge Height (m)	Ave.Water Depth (m)	Width of River (m)	Ave. Velocity (m/s)	Total Flow Area (m2)	Discharge (m3/s)
1	4BE01	29 03 2018	0.63	0.48	14.3	0.25	7.08	2.40
		04 04 2018	0.71	0.60	15.0	0.33	8.68	3.72
		11 04 2018	1.08	1.04	17.0	0.76	17.63	16.61
2	4BE10	No record						
3	4CC08	29 03 2018	0.70	0.54	19.0	0.22	10.17	3.10
		04 04 2018	1.02	0.74	22.0	0.39	16.23	8.76
		10 04 2018	1.10	0.93	22.0	0.39	20.49	9.38
		11 06 2018	1.54	1.45	23.0	0.77	33.32	28.84
4	4DD02	28 03 2018	1.22	1.07	29.0	0.62	30.89	22.19
		10 04 2018	1.27	1.14	27.0	0.56	30.91	21.12
5	4EA07	No record						
6	4F10	27 03 2018	0.54	0.64	35.0	0.40	22.26	10.25
		02 05 2018	0.84	1.13	37.0	0.52	42.22	24.44
		07 06 2018	0.72	1.03	35.0	0.42	35.34	0.97
		08 06 2018	0.70	1.01	35.0	0.39	35.75	16.92
		12 06 2018	0.65	0.93	36.0	0.44	33.61	16.03

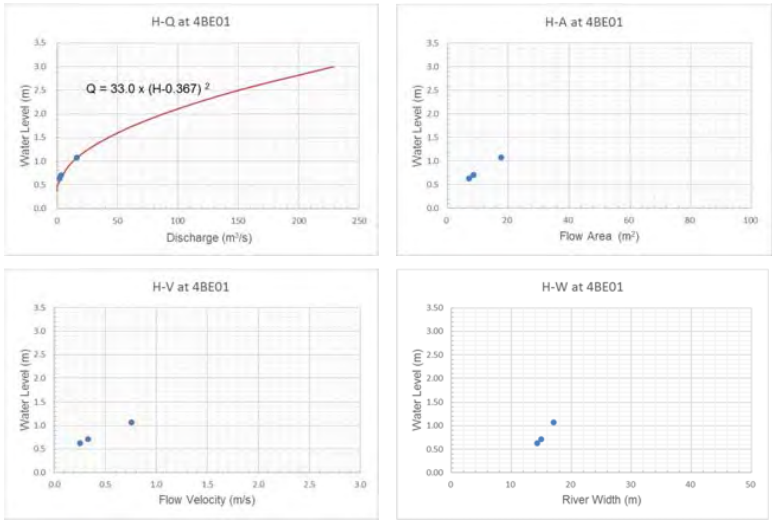
Part 4. Development of H~Q Curves and Conversion from H to Q

Available H-Q Curves at Six Target RGS (MU RGS)

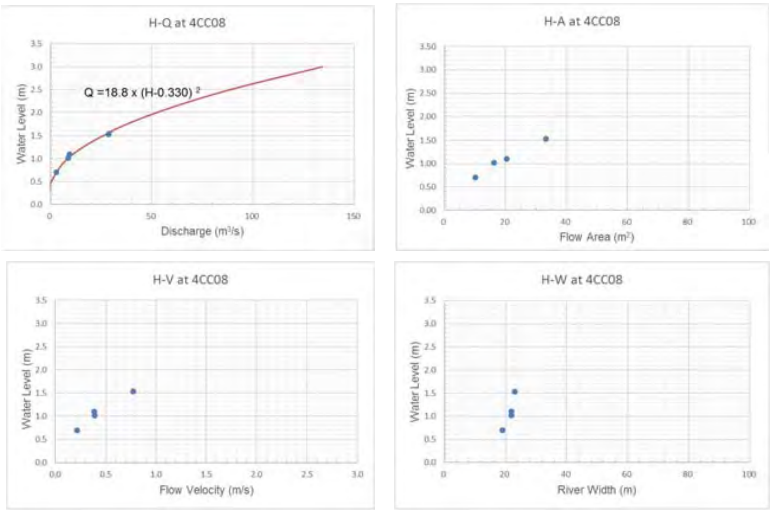
No	RGS Name	Year Prepared	Equation	Applicable Period
1	4BE01	?	?	?
2	4BE10	?	?	?
3	4CC08	?	?	?
4	4DD02	?	?	?
5	4EA07	?	?	?
6	4F10	?	?	?

Note:
We need to clarify any information about existing H-Q relation material (tables and figures, etc.) to compare and validate the results of current exercises to develop and improve reliable curves.

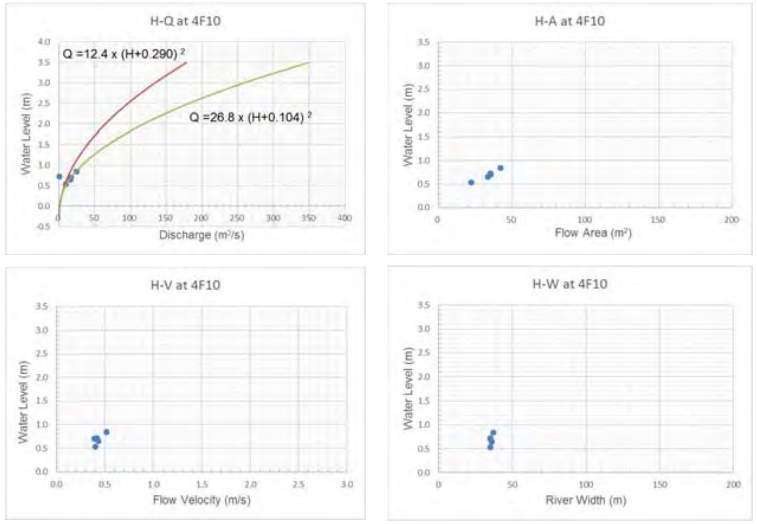
H-Q Curve Development (at 4BE01)



H-Q Curve Development (at 4CC08)



H-Q Curve Development (at 4F10)



H-Q Curve Development

- H-Q curves at 3 sites were tentatively set as follows:

As of Jun. 25, 2018

Site	Equation	Available Data Set
4BE01	Q = 33.0 x (H-0.367) ²	3
4CC08	Q =18.8 x (H-0.330) ²	4
4F10	Q =26.8 x (H+0.104) ²	4

- The water level record should be converted to discharge by means of the equations above at 3 RGS.

Part 5. Preparation of DM Manual (Draft)

Table of Contents of DM Manual (Draft Version)

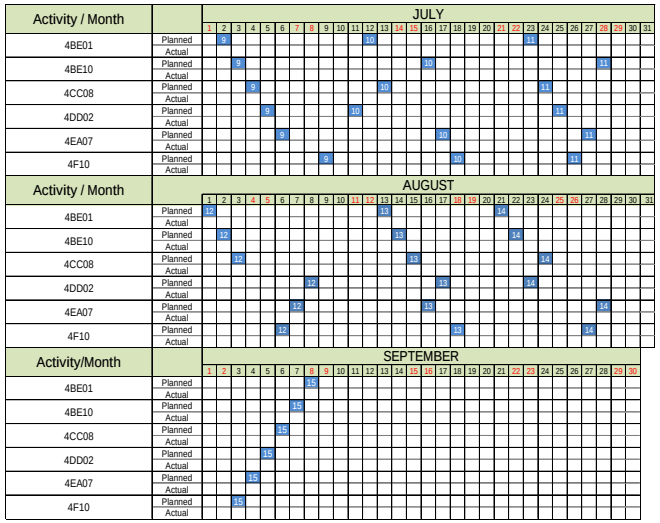
Procedure and Time Schedule of H-Q Curve Development

- Compilation of DM results at least 15 cases (pair data of H and Q) at 6 sites (by mid. Sep. 2018)
- Conduct first trial to fit H-Q curves on the graphics at 6 sites
- Revalidate and review of DM results at 6 sites (end of Sep.)
- Retry to fit H-Q curves at 6 sites (end of Sep.)
  (Compilation of DM Manual in parallel) ⇩ by NARIANA

- Compile daily water level records at 6 sites by each SRO
- Convert from H to Q by H-Q curves at 6 sites
- Compile daily discharge data at 6 sites

Part 6. Incoming Schedule of DM Works

Incoming DM Works Schedule (July to September)
（originally set in March 2018, need to modify）



Recommendation for Further Enhancement for Quality DM Works from JICA Expert Team

- Field measurement and verification of DM results
  ⇨ Active participation from RO/SRO
- Practices to update of summary sheet of DM results
  ⇨ Self-checking and update of H-Q curves
- Conversion from H to Q by applying rating curves updated
  ⇨ Preparation of daily discharge series without interruption period
- Storing records its sharing in appropriate manner
  ⇨ Printing and filing of tables and graphics

Part 7. Outstanding Meteohydrological Records and Flood Monitoring during Events in March to May 2018

Presenters

- Ms. A.W. Migui (Embu RO)
- Mr. D. Gathima (Garissa SRO)
- Ms. F. Mbathi (Murang'a SRO)
- Ms. L. Fundi (Kerugoya SRO)
- Mr. A. Kimotho (Meru SRO)
- Mr. E. Mwangi (Kitui SRO)

Objective of Data/ Information Sharing in Part 7

It is essential to recognize that the experiences of flood events in March to May 2018 provided us a good opportunity for reviewing current hydrological monitoring routine including gauge reading, collection/ transmitting of field records, data storage and analyses and every related manual/ guidelines in the Tana Catchment.

In this context, we share the following information from each Sub-regional office in this Part 7:

(1) Narrative description on overview of flood events
(2) Status of collected data and availability of records from January 2018 to date (June 2018) (The latest list of gauging stations be included)
(3) Present status of gauging stations under territory of each sub-regional office after floods (detailed damage to the properties)
(4) Pictorial/ graphical information on flood events
(5) Required actions to be taken for improvement in the future

38

Part 8. Status of Data Recording, Storing and Utilization in Tana Catchment

- Clarification of current status through interviews at SROs and review of "Handing Over Report", by Mr. L.Thooko, 2016
- Discussions for strengthening and improvement for meteohydrological data management

Current Monitoring Network in Tana Catchment

Summary of gauging stations by sub-region

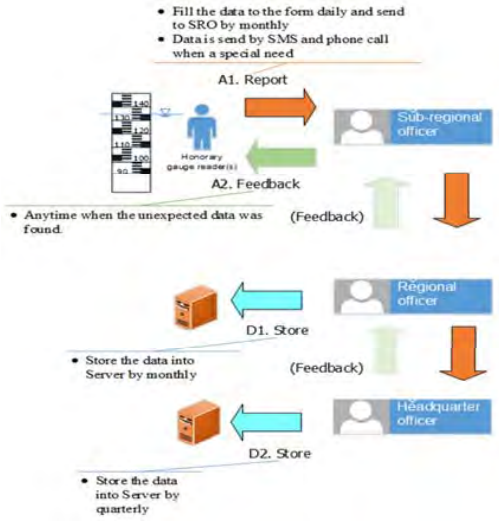
Sub-region	National	MU	Intra-MU	Special	Total	Operational (%)
Kathita/ Mutonga	0	2	8	6	16	44
Lower Tana	1	0	0	2	3	100
Thiba	0	1	4	2	7	43
Tiva Tyaa	0	0	0	0	0	0
Upper Tana	0	4	9	11	24	75
Total	1	7	21	21	50	62
Operational (%)	100	57	62	62	62	

Expected instruments:

Intsrument	National	MU	Intra-MU
Gauge plates	○	○	○
Weirs in selected stations	○	○	○
Automatic WL recorders/ data loggers/ divers	○	○	-

40

Current Status of Data Management in Tana Catchment (1/2)



Current issues :

- ◆ Some RGS with absence (not existence) are found.
- ◆ Printing and filing of data sheets should be appropriately ensured.
- ◆ Periodical quality check of data should be conducted as routine works of surface water officers.
- ◆ Computer and server system should be renewed.

41

Current Status of Data Management in Tana Catchment (2/2)

No.*	Action	From	To	Manner	Timing/ Frequency
A1	Report	GR	SRO	Filled forum	Monthly
A2	Feedback	SRO	GR	Call	Anytime when unexpected data was found.
B1	Report	SRO	RO	Quarterly	Monthly
		SRO	RO	Excel format	Every month
B2	Feedback	RO	SRO	Call/ write e-mail	Anytime when unexpected data was found.
C1	Report	RO	HQ	Export back-up	Quarterly
C2	Feedback			Call/ write e-mail	Anytime when unexpected data was found.
D1/D2	Store	HQ/RO	Server	(Mike Basin)	Quarterly

Note: *, Refer to previous slide
GR, Gauge reader SRO, Sub-regional Office RO, Regional Office

42

Way Forward for Future Enhancement

Action Plan (Short-term: 2018-2020)

Subject	Means and Procedure	Responsible Office	Time Frame

Hints: Necessity of improvement on,
monitoring network, equipment of gauging stations, system on data acquisition and storing, computer system/software, training of human resources, outsourcing of part time job, etc.

43

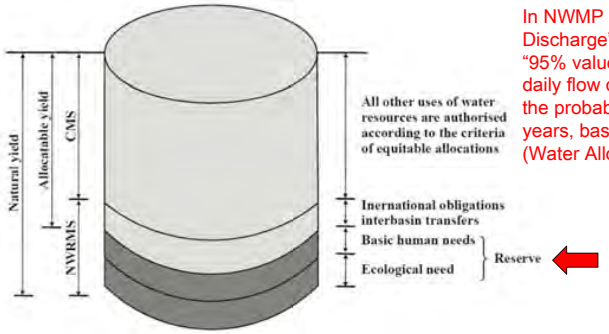
Part 9. River Maintenance Flow

Guidelines for Water Allocation in Kenya

- The Water Act 2002 Section 8 mandates WRMA "to develop the principle, guidelines, and procedures for the allocation of water resources". The first edition of the "Guidelines for Water Allocation" was issued in March 2010 to set out the guidelines to be followed by WRMA in decision making on the allocation of available water resources.
- The guideline generally consider the allocation of four demands of (1) ecological demand, (2) basic human needs, (3) international obligation and interbasin transfers, and (4) demand allocated for individual use by means of permit. (Refer to the figure in next slide)

Definition of Reserve Discharge in Kenya

- "Guidelines for Water Allocation, Mar. 2010" defines as follows:
  - The reserve is the portion of the water resource which is set aside to meet demands for ecological and basic human needs. The reserve needs to be defined with respect to the quantity, reliability and quality. (Detailed discussion is shown in WAG.)



In NWMP 2030, the "Reserve Discharge" was specified as "95% value of the naturalized daily flow duration curve with the probability of once in 10 years, based on the WAG (Water Allocation Guideline).

Definitions of Related Terms in Japan (1/2)

- There are two types of flow discharge to be determined.
- The first is the flow discharge determined in total consideration of water functions such as navigation; fisheries; tourism; maintenance of clean river water; prevention of salt damage; prevention of river-mouth clogging; protection of river management facilities; maintenance of groundwater levels, landscape values, and ecosystems; and the securing of opportunities for human interactions with the river. This discharge is hereinafter referred to as "Maintenance Flow Discharge".
- The second is the flow discharge necessary for water utilization downstream of the point for which the maintenance flow discharge has been determined (hereinafter referred to as "Water Utilization Flow Discharge"); this discharge is determined at a point that serves as the reference point for appropriate river management.
- The "Normal Flow Discharge", if necessary, should be determined for each of the river reach represented by annual fluctuations in the maintenance flow discharge and water utilization flow discharge.

Definitions of Related Terms in Japan (2/2)

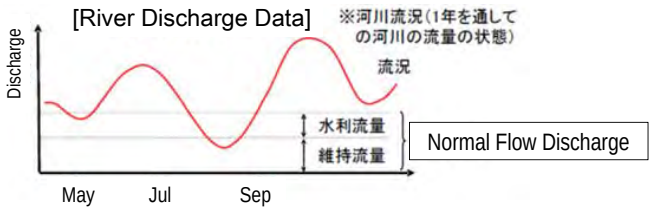
- Normal Flow Discharge
  - "Normal Flow Discharge" is defined as the required discharge to satisfy the both "Maintenance Flow Discharge" and "Water Utilization Flow Discharge".

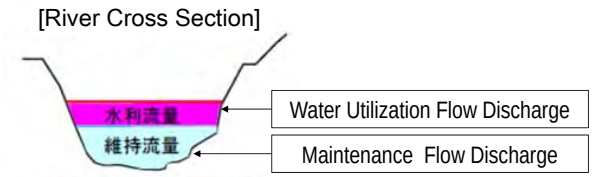
Normal Flow Dischagre = Maintenance Flow Discharge + Water Utilization Flow Discharge

  - Even in case of drought year, the one required for total consideration of water functions is the "Normal Flow Discharge".

Therefore, the "Normal Flow Discharge" is not determined as desired for normal year ⇒ Discharge to maintain water function at minimal level.

Graphical Image of Normal Flow Discharge

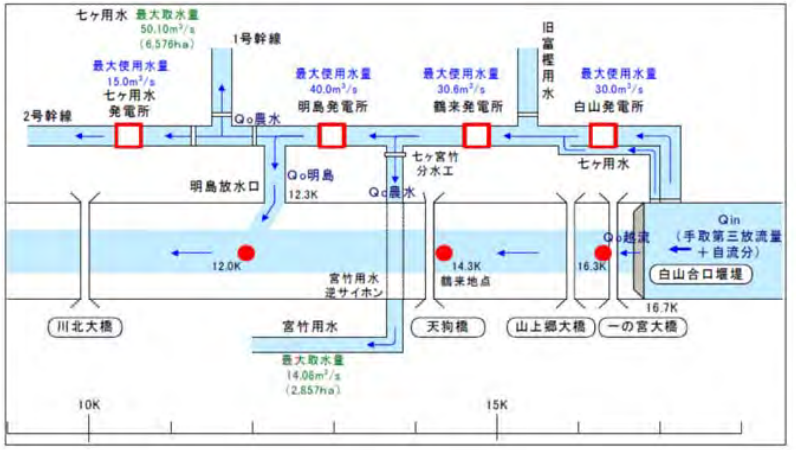




Note: WUFD is fluctuated by seasons.

Consideration of Normal Flow Discharge
Schematic Diagram of Water Utilization (sample)

In case of Tedori River, Toyama Pref. in Japan



End of 2nd Workshop

Thank you for your active participation!

Part 7 Outstanding meteorological Records and flood monitoring during events in March to may 2018

Embu RO

Discharge measurement workshop

PRESENTATION BY

A.WANJIKU MIGWI

Tana **catchment overview**

- Geographically the Tana Catchment Area extends from the crests of Mt. Kenya, the Aberdares Ranges and the Nyambene Hills in the north extending southwards to the Indian Ocean bounded by the Yatta Plateau to the west. the Catchment Area covers an area of 126,000 km2 .The bounded by Latitudes of 0° 30' north and 2° 30' south, and longitudes 37° 00' east and 41° 00' east.

Hydrometelogical network

- The Hydrometerological networks for discharge and rainfall measurements allocated in the five Sub Regions in Tana namely, Thiba (Kerugoya), Upper Tana (Murang'a) , Kathita Mutonga (Meru), Tiva Tyaa (Kitui) and Lower Tana (Garissa).
- Currently there are 69 RGS stations that are operational and 23 Rainfall in the Region are operational.

RGS status at the Sub Regions

Sub Region	National	MU	Intra-MU	Others	Operational	Total	% Operational
Thiba	0	1	3	9	13	13	100
Upper Tana	0	4	10	44	46	58	79
Lower Tana	1	2	0	0	3	3	100
Tiva Tyaa	0	0	0	0	0	0	0
Kathita Mutonga	0	2	7	29	7	38	20
Total	**1**	**9**	**20**	**82**	**69**	**112**	

Rainfall network status

SUB region	Rain fall	% operational	Evaporation	% operational	Weather	% operational
Thiba	6	50	3	100	1	0
Upper Tana	10	95	3	100	3	100
Tiva Tyaa	5	40	1	100	1	0
Lower Tana	5	75	4	25	0	0
Kathita/Mutonga	6	50	3	66	0	0

Rehabilitated RGS station By JICA from Jan 2018 to May 2018

SUB REGION	Stations	Achievement
Sub Region		
Thiba	4DD2 Thiba	construction of stair case
Upper Tana	4BE10 Tana Rukanga	- construction of water runaway canal Installed 5 No. staff gauge from 1.5m to 8m - installed Bill board
Kathita Mutonga	4F10 kazita	Installed 3 No. staff gauge from 1.5m to 4m - installed Bill board 2 no.
Tiva Tyaa	NONE	
Lower Tana	NONE	

DATA Received from Rehabilited

STATION	From jan to may 2018	Remarks	
Mutonga 4EA7	Jan 2018 to feb 2018	Updated in the data base	
Kazita 4F10	Telemetric only	the gauge reader stopped taking data. From DEC 2017	
Thiba 4DD2	Jan to march 2018	Both telemetric and manual Working	
Thika 4CC08	None	the gauge reader stopped taking data. From October 2017 SW0 unable to download the data. (equipment not working)	
Maragua 4BE01	From Jan to may 2018	Updated in the data base	

conclusion

- According to the JICA Project objective, to enhance capacity of water resources management in WRA through ;
  - Establishment of appropriate hydro meteorological network and its management has been achieved by about 70 % since most of 4 out of 6 rehabilitated stations are in good order and have submitted data .

Garissa SRO

Outstanding Meteo-hydrological Records and Flood Monitoring during Events in March to May

Lower Tana Sub Region

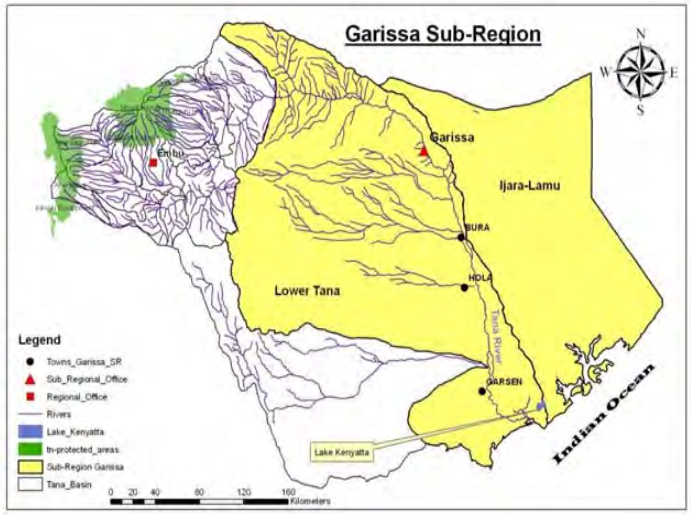
Garissa

By Daniel G Wanyumu

INTRODUCTION

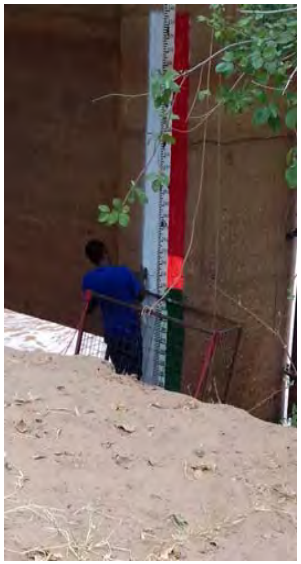
- **Lower Tana sub region covers Garissa county, Tana River county, Lamu county, part of Kitui and Malindi counties with a total coverage of 77,400Km². It is one of the five Sub regions in Tana Catchment. The sub-region borders Ewaso nyiro North catchment area to the North, Athi catchment area to the south west and Somalia to the east**
- **It is classified as semi arid area falling under ecological zone 5,6 and 7**
- **The weather is generally hot with temperatures above 30˚c in most parts**
- **The rainfall pattern is bimodal with long -rainfall season coming in the month of April-May and the short rains in the month of October – November**
- **The annual precipitation is unreliable, erratic and varies widely across in space and time, averaging below 300mm annually**
- **The sub Catchment has an irrigation potential of approximately 205,000ha from Balambala to Kipini (Tana basin)**

Lower Tana sub region Monitoring stations



Overview of flood events in March to May 2018

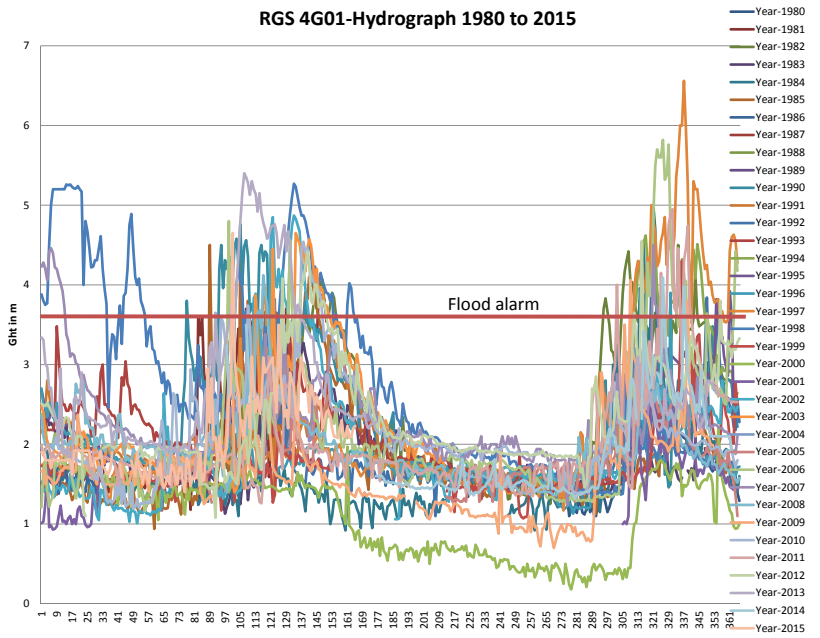
- Historically effects of floods in lower Tana have been high during the short rains as illustrated in the graph below.
- However from 16th March 2018 the water levels rose to 3.40m from 1.69 the previous day. Flood alert in Garissa starts at 3.50m.
- The office started sending sms to all riparian area through WRUA members and stakeholder especially chiefs and County Commissioner.
- On 24th April we created a WhatsApp group of 175 members involved with floods.
- Frequent FM radio updates were given in local language by the SRM.

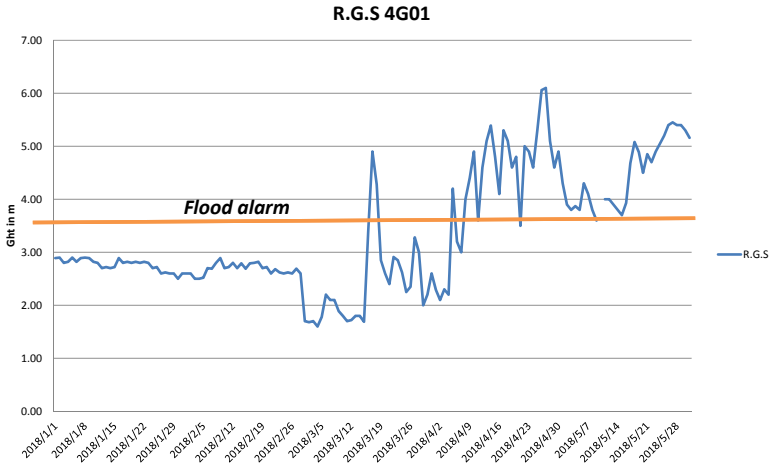


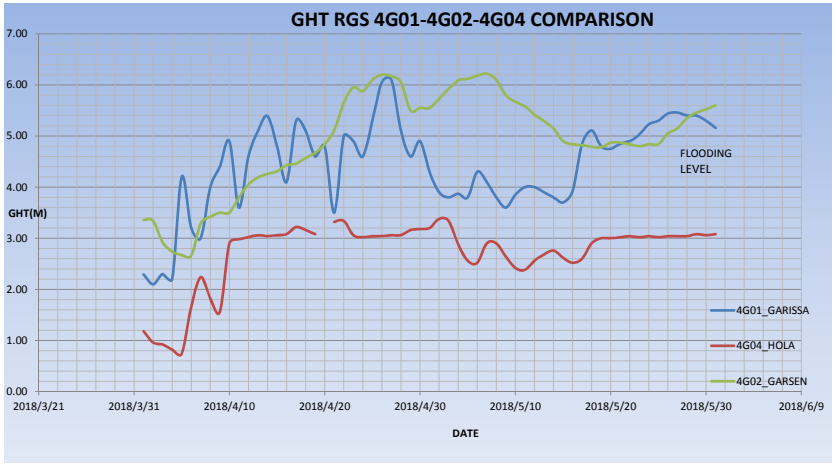
RGS 4G01 in Tana Garissa

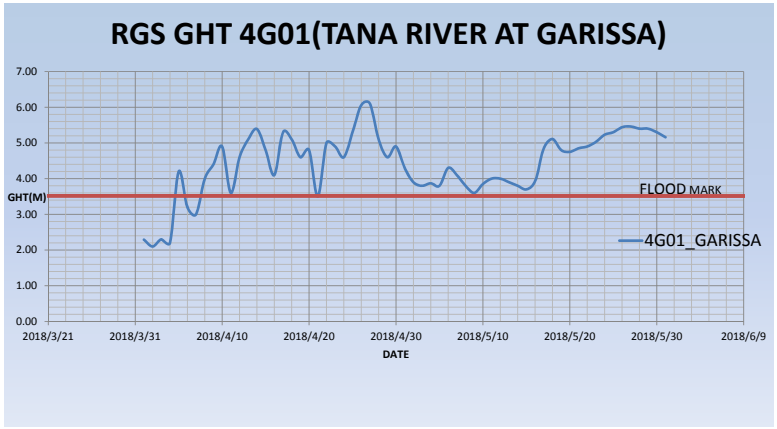
RGS 4G04 in Tana Hola

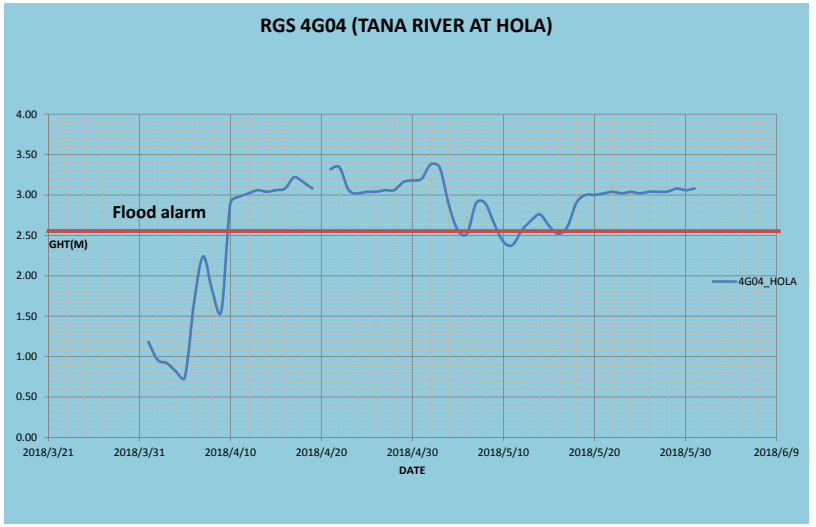
RGS 4G02 in Tana Garsen

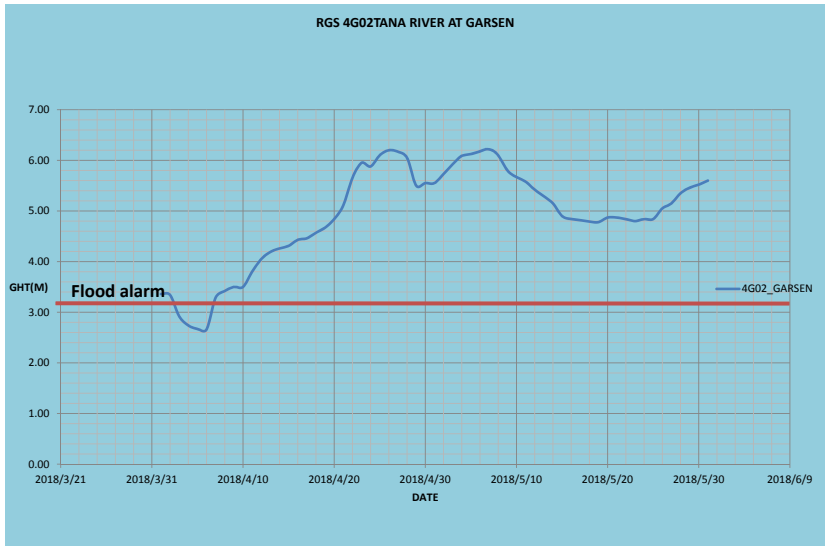


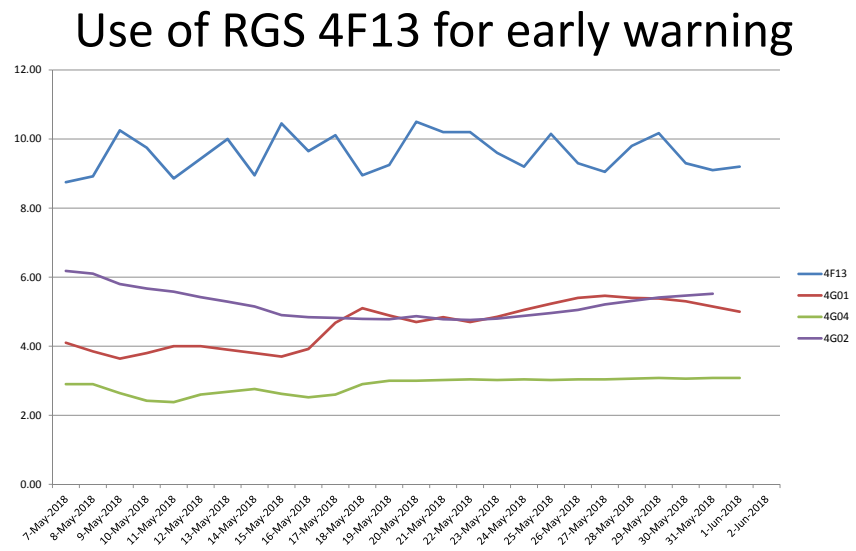





RGS GHT 4G01(TANA RIVER AT GARISSA)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
GHT(M)
FLOOD MARK
4G01_GARISSA
2018/3/21
2018/3/31
2018/4/10
2018/4/20
2018/4/30
2018/5/10
2018/5/20
2018/5/30
2018/6/9
DATE


RGS 4G04 (TANA RIVER AT HOLA)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Flood alarm
GHT(M)
4G04_HOLA
2018/3/21
2018/3/31
2018/4/10
2018/4/20
2018/4/30
2018/5/10
2018/5/20
2018/5/30
2018/6/9
DATE


RGS 4G02TANA RIVER AT GARSEN
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
GHT(M)
Flood alarm
4G02_GARSEN
2018/3/21
2018/3/31
2018/4/10
2018/4/20
2018/4/30
2018/5/10
2018/5/20
2018/5/30
2018/6/9
DATE


Use of RGS 4F13 for early warning
12.00
10.00
8.00
6.00
4.00
2.00
0.00
4F13
4G01
4G04
4G02
7-May-2018
8-May-2018
9-May-2018
10-May-2018
11-May-2018
12-May-2018
13-May-2018
14-May-2018
15-May-2018
16-May-2018
17-May-2018
18-May-2018
19-May-2018
20-May-2018
21-May-2018
22-May-2018
23-May-2018
24-May-2018
25-May-2018
26-May-2018
27-May-2018
28-May-2018
29-May-2018
30-May-2018
31-May-2018
1-Jun-2018
2-Jun-2018

Effects of Floods in Lower Tana

- Tana River County
- ➢ The flooding affected mainly communities living along the riverine and others in the hinterlands affecting approximately 117 villages translating to 12,809 households. Total population affected was 64,045 (32, 205 female and 31,840 male).
- ➢ A total number of 9,539 acres of crops have been destroyed by the floods.
- ➢ About 49 primary and secondary schools have either been submerged or completely cut off.
- ➢ Health facilitates and Roads were affected prompting high food prices fluctuations
- ➢ Water related diseases were reported with cholera confirmed in Madogo.

Effects of Floods in Lower Tana

- Garissa County
- ➢ Approximately 10,926 people were affected , including 1564 HHs who were displaced in spontaneous camps. It was also reported that, 5 cows, 88 goats were drown, over 600 farms washed away by floods.
- ➢ Water related diseases were reported
- ➢ Nairobi-Garissa, Garissa- Garsen -Lamu, Garissa-Balambala and Garissa –Masalani Roads were destroyed.

Flood photos


RGS 4G02 in Tana Garsen during flood


Distribution of food during flood in Tana River


Effects of Laghas during floods


Farms destroyed by floods in Garissa

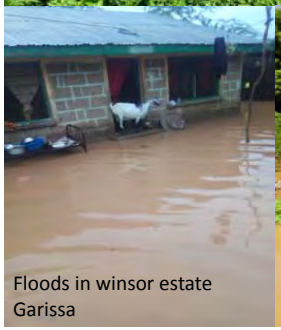

RGS 4G01 manual and telemetric housing

flood photos


Farm intake pump house about to be washed away


Garissa Nairobi road about to be covered by floods


Red cross team in Garsen saving lives


Floods in winsor estate Garissa


Farms in Hola destroyed by floods


People moving from their home

Required actions

- Installation of an RGS upstream of RGS 4G01 for early warning for community downstream of RGS 4G01. It should be downstream of RGS 4F13 and Dry river beds from Kitui and Garissa (Tyaa, Rahole, Al amin moju and Chanyigi)
- Develop a model that can give early warning using WRA data.

Jica workshop:
27th - 28 th June 2018.

Murang'a SRO

WATER RESOURCES AUTHORITY – UPPER TANA SUB REGION.

Catchment overview

- The Upper Tana Sub-Region is one of the five sub-regions in Tana catchment Area. It has an approximate area of coverage of 5,202Km2 out of the 126,026 km2.
- Is between Aberdare and Mt kenya water towers .
- Has an estimated population of 1.9 million people and an average population density of 365 persons per Km2 .

Catchment management units.

- For management purposes the Sub-Region is divided into five management units namely
- Sagana Gura – Drainage area 4A
- Lower Sagana – Drainage area 4B
- Upper Thika – Drainage area 4CA
- Thika Urban – Drainage area 4CB
- Lower Thika – drainage area 4CC

Overview of floods events

- The onset of Long rains started in early March 2018 and most part of Upper Tana Catchment, received little rainfall which was not evenly distributed.
- During the months of April and May 2018, there was intensive increase in rainfall and most rivers registered high flows. which coursed flash floods in all areas and river induced flooding in lower zones.

Cont, overview of Floods

- With the continues extremely heavy precipitation which occurred in the month of April and May 2018, generated high volume of runoff in excess of the drainage capacity coursing flooding in most of the sub reginal rivers
- Many Springs were spawned out .

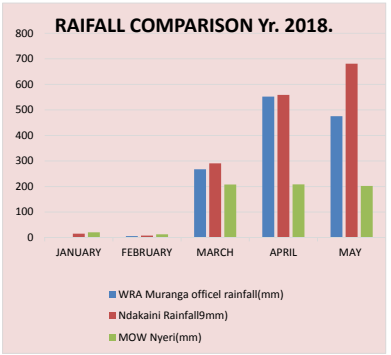
Cont, floods overview -Rainfall

- March 2018-The onset of Long rains. Registered little and moderate rains not well distributed within the sub region.
- April 2018- heavy rainfall well distributed
- May 2018- intense rainfall well distributed

cont. Rainfall

The chart below depict rainfall comparison for 3stns-Ndakaini R/stn registered more rainfall than Muranga R/stn and Nyeri R/Stn.

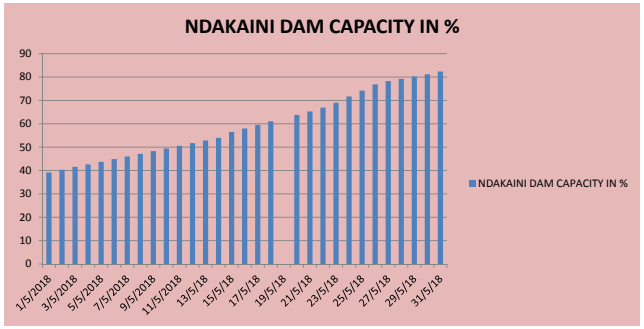
Rainfall comparison			
	WRA Muranga officel rainfall(mm)	Ndakaini Rainfall9mm)	MOW Nyeri(mm)
January	0	15.3	20.6
Februar y	5.7	7.7	12.7
March	267.5	290.6	207.7
April	551.9	558.53	208.2
May.	475.3	680.8	202.1



Dams Capacity

- Sasumua Dam –100% full capacity (15.91MM3) by 11/5/2018
- NDakaini dam by 11/5/2018 was 50.54% (35,377,651M3) out of 70MM3.
- Ndakaini capacity was 82.34% (57,637,680MM3) BY 31/5/2018.

DAM WATR LEVEL TREND



Effects of flooding

- Land slides
- Mad slides
- Aquiver severe cracks
- Infrastructure destructions- Regular gauging Stations,bridges, water intakes, water channels, Roads ,Buildings etc
- High erosion coursing high river siltation.
- Deaths and Relocation of people.

Cont, Effect of floods

- 5 RGS Were Damaged .
- 1.4BE1 R. Maragua 1st staff gauge washed away.it was automated with multiparameter and hobo data loggers.
- 4AA02 R. Thegu mutiparameter and hobos washed away.
- 4BE10-Tana Rukanga –telemetric house was submerged by flood these affected the telemetry data logger equipment. The 3rd gauge plate was damaged. The floods mark was beyond the last staff gauge - 8M
- 4BD01 R. Mathioya –Vandalized
- 4AA1 R.Sagana –gauge plate damaged.

COLLECTED DATA

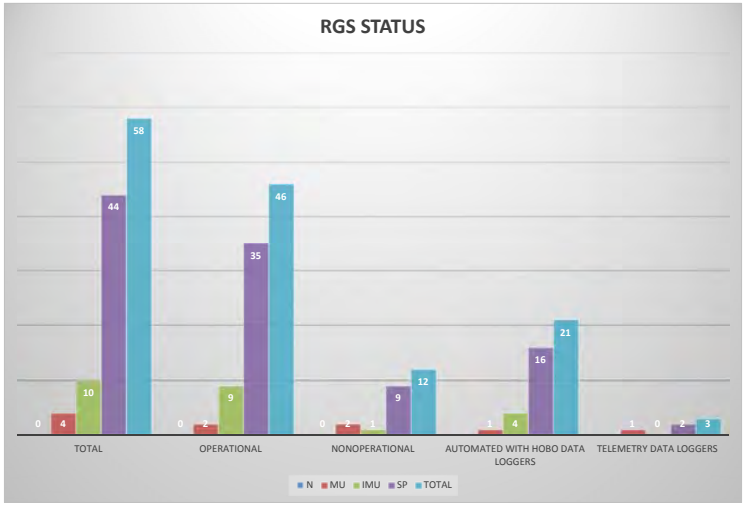
- Discharge data- 74 gauging from 24 Stations.
- Water level data- from 17 RGS , 9 No.Hobos downloaded
- Water quality data-1200 water samples collected and analysed . Insitu water parameters collected from 24 RGS.
- Rainfall data-data collected from 8 No. stations
- Evaporation data-3 stations

Status of Monitoring Netwok

- Regular gauging stations- 58
- Rainfall stations-19
- Evaporation stations-3
- Full weather statio-1

RGS STATUS

category	total	operational	nonoperational	automated with hobo data loggers	telemetry data loggers
N	0	0	0		
MU	4	2	2	1	1
IMU	10	9	1	4	0
SP	44	35	9	16	2
Total	58	46	12	21	3



STATUS-WEATHER STATIONS

STATIONS	OPERATIONAL	NONOPERATIONAL	TOTAL	TELEMETRIC
RAINFALL STNS	17	4	19	5
EVAPORATIN	3	0	3	0

REQUIRED ACTION FOR IMPROVEMENT.

-More facilitation for establishment and rehabilitation of monitoring network

-Automation and upgrading of station

-Ensuring the data software is available to all sub regions.

--introduction of mobile SMS code to ease data data transmission.

4BE10 FLOODED-RECORDER HOUSE

WATER LEVEL-SAME DAY

4BE10 -2ND Gauge plate damaged.

FLOW MEASUMENT AT 4AC3 R.SAGANA –ADCP.

discharge Measument –ADV and lab analysis

Floods-Relocation

R.MARAGUA -FLOODED

Land slides

Loss of properties.

FAITH MBATHI-THANK YOU

Kerugoya SRO

THIBA SUB REGION
2nd DM workshop presentation

26th June 2018

Flood event

- Thiba sub region like other parts of the country, received above normal rainfall whose onset was the first week of March 2018.
- Rains intensified with time and by the moth of April and May the sub region was already reporting flood situation in various areas. Most affected was the lowlands to the south of the sub region.

Flood events cont`

- All rivers recorded high water levels, with some exceeding highest starve level thus marking of flood points was done.
- At least 10no human beings were reported to have drowned (Rupingazi, Icakimangu, Rutui, Thiba, Ena, Dallas swamp.)
- Several houses were sub merged (eg. Thiguku village recorded 50houses, Dallas area recorded 35 houses)

Count`

- Infrastructure, including foot bridges, were also damaged.
- Several feeder roads were cut off, crop damaged and livestock died
- About 140 persons were displaced at Thiguku village, 35 at Dallas

Data collected

- Water level data
- Flood plain marks
- Rain fall
- Evaporation
- No of displaced human and livestock
- No of sub merged and destroyed houses
- Estimated acreage of damaged crop

RGS status

- All 13No RGS are functional.
- 3No RGS were rehabilitated just before the onset of rains under capital project

Flood events: Data comparison

Station	Date (2018)	WL (M)	Date (2017)	WL (M)
THIBA 4DD2	15/5/2018	Over 5m gauge	15/5/2017	1.87
	16/5/2018	4.94	16/5/2017	1.73
	17/5/2018	3.97	17/5/2017	1.68
	18/5/2018	3.42	18/5/2017	1.60
	19/5/2018	3.07	19/5/2017	1.57
	20/5/2018	2.90	20/5/2017	1.53
	21/5/2018	2.99	21/5/2017	1.48
	22/5/2018	3.35	22/5/2017	1.42
	23/5/2018	4.86	23/5/2017	1.33

Required actions

- Mapping of wetland riparian areas
- Marking of all flood plains
- Riparian and catchment rehabilitation for infiltration and reduced surface runoff velocity
- High flow measurement for updated rating curves
- Early warning systems established and improved

Flood situation

Conti`

- 

Meru SRO

KATHITA MUTONGA DATA

COMPONENT

- Rainfall stations
- Evaporation stations
- River gauging stations

MU Rainfall stations

- Meru DWO
- Meru forest
- Maua DO office
- Kionyo dispensary
- Gacuru
- Kinna
- Mumbuni
- Ura
- Marimanti

Other Rainfall Stations

- DO OFFICE Nkubu
- Nkubu water supply
- Kaguru FTC
- Mikinduri Pry school
- Marimba farm
- Chuka forest
- Kiamuriuki
- Kibugua
- Thuci barrier
- Mwangarimwe
- Chogoria gate
- Chiakariga Kewi Campus

MU Evaporation Stations

- Meru DWO
- Maua DO office

Other evaporation station

- Chiakariga Kewi Campus

Operational Rainfall Stations

- Meru forests
- DO office Nkubu
- Maua DO office
- Mikinduri Pry School
- Meru DWO

Operational Evaporation Stations

- Meru DWO
- Maua DO office

River Gauging Stations (RGS)

NAME	
Tana grand falls 4F13	Liutu 4FB
Kathita 4F19	Thuci 4EB4
Kathita 4F31	Thuci 4EB7
Kathita 4F10	Ruguti 4EB5
Thingithu 4F17	Ruguti 4EB6
Mutonga 4EA7	Maara 4EB16
Tungu 4EB9	Maara 4EB12
Kithinu 4EA3	Maara 4EB13
Mutonga 4EA6	Maara 4EB11
Thangatha 4F8	Kinyaritha main 4F new
Nithi 4EB1	Kinyaritha minor 4F new
Mutonga 4EA1	Thanantu 4F20
Kathita 4F29	Ura 4F09

stations priority

MU	IMU	SPECIAL	OTHERS
Kathita 4F10	Thanantu 4F20	Tana 4F13	Kathita 4F19
Mutonga 4EA7	Ura 4F9	Tana 4F16	Kathita 4F31
	Ruguti 4EB6	Ruuji Rweru 4F18	Thingithu 4F4
	Tungu 4EB9	Kithino 4EA3	Nithi 4EB1
	Mutonga 4EA6	Thangatha 4F8	Mutonga 4EA1
	Thingithu 4F17		Kathita 4F29
	Maara 4EB11		Liutu 4FB
			Thuci 4EB4
			Thuci 4EB7
			Ruguti 4EB5
			Maara 4EB16
			Maara 4EB12
			Maara 4 EB11
			Kinyaritha main 4F

Discharge measurement Jan to Jun 2018

Stn Name	Jan 2018		Feb 2018		Mar 2018		April 2018		may 2018		Jun 2018	
	GHT	DM(M3)	GHT	DM(M3)	GHT	DM(M3)	GHT	DM(M3)	GHT	DM(M3)	GHT	DM(M3)
Kathita 4F31	0.16	0.3669	0.12	0.2809	0.12	0.2809	0.53	-	0.39	1.4356		
Thingithu 4 F4	0.46	0.4024	0.4	0.2333	-	-	-	-	0.9	5.5966		
Mutonga 4EA6	0.44	1.8268	0.35	1.7107	0.35	1.7107	-	-	2.28	35.112		
Maara 4EB11	0.19	2.0846	0.11	2.0329	0.11	2.0329	-	-	1.24	12.7313		
Ruguti 4 EB6	0..52	0.7385	0.47	0.4544	0.47	0.4544	-	-	1.68	5.7709		
Thuci 4 EB 7	-	0.3390	-	0.0288			-	-	1.45	8.705		
Tungu 4 EB9	0.09	0.0.0794	0.0	0.0482	0.0	0.0482	-	-	1.0	2.9316		
South Maara 4 ED12	0.16	0.4773	0.07	0.3207	0.07	0.3207	-	-	-	-		
Kithino 4EA3	-	0.3125	0.36	0.0290	-	-	-	-	0.87	3.7752		
	-	-		-	0.39	0.0716	-	-	1.0	8.288		

Status of the Stations

Station name	Status	Remarks
Kathita 4F10	Operational	Station okay
Mutonga 4EA7	Operational	Station okay
Thanantu 4F20	Not operational	No gauge plate
Ura 4F9	Operational	Station okay
Ruguti 4EB6	Operational	Station okay
Tungu 4EB9	Operational	Station okay
Mutonga 4EA6	Operational	Station okay
Thingithu 4F17	Not operational	First gauge swept away
Maara 4EB11	Operational	Station okay
Tana 4F13	Operational	Station okay
Tana4F16	Operational	Station okay
Ruujirweru 4F18	Operational	Station okay
Kithinu 4EA3	Operational	Station okay

Status of other Stations

Station name	Status	Remarks
Kathita 4F19	Not operational	Needs to be rehabilitated
Kathita 4F31	operational	Station okay
Thingithu 4F4	Not operational	Install first gauge
Nithi 4EB1	Not operational	Needs to be rehabilitated
Mutonga 4EA1	Not operational	Needs to be rehabilitated
Kathita 4F29	Not operational	Needs to be rehabilitated
Liutu 4FB	Not operational	Needs to be rehabilitated
Thuci 4EB4	Not operational	Needs to be rehabilitated
Thuci 4EB7	Operational	Station okay
Ruguti 4EB5	Not operational	Needs to be rehabilitated
Maara 4EB16	Not operational	Needs to be rehabilitated
Maara 4EB12	Operational	No gauge reader
Maara 4EB13	Not operational	Needs to be rehabilitated

Flood Events

Flush flood events were experienced in the region.
The following are the affected stations

- Thangatha 4F8
- Thingithu 4F17
- Thingithu 4F4
- Thuci 4EB7
- Kathita 4F10
- Maara 4EB11
- Kithinu 4EA3
- Thanantu 4F20

Lesson Learnt

- Challenges of anchoring concrete pillars
- Vandalism of gauge plate
- Gauge readers not co operating
- High flow requirements are required

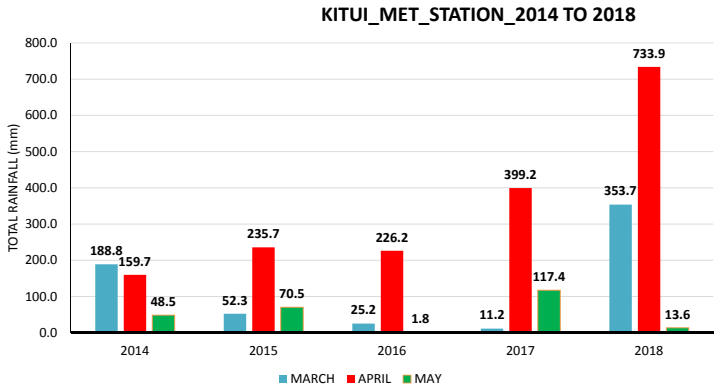
Introduction

- Tiva-Tyaa (Kitui Sub Region) covers an Arid and Semi-arid area characterized by small hills and flat areas which are well drained.
- The River courses are well defined and most of them maintain the flash floods within their River banks, hence, very few and occasional incidences of floods of negative impacts are reported.

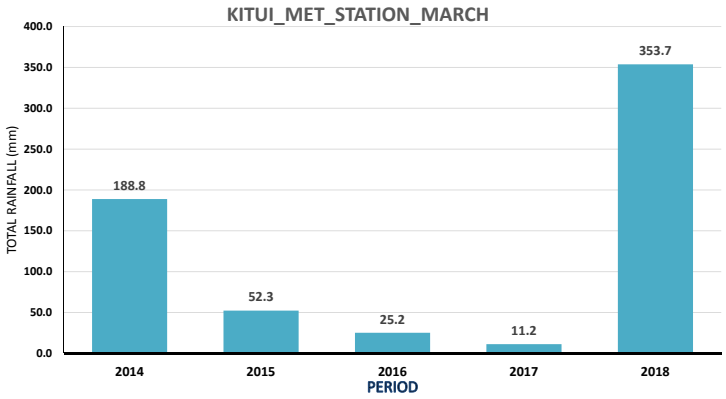
Data Collected

- The sub region has no river gauging stations. However, trends on rainfall data collected from Kitui Met Station are shown below. The data covers a period of 5 years.
- While it is apparent from the demonstration that more rain was received this year compared to the last five years, most of it came in March and April. In fact, May 2014, 2015 & 2017 was wetter than May 2018 in Kitui.
- The month of April was consistently wetter than any other month throughout except in 2014 when march received more rainfall.
- Some flood data was collected and some pictures are shared in the presentation

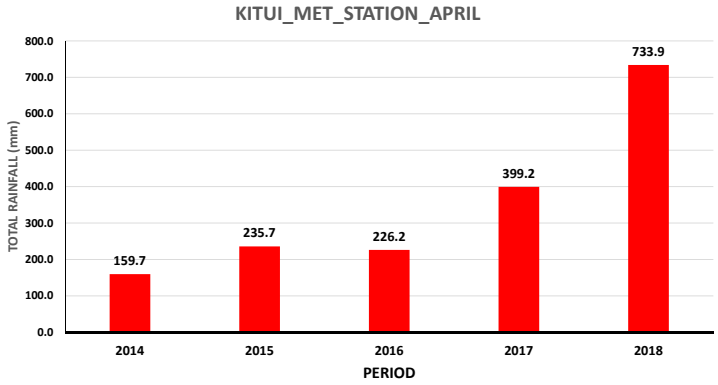
MAM Rainfall Comparison, 2014 to 2018



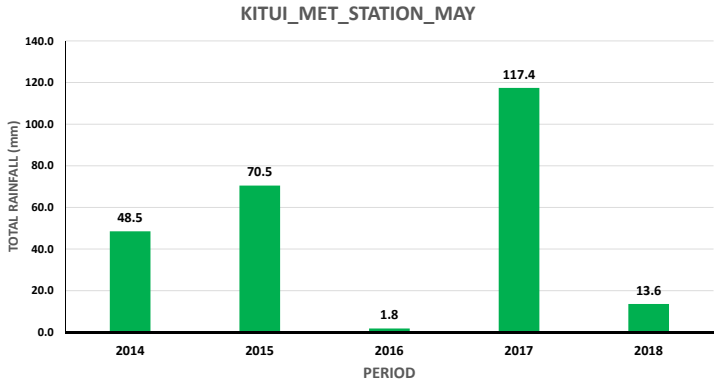
Months of March 2014 to 2018



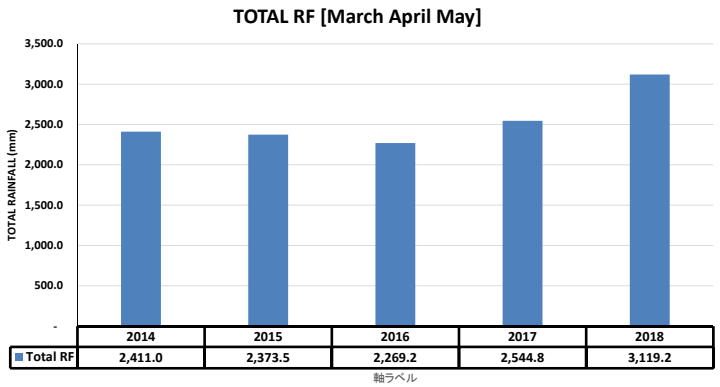
Months of April 2014 to 2018



Months of May 2014 to 2018



TOTAL MAM RAINFALL 2014 - 2018



FLOOD EVENT PICTURES

The following pictures were taken
at Thua river during a flood survey

Kalambani Market

Kalambani Market

Kalambani Market

Thua River at Kalambani

The right river bank that had vegetation was protected while the left bare river bank where the market is located suffered a lot of deposition

Kalambani Market

Kalambani Market

Kalambani Market

Thua River

A 'Makuti' structure formerly located here washed away

Huge trees carried by the flooded river and deposited in the market

Kalambani Water Supply

Water level at the pump house

Pump destroyed by the floods

Thank you

THE END

Appendix 7

Guideline for Maintenance of Regular Gauging Stations

WATER RESOURCES AUTHORITY

**JAPAN INTERNATIONAL COOPERATION AGENCY/
WATER RESOURCES MANAGEMENT EXPERT**

GUIDELINE
FOR
MAINTENANCE
OF
REGULAR GAUGING STATION

JANUARY 2019

NIPPON KOEI CO., LTD

1. Objective of Guideline

This guideline aims to support the management of maintenance work of RGS (Regular Gauging Station) in WRA (Water Resources Authority). The consistent maintenance work of RGSs should be achieved for keeping the quality of observed data high by means of checklist form. It is expected that the communication and information sharing of the RGS's status between each office will be improved by using the checklist, and then appropriate management of maintenance work will be established.

2. Management of Maintenance Work

2.1 Maintenance Work

The staff of SRO (Sub-Regional Office) engages in maintenance work of RGSs. The maintenance work should be complied with a letter "Maintenance of Regular Gauging Station" issued by ATCM (Assistant Technical Coordination Manager) on 28th January 2014. The letter indicates three reference guidelines for maintenance work of RGS. The maintenance work should be implemented on a monthly basis.

Table 1 Maintenance Work

No.	Item	Contents
1	Person in Charge	Staff of SRO (Sub-Regional Office)
2	Items of Inspection	Devices of observation, Structures of station, Calibration of gauging, Clean up the area of station
3	Regulations	Comply with a letter "Maintenance of Regular Gauging Station" issued by ATCM on 28th January 2014 Reference Guidelines: ■ Guide to Hydrological Practices, WMO-No.168 ■ ISO 1100-1, Measurement of liquid flows in open channels ■ Guidelines for Assessment of River Gauging Stations
4	Frequency	On a monthly basis

2.2 Handling of Checklist

The Checklist is prepared, transferred, compiled and stored in accordance with the following procedure:

- The Checklist form attached on this guideline should be filled after completion of maintenance work by SRO's staff, and SRO submits the Checklist to RO (Regional office) on a monthly basis.
- RO compiles the received Checklists from SROs and submits to HQ (Head Quarter) on a quarterly basis.
- HQ compiles the received Checklists from ROs. HQ utilizes the compiled Checklist for studying strategy and budget formulation of maintenance work.

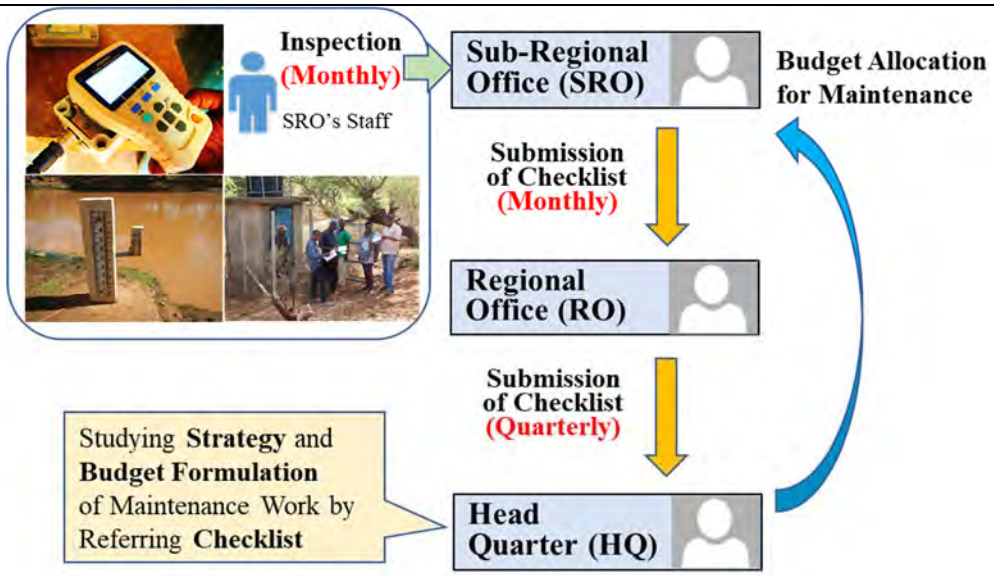


Figure 1 Management of Maintenance Work of RGS

3. Roll of the Tasks

The roll of tasks for management of maintenance work are indicated in the table below;

Table 2 Roll of Tasks

Function	Responsible Institution		
	HQ	RO	SRO
1. Inspection		○[1)]	○[2)]
2. Maintenance		○[1)]	○[2)]
3. Securing Quality of Facilities		○[1)]	○[2)]
4. Planning Strategy	○	△	
5. Budget Formulation	○	△	

Note: ○ : Main roles, △ : Assisting roles
1) Responsibility of quality securing
2) Responsibility of work implementation

Attachments

- Checklist for Maintenance Work of Regular Gauging Station
- Sample of Summary Table of Checklist

Checklist
for
Maintenance Work
of
Regular Gauging Station

Month and Year of Checklist: _____ in _____
Office Name: _____
Recorded by _____
Recorded Date: _____

The maintenance works had been checked with the items below and summarized on the attached summary table.

Check Items for Maintenance Works

No.	Check Items	Check Contents
1	Facility	The facilities such as observation hut, staff gauge and bench mark have been functioned without significant damage
2	Device	The devices such as sensor, recorder and telemeter have been functioned
3	Replacement	The necessary replacements such as battery, recording paper and cartridge pen have been replaced with new ones or remain enough balance until next inspection
4	Calibration	The recorded data coincided with the value of observation at the time of site inspection
5	Cleanup	The cleanup works such as grass mowing, wiping devices and taking stuck branch off facilities have been accomplished

Signed by Office Manager:

_____

Name :
Position :

Filled by ________ Checked by ________

Checklist for Maintenance Work of Regular Gauging Station

TANA BASIN 2019/1/17

S/ No	STATION ID	STATION NAME/ RIVER	CONSTITUENCY	COUNTY	LOCATION	REGION	SRO	CHECK ITEMS										COMMENTS	
								Facility		Device		Replacement		Calibration		Cleanup		ISSUES	REQUIREMENTS
								YES	NO	YES	NO	YES	NO	YES	NO	YES	NO		
1	4AA06	LOWER SAGANA	KIENI	NYERI	Kabaru forest station to Hombe foest station road	TANA	Upper Tana	☑	☐	☐	☑	☑	☐	☑	☐	☑	☐	Observation sensor was broken and not functioned	Observation sensor should be replaced
2	4AA07	U.SAGANA	KIENI	NYERI	Kabaru forest station to Hombe foest station road	TANA	Upper Tana	☑	☐	☑	☐	☑	☐	☑	☑	☑	☐	None	None
3	4AA1	SAGANA	MATHIRA	NYERI	Rocky	TANA	MURANGA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	☑	☐	None	None
4	4AA2	THEGO	KIENI	NYERI	Chaka-state lodge road	TANA	MURANGA	☐	☑	☑	☐	☑	☐	☑	☐	☑	☐	One staff gauge had been flowed out	To re-install a staff gauge is required
5	4AA4	NAIROBI	NYERI TOWN	NYERI	Chaka state lodge road	TANA	MURANGA	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	None	None
6	4AA5	SAGANA	NYERI TOWN	NYERI	Marua-Kiganjo Sagana bridge	TANA	MURANGA	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	None	None
7	4AB01	MURINGATO	NYERI TOWN	NYERI	Kiganjo-Nyeri at Muringato bridge	TANA	Upper Tana	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	None	None
8	4AB02	MWEIGA	NYERI TOWN	NYERI		TANA	Upper Tana	☐	☑	☑	☐	☑	☐	☑	☐	☑	☐	The revetment for securing observation hut had been eroded partially	To repair the revetment is required

Appendix 8

Guideline for Management of Hydrometeorological Database

WATER RESOURCES AUTHORITY

**JAPAN INTERNATIONAL COOPERATION AGENCY/
WATER RESOURCES MANAGEMENT EXPERT**

GUIDELINE FOR HYDROMETEOROLOGICAL DATABASE MANAGEMENT

JANUARY 2019

NIPPON KOEI CO., LTD

1. Objective of Guideline

This guideline aims to enhance the hydrometeorological database management in Water Resources Authority. The consistent data storage should be achieved by clear demarcation of the tasks of each office by means of checklist form. It is expected that the communication and data sharing between each office will be improved by using the checklist, and then appropriate hydrometeorological database management will be established.

2. Procedure of Database Management

The observed hydrometeorological data are recorded, transmitted and stored in accordance with the following procedure:

(i) Sub-Regional Office (SRO)

- The observed hydrometeorological data is recorded on a monthly record form by a staff of Sub-regional Office,
- When the staff found any unexpected data, the staff should research the reason and update the data. If the trouble could not be fixed, note the reason and requirement on a table of checklist,
- The staff of Sub-regional Office sends the excel file of monthly record form with attaching a PDF file of checklist form (CHECKLIST-SRO) and excel file of summary checklist table to Regional Office on a monthly basis,

(ii) Regional Office (RO)

- The staff of Regional Office converts the water levels into discharges by using a latest H-Q curve,
- The converted discharges are recorded on a monthly record form and stored into a server at Regional Office,
- The staff of RO compiles the received summary checklist tables of SROs in one excel file, and fills the checklist table in accordance with the attached checklist form (CHECKLIST-RO),
- The staff of RO sends the excel file of monthly record form with attaching two PDF files of checklist forms (CHECKLIST-SRO and CHECKLIST-RO) to the Headquarter on a quarterly basis,

(iii) Headquarter Office (HQ)

- The staff of the headquarter compiles the received summary checklist tables of ROs in one excel file, and fills the checklist table in accordance with the attached checklist form (CHECKLIST-HQ),
- The staff of the headquarter stores the monthly record and summary checklist table into a server at the Headquarter.
- When the staff found any issues on the summary checklist table such as requirement of repairing and replacement of some equipment, the Headquarter handles the matter in cooperation with SRO and RO.

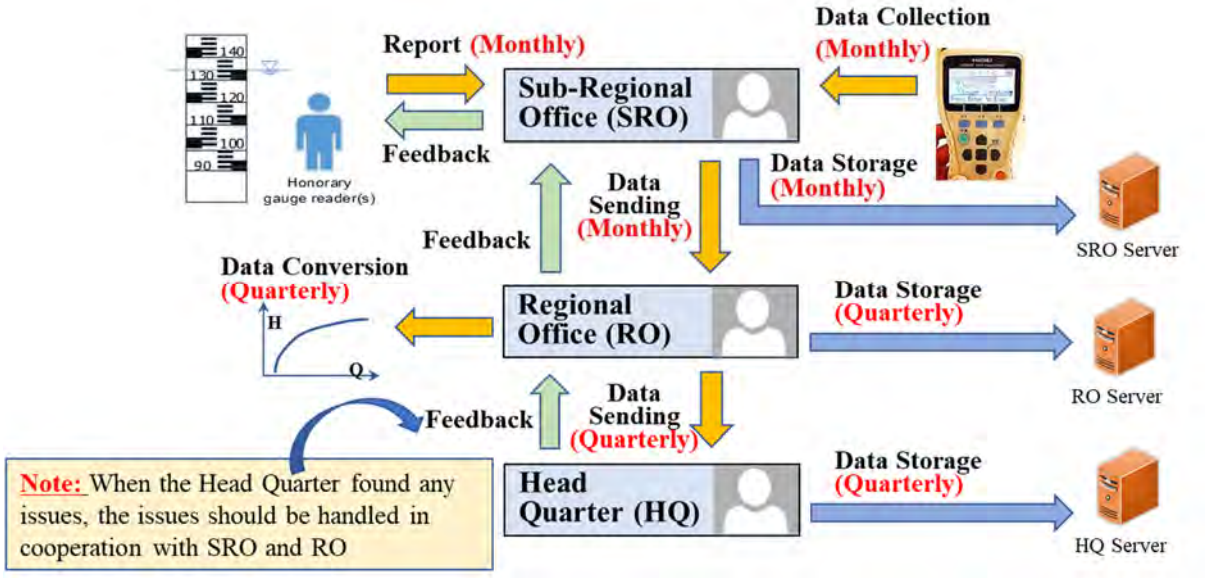
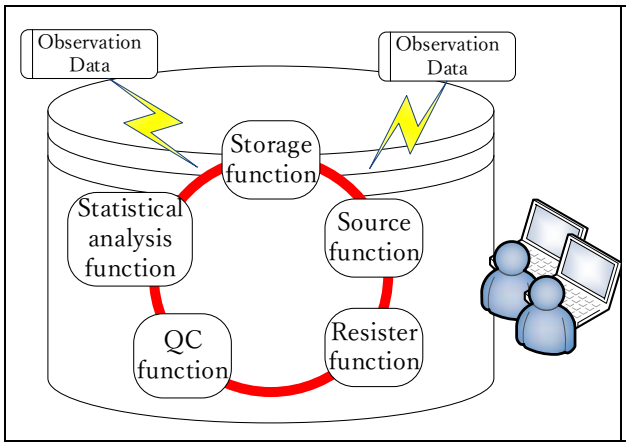


Figure 1 Communication for Hydrometeorological Database Management

3. Roll of the Tasks

The functions of database are divided into five categories as shown in the figure below. The roll of task of each function is indicated in the table below;



1	Storage function	Sourced data on a daily/monthly basis and develop a repository.
2	Source function	Retrieve and organize the data
3	Register function	Add, amend and delete data as required
4	Quality control (function)	To ensure the integer and consistency of the data
5	Statistical analysis (function)	Utilize the date for rationalization by statistical analysis.

Figure 2 Functions of Database

Table 2 Roll of Tasks

Function	Responsible Institution		
	HQ	RO	SRO
Storage function	○[1)]	○[2)]	△
Source function		○[1)]	○[2)]
Register function		○[1)]	○[2)]
Quality control	○[1)]	○[1)]	○[1)2)]
Statistical analysis	○	△	

Note: ○：Main roles, △：Assisting roles
1) Responsibility of quality securing, 2) Responsibility of work implementation

4. Handling of Documents and Data

The handling action and timing for hydrometeorological database management at each office, are sumurrized in the tables below:

Table 3 Preparation of Documents

Office	Documents of Preparation	File Type	Timing
SRO	(1) Monthly Record Form at regular gauging station	Excel	Monthly
	(2) Checklist of form 'CHECKLIST-SRO' in handwriting	PDF	Monthly
	(3) Summary Checklist Table	Excel	Monthly
RO	(4) Monthly Record Form at rainfall/ water level gauge station	Excel	Quarterly
	(5) Checklist of form 'CHECKLIST-RO' in handwriting	PDF	Quarterly
	(6) Summary Checklist Table	Excel	Quarterly
HQ	(7) Checklist of form 'CHECKLIST-HQ' in handwriting	PDF	Quarterly
	(8) Summary Checklist Table	Excel	Quarterly

Note: PDF file is prepared by scanning the checklist paper in handwriting

Table 4 Transmission of Data

Office	Data of Transmission	Transfer to	Timing
SRO	(1) Monthly Record Form at rainfall/ water level gauge station	RO	Monthly
	(2) Checklist of form 'CHECKLIST-SRO'		Monthly
	(3) Summary Checklist Table		Monthly
RO	(4) Monthly Record Form at rainfall/ water level gauge station	HQ	Quarterly
	(5) Checklist of form 'CHECKLIST-SRO and RO'		Quarterly
	(6) Summary Checklist Table		Quarterly

Note: Data is sent by SMS

Table 5 Storage of Data

Office	Data of Strage	Server	Timing
SRO	(1) Monthly Record Form at rainfall/ water level gauge station	SRO	Monthly
	(2) Checklist of form 'CHECKLIST-SRO'		Monthly
	(3) Summary Checklist Table		Monthly
RO	(4) Monthly Record Form at rainfall/ water level gauge station	RO	Quarterly
	(5) Checklist of form 'CHECKLIST-SRO and RO'		Quarterly
	(6) Summary Checklist Table		Quarterly
HQ	(7) Monthly Record Form at rainfall/ water level gauge station	HQ	Quarterly
	(8) Checklist of form 'CHECKLIST-SRO, RO and HQ'		Quarterly
	(9) Summary Checklist Table		Quarterly

Note: SRO and RO should also file and store the paper of Monthly Record Forms at each office

Attachments

- CHECKLIST-SRO: Checklist of Sub-Regional Office
- CHECKLIST-RO : Checklist of Regional Office
- CHECKLIST-HQ : Checklist of Headquarter
- Sample of Summary Table of Checklist

CHECKLIST-SRO

Checklist for Hydrometeorological Database Management at Sub-Regional Office

Month and Year of Checklist: _____ in _____
Office Name: _____
Recorded by _____
Recorded Date: _____

The database management had been checked with the items below and summarized on the attached summary table.

Check Items for Hydrometeorological Database Management of SRO

No.	Check Items	Check Contents
1	Data Filling	The monthly record form was filled by observed data without missing value
2	Data Matching	The observed data is correct data at the target station
3	Expected Data	The observed data did not include any unexpected data such as high water level without raining
4	Paper Filing	The monthly record form filled by observed data was filed on paper based, and the file was stored in a shelf
5	e-Data Storing	The excel file of monthly record form with attaching a PDF file of checklist form (CHECKLIST-SRO) was stored to the server at Sub-Regional Office

Signed by Sub-Regional Manager:

_____

Name :
Position :

CHECKLIST-RO

Checklist
for
Hydrometeorological Database Management
at
Regional Office

Month and Year of Checklist: _____ in _____
Office Name: _____
Recorded by _____
Recorded Date: _____

Check Items for Hydrometeorological Database Management of RO

No.	Check Items	Check Contents
1	Data Filling	The monthly record form was filled by observed data without missing value
2	Data Conversion	The water level was converted into discharge by using latest H-Q curve ※Note: In case of rainfall gauge station, marks 'YES' as no issues
3	e-Data Storing	The excel file of monthly record form was stored to the server at Regional Office

Signed by Regional Manager:

_____

Name :
Position :

CHECKLIST-HQ

Checklist for Hydrometeorological Database Management at Headquarter

Month and Year of Checklist: _____ in _____
Office Name: _____
Recorded by _____
Recorded Date: _____

Check Items for Hydrometeorological Database Management of HQ

No.	Check Items	Check Contents
1	Data Filling	The monthly record form was filled by observed data without missing value
2	e-Data Storing	The observed electric data was stored to the server at Headquarter

Signed by Assistant Technical Coordination Manager:

_____

Name :
Position :

Sample of Summary Table of Checklist

Filled by ____________ **Checked by** ____________

Checklist for Hydrometeorological Database Management

TANA BASIN **2019/1/17**

S/ No	STATION ID	STATION NAME/ RIVER	CONSTITUENCY	COUNTY	LOCATION	REGION	SRO/ RO	CHECK ITEMS																				COMMENTS	
								SRO										RO						HQ					
								Data Filling		Data Matching		Expected Data		Paper Filing		e-Data Storing		Data Filling		Data Conversion		e-Data Storing		Data Filling		e-Data Storing		ISSUES	REQUIREMENTS
								YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO		
1	4AA06	LOWER SAGANA	KIENI	NYERI	Kabaru forest station to Hombe foest station road	TANA	Upper Tana/ Embu	☑	☐	☑	☐	☑	☐	☑	☐	☐	☑	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	**SRO:** There is no server computer for storing e-data **RO:** None	**SRO:** The budget for purchasing one server computer is required **RO:** None
2	4AA07	U.SAGANA	KIENI	NYERI	Kabaru forest station to Hombe foest station road	TANA	Upper Tana/ Embu	☑	☐	☑	☐	☑	☐	☑	☐	☐	☑	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	**SRO:** There is no server computer for storing e-data **RO:** None	**SRO:** The budget for purchasing one server computer is required **RO:** None
3	4AA1	SAGANA	MATHIRA	NYERI	Rocky	TANA	MURANGA / Embu	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	**SRO:** None **RO:** None	**SRO:** None **RO:** None
4	4AA2	THEGO	KIENI	NYERI	Chaka-state lodge road	TANA	MURANGA / Embu	☑	☐	☑	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	☑	☐	☑	☐	☑	☐	☑	☐	**SRO:** None **RO:** None	**SRO:** None **RO:** None
5	4AA4	NAIROBI	NYERI TOWN	NYERI	Chaka state lodge road	TANA	MURANGA / Embu	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☐	☑	☐	☑	☐	☑	☐	☑	**SRO:** None **RO:** No preparation of H-Q curve for converting water level into discharge	**SRO:** None **RO:** Discharge measurement for preparing H-Q curve should be conducted
6	4AA5	SAGANA	NYERI TOWN	NYERI	Marua-Kiganjo Sagana bridge	TANA	MURANGA / Embu	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	**SRO:** None **RO:** None	**SRO:** None **RO:** None
7	4AB01	MURINGATO	NYERI TOWN	NYERI	Kiganjo-Nyeri at Muringato bridge	TANA	Upper Tana/ Embu	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	**SRO:** No budget for paying allowance to observing honorary **RO:** None	**SRO:** The budget for paying allowance to observing honorary **RO:** None
8	4AB02	MWEIGA	NYERI TOWN	NYERI		TANA	Upper Tana/ Embu	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☑	☐	☐	☑	☑	☐	**SRO:** None **RO:** None	**SRO:** None **RO:** None

Appendix 9

Newsletters

Water Resources Management Experts

JICA Experts Team

No.1 (March 2017)

Beginning of January 2017, two Japanese Experts commenced the project **JICA Experts for Water Resources Management**. During the first stay in Kenya, they carried out the kick off meeting and site reconnaissance in Tana Catchment Area. This newsletter describes the project outline and work actives recently.

1. Project outline

A study of "The National Water Master Plan 2030", which was conducted in 2013 with the assistance of JICA, formulated the National Water Master Plan towards the year 2030 taking into consideration of climate change.

One of the outputs of the National Water Master Plan (NWMP) is the Water Resources Management Authority (WRMA) action plan on strengthening of its capacity on water resources management by; 1) establishment and operations of Catchment Forum for strengthening of river basin governance, 2) strengthening of hydro meteorological information management, 3) improvement of flood and drought disaster management are proposed as the urgent and priority actions to be undertaken among the others.

To achieve this action plan, WRMA has been making efforts to enhance its water resource management capacity by strengthening of the hydro meteorological monitoring system, and formulation of catchment strategy and sub catchment management plans.

MOTOKI Yoshihiro
PL, Water resources management expert

KATO Yusuke
Water resources management and database expert

There are however emerging challenges on low level of monitoring, evaluation, analysis and collection of water resources data, resulting in poor data management. In this regard, there is an urgent need for capacity development of WRMA staff engaged in hydro meteorological monitoring as the information generated is essential for water resources management including water allocation decision making, water resources investment projects, production of water situation reports, etc.

2. Objective

The Project is a technical cooperation project and objective is to enhance capacity of water resources management in WRMA with the following three expected outputs through JICA Experts Team.

Output 1:	Enhancement of surface water monitoring to improve water resources management by WRMA in line with the National Water Master Plan 2030 (NWMP)
Output 2:	Establishment of appropriate hydro meteorological network and management of the same
Output 3:	Provision of guidance to WRMA on future support for water resources management through Japan's ODA or from any other organizations

3. Project Duration

The Project is carried out in the process of about 26 months from January 2017 to the end of February 2019.

4. Working Activities

To achieve three outputs, total 10 activities will be conducted with the assistance of JICA Experts Team.

Output 1	**Enhancement of surface water monitoring to improve water resources management by WRMA in line with the National Water Master Plan 2030 (NWMP)**
Activity 1.1	Assistance in the determination of the location of gauging stations of main river, lakes and springs
Activity 1.2	Assistance in updating the meteorological and hydrological observation network
Activity 1.3	Training on how to operate the equipment for discharge measurement
Activity 1.4	Assistance for stage-discharge curves (H-Q curves)
Activity 1.5	Assistance for the improvement of the operation system for the meteorological and hydrological gauging stations
Activity 1.6	Advise on the determination of the discharge amount for river maintenance flow
Output 2	**Establishment of appropriate hydro meteorological network and management of the same**
Activity 2.1	Confirmation on the current condition for the meteorological and hydrological database
Activity 2.2	Assistance in the improvement for meteorological and hydrological database
Output 3	**Provision of guidance to WRMA on future support for water resources management through Japan's ODA or from any other organizations**
Activity 3.1	Advise on the past performance of water resource management
Activity 3.2	Specification the required items for training and preparation of the training program

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5. Project Area

There are six catchment areas in Kenya in the WRMA catchment boundary. Tana Catchment area is the project area for the implementation of activities, especially for Output 1 and Output 2.

Due to security concerns, JICA Experts Team in accordance with JICA's security regulation will not be able to conduct activities in East Garissa and therefore WRMA Staff of Garissa Sub-regional office are requested to participate in activities conducted at the regional office or at the other selected pilot sites in Tana Catchment Area.

6. Site Reconnaissance in TCA from 23 Jan. to 25 Jan.

Experts Team carried out the site reconnaissance in Tana Catchment Area with Headquarter Officer, Ms.Julia, and Embu Regional office Manager, Mr.Wachira and surface water O fficer, Ms.Migwi.

They assessed current condition of river gauging stations and identified technical issues to solve this project.

7. Way Forward

Two JICA experts are now ready to implement 10 activities to achieve the three outputs together with Cps from WRMA. The project will run for two years, and during which the stay of the JICA experts will be intermittent. Corporation with WRMA staffs is key factor in achieving the project goals.

JICA Experts Team

Water Resources Management Experts

JICA Experts Team

No.2 (June 2017)

After one month break, the JICA Experts Team restarted project activities for the Water Resources Management Experts in the middle of May 2017. They conducted the site reconnaissance with WRMA counterpart personnel in the Upper Tana catchment, which is the target area for the Project, to decide the sites for construction and rehabilitation of river gauging stations and discharge measurement. The sites were mutually agreed by WRMA and duly recorded in the Technical Note No.2. This Newsletter No.2 covers the major project activities carried out during the period covering May to June 2017.

1. Outline of Activities

Major activities in connection with three Outputs achieved in this period are listed as follows:

Output 1: Enhancement of surface water monitoring to improve water resources management by WRMA in line with the National Water Master Plan 2030 (NWMP)

- Task 1-4 Study of current condition of observation network
- Task 1-7 Confirmation of appropriateness of location of existing G/S
- Task 1-8 Rehabilitation of existing G/S and installation of a new G/S
- Task 1-9 River cross survey at existing G/S

Output 2: Establishment of appropriate hydro meteorological network and management of the same

<No activity in this period>

Output 3: Provision of guidance to WRMA on future support for water resources management through Japan's ODA or from any other organizations

- Task 3-1 Advice on the past performance of water resources management

Common Activities: Procurement of equipment

2. Site Reconnaissance

In order to decide the sites for rehabilitation of the existing gauging stations (5 sites) and construction of new gauging station (1 site) for project activities, the JICA Expert Team conducted site reconnaissance with WRMA representatives from the Headquarters and the Regional Office (Embu) on May 23 and June 13 to 15.

As a result of the reconnaissance, the target 6 sites were decided as below:

No.	Code No. of RGS	River	River Cross Section Survey	G/S
1	4EA07	Mutonga	○	-
2	4DD02	Thiba	○	To rehab.
3	4BE10	Tana Rukanga	○	To rehab.
4	4BE01	Maragua	○	-
5	4CC08	Thika	○	-
6	4F10	Kathita	○	To install

At RGS 4F10 (Kathita River, June14, 2017)

Upstream view of Tana mainstream from existing RGS 4F13(Jun. 13, 2017)

The WRMA representatives and the Expert Team conducted reconnaissance at mainstream of Tana River as well to find suitable site for river discharge monitoring. They confirmed that mainstream may not suitable for the Project activities such as discharge measurement, because discharge amount is rather big even within dry seasons. On the other hand, they preliminarily confirmed possibility of restoring cable and tower facilities crossing over the river.

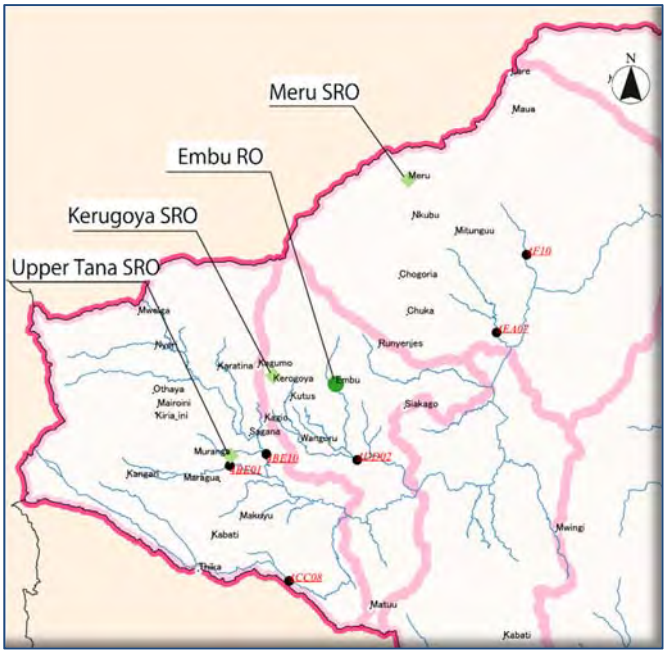
3. Sub-Contract Works

Within this period, the Expert Team made two contracts with local contractors for field works as follows:

- River Cross Section Survey
  - Objective:
    To make river cross sections at Management Unit Stations in order to utilize for developing stage-discharge curves.
  - Contract period: July to August 2017
  - Target sites: 6 existing river gauging stations in Upper Tana Catchment (Refer to the table in Page 1)
  - Number of survey line: 3 sections per site

- Rehabilitation of Existing Gauging Station and Installation of a New Gauging Station
  - Objective:
    To enhance monitoring network with replacing staff gauges and installing water level sensors
  - Contract period: September to November 2017
  - Target sites: Two for rehabilitation of existing G/S and one for new installation of G/S (Refer to the table in Page 1) in the Kathita River, which is a tributary of the Tana River

A location map of target gauging stations is illustrated in the following figure:



Location Map of Target Gauging Stations

4. Tana Catchment Management Strategy 2014-2022

The Expert Team collected information on the current status of Catchment Management Strategy 2014-2022 for the Tana Catchment Area from Embu Regional Office (RO). Among the programs which have been conducted and accomplished by the RO, some distinguished issues are extracted as follows:

Chapter 9: Flood and drought management

⇒ 27 nos. of small catchment management plans were developed

Chapter 10: Climate change adaptation

⇒ 12 nos. of monitoring stations were rehabilitated/ upgraded

Chapter 14: Institutional strengthening

⇒ On-going under JICA's current project

The Expert Team will further analyze significant achievements and future challenge based on the document as well as interview to the staff concerned in the regional and sub-regional offices.

5. Way Forward

The Expert Team will remobilize and continue Project activities with WRMA CPs in September. Even during their absence in Nairobi, the sub-contracted works will continue.

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Water Resources Management Experts

JICA Experts Team

NEWSLETTER No.3 (October 2018)

The JICA Experts Team remobilized and restarted project activities for the "Water Resources Management Expert" in the beginning of September 2017. They proceeded activities with WRA counterpart personnel in the Upper Tana catchment in accordance with the Work Plan including site reconnaissance to supervise contractor's works for river cross section survey and construction and rehabilitation of river gauging stations. Within the assignment period, equipment purchased in Japan has been shipped and delivered to the Team's office in WRA through custom clearance in Kenya. This Newsletter No.3 covers the major project activities conducted during the period from September to October 2017.

1. Outline of Activities

Major activities regarding three Outputs achieved in this period are listed as follows:

Output 1: Enhancement of surface water monitoring to improve water resources management by WRMA in line with the National Water Master Plan 2030 (NWMP)

- Task 1-5 Assistance for updating meteorological and hydrological observation network
- Task 1-8 Rehabilitation of existing G/S and installation of a new G/S
- Task 1-9 River cross survey at existing G/S and discharge measurement

Output 2: Establishment of appropriate hydro meteorological network and management of the same

- Task 2-2 Study and assistance for improvement of meteorological and hydrological database

Output 3: Provision of guidance to WRMA on future support for water resources management through Japan's ODA or from any other organizations

- Task 3-4 Preparation of training program to improve the capacity of WRMA staff

Common Activities:

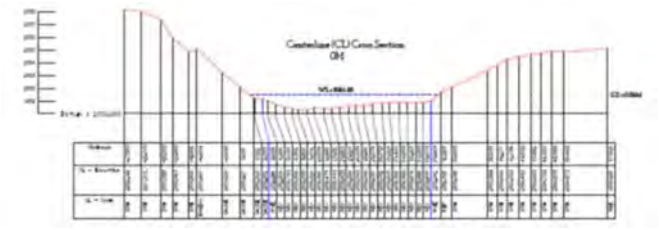
- Procurement of equipment
- Issuance of Newsletter No.3

2. Highlights in Output 1

The Experts Team and CP of WRA has selected the contractors for both river cross section survey and rehabilitation of existing G/S and installation of a new G/S and made contracts in June 2017.

River cross section survey

River cross section survey at six gauging stations (G/S) in the Upper Tana Catchment has been completed by the end of September. Now a total of 18 cross sections at six G/S are available. Following figure shows one of the final products for example (at RGS 4DD02 in Thiba River). These outcomes will be efficiently utilized for creating H~Q curves to convert from water levels to discharge values through Project activities:



River Cross Section at 4DD02

Rehabilitation of existing G/S and installation of a new G/S

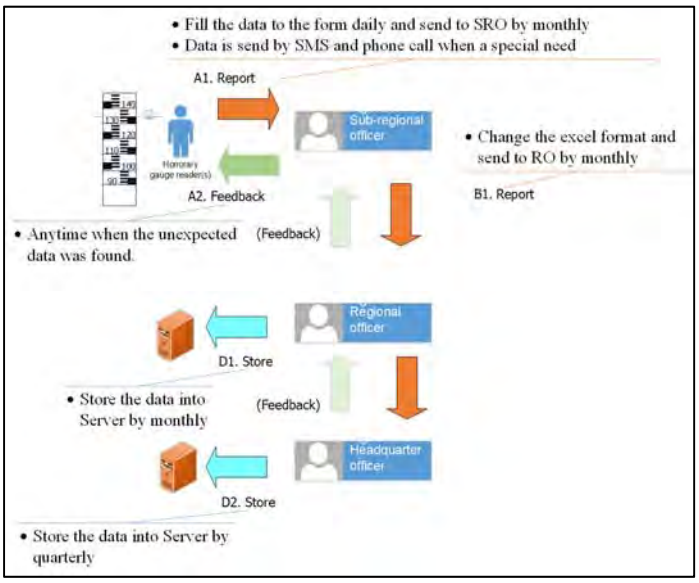
Rehabilitation of existing G/S and installation of a new G/S has been commenced in September at RGS 4BE10 (Tana Rukanga), 4DD02 (Thiba) and 4F10 (Kathita) through a sub-contract. New water level sensor will be installed at 4F10 and new staff gauges will be installed at all three G/S by the end of November 2017.

It is noteworthy that these six stations will have equivalent datum above mean sea level connecting with national grid. Therefore, hydraulic computation by means of observed water level records at these stations can be conducted as an integrated river system.

Joint Site Inspection at RGS 4F10 (Oct.11, 2017)

3. Highlights in Output 2

The Expert Team as well as CP in WRA HQ conducted interview survey at the Region/ Sub-region Offices concerned in Tana Catchment to clarify the status of data management of surface water. Manner of data transfer and storage was confirmed and clarified issues as illustrated below:



Current Mechanism of Data Transfer and Storage in WRA (water level data)

Key Issues clarified

- ✧ To clearly define roles and functions in data management among HQ, RO and SRO
- ✧ To improve hardware and software of computer system in RO and SRO
- ✧ To enhance basic skill of data management in terms of quality control at SRO and RO

4. Highlights in Output 3

The Expert Team together with CP of WRA still need to identify and justify the potential area for future technical assistance in water resources management in Kenya. In this connection, WRA's current activities and achievement are now researching and updating from Tana Catchment with CP in WRA HQ.

In addition to such activities envisaged in the approved Work Plan, the Expert Team proposed 1st Joint Meeting with the "Kenya Water Security and Climate Resilience Project", which has been commenced in May 2017 funded by World Bank. The Project Manager of Project Implementation Unit (PIU) called the key personnel concerned in WRA and Team Leader of the ISC, and organized the meeting on Oct.6 at PM's office.

The Expert Team recognized that the purpose of the meeting is to exchange information on outstanding activities and achievements of the two on-going projects in WRA aiming at further elaboration of project outcome. Through the discussions, all attendants acknowledged importance of sharing data /information and building the knowledge base (database) on both projects avoiding duplication which optimize the available resources.

5. Procurement of Equipment

The Expert Team procured equipment from Japan as listed below through substantial assessment and acceptance with CP in WRA HQ. Those were delivered and available already until Oct.12 at the office of Expert Team. The items 1 to 4 in the table below will be installed by the Contractor of "Rehabilitation of existing G/S and installation of a new G/S". Item 5 will be utilized in "Discharge Measurements" which is scheduled to commence from February 2018.

Procured Equipment from Japan

No.	Name of Item	Qty.
1	Water level sensor (20 m@ 2 sets and 30 m @ 2 sets)	4 units
2	Data logger	4 units
3	Data collector	2 units
4	Staff gauge plate with sticker	50 pcs
5	Current meter	3 units

6. Way Forward

The Expert Team will remobilize and continue Project activities with WRA CP in February 2018. Even during their absence in Nairobi, the sub-contract works will continue with assistance of local consultants.

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Water Resources Management Experts

NEWSLETTER No.4 (March 2018)

The JICA Experts Team remobilized and restarted project activities for the "Water Resources Management Expert" in the beginning of January 2018. They proceeded activities together with WRA counterpart personnel in the Upper Tana catchment to supervise contractor's works for construction and rehabilitation of three river gauging stations. In addition, another sub-contract works of "Discharge Measurement" has been awarded and commenced on 6th March. During the contract period, procured equipment (current meter, etc.) through the present project will be effectively utilized. Further, JICA Expert intensively discussed future assistance program/project, on which deliberation will be continued between WRA and JICA Expert Team. This Newsletter No.4 covers the major project activities conducted during the period from January to March 2018.

1. Outline of Activities

Major activities regarding three Outputs achieved in this period are listed as follows:

Output 1: Enhancement of surface water monitoring to improve water resources management by WRMA in line with the National Water Master Plan 2030 (NWMP)

- Task 1-10 Assistance for updating meteorological and hydrological observation network
- Task 1-11 Rehabilitation of existing G/S and installation of a new G/S

Output 2: Establishment of appropriate hydro meteorological network and management of the same

- Task 2-2 Study and assistance for improvement of meteorological and hydrological database

Output 3: Provision of guidance to WRMA on future support for water resources management through Japan's ODA or from any other organizations

- Task 3-4 Preparation of training program to improve the capacity of WRMA staff
- Task 3-3 Advice on the water resources management program

Common Activities:

- Issuance of Newsletter No.4
- Preparation of Progress Report

2. Highlights in Output 1

The Experts Team and CP of WRA have checked completion status of the rehabilitation of existing G/S and installation of a new G/S from March 2 to 3, 2018.

Rehabilitation of existing G/S and installation of a new G/S

Rehabilitation of existing G/S and installation of a new G/S has been completed at RGS 4BE10 (Tana Rukanga), 4DD02 (Thiba) and 4F10 (Kathita) through a sub-contract in March. New water level sensor was installed at 4F10 and new staff gauges and signboard were installed at all three stations. Beside the staff gauge installation, river bank protection works by gabion mattress and construction of small drain canal were also completed at 4F10 and 4BE10 respectively.

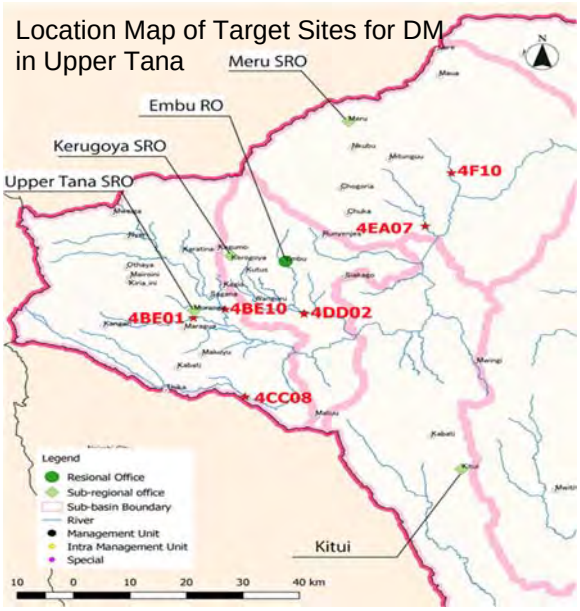
Completed staff gauge posts at RGS 4BE10 (Mar.2, 2018)

Upon completion of the sub-contract works, the target stations, can be utilized for monitoring water levels. In order to properly maintain these facilities, close coordination between the neighboring villages and WRA RO & SROs will be prerequisite.

Discharge Measurement (DM)

The workshops (2 times in March and June 2018) on discharge measurement are decided to be held for capacity development of CP. The Expert Team delivers lectures and presentation of technical knowledge on detailed methodology of discharge measurement and creating H~Q curves, etc.

Discharge measurement (DM) will be conducted 15 times each at six river gauging stations (total 90 times until September 2018) in Upper Tana catchment where river cross section survey was conducted in the previous year, as illustrated below:



The first workshop was conducted at WRA Regional Office in Embu on March 8. Mr. Motoki (Team Leader) delivered lectures on technology of DM and facilitated the workshop to 19 attendants of CP from RO and SROs.


Discussions at 1st Workshop on DM

On March 9, a demonstration and practice of DM at RGS 4BE10 (Tana Rukanga, one of the target 6 sites) were conducted by means of a boat. As for the measurement, a new current meter (Type MCM-3, MT precision), which was procured by the Project was used. All personnel, who attended the workshop on the previous day participated in the practice.


Practice of DM at RGS 4BE10

3. Highlights in Output 2

In line with the activities for assistance for improvement of meteorological and hydrological database, WRA had an urgent request to improve their database at HQ such as water body registration and sub-basin layer update with WRUA boundary harmonization, etc. As the results of discussion with the Expert Team, the Team agreed to help the GIS works under the Project.

4. Highlights in Output 3

The Expert Team collected information together with Project Manager on the staff training in order to identify the technical areas and themes demanded by WRA and to recommend affordable and effective training program in the future. Human Resource Department provided three kinds of material, which consist of (a) training needs assessment, (b) training plan for the financial year 2017/2018, and (c) training requirements. Based on the references, the Expert Team preliminarily verified the potential areas for staff training in water resources management sector.

5. Way Forward

The Expert Team will remobilize and continue Project activities with WRA CP in June 2018. Even during their absence in Nairobi, the contractor will continue to conduct DM with assistance of local consultants.

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Water Resources Management Experts

NEWSLETTER No.5 (July 2018)

The JICA Expert Team remobilized and restarted project activities for the "Water Resources Management Expert" in the end of May 2018. They proceeded activities together with WRA counterpart personnel in the Upper Tana catchment to supervise contractor's works of the "Discharge Measurement (DM)", which has been commenced on 6th March this year. In this connection, 2nd Workshop has been held at conference room of the Regional Office of WRA in Embu to discuss the intermediate results of DM and exchange the latest hydrological information/ data in the basin. Further, JICA Expert intensively discussed and supported to make up an idea of future program/project assisted by the Japanese Government, on which deliberation will be continued between WRA and JICA Expert Team. This Newsletter No.5 covers the major project activities conducted during the period from May to July 2018.

1. Outline of Activities

Major activities regarding three Outputs achieved in this period are listed as follows:

Output 1: Enhancement of surface water monitoring to improve water resources management by WRA in line with the National Water Master Plan 2030 (NWMP)

- Task 1-5 Assistance for updating the meteorological and hydrological observation network
- Task 1-10 Review and updating of existing stage-discharge curves (H-Q curve)
- Task 1-14 Advise on determination of discharge amount for river maintenance flow

Output 2: Establishment of appropriate hydro meteorological network and management of the same

- Task 2-2 Study and assistance for improvement of meteorological and hydrological database

Output 3: Provision of guidance to WRA on future support for water resources management through Japan's ODA or from any other organizations

- Task 3-3 Advice on the water resources management program

Common Activities:

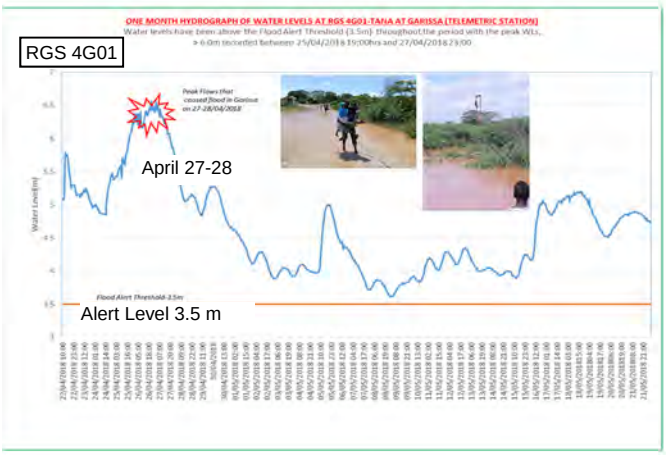
- Issuance of Newsletter No.5
- Discharge Measurement (2nd Workshop)

2. Highlights in Output 1

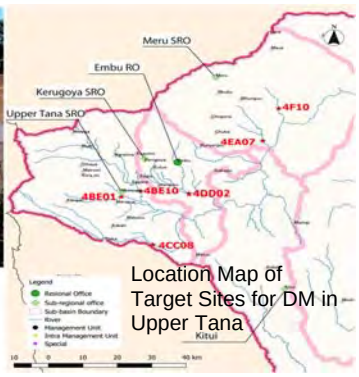
Flood Situation at Tana Catchment in 2018

The Experts Team has collected information on flooding occurred from March to May 2018 through newspaper articles and web sites as well as from WRA Regional Office in Embu. Tana Catchment has been serious hit by extraordinary downpour. In particular, Garissa Sub Region was most seriously affected among five sub regions in the Tana Catchment.

The following figure illustrates a hydrograph at RGS 4G01 (in Garissa Town) and the peak water level reached above 6m (more than 3.0 m higher than the alert level was recorded.



Flood condition at 4BE10 (Tana Rukanga) on May 4, 2018 (one of target site for rehabilitation of the Project)



Location Map of Target Sites for DM in Upper Tana

Discharge Measurement

Discharge Measurement (DM) has commenced from March 2018 to update/create rating curves at six target sites in Upper Tana. Nariana Enterprises Ltd. (the Contractor) is undertaking the exercise with supervision by Experts Team and will conduct a total of 15 measurements at each site until September 2018. The picture below shows the DM works by current meter method at RGS 4F10 in Kathita River.

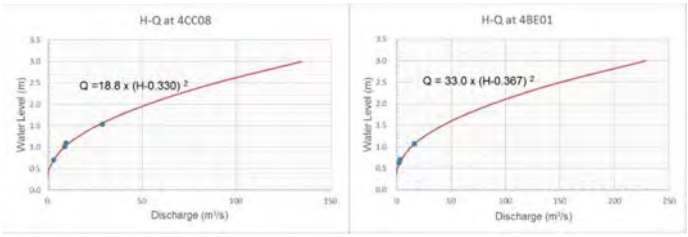
DM works at 4F10 (Kathita, Jun.12)

2nd Workshop

The 2nd Workshop attached to the DM was held on June 26th and 27th at WRA Regional Office, Embu. The participants were the counterpart personnel (CP) assigned for the Project. The Workshop was planned not only to share the intermediate DM results but also to discuss current hydrological monitoring works during the flood season for identifying crucial issues for further enhancement to the monitoring network in each sub catchments.

Opening Remarks by Eng. B. Omuya (Regional Manager of WRA at 2nd Workshop, Embu, Jun.26)

The contents of the 2-day Workshop were divided into 9 Parts and the CP has learnt the practical method to fit discharge rating curves at three RGS, namely 4BE01, 4CC08 and 4BE10 by using their own Personal Computers. The following graphs illustrate the rating curves at 4BE01 and 4CC08.



Participants of 2nd Workshop (Embu, Jun.27)

3. Highlights in Output 2

In line with the activities for assistance for improvement of meteorological and hydrological database, the Expert Team continued analyses by GIS together with WRA's engineers at Headquarter. One of outstanding complete output is modification to harmonize between sub catchment boundaries and WRUAs' boundaries in all six catchments in the country. This is expected to greatly help management of water right in WRA with more accurate estimation of water resources potential.

4. Highlights in Output 3

The Experts Team collected and thoroughly reviewed related key documents in the Ministry of Water and Sanitation (MWS) and WRA as follows:

(1) Gazette Notice No.5628 (June 8, 2018)
"The Kenya Water Act" (dam safety task force)
(2) "Rapid Results Initiative (RRI)"

In line with formulating prospective project/ program, the Experts Team will continue to discuss and assist personnel in charge for further enhancement and contribution to water sector reform by WRA's initiative.

5. Way Forward

The Expert Team will return to Nairobi and continue Project activities with WRA CP in middle of September 2018. The Contractor will continue to conduct DM works with assistance of local supervio

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Water Resources Management Experts

NEWSLETTER No.6 (October 2018)

The JICA Expert Team of the "Water Resources Management Expert" together with WRA counterpart staff continued their activities from September to October 2018. Within the period, Mr. Tokuaki Kawaguchi, senior hydrologist of Nippon Koei Co., Ltd., joined in the Expert Team for substitution of Mr. Yusuke Kato to further enhance project activities with the counterpart of Water Resources Authority (WRA). They conducted 4-day field reconnaissance to inspect current conditions including completed rehabilitation works of the facilities of the target six gauging stations in the upper Tana Catchment. In parallel, they supervised and advised the Contractor of the Discharge Measurements to expedite field works and preparation of the outputs as stipulated in the contract agreement. Further, the Expert Team prepared draft guidelines for supporting maintenance works of regular gauging stations and hydrological database management by WRA. This Newsletter No.6 covers the activities conducted during the period from September to October 2018.

1. Outline of Activities

Major activities regarding three Outputs achieved in this period are listed as follows:

Output 1: Enhancement of surface water monitoring to improve water resources management by WRA in line with the National Water Master Plan 2030 (NWMP)

- Task 1-5 Assistance for updating the meteorological and hydrological observation network
- Task 1-6 Training how to operate the equipment for discharge measurement
- Task 1-12 Assistance for the improvement of the operation system for the meteorological and hydrological gauging stations

Output 2: Establishment of appropriate hydro meteorological network and management of the same

- Task 2-2 Study and assistance for improvement of meteorological and hydrological database

Output 3: Provision of guidance to WRA on future support for water resources management through Japan's ODA or from any other organizations

- Task 3-3 Advice on the water resources management program

Common Activities:

- Issuance of Newsletter No.6
- Discharge measurement and check the results (continued)

2. Highlights in Output 1

Flood Reconnaissance

During the field reconnaissance from Sep. 26 to 29, the Experts Team inspected and confirmed status of the completed works of installation of new gauging station and rehabilitation of existing gauging stations in the target areas. As the results, one piece of 1.0 m staff gauge plate at 3rd post (from 3.0m to 4.0) was washed away and lost. There is therefore need to place a spare plate, which was procured by the current project.

Further, the Expert Team together with SRO CP staff collected water level records after installation in February 2018 to date at 4F10.


RGS 4F10 (Kathita River)


Data Collector


Data transfer from data logger to PC by using Data Collector at RGS 4F10 (Sep. 26, 2018)

Discharge Measurement

Discharge Measurement (DM) continued by Nariana Enterprises Ltd. (the Contractor). A total of 80 measurements out of 90 of the target at six sites in the Upper Tana as shown in the table below has so far been carried out:

RGS No.	River Name	Method		Improvement Works
		CM	FM	
4BE01	Maragua	12	4	-
4BE10	Tana Rukanga	12	0	New staff gauges
4CC08	Thika	12	5	-
4DD02	Thiba	12	0	New staff gauges
4EA07	Mutonga	9	0	-
4F10	Kathita	13	1	New WL sensor and staff gauges
Total		70	10	

Note: CM, Current meter method FM, Float method

The H-Q curves will be updated based on the DM results by means of the methodology, which was delivered to the CP during the 2nd Workshop in June 2018.

The Expert Team and the Contractor agreed that remaining DM works should be completed by the end of October 2018 assuming no extraordinary water level fluctuation at the target sites. Further, due to the interruption caused by extraordinary floods between March and May this year, the contract period was extended to January 25, 2019 (Originally October 31, 2018).

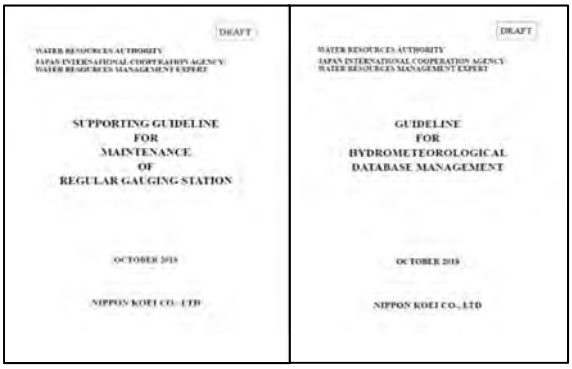
3. Highlights in Output 2

In connection with the activities for enhancement of maintenance of Regular Gauging Stations (RGS) as well as improvement of meteorological and hydrological database, the Expert Team prepared two draft guidelines and shared it with HQ, Embu RO and 3 SROs (Muranga, Kerugoya and Meru) for trial utilization:

Explanation on the Guidelines at Embu RO (Sep.28, 2018)

These Draft Guidelines include simple Checklists as Quick Reference showing the latest conditions of RGSs and data collection status. It is expected that those will supplement existing QMS documents of WRA.

On order to evaluate effectiveness and further elaborate the Drafts, Embu RO and SROs are requested to submit the Checklists periodically to the Expert Team within the trial period from October to December 2018.



4. Highlights in Output 3

The Experts Team continued to collect and reviewed related key documents in the Ministry of Water and Sanitation (MWS) and WRA to identify appropriate areas to cooperate in the future. In particular, following two documents were reviewed in this assignment period:

(1) Draft Sessional Paper No.**of 2018 on National Water Policy, Version of 21 June 2018, by MWS
(2) Capacity Development and Institutional Strengthening for WRA, A Concept for Support to JICA, July 2018, by WRA

In this connection, WRA is now preparing New Strategic Plan 2018-2023. Since this document will demonstrate further directives of WRA and prioritized areas to be strengthened in water resources management, the Expert Team will focus the details of the new strategy to wrap-up their recommendation.

5. Way Forward

The Expert Team will return to Nairobi and continue Project activities with WRA CP in the beginning of January 2019. The Contractor will continue to conduct DM works with participation of SRO staff concerned

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Water Resources Management Experts

NEWSLETTER No.7 (January 2019)

After opening New Year 2019, the JICA Expert Team consisting of Mr.Y.Motoki and Mr. T.Kawaguchi remobilized Nairobi to resume the Project activities on January 8 and stayed until 30th January. Within the period, they conducted a Progress Meeting at Embu Reginal Office to share the latest project activities with the counterpart personnel. In particular as reported in the previous Newsletter No.6, they created and distributed two kinds of guidelines, namely "Guideline for Maintenance of Regular Gauging Stations" and "Guideline for Hydrological Database Management" in last October. In accordance with the agreement, RO/SROs started to utilize them for their routine operation in tasks. The Checklist for October 2018 was shared among the CPs and the Expert Team. Further, the Discharge Measurement, which has been commenced from March 2018 and continued to date, was finally completed by Nariana Enterprises Limited. Based on the results of the measurements, rating curves at 6 target sites in the Upper Tana were finally created and presented in the Progress Meeting. This Newsletter No.7 covers the activities conducted between November 2018 and January 2019.

1. Outline of Activities

Major activities regarding three Outputs achieved in this period are listed as follows:

Output 1: Enhancement of surface water monitoring to improve water resources management by WRA in line with the National Water Master Plan 2030 (NWMP)

- Task 1-5 Assistance for updating the meteorological and hydrological observation network
- Task 1-6 Training how to operate the equipment for discharge measurement
- Task 1-10 Review and update for existing stage-discharge curves (H-Q curve)

Output 2: Establishment of appropriate hydro meteorological network and management of the same

- Task 2-2 Study and assistance for improvement of meteorological and hydrological database

Output 3: Provision of guidance to WRA on future support for water resources management through Japan's ODA or from any other organizations

- Task 3-3 Advice on the water resources management program

Common Activities:

- Progress Meeting
- Issuance of Newsletter No.7
- Hand over of the equipment procured

2. Common Activities

Progress Meeting at Embu RO (Jan.15, 2019)

In order to share the progress of the Project activities, the Progress Meeting was held at Regional Office in Embu on Jan.15, 2019 with the agenda as follows:

(1) Data management by means of Guideline and Checklist
(2) Discussions on data calibration/ adjusting of data logger and sensor
(3) Discharge measurement results at 6 target sites
(4) Self-evaluation on Project activities and capacity development

A Scene of discussions in the Progress Meeting

A total of 12 counterpart personnel from WRA HQ, RO and SROs (Kerugoya, Muranga and Meru) attended and shared latest output and information of the Project. On Item (1) data management, the attendants discussed responsibilities of respective offices in the aspect of database functions. As the results, they concluded the demarcation as follows:

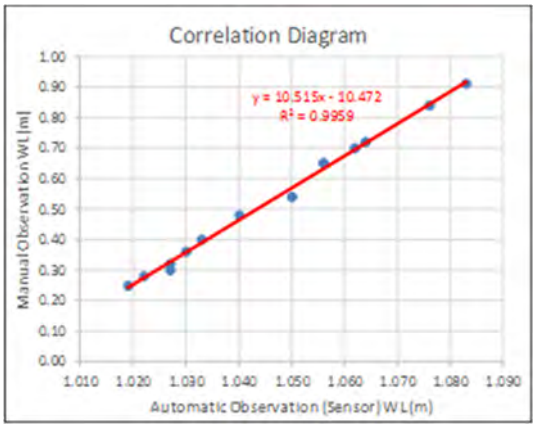
Responsibilities for Database Management

Function of Database	Responsibility		
	HQ	RO	SRO
Storage function	○1)	○2)	△
Source function	–	○1)	○2)
Register function	–	○1)	○2)
Quality control	○1)	○1)	△⇒○1)2)
Statistical analysis	○	△	

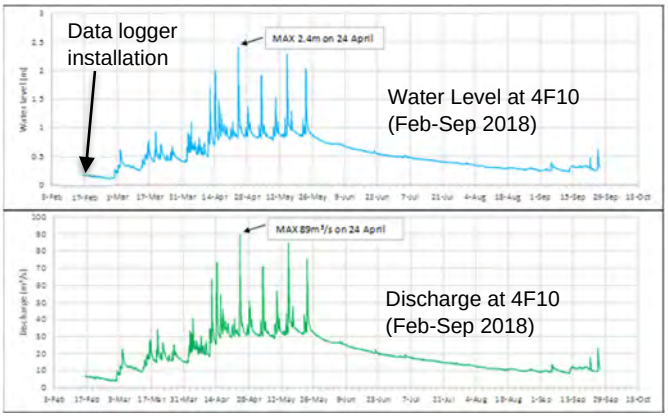
Note: ○, Main roles △, Assisting roles
1) Responsibility of quality securing,
2) Responsibility of work implementation

Since the preliminary check of raw data (gauging reading records) by SRO is important as first step, the "Quality Control" at SRO was modified from "Assisting" to "Main" roles.

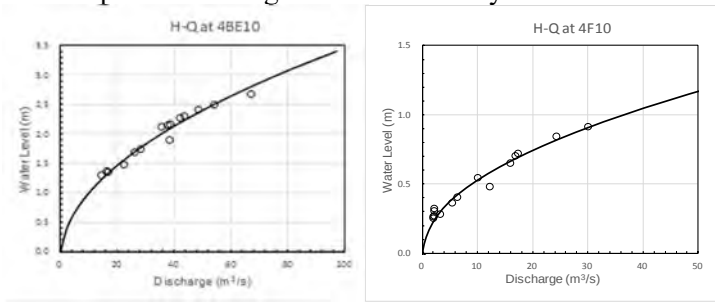
On Item (2), Mr. Kawaguchi (Data Management) of JICA Expert Team explained the calibration method of records from data loggers of water level sensor at 4F10 (Kathita), which was installed by the Project in last February. Although the sensor detected and recorded fluctuation of water levels continuously, the records were not yet adjusted to the same datum of staff gauge. The following figure shows the correlation between automatic records of the sensor and manual observation during the discharge measurements.



The calibration was successfully done with a high correlation ratio of 99.6%. The difference between two data is in a rage of 2 to 3 cm only. Based on the equation, the automatic water level records from February to September 2018 were converted.
By applying the H-Q curve (Ref: A figure of 4F10 in right row), such water level data were further converted to discharge data set at 4F10. The two kinds of hydrograph were drawn in the following figure:



On Item (3), Mr. Motoki (TL/ Water Resources Management) explained and shared the results of discharge measurement with estimated H-Q curve equations at 6 target sites. Nariana Enterprises Limited has completed discharge measurements by Jan. 2019.



H-Q Curves at and 4BE10 (Tana Rukanga) and at 4F10 (Kathita)

Handing Over of Equipment Procured by the Project

In January 2019, the following equipment, which have been procured by the Project were transferred to WRA.

No.	Name of Item	Qty.
1	Water Level Sensor (with cable L=20 m @2 and 30 m@2)	4 sets
2	Data Logger	4 sets
3	Data Collector	4 sets
4	Gauge Plate with Stickers (L=1.0m/pc)	50 pcs
5	Current Meter with Rod (L1.0m)	3 sets
6	Desktop PC	2 units
7	GIS software (ArcGIS with spatial analyst)	1 set
8	Microsoft Office (Operation System)	2 sets
9	GPS (Global Positioning System)	1 set
10	UPS (Urgent Power Supply)	1 set

3. Way Forward

The Expert Team (only Mr. Motoki) will return to Nairobi and continue Project activities with WRA CP in the middle of March 2019. This is the last assignment period for the Expert Team of the Project. Therefore, active CP's active participation would be expected.

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Photos

1． Meetings at WRA Head Office

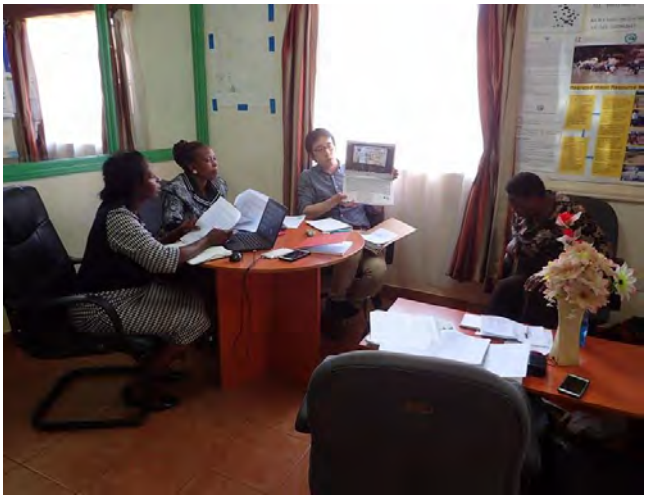
Kick-off Meeting on commencement of the Project (2017/01/18)

Presentation of the Work Plan (2017/03/31)

2． Meetings in the Pilot Area (Tana Catchment)

First meeting at Regional Office (Embu, 2017/01/23)

Three-group Meeting for the Rehabilitation of Gauging Stations (Embu, 2017/09/18)



Explanation of the Project activities
(Mr. Kato, Muranga SRO, 2017/09/28)

Explanation of the Project activities
(Mr. B. Omuya- New Regional Manager, 2018/02/22)

3. Conditions of the Pilot Area

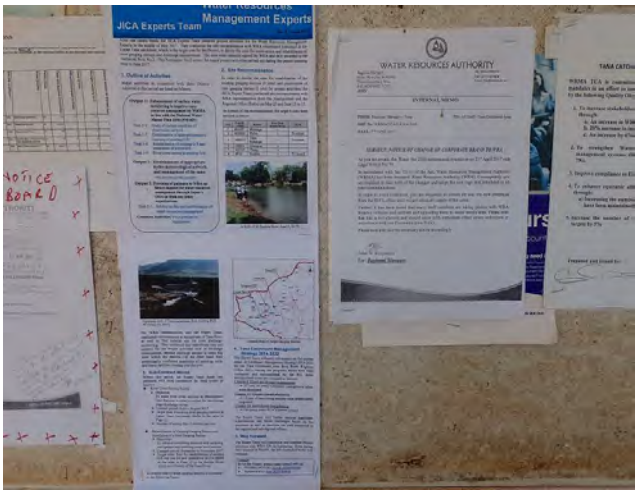
Existing staff gauges (4F13 =along Tana mainstream, 2017/06/14)

A tower to stay cables for discharge measurement
(4F13, 2017/06/14)

Crossing cable for moving a cage (4F13, 2017/06/14)
(No usage for long time)

Tana mainstream (u/s view from 4F13, 2017/06/14)

Tana mainstream (a view from d/s of 4F13 toward u/s, 2017/06/14)



Newsletter No.2 published on the board
(at Embu Regional Office, 2017/09/27)

Gauge house (4BE10: Tana Rukanga, 2017/09/28)

Staff gauges before rehabilitation (4BE10、2017/04/05)

New and old gauge houses (4DD02: Thiba, 2017/10/12)

Staff gauges before rehabilitation (4DD02, 2017/10/12)

Gauge house (4F10: Kathita, 2017/09/27)

Bank erosion in front of gauge house (4F12017/09/27)

4． Sub-contract Works

Bench mark for river cross section survey
(4DD02, 2017/10/12）

Bench mark for river cross section survey
(4F10, 2017/09/27)

Joint site inspection with staff-in-charge of Sub-regional Offices
(4DD02, 2017/09/19)

Joint site inspection with the contractor
(4F10, 2017/10/11)

Completed sign board at gauging stations
(at road side to branching to 4BE10, 2018/02/22)

Steel form and reinforcement bars for construction of a concrete post to fix staff gauge (4BE10, 2018/02/22)

Construction of concrete posts (4BE10, 2018/02/22)

Construction of drain canal (4BE10, 2018/02/22)

Completed concrete post with staff gauge
(4F10, 2018/02/16)

Test of the Data Collector (4F10, 2018/02/16)

５． Procured Equipment for Field Measurement

Staff gauge and propeller-type current meter with rods)
(at office of JICA Expert Team, 2018/02/26)

Water level sensor, data logger and data collector
(at office of JICA Expert Team, 2018/02/26)

6． Rehabilitation of Existing Gauging Stations and Installation of A New Gauging Station

Completed staff gauge posts: 4F10 (2019/03/01)

Completed stairs with hand rail and river bank protection (4F10, 2019/03/01)

Completed signboard (beside a branch road to 4F10)
（2019/03/01）

Completed staff gauge posts (4DD02, 2019/03/02)

Completed staff gauge posts (4BE10, 2019/03/02)

Completed drain canal (4BE10, 2019/03/02)

7． 1st Workshop (Discharge Measurement)

Opening remarks by Mr. L. Thooko (Project Manager) (2019/03/08)

Explanation of data collector (Mr. Motoki, 2019/03/08)

Participants of the 1st Workshop (2019/03/08)

Preparatory works of discharge measurement (assembling rubber boat, 4BE10, 2019/03/09)

Discharge measurement
(test of current meter at 4BE10, 2019/03/09)

Recording of measurement results by each participant (4BE10, 2019/03/09)

8. Discharge Measurements (NARIANA Enterprise Ltd.)

Discharge measurement by float method
(4BE01: Maragua, 2019/06/11)

Discharge measurement by current meter method
(4CC08: Thika, 2019/06/11)

Discharge measurement by current meter method
(4F10: Kathita, 2019/06/12)

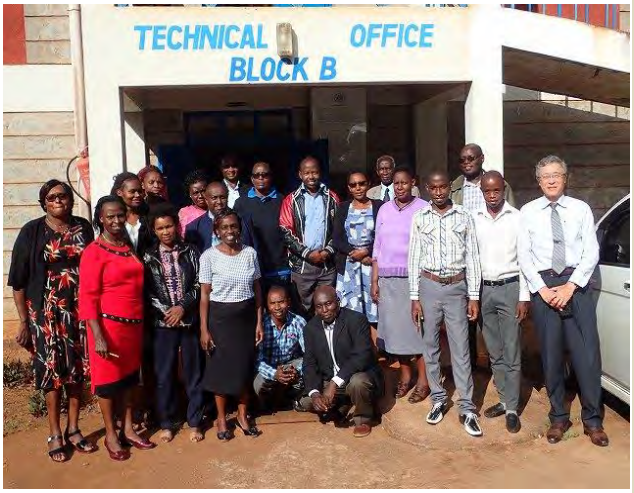
Bank protection works (installed at 4F10 to protect existing gauge house, 2019/06/12）

9. 2nd Workshop (Discharge Measurement)

Opening remarks by Mr. B. Omuya (Regional Manager, Embu, 2019/06/26)

Presentation of the Action Plan by Mr. Gathima (Surface Water Officer, Garissa SRO, 2019/06/27）

Comments on the Action Plans by Ms. J. Kiruri (Project Coordinator, 2019/06/27)



Participants of 2nd Workshop (2019/06/27)

10. Discussions on Enhancement of Data Management at Sub-regional Offices

Muranga Sub-regional Office (2019/09/26)

Kerigiya Sub-regional Office (2019/09/28)

11. Final Meeting at WRA Head Office (Joint Meeting with World Bank Project Team)

Presentation of overall project activities (WRA senior staff, JICA Representatives and Mr. Motoki, 2019/04/09）

Same as left photo