MWI (Ministry of Water and Irrigation)

RV-WSB (Rift Valley Water Services Board)

PREPARATORY SURVEY REPORT
ON THE PROJECT FOR AUGMENTATION OF WATER SUPPLY SYSTEM IN NAROK TOWN IN THE REPUBLIC OF KENYA

December 2012

JAPAN INTERNATIONAL COOPERATION AGENCY

NJS CONSULTANTS CO., LTD.

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SUMMARY

1. Background and Outline of the Project

The government of Kenya (hereafter GoK) sets concrete numerical targets for the fields of tourism, agriculture, water resources, and education, etc. in Kenyan National Development Policy of "Vision 2030". Of the above fields, especially in the field of water supply and sewerage, GoK targets to implement projects for improvement of insufficient water supply amount. The projects include improvement in wide areas which range from rehabilitation of water supply facilities to conservation of water source forests. The Vision represents positive intents to approach the necessity of water supply as national issues.

The current available annual water resource per capita in Kenya is 650m^3, a figure far below 1,000m^3 which is decision criteria for adequate water resource per capita set by UNDP. This figure is threatened to be further reduced to 235m^3 by 2025 owing to rapid population growth. It is imperative that new water resources be developed in tandem with the reduction in Non-revenue Water (NRW) to realize optimal water usage.

Narok Town is situated in front of the world famous Masaimara National Park, and future industrial and tourism development is anticipated. It is regarded as one of 15 towns prioritized for water service development designated in Vision 2030.

Although the existing water supply facilities were expanded three times from 1930s to 1980s, water demand in Narok Town has been rising due to increased influx of tourists (due to proximity to tourism sites), students (due to the presence of large universities) and residents (due to full-scale housing development). Piped water supply covers only 18,000 persons, out of the town's population of 42,505, and the water supply service is not available for 24 hours. Unserved areas are supplied by water tankers. This condition is seen to worsen as demand increases in the future.

Most of the distribution pipes were installed in 1930's, and have become rusty and leaky, contributing to high NRW, which was 54% in 2010. For these reasons, rehabilitation of water supply facilities is urgently needed in Narok Town.

To improve this situation, GoK requested the Government of Japan (hereafter GoJ) for the implementation of water supply system augmentation project through Japanese Grant Aid Scheme on June 2010.

2. Outline of the Survey Results and Project Contents

As a result of the request, GoJ decided on a preparatory survey on the project for augmentation of water supply system in Narok Town, and thereafter, through JICA, sent missions for coming up with an outline design during February to April in 2012, and for the explanation of draft outline design report on October 2012.

Considering the requirements and discussions with GoK, 14 districts are proposed to be the target water service area. The target year for this project is set for 2020, for a population of 49,980, and the total water amount is estimated at 5,000m^3/day.

The design for the water supply facilities is based on the following policies;

I. Facility design shall be carried out based on the Kenyan Practical Manual for Water Supply Services in Kenya, October 2005, MWI. (hereafter "Kenyan Practical Manual")

II. The existing Central WTP is planned to be operated after simple rehabilitation by the combined use of and after the completion of the proposed North WTP.

III. Proposed intake facility is constructed in the distance of 3km from the existing one in the upstream of the Enkare Narok River. Intake water is boosted to the proposed North WTP by intake pumps. In the prpposed intake facility, girt collector and fine mesh screen are equipped to surely protect the inflow of sand and soils and of rubbishes such as floating leaves.

IV. Raw water transmission pipe installation route shall be a linear one, connecting the proposed water intake facility with the proposed North WTP (ϕ200mm×1.5km). The raw water transmission pipe shall be buried under the ground. The raw water transmission pipe material is DI pipe.

V. The proposed North WTP and clear water reservoir shall be constructed at the high elevation area, and basically distribute water to the service area by gravity.

VI. Water treatment process will conform to the WHO drinking water standard and Kenyan water quality standard. The optimum treatment method with minimum required equipment, minimum power requirement, and easy O&M will be selected. Automatic control will be minimized, and plant will be manually operated.

VII. The clear water transmission pipe is a gravity flow system. The clear water is transmitted from the clear water reservoir constructed in the proposed North WTP site to the existing Fanaka high school tank (250mm×3.8km). The pipe route shall be the same as the existing

transmission pipe.

VIII. According to "Kenyan Practical Manual", the capacity of a clear water reservoir is set at 2,000m^3 for 12 hours. The new clear water reservoir shall be constructed in the North WTP site.

IX. The clear water distribute from the clear water reservoir in the proposed North WTP site to water service area in Narok Town by gravity.

Table -1 Outline of the Design

(1) Facilities

Facility	Contents of Facility and Scale
Water Intake Facility	Intake Weir, Grit Chamber, Intake Pump Pit, Intake Pump (1.5m^3/min×102m×45kW×4 units (included 2 stand-by), Control Panel, Flow Meter
Raw Water Transmission Pipe	ϕ 200mm × Length 1.5km (DIP)
Existing Central WTP	Proposed Water Amount: 1,000m^3/day − Rehabilitation: Replacement of Filter Sand, Chemical Dosage Equipment and Chemical Storage House
Proposed North WTP	Proposed Water Amount: 4,000m^3/day − Construction: Receiving Well/ Rapid Mixing Chamber, Flocculation Basin, Sedimentation Tank, Rapid Filter, Rapid Mixing Tank, Elevated Backwash Tank, Drying Bed, Drainage Pond, Chemical House, Operation Building, Generator/ Electrical House, Guard House, Mechanical Equipment, Electrical Equipment, Power Receiving Facility, Chemical Dosing Facility, Clear Water Reservoir
Clear Water Transmission Pipe	North WTP – Fanaka High School Reservoir ϕ 250 mm × Length 3.8 km (DIP)
Distribution Pipe	Distribution Main: ϕ 150mm～300mm × Length 12km (DIP) Distribution Branch: ϕ 50mm～75mm × Length 68km (uPVC/GI)
Reservoir	Existing Reservoir 7units − Rehabilitation: Water Proof Paint

(2) Equipments

Equipment Name	Contents of Equipment and Scale
Materials/ Equipment for House Connection	− House Connection Pipe ϕ 13mm × Length 16km − Water Meter ϕ 13mm…1,600 units − Repair Valve…2 units − Rodding Instrument for Ferrule with Saddle…2 units − Examine Equipment of Water Meter…1 unit
Water Quality Analysis Equipment	− pH Meter…1 units − Turbidity Meter…1 unit − Residual Chlorine Meter…1 unit − Electric Balance Scale…1 unit − Experiment Table…1 unit − Autoclave…1 unit − Incubator…1 unit − Absorption Spectrophotometer…1 unit − Jar Tester…1 unit

	− Refrigerator…1 unit − Pure Water Production Equipment…1 unit − Hot Plate Stirrer…1 unit − Water Bath…1 unit − Fixed Temperature Drying Machine…1 unit − Device to be cool for Chemicals …1 unit − Filtration Equipment for Clarifying…1 set − Portable Type Ultra-sonic Flow Meter…1 lot − Colony Counter…1 unit − Reagent for Spectrophotofluoro Meter…1 lot − Instrument for Water Quality Analysis (Beaker, Pipette, Syringe etc.)…1 set
O&M Equipment	− Computer…5 units − Printer…4 units − UPS (Uninterruptible Power Supply)…4 units

(3) Soft Components

Programe Name	Contents
1. O&M of Water Supply Facility	O&M capacity building for whole water supply system covering water intake facility to house connection facility
2. Upgrading Supervising Capacity for Pipe Installation	Master appropriate construction supervision in the installation of pipe / house connection and water meter.
3. Strengthening Managerial Capacity of Water Supply Undertaking	Business management capacity development by systematic water charge billing/collection and accounting works and by fulfilling customer control and water services

3. Schedule and Cost of the Project

The schedule of implementation shall be five months for the detailed design, three-and-half-months for tendering procedures, 24 months for procurement and construction works are planned. The total number of months including soft components shall be 34 months. The project cost to be borne by the Kenyan side is estimated at 63.89 million yen.

4. Project Evaluation

(1) Relevance

The existing Central WTP capacity is inadequate to supply water to the growing population of the central area of Narok Town. It is also overloaded, thus treated water cannot be assured to match of the service area such as schools, hospitals, households and so on. This is aggravated by numerous leaks in the old pipelines. Furthermore, the town has pockets of unserved areas.

Since significant project benefits on water supply service in Narok Town is expected and this project broadly contributes to residents' BHN upgrading, project implementation through Japanese Grant Aid scheme is judged as appropriate for the following reasons:

i) Narok Town is located very close to the world famous Masaimara National Park, therefore industry and tourism is expected to grow. It has also been nominated as one of 15 cities prioritized for water supply system development in Vision 2030.

ii) In 2008, national road B3 was connected to Masaimara National Park. The construction of housing units has been rapidly on-going, with the attendant increase in population in the area.

iii) Currently, there is not 24 hours water supply service, and water supply hours are uncertain.

iv) Fetching of water is mainly performed by women and children, and has become a huge burden, since water service area is limited, even if there is water supplied by KIOSKs.

v) The existing Central WTP produces water beyond its capacity, so the water quality of treated water is compromised.

vi) Advancing Narok universities and some schools in Narok Town remarkably.

vii) Since the existing Central WTP and reservoirs are still available, a full package water supply system is not required, thereby reducing and construction cost.

viii) Since schools, hospitals and houses are concentrated in the centre of Narok Town, the length of distribution pipelines for the project is reduced, leading to substantial savings.

ix) There is no foreseen technical problem because target water supply facilities are of the same type and same method with that applied in the local water supply system. Furthermore, procured materials and equipment are indispensable to achieve the target water service ratio.

x) Only the cost needed for O&M is covered by water tariff income and thus, this project will not be a big burden to water consumers.

xi) Minimum environmental impact is foreseen during construction works and system operation.

xii) Smooth project implementation through Japanese Grant Aid scheme is feasible.

(2) Effectiveness

<Quantity Effectiveness>

Indices	At Present (2012)	Target Year (2020)
Served Population	18,000 person *1)	49,980 person
Supply Amount	2,000m^3/day *2)	5,000m^3/day

*1): Current served population. But water supply is unstable and water service time is not regularly.

*2): Current water supply amount. But water is treated beyond its design capacity, resulting to water quality that does not conform to standards

<Qualitative Effectiveness>

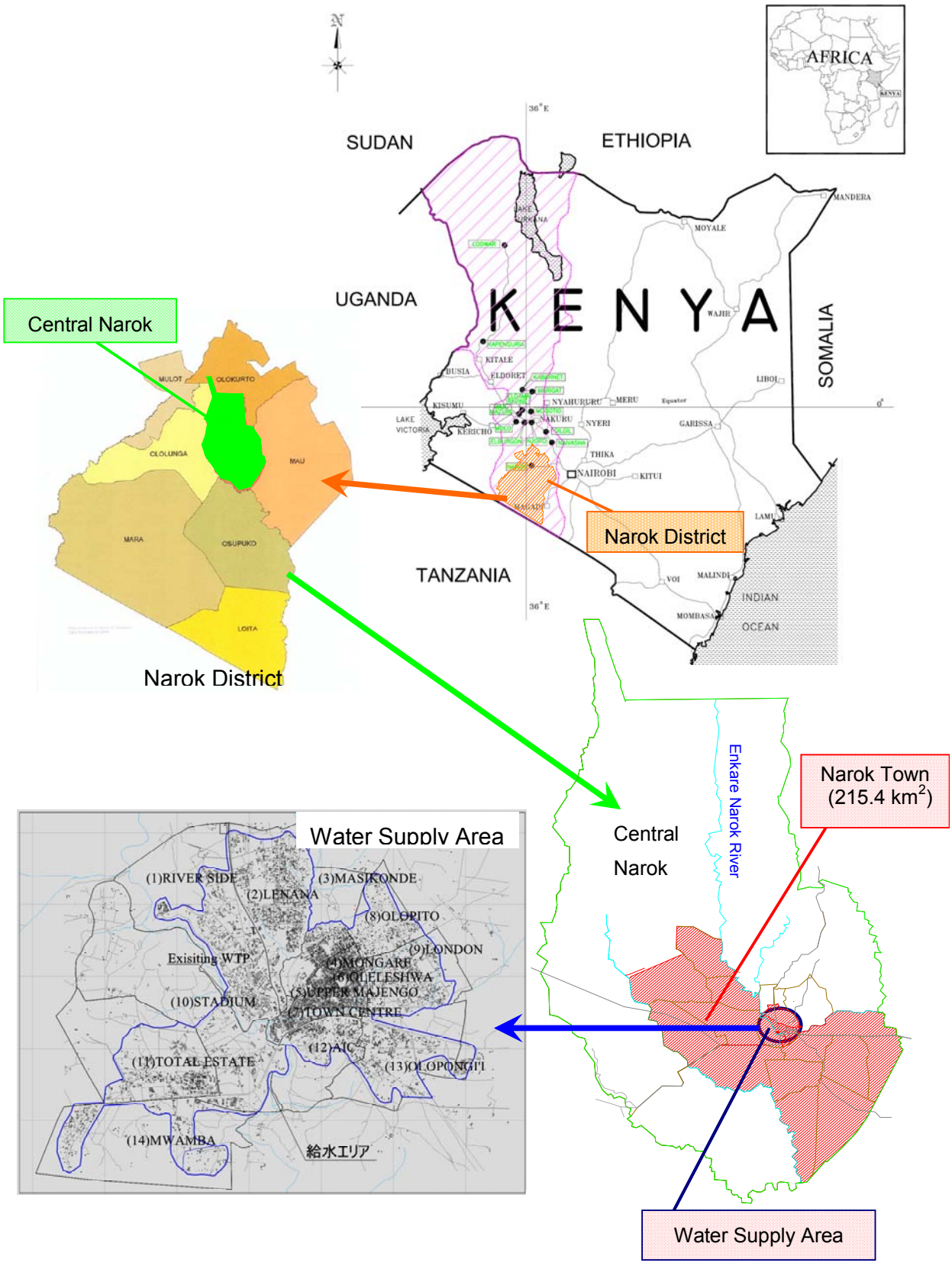
Current Status and Issues	Countermeasures to be implemented by this Project	Project Effects
A：Direct Effects		

Current Status and Issues	Countermeasures to be implemented by this Project	Project Effects
(1) Water supply capacity ・Water supply capacity is extremely deficient compared with water demand	・Construction of the proposed North WTP ・Construction of the new clear water reservoir (2,000m^3) within North WTP premises as clear water reservoir ・Installation of distribution pipe (80km)	・Water amount equivalent to water demand can be supplied by distribution pipe installation
(2) Stable water supply ・Currently, 24 hours water supply is not performed and water supply hours are uncertain	・Construction of new WTP with sufficient capacity ・Construction of reservoir and distribution pipe to system augmentation	・24 hours water supply is available.
(3) Water quality ・Operation of the existing Central WTP in overloaded, treated water quality is below potable water standard ・Proper water quality control has not been practiced	・Construction of new WTP where adequate water treatment is possible ・Construct the chemical house and procure chemical dosage equipment for the existing Central WTP ・O&M upgrading through Soft Component	・Supplied water quality is to be improved by construction of new WTP and repair/ and O&M capacity upgrading of the existing Central WTP
(4) NRW measure / water charge collection ・According to current water service, registered house connections number 2,131 but water charge is collected from only 1,175 which has negatively affected financial health of the water system. ・NRW rate is high. Improvement shall be required	・Procurement of water meters and house connection pipes ・NRW rate is to be reduced by laying of new distribution pipes	・Increasing water income and amount ・NRW reduction, proper water charge billing/collection by water meter installation stabilize managerial status of NARWASSCO
B：Indirect Effects		
(1) Water-borne diseases ・Safe and sanitary potable water supply has not been secured or is insufficient and this causes high morbidity due to water-borne diseases	―	・Stable supply of safe and sanitary potable water supply will contribute to the reduction of water-borne diseases morbidity, such as Diarrhea, Typhoid and Cholera
(2) Water fetching labor ・Water fetching labor is mainly performed by women and children and this becomes a huge burden	―	・Water fetching labor will be mitigated by house connection

Current Status and Issues	Countermeasures to be implemented by this Project	Project Effects
(3) Effect of global warming ・ Intensity of rainfall fluctuation, drought might increase by climate change caused by global warming	—	・ By completion of this project, safe and stable water supply is realized and social adaptability against climate change is improved

PREPARATORY SURVEY ON THE PROJECT
FOR AUGMENTATION OF WATER SUPPLY SYSTEM
IN NAROK TOWN IN THE REPUBLIC OF KENYA

【Appendix】



Location Map

Architect's Conception of the finished building（North Water Treatment Plant）

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Abbreviations

AC Pipe:	Asbestos Pipe
AfDB:	African Development Bank
AFD:	Agence française de développement
A/P:	Authorization to Pay
B/A:	Banking Arrangement
BHN:	Basic Human Needs
CAAC:	Area Advisory Committees
DANIDA:	Denmark International Development Assistance
dB:	Decibel
DI Pipe:	Ductail Iron Pipe
EAC:	East African Community
EIA:	Environmental Impact Assessment
EMP:	Environmental Management Plan
E/N:	Exchange of Notes
F/S:	Feasibility Study
GDP:	Gross Domestic Product
GI Pipe	Galvanized Iron Pipe
GPS:	Global Positioning System
GTZ:	Deutsche Gesellschaft fur Technische Zusammenarbeit
GNI:	Gross National Income
HDPE Pipe:	High Density Polyethilene Pipe
HWL:	High Water Level
IEE:	Initial Environmental Evaluation
JICA:	Japan International Cooperation Agency
KENHA:	Kenya Highway Authority
KeRRA:	Kenya Rural Road Authority
KURA:	Kenya Urban Road Authority
KfW:	Kreditanstalt fur Wiederaufbau
Kshs:	Kenyan Shilling
KVA:	Kilowwatt-Voltage-Ampere
KWh:	Kilowatt-hour
Laeq	Equivalent Sound Level
LPCD:	Litter per Capital Day
LWL:	Low Water Level
RV-WSB:	Rift Valley Water Services Board
M/D:	Minutes of Discussion
MWI:	Ministry of Water and Irrigation
NEMA:	National Environment Management Authority
NWRMS:	National Water Resources Management Strategy

NWCPC:	National Water Conservation and Pipeline Corporation
NARWASSCO:	Narok Water and Sanitation Company
NEMA:	National Environment and Management Authority
M/M:	Man Month
NGO:	Nongovernmental Organization
NRW:	Non-revenue Water
ODA:	Official Development Assistance
OECD:	Organization for Economic Cooperation and Development
Q:	Quantity
RVWSB:	Rift Valley Water Service Board
SIDA:	Swedish International Development Agency
TOR:	Terms of Reference
TSS:	Total Suspended Solid
VAT:	Value-Added Tax
V:	Velocity
UNDP:	United Nations Development Program
UNICEF:	United Nations Children's Fund
uPVC Pipe:	Unplasticized Polyvinyl Chloride Pipe
US$:	US Dollar
WAB:	Water Appeal Board
WHO:	World Health Organization
WRMA:	Water Resources Management Authority
WRUA:	Water Resources Users Association
WSRB:	Water Services Regulatory Board
WSTF:	Water Services Trust Fund
WSB:	Water Services Board
WSP:	Water Services Provider
WTP:	Water Treatment Plant

Chapter 1

Background of the Project

Chapter 1 Background of the Project

1-1 Background and Outline of Grant Aid Request

The current available annual water resource per capita in Kenya is 650m^3, a figure far below 1,000m^3 which is decision criteria for adequate water resource per capita set by UNDP. This figure is threatened to be further reduced to 235m^3 by 2025 owing to rapid population growth. It is, imperative that new water resources be developed in tandem with the reduction in Non-revenue Water (NRW) to realize optimal water usage. The followings are the major objectives of the sector based on Vision 2030, Kenyan National Development Policy:

1. Water supply and sanitary condition upgrading are one of the most significant development objectives
2. Improve water service ratio in rural areas from 40% to 59%
3. Reduce NRW rate from 60% to 30%

Narok Town is the capital of Narok North District, Rift Valley State and is located 140km west of the national capital, Nairobi, where the African Rift Valley exists. Based on 2009 Census, the population of Narok stands at 42,505, and the land area is 215km^2. Narok Town is situated in front of the world famous Masaimara National Park, and future industrial and tourism development is anticipated. It is regarded as one of 15 towns prioritized for water service development designated in Vision 2030.

Although the existing water supply facilities were expanded three times from 1930s to 1980s, water demand in Narok Town has been rising due to increased influx of tourists (due to proximity to tourism sites), students (due to the presence of large universities) and residents (due to full-scale housing development). Current capacity is 1,500m^3/day from the design capacity of 2,400m^3/day due to the aging and deterioration of its facilities. As most of distribution pipes were installed in 1930's, these are old, rusty and leaky, and pipe degradation has had negative effects on NRW, which is a high 54% *[2] in 2010.

To improve the situation, Government of Kenya (hereafter GoK) requested the Government of Japan (hereafter GoJ) for the implementation of water supply system augmentation project comprised of construction of intake weir and reservoir, rehabilitation of the existing Central WTP, and installation of transmission and distribution pipes through Japanese Grant Aid Scheme on June 2010.

Majengo Area, one of the study areas proposed by this project is also selected as project site by on-going Japanese Technical Cooperation Project called "NRW Control Project" to be completed on October 2014. The objectives proposed in the "Pilot Project" are:

① Supervise the execution of NRW reduction measure and implement structure development

*[2] "Strategy Plan 2010－2015" and "Bussiness Plan 2010-2015", NARWASSCO

② Replace distribution branches to reduce NRW by leakage

③ Install house connection pipes and water meters

Synergy effect can be expected by hardware development through this project.

Table 1-1-1 Contents of the Request

No.	Components	Specifications	Quantity
Facility Construction			
1	Construction of Intake Weir		1 unit
2	Installation of Conveyance Pipe	ϕ 200mm	3km
3	Rehabilitation of WTP	2,500m^3/day	1 set
4	Provision of Transmission Pumps and construction of Pump House		1 unit
5	Installation of Transmission Pipe	ϕ 150mm	2.6km
6	Construction of Reservoir	2,500m^3	1 unit
7	Rehabilitation of Reservoir		4 units
8	Installation of Distribution Pipes including Water Meters		25km
9	Construction of Chemical Storage Room and Laboratory		1 set
10	Construction of Generator Room		1 set
11	Additional construction of Staff Office		1 set
Equipment Procurement			
1	Chemical injection equipment and water quality analysis equipment		1 Lot
2	Generator as stand-by power	250 kVA	1 Lot
3	Computer and Printer		1 Lot

1-2 Natural Conditions

(1) Topography

Narok Town is located on the west end plateau of rift valley running through Kenya from north to south. There is vast and plain grassland in mountainous areas within rift valley and there are old volcanoes in various sizes. Narok Town is the confluent point of Kakiya Valley and Sampurupuru Valley, where also limpid stream of the Enkare Narok River flows in. Discontinuous heights with elevations of 1,800m to 1,960m range within semiarid savannah area with grasses and bushes.

Narok Town is composed of a plateau with lava and volcano ashes. The central area was eroded by river flow and the ground has temperate slope heading to south-west. Due to this natural ground slope, storm water drainage is favorable. Since quarrying is active here, many quarries exist within the town boundary.

(2) Geology

Several lava flows found in plain grassland in rift valley have formed a lava plateau. Production age

of these volcanoes, lava and volcano ash is relatively young and they were produced in Cenozoic the Neogene ages.

Geology of ground surface in study areas is reddish-brown or gray-brown lateritic soil, weathered salty or clayish fine grained soil and below this soil layer, volcanic eject range as tuff, breccias tuff and welded tuff. Tuff is exposed at basaltic lava, river side and roads. Heavy weathering was observed in tuff near the ground surface. Elevation of the Enkare Narok River bed is lower than 80m from surrounding ground level due to river flow erosion and exposed basaltic lava. These igneous rocks were formed in Cenozoic Quarterly, younger than rift valley.

(3) Climate

Figure 1-2-1 shows the monthly average rainfall, maximum and minimum temperature recorded at Narok Town meteorological weather station during the past 11 years, or from 2001 to 2011. Annual average rainfall is 786mm and according to Kenyan Agricultural Climate Division, specified by Patt and Gwynne in 1997, Narok Town belongs to sub-humid climate area.

There are two rainy seasons in a year. Average maximum rainfall of 93mm is recorded during January to May, and second average rainfall of 56mm is recorded during August to December. Meanwhile, average minimum rainfall of 16mm is recorded during June to July.

In general, long intense rainfall with thunder has been recognized mainly during the night, but short rainfall is relatively temperate and mostly occurs during early evening time. Temperature tends to be lower during dry seasons and higher during wet seasons. Although the annual average temperature difference between dry season and rainy season is around 4℃, the difference between the maximum and the minimum temperature is 17.1℃. This is due to the ground elevation of Narok Town. Since the town is situated in the highlands, with an elevation of 1,950m, temperature falls in the morning and evening time. While temperature rises during daytime due to sunshine, such climate condition contributes to large temperature differences. Matching these climate divisions, there is specific types of vegetation in the area.

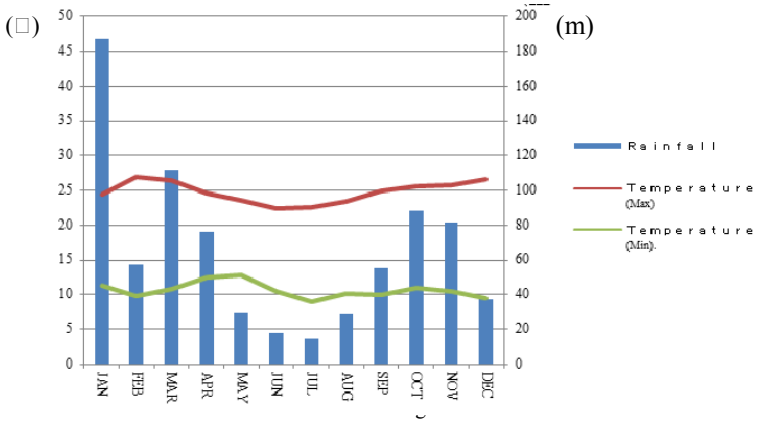


Figure 1-2-1 Monthly Rainfall, Highest and Lowest Temperature

(4) Water Quality

The five water quality samples taken and analyzed at public water quality analysis laboratory are as follows:

① Raw water at existing intake facility (fine day and rainy day)
② River water of proposed water intake point (fine day and rainy day)
③ Treated water at the existing Central WTP

1) Raw Water Quality

Raw water samples were taken at the existing intake point and at the proposed water intake point located upstream of the existing Central WTP. Samples were taken twice, once during fine weather, and another during a rainy day, and then were subsequently analyzed. Refer to **Table 1-2-1**. According to the results, Fe concentration at the existing and proposed intake points during fine weather were 2.5mg/L and 2.7mg/L, respectively, and these exceed the standard value of 1.5 mg/L stated in the WHO Guideline. Furthermore, high concentrations of turbidity and color (supposed to be derived from Fe and Mn) were observed at both existing and proposed intake points. The concentrations were higher in rainy weather where turbidity of 660 NTU and 1,450 NTU, color of 8,850 TCU and 3,625 TCU were recorded. Concentrations of domestic pollutants, such as N and P were not remarkable. Water quality at the proposed water intake point located upstream of the existing one was slightly better, but this may not influence treatment cost.

2) Treated Water Quality

A sample of treated water at the existing Central WTP was taken and analyzed. As to turbidity and color of the treated water, these were 19 NTU and 57 TCU respectively, several times higher than the WHO Guideline standard values of 5 NTU and 15 TCU. Although E-Coli and Fecal-Coli were detected in raw water, these were not observed in the WTP treated water. The detected residual chlorine concentration was 0.5mg/L, which is equivalent to upper limit of Kenyan potable water standard. This means chlorine disinfection has been practiced satisfactorily. As to F concentration,

since igneous rock such as lava and tuff of Rift Valley are dispersed in Narok Town area, it can be assumed that F contained in the igneous rock has seeped into the groundwater. High EC, (higher than other river water) also confirms the said F seepage. However, F concentrations were 4.55mg/L for raw water, less than 0.4mg/L in treated water at the WTP and 0.47mg/L in KIOSK faucets. As Fluorine was duly removed by coagulant absorption, Fluorine content will not be a serious issue as far as coagulated sedimentation is being conducted properly. Therefore, the establishment of water treatment system to remove Fluorine is needed.

Table 1-2-1 Results of Water Quality Analysis conducted during Field Survey (Raw Water and Central WTP Treated Water)

Samples	Existing Water Intake Point		Proposed Water Intake Point		Existing Central WTP							WHO Guideline	Kenyan Potable Water Standard	Kenyan Allowable Limit
	Fine Day	Rainy day	Fine Day	Rainy day										
Sampling Water	River water		River water		Raw water		After sedimentation		After filtration		Treated water			
Sampling Day	2012.3.3	2012.3.19	2012.3.3	2012.3.19	2012.2.29	2012.3.6	2012.2.29	2012.3.6	2012.2.29	2012.3.6	2012.3.3	—	—	—
Sampling & Analysis	SC	SC	SC	SC	JST	JST	JST	JST	JST	JST	SC	—	—	—
pH	8.0	7.8	8.0	7.7	8.5	>7.6	7.1	7.0	7.3	7.2	7.4	—	6.5-8.5	6.5-9.2
EC (μS/cm)	42	0.028	43	0.035	408	347	425	370	446	377	44	—	—	—
Turbidity (NTU)	43	1450	40	660	29.7	117	12.2	33	14	28.5	19	5	5	25
Color (TCU)	85	8850	83	3625	116	355	61	138	53	132	57	15	15	50
COD (mg/L)	128	380	64	300							32	—	—	—
Total Hardness (mg/L)	56	40	52	35							49	500	500	—
Ammonium (mg/L)	0.39	16.5	0.26	6							0.28	—	0.5 (as N)	—
Nitrite (mg/L)	0.6	2.32	0.5	1.7							0.4	3	—	—
Nitrate (mg/L)	2	—	3	—							3	50	50	—
P (mg/L)	<0.1	—	<0.1	—							<0.1	—	—	—
F (mg/L)	2.5	<1	2.7	<1	1.5	1.5	<0.4	<0.4	<0.4	-	2.5	1.5	1.5	—
Fe (mg/L)	1	3.6	0.8	1.35	<0.2		<0.2		<0.2		0.6	0.3	0.3	1.0
Mn (mg/L)	5	1.13	0.2	0.67	<0.5		<0.5		<0.5		0.1	0.4	0.1	0.5
Cu (mg/L)	0.027	<0.004	0.033	<0.004							<0.004	2	0.1	1.5
As (mg/L)	0	0.003	0	0.011							0	0.01	0.05	—
Residual Chlorine (g/L)	0.4	0	0.3	0							0.5	5	0.2-0.5	—
E-Coli (MPN/mL)	130	800	17	170							0	ND	ND	—
Fecal Coli (MPN/mL)	36	280	41	33							0	ND	ND	—

SC: Subcontract, JST: JICA Study Team, ND: Not Ditected

3) Water Truck, KIOSK, Yard Tap, House Connection

The results of water quality analysis conducted in water service system such as water truck, KIOSK, yard tap and house connection and hotels are shown in **Table 1-2-2**.

① All measured pH values are within the Kenyan standard (6.5-9.2) but values of large scale consumers, namely Season Hotel, Kenol Petrol Station, Maralink Hotel, St.Mary's School are relatively high.

② As to Turbidity, four samples were within Kenyan standard of 25NTU, seven samples exceeded the limit, and six samples exceeded the color limit of 50 TCU.

③ E-Coliform was not detected in the Maralink Hotel sample, but was detected in all other samples. Contamination is possible in water delivery process.

④ Fecal Coli form was not detected in the water truck sample, but was detected in all other samples. Since values measured in samples of KIOSK and yard taps were high, contamination in water delivery process is doubtful, which is the same as in the E-Coli case.

⑤Though Kenyan standard for residual chlorine is 0.2-0.5mg/L, measured values of house connection samples were less than 0.2mg/L.

Table 1-2-2 Results of Water Quality Analysis（Water Truck, KIOSK, Yard Tap, House Connection and Hotels）

Samples	Water Truck	KIOSK			Yard Tap		House Connection					WHO Guideline	Kenyan Potable Water Standard	Kenyan Allowable Limit
		No1	No5	No7	Sosotua	Osotua	Teacher Training Center	Seasons Hotel	Kenol Petrol Station	Maralink Hotel	St. Mary's Primary School			
Sampling Day	2012.3.20	2012.3.8	2012.3.20	2012.3.20	2012.3.8	2012.3.20	2012.3.20	2012.3.20	2012.3.20	2012.3.20	2012.3.20	－	－	－
pH	7.3	7.6	7.7	7.7	7.4	7.6	7.4	8.2	8.1	8.3	7.9	－	6.5-8.5	6.5-9.2
Turbidity (NTU)	65	39	660	660	28	181	26	26	65	5	25	5	5	25
Color (TCU)	30	59	3625	3625	43	90	70	190	380	22	135	15	15	50
Residual Chlorine (mg/L)	0.3	－	0	0	0.4	0.5	0.3	<0.2	<0.2	<0.2	<0.2	5	0.2-0.5	－
E-Coli (MPN/mL)	4	－	170	170	13	－	80	22	90	0	60	not detected	not detected	－
Fecal Coli (MPN/mL)	0	－	33	33	27	133	38	－	－	－	－	not detected	not detected	－

1-3 Environmental and Social Considerations

The Project is categorized as Category B because its implementation has been judged not to have a big impact on the environment. The project also adheres to the Guidelines for Environmental and Social Considerations (enacted on April 2010) by JICA. In addition to the environmental and social impact assessment in the project's implementation, the study proposes to support an implementation organization that will finalize environmental checklists and undertake monitoring based on the plans for project implementation.

1-3-1 Environmental Impact Assessment

1-3-1-1 Laws and Regulations on Environmental and Social Considerations in Kenya

(1) Progress of EIA Procedures

The JICA study team handed over the outlines of facility plans and results of environmental and social consideration study to NEMA registered local engineers and the local engineers finalized "the Project Report".

NARWASSCO submitted 10 copies of the Project Report to NEMA on June 6, 2012. As a result of reviewing the Project Report, NEMA is satisfied with the contents of the Project Report as EIA report. NEMA intends to issue EIA approval after payment of the EIA license fee by RVWSB by November 2012.

NEMA accepted the Project Report as an EIA report and will grant an EIA approval to NARWASSCO after payment of EIA license fee by RV-WSB. RV-WSB had already paid EIA license fee on October 5, 2012. So, the final approval from NEMA will be issued soon.

(2) Progress of Water Rights Permission Procedures

The Authorization letter for water rights (Water Permit No. WRMA/20/NAR/2KR/1/S) was issued by WRMA to NARWASSCO on May 9, 2012 and the authorized intake amount for the Project was set at 5,000 m^3/day.

Subsequent to the authorization letter, the application of water rights is generally conducted. However, since its application needs a copy of EIA license, it shall be conducted at post-EIA approval. The procedures of EIA approval need the period of about six months. Thus, issuance of water rights is supposed to be after completion of this study. Permission of water rights will be needed if the Project operates new water supply system and supplies drinking water to users.

EIA approval is intended to be issued by the end of November of 2012 by NEMA and upon issuance of the EIA license, application for water right of 5,000 m^3/day for the Project can be commenced by RV-WSB. RV-WSB shall take a necessary action to acquire the water right of 5,000m^3/day after issuance of the EIA license.

1-3-1-2 Zero Option

As described in **2-2-2** Basic Plan, based on the comparison study on three alternatives of Narok Town water supply system augmentation, Alternative Plan 3, or the plan to construct Intake Facility, WTP and Reservoir 5 km upstream of the existing Central WTP, was adopted.

Zero option presumes that Alternative Plan 3 selected for the Project is not implemented in the future and the existing water supply system is kept without major improvement. The project area in Narok Town is composed of 14 estates, which have a combined area of 20.36 km^2 and a total population of about 36,000, as of the current National Census value of 2009. In the target year of 2020, the population is estimated to grow to 49,980. Of these 14 estates, distribution pipelines are presently installed only in a part of central area of Narok Town. Furthermore, the water supply conditions are in need of improvement due to age and deterioration. **Table 1-3-1** shows water supply area and supply conditions in Narok Town.

Table 1-3-1 Water Supply Area and Supply Condition in Narok Town

No	Estate Name	Area (km^2)	Population in 2009	Ratio of Supply Area by Distribution Pipelines (%)	Water Supply Condition
(1)	River Side	3.01	2,631	1	Distribution pipelines are almost not installed.
(2)	Lenana	1.75	3,694	20	Distribution pipelines are installed in only 20 % of total area.
(3)	Masikonde	1.07	4,732	5	Distribution pipelines are installed in only 5 % of the estate.
(4)	Mongare	0.17	4,420	5	-Ditto-
(5)	Upper Majengo	0.12	2,909	100	Distribution pipelines are installed in all the area of the estate. The housing complex often depends on supply by Kiosk.
(6)	Oleleshwa	0.24	5,232	100	-Ditto-
(7)	Town Center	0.35	2,387	100	-Ditto-
(8)	Olopito	0.75	1,129	-	No distribution pipelines
(9)	London	1.20	2,097	-	-Ditto-
(10)	Stadium	3.48	1,378	5	Distribution pipelines are installed in only 5 % of the estate.
(11)	Total Estate	2.37	2,512	5	-Ditto-
(12)	AIC	1.12	935	-	No distribution pipelines
(13)	Olpopongi	1.82	1,793	-	-Ditto-

(14)	Mwamba	2.91	1,109	-	-Ditto-
Total		20.36	36,978		

In areas where distribution pipelines are not presently installed, residents obtain domestic water from Kiosks or purchasing from water sellers. In case of purchasing from water sellers, water charge is several times higher than that charged by water supply and Kiosks and high cost becomes a burden to the residents. In addition, if the area has distribution pipelines for water supply, its supply condition is unsatisfactory both in terms of quality and quantity, as the existing Central WTP supplies muddy water for water supply because floc is not completely removed due to the overloading of operational capacity in the WTP to treat 2,000 m^3/day versus design capacity of 1,500 m^3/day.

If the Project is not implemented and current water supply conditions are not improved, and only the existing WTP is utilized, the result will be the following: 1) Overloaded operation of the existing WTP will worsen affecting both water quality and quantity that may cause continued unreliable water service and increased incidence of waterborne diseases; 2) Hygienic environment in Narok Town will turn from bad to worse because water supply cannot keep up with future population growth; 3) The burden of fetching water from kiosks will not be lifted from females and children; and 4) The areas currently without water supply will not enjoy the benefits of piped water in the future.

Based on the above reasons, zero option is not recommended because it leads to the degradation of living standard by the worsening of hygienic and social environments in the areas.

1-3-1-3 Survey Results of Environmental and Social Considerations

Table 1-3-2 Survey Results of Environmental and Social Considerations

No	Environmental Impact	Survey Result of Environmental and Social Considerations
1	Air pollution	U-Const: Proposed construction site for new WTP is located in wide area of public lands (shrub), and in the surrounding area, there are no residential houses. Thus, air pollution which is caused by the operation of construction machineries will not give significant impact to environment.
2	Water pollution	U-Const: Planned intake weir is constructed in the river channel and water pollution may be caused more and less due to drain water during construction works. However, since volcanic rocks are distributed over the entire river bank in the proposed sites, the weir is constructed by foundation works using breaker and others. Thus, if its construction works are conducted carefully not to discharge earth and sand, it may be able to protect water pollution to some degree. In order to protect discharge of earth and sand, sand bags shall be piled when flowing channel is changed, and silt trap net shall be set up to protect discharge of sediment toward the downstream. In order to protect sediment discharge during the raining season, installation works of transmission pipelines and construction works of new WTP, drain water needs to be discharged after sedimentation of earth and sand by storing of discharge water in drain ponds.
3	Waste	U-Const: Excavation surplus soils and waste materials generated during pipe laying can be disposed without charge in Narok Town's general waste dumping site (quarry disposal site: 5 acre (20.234 m^2) and adjacent area: 250 acre (1,011.71 m^2)) . Operating: The study revealed that sludge contained fluorine of more than two percent in

No	Environmental Impact	Survey Result of Environmental and Social Considerations
		weight. This fluorine is derived from water quality of the river. Though treated water is safe because most part (94%) of fluorine in raw water is removed in water treatment, removed fluorine is condensed in sludge. According to environmental law, sand and soils, which contain fluoride concentration more than 1 percent, must be disposed as hazardous waste and by NEMA registered contractor. However, as Kenyan country has no sanitary landfills and other facilities for hazardous waste, NARWASSCO is planned to select two candidate disposal sites by discussion with NEMA so as not to have not large impact to environment.
4	Soil contamination	U-Const: Soil contamination caused by spill and discharge of oil and grease can be protected if contractor conducts construction works with care. As the project plans to employ an environmental safety officer for environmental monitoring and management, he has to establish environmental management plans to manage environmental conditions and not to cause soil contamination.
5	Noise and vibration	U-Const: As in the proposed construction site for new WTP, there is hard support base several meters below ground and WTP buildings are directly supported by spread foundation, thus, piling works need not to be conducted. Thus, large noise and vibration will not be caused during construction stage. In addition, hard rock outcroped at the construction site of intake facility is crushed by using breaker and others. It shall not cause serious noise issues as there are no residential houses in the distance within 500 m from the proposed construction site. As in laying works of pipeline, Environmental and Management Coordination Regulations (noise and excessive vibration pollution) control the maximum permissible noise level in nighttime to be 35 dB, which is a very severe value, the pipe laying works should be conducted in the daytime (6:01-20:00). Outside the residential area, maximum permissible noise level in the daytime is 50 dB, so small excavators and manual excavations are recommended. In addition, as its maximum noise level in silent zone such as places of worship is 40 dB, manual excavation for pipe laying is recommended. Operating: The result of the of combined noise levels based on the layout plan of machines and equipment in planned WTP and on the magnitude of sound levels in noise sources, it is clear that there will be no noise generated. In addition, excess vibration by operation of machines and equipment does not generate large issues due to attachment of vibration protection device to them.
6	Existing social infra and social service	U-Const: In the pipe laying works at crowded roads in Narok Town, traffic jam is supposed to be caused. In Kenya, there are no regulations concerning traffic control in roads. Though road control authorities regulate necessity of work permission at roads, they do not have any written guidelines for road control and persons in charge of work permission judge by themselves and issue work permission at roads. Thus, contractor must propose prevention plans of traffic accidents and jam when they apply work permission at roads. Prevention plans of traffic accidents and jam are to set up sign posts for construction works, to enclose the areas by tapes, to arrange watchmen and security guards, and in the night time, to set up electric signal devices to indicate construction spots. The contractor must conduct sufficient safety countermeasures. In addition, the contractor must conduct pipe laying works only on one side of the roads and set up guide-paths not to interrupt traffic of vehicles and passers-by and watchmen must guide safely the passers-by and control traffic.
7	Infectious diseases of HIV/AIDS	U-Const: Contractor must enhance their consciousness of incoming labors by conducting explanatory sessions for hazardous nature of pathogenesis of infectious diseases of HIV/AIDS and on its protection manners before the starting of construction works or at any necessary any time against incoming labors into Narok Town.
8	Work environment	U-Const: Safety management of labors at construction site "Occupational Safety and Health Act, (2007)" regulates that employer or occupier of work places must ensure the safety of employees' works and employees have to put on preventive equipment and clothes. Thus, safety management officer with contractor's project manager and site manager always establishes environmental safety management plans and must control safety management against employees. Operating: The same to the above on "Occupational Safety and Health Act, (2007)".

No	Environmental Impact	Survey Result of Environmental and Social Considerations
		NARWASSCO must instruct and enforce safety management to the employees when they operate new water supply system.
9	Accidents	U-Const: Protection of traffic accidents against pedestrians and passing vehicles during pipe laying works on roads In case that pipe laying works are conducted in heavy traffic roads, contractor should get work permission from KENHA and KeRRA in advance by submitting work layout plans and work schedules. Since KENHA prohibits to block traffic on national roads B3 and C 57 which have heavy traffic due to important roads, pipe laying works must be conduct carefully in the road side and enough safety countermeasures such as placement of watchmen with enclosed tapes and markers and posts, especially electrical lamp signals during nighttime must be arranged in order not to cause accidents to the workers. Contractor should set up guide-paths not to cause interference to pedestrians and put watchmen for safely controlling traffic and passers-by.
10	Trans-boundary impact and climate change	Operating: *Protection of Aquatic Ecology in the River* The Enkare Narok river empties into Lake Natron which is located about 120 km away from Narok Town. Lake Natron is a registration site of Ram Sar Convention and is of flamingo habitat. If backwashing water including high concentration of chlorine is discharged, there is almost no impact to the habitat because Lake Natron is located in very far place. However, it directly drains to the river; and there may be impact on aquatic ecology in the natural river. Thus, drain water is stored one time in a drain pond to release chlorine naturally to the atmosphere, then water is drained to the river. *Climate Change* ● Climate Change and Significance of Implementation of the Project Recently, in Kenya, drought and flooding has tendency to occur more frequently. The implementation of the Project shall improve intermittent water supply and overloaded operation of existing WTP, and will realize stable water supply even in the dry seasons. The implementation of the Project shall alleviate impact against climate change, which includes the recent drought. It will also give positive social impact in Narok Town. ● Impact to Climate Change by Implementation of the Project, Itself The implementation of the project sees no positive impact on climate change because the operation of new facilities adversely consumes commercial electric power. The electric power generator will release bicarbonate to environment. Its consumable electric charge is 119.5 KWh and bicarbonate gas exhaust is estimated to be about 48.1 CO2 tons/ month, or about 585.2 CO2 tons/year.

1-3-1-4 Environmental Impact Assessment

(1) Adverse Impact and Mitigation Measures at Construction Stage

Adverse impact and mitigation measures against environment at construction stage are shown in **Table 1-3-3.**

Table 1-3-3 Adverse Impact and Mitigation Measures at Construction Stage

No	Adverse Impact	Mitigation Measures	Relating Regulation and Organization
1	Soil erosion by land cut and fill, and temporary sedimentation of natural waterways	To plan carefully construction schedule. To maintain stable slope of filled surface. To avoid unnecessary exposure of soil by excavation. To create and protect discharge passage by piling of sand bag or other suitable manners during construction of weir in the river.	Environmental Management and Coordination Act, (1999), NEMA

No	Adverse Impact	Mitigation Measures	Relating Regulation and Organization
		To conduct adequate compaction of filled slope surface. To conduct vegetation (grass) on erodible surface (especially filled areas) as soon as possible.	
2	Adverse impact on surface hydrology	To avoid discharge of surface water with high turbidity to stream by earthworks activities during construction stage, it should be firstly drained to the sedimentation pond, and after other sedimentation of soils, supernatant water is discharged to the stream. In case of high turbidity in supernatant water, silt trap device to reduce its concentration shall be used.	-Ditto-
3	Ground and surface water contamination by oil, grease and fuel	To avoid setting up of construction machines near flowing and drainage channel. Safety disposal and storage of grease etc. To clean labor campsites and storage sites of construction machines, and to avoid environmental pollution by spillage of fuel and oil.	-Ditto-
4	Creation of stagnant water bodies in dumping sites of surplus excavation soils, borrow pits, and quarries, etc. suited for mosquito and other vectors to breed, impairing aesthetics or posing danger to humans/animals	To make earth fill or to keep clean drainage to avoid creating aquatic habitats. To keep original landscaping after use.	-Ditto-
5	Dumping of surplus excavation soils caused by pipe laying	Dumping to general waste dumping site	
6	Noise and vibration pollution at the time of construction works	Environmental management and coordination (noise and excessive vibration pollution) regulation control noise levels at the construction stage. Especially, since the permissible noise values in housing area, health and educational facilities, etc. at night time are very severe and are regulated below 35 dB, the construction works should be conducted at daytime. In addition, by using medium or small scale of back hoe, etc. and equipment with silencer etc., the contractor should make an arrangement so as not to cause large noise and vibration.	Environmental Management and Coordination (noise and excessive vibration pollution) (control) Regulation, 2009, NEMA
7	Fog and dust during construction works	To avoid fog and dust caused by construction works, it is necessary to conduct water spray before or during construction works.	Environmental Management and Coordination Act, (1999). NEMA
8	Traffic accidents and disturbance during pipe laying works at roads	In case that pipe laying works are conducted on main roads with heavy traffic conditions, the contractor must get construction permission for pipe laying from KENHA and KeRRA offices by showing pipe laying sites and construction schedule in advance. In national roads B3 and C57 with heavy traffic managed by KENHA, traffic disturbance by pipe laying works is banned. Thus, traverse pipelines shall be installed in the existing box culverts and in case of conducting pipe laying works at one side of roads, the contractor must put construction signs and posts with color taping with temporary fences, and also deploy watchmen. In addition, at night time, the contractor must put electric lightning signal equipment indicating construction site for safety traffic control. The contractor must conduct safety traffic control so as not to cause traffic disturbance of vehicles and passers, etc. and have to conduct controls by watchmen.	In advance to start of pipe laying works, the contractor needs to get KENHA's or KeRRA's permissions by submissions of "Traffic Management Plan" of pipe laying works in the roads, including construction design plan, work schedule, traffic control plan to KENHA and KeRRA offices.
9	Accidents by entrance and exit of construction vehicles at construction site	Though numbers of traffic passage are few in the roads near the construction sites such as WTP and distribution reservoir (2,000 m^3), there are often vehicles which pass	-Ditto-

No	Adverse Impact	Mitigation Measures	Relating Regulation and Organization
		through. The contractor must all the time conduct safety control of construction vehicles by posting a watchman. In addition, the contractor must teach drivers safety traffic control to avoid traffic accidents. The contractor should ban intrusiveness of the public and put fences and sign boards of no trespassing.	
10	Dirtied roads by adhering tires of wetted soils, and fallen objects by vehicles for transportation of equipment and materials and surplus excavation soils	In case that transportation vehicles for construction works drop construction-related objects or debris, the contractor must organize a way to be able to pick up them. The contractor should confirm drops of any hazardous materials which may disturb traffic by going around roads at least two times per day. Furthermore, the contractor should ensure that vehicles, especially vehicle tires, are clean at all times to avoid dirtying parts of the roads.	-Ditto-
11	Possibility of prevalence of infectious diseases of HIV/AIDS	Contractor must enhance their consciousness of incoming laborers by conducting sessions explaining the hazardous nature of pathogenesis of infectious diseases of HIV/AIDS and how to protect themselves before the start of construction works into Narok Town.	
12	Discharge of muddy water by construction works	Muddy water caused by construction works has to be drained to a vacant area, trench, and pond. If in neighboring places of construction sites, proper drain sites are not found, the contractor should lay temporary drain pipes and build provisional trenches so as not to be a nuisance to the residential houses / areas.	Environmental Management and Coordination Act, (1999), NEMA
13	Wastewater and solid wastes caused by construction sites and camps	In the neighboring area of construction sites and workers' camp, the environment must be always kept in clean condition. Waste must be properly dumped by bins, and cans segregating oils and general rubbish and hazard materials, etc must be provided. In the neighboring area of construction sites and laborer's camps, portable toilets and temporary water supply system for cleaning and hand washing should be set up to maintain hygiene and cleanliness.	Occupational Safety and Health Act, (2007), Ministry of labor
14	Safety control of construction workers	Any worker and personnel who enter into construction sites have to bear safety shoes and hats for construction works. Site manager of the contractor must conduct morning assembly every day by collecting all the laborers and giving them instructions on safety control of construction site and to thoroughly conduct safety management of the sites. In the construction site where heavy machines for construction are operated, trespassing except concerned parties should be banned.	-Ditto-

1) Noise and Vibration Control

Noise and vibration generated by the project is supposed to be (a) construction machinery and equipment during construction works, (b) after completion of the plant, the noise which will be generated by operation of pumps and generators for emergency installed in the purification plant. The maximum permissible limits by regulations, magnitude of noise, and their countermeasures are reviewed as below,

2) Legal Control of Noise and Vibration

Noise and vibration is regulated by "Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, (2009)". **Table 1-3-4** shows maximum

permissible noise level. It divides noise control duration-time into two categories of day-time (6:01 a.m.-20:00 p.m.) and night-time (20:01 p.m.-6:00 a.m.), and categorizes the control zones for noise into A: Silent zone, B: Places of worship, C: Residential area, D: Mixed residential area (with some commercial and places of entertainment), E: Commercial area with each maximum permissible noise level. In addition, silent category zone is defined as a designated area that includes health facilities, educational and research institutions, courts, and any other area declared by NEMA.

Table 1-3-4 Maximum Permissible Noise Limit for Categorized Area

Category Zone for Noise Control		Maximum Noise Level dB (Leq)		Noise Rating Level (Leq)	
		Day Time (6:01 a.m.- 20:00 p.m.)	Night Time (20:01 p.m.- 6:00 a.m.)	Day Time (6:01 a.m.- 20:00 p.m.)	Night Time (20:01 p.m.- 6:00 a.m.)
A.	Silent Zone	40	35	30	25
B.	Places of Worship	40	35	30	25
C.	Residential (Indoor) （Outdoor）	45 50	35 35	35 40	25 25
D.	Mixed Residential (with some commercial and places of entertainment)	55	35	50	25
E.	Commercial	60	35	55	25

(Information source): Environmental management and coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, (2009)

In addition, regarding noise control during construction works, its regulations control the maximum permissible noise level during construction works. **Table 1-3-5** shows maximum permissible noise level during construction works.

Table 1-3-5 Maximum Permissible Noise Level for Construction Sites

（Measurement taken within the facility）

Facility		Maximum Permissible Noise Level (Leq) (dB)	
		Day Time (6:01 a.m.- 20:00 p.m.)	Night Time (20:01 p.m.- 6:00 a.m.)
(i)	Health Facilities, Educational Institutions, Homes for Disabled, etc.	60	35
(ii)	Residential	60	35
(iii)	Areas other than Those Prescribed in (i), (ii).	75	65

(Information source): Environmental management and coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, (2009)

The regulations state that no person shall make and cause to be made excessive vibrations which annoy, disturb, injure, or endanger the comfort, repose, health or safety of others and the environment, and further cause to be made excessive vibrations which exceed 0.5 centimeters per second per second beyond any source property or 30 meters from any moving source. Its vibration acceleration is calculated to equal to 54 dB in conversion by decibel unit. This vibration level has no effect on sleep but it is magnitude level that persons may feel vibration in their houses.

3) With and Without of Pilling Method

In the construction of WTP, hard support layers are distributed several meters below ground. As ground support is judged to be strong enough, piling method will not be necessary and water supply facilities will be constructed by spread foundation. Thus, noise and vibration issues caused by the piling construction method will not be generate.

4) Vibration by Construction of Planned Water Supply System and Construction Machines

Planned equipment and machineries to be installed for the water supply system has vibration prevention measures. In the construction of the intake weir and water treatment facility, medium and small types of excavation machines are planned to use. Thus, vibration effect on environment is minimal.

(2) Adverse Impact and Mitigation Measures at Operation Stage

Adverse impact and mitigation measures at operation stage are shown in **Table 1-3-6**.

Table 1-3-6 Adverse Impact and Mitigation Measures at Operation Stage

No.	Adverse Impact	Mitigation Measures (Environment Management Plan)	Relating Regulation and Organization
1	Labor accidents caused by installation of machines and equipment to new water intake and water treatment plan and by its operation.	Installation of machines and equipment and trial operation should be conducted under an experienced supervisor. If necessary, safety fences shall be installed. On the operation procedures, operation manuals shall be prepared and equipment / machine operation shall be based on its manuals.	Occupational Safety and Health Cct, (2007), Ministry of Labor
2	Chlorine gas leakage by using chlorination agent	Chlorination agent is planned to be the tablet type of calcium hypochlorite. Thus, it will not cause leakage of chlorine gas. The use of rubber gloves by workers is necessary to control or eliminate accidents.	ditto
3	Discharge of backwashing water including chlorine from WTP to river	As backwashing water includes chlorine, its direct discharge to the river may cause disappearance of aquatic microorganisms. Thus backwashing water is planned to be discharged after storage in a drain pond before its final discharge to reduce or eliminate adverse impacts to aquatic ecology in the river.	Environmental Management and Coordination (water quality) Regulations, (2006), NEMA

No.	Adverse Impact	Mitigation Measures (Environment Management Plan)	Relating Regulation and Organization
4	Noise caused by operation of machineries at planned intake facility and WTP	The operation of machineries at the intake facility will not cause environmental noise problems because very wide and vacant public areas surround the facility, and there are no houses in the distance of within 500 m. In addition, noise caused by the operation of machineries at the WTP will have not effect because there are no residential houses close by. There is only the manager's house of National Pastoral Training Center (NPTC), but based on measured distance from manager house to WTP's machineries, the gtenerated sound levels calculated was below the limit of maximum noise level of Environmental Management Coordination. Thus, noise problems will not be caused.	Environmental Management and Coordination (noise and excessive pollution) Regulations, (2009), NEMA
5	Sludge disposal	River water is the source for planned WTP, and this contains fairly high concentration of fluorine at 2.7 mg/L. In the process of water treatment, most fluorine is removed and is precipitated in the sludge. Concentration of fluorine in sludge is estimated to be about 2 % of sludge weight. This sludge has to be disposed as hazardous waste based on Environmental Management and Coordination (waste management) Regulation, (2006). Sludge amount to be generated is about 0.43 $m^{3/}$day. NARWASSCO and RVWSB shall discuss with NEMA how sludge is disposed by authorized contractor by NEMA, based on the Environmental Management Coordination (waste management) Regulations. Thus, its disposal will not cause significant issues after completion of planned WTP.	Environmental Management and Coordination (waste management) Regulations, (2006), NEMA
6	Disposal of construction waste soils generated at the time of pipe laying works	Permission to dispose construction waste soils to the general waste disposal site was already acquired from the Town.Council. Thus, its disposal will not cause problems.	Ditto

1) Sludge Disposal

① Generation of Sludge

The planned system will take water from a river intake facility at the Enkare Narok and will convey this raw water to a grid removal chamber for sedimentation of sands and soils present in the river water. The supernatant water is then transferred to a chemical sedimentation basin and after passing through successive rapid filters, the filtered water is stored in a treated water reservoir, after which it is distributed to the service area In that treatment process, sludge is generated from de-sludging the sand and soil at the grid removal chamber and the chemical sedimentation basin, and from backwash water at rapid filter. With a daily water treatment volume of 4,000 m^3/day, sludge generated is 0.43 m^3/day with the assumption of a water

content of 65%.

② Laws and Regulations Relating to Sludge Disposal

The disposal of waste, including sludge, is controlled by "the Environmental Management and Coordination (Waste Management) Regulations (2006)" and the supervisory /regulatory authority is NEMA. General conditions requires that (a) waste disposal is the responsibility of the waste generator, (b) personnel responsible for waste transportation and the operation and management of waste disposal site need license issued by NEMA, (c) every licensed owner or operator of waste disposal site or plant shall carry out an annual environmental audit. As to industrial wastes, it must be disposed in the manner not to generate environmental pollution by using anti-pollution technologies that may be prescribed by NEMA. In addition, it prescribes hazardous wastes in Fourth Schedule and Fifth Schedule and it regulates other wastes to dispose non-hazardous wastes. It also regulates that EIA approval to treat hazardous wastes is necessary and its storage facilities are labeled by Kiswahili and English.

Hazardous wastes which are prescribed in the Fourth Schedule are those polluted by radio-nuclides, generated from medical care centers, pharmaceuticals, virus, decay-preventing agents for wood preservation, organic solvents, fluorine, and heavy metals with concentrations of 1,000 ppm or 10,000 ppm in wastes and its organic compounds, asbestos, and strong acidity and alkalinity solutions, etc. The hazardous wastes that are prescribed in the Fifth Schedule are special ones with explosive and acute toxic/poisonous characteristics, etc.

③ Fluorine Concentration of Sludge Generated from Planned Water Treatment Plant and Disposal Method

Sludge generated from the planned water treatment plant is deposited and flocculated sand and soils in river water by an aggregating agent. The Enkare Narok River water sample was analyzed on March 2, 2012 by a registered laboratory of NEMA, and results indicate that it contained a fairly high concentration of fluorine at 2.7 mg/L. Though raw water contains fairly high concentration of fluorine, treated water, however indicates that flourine concentration is reduced to 0.4 mg/L, which is less than drinking water standards (1.5 mg/L) regulated by Water Act (2002), as long as coagulating sedimentation properly treats as shown in "Table 1-2-2 of 2-2-2 Natural Condition, (4) Water Quality, 2) Treated Water Quality". In the process of water treatment, most fluorine (about 94 %) is removed and is precipitated in the sludge, together with backwash water and aggregating agent. Concentration of fluorine in sludge is estimated to be 2 % of sludge weight. This sludge has to be disposed as hazardous waste based on Environmental Management and Coordination (waste management) Regulation, (2006).

As a result of discussion with NEMA on disposal method of sludge, NEMA suggested that the

sludge should be disposed by the contractor(s) licensed by NEMA and to its disposal site. The selected disposal site that will have the most minimal effect on the environment will be reviewed by NEMA and the contractor.

After that, as a result of discussion with NARWASSCO, they intended to selected two candidate sites for disposal of sludge with discussion NEMA. Considering the vast areas adjacent to the general waste disposal site without residential buildings recommended by JICA study team as one of candidate sites, RV-WSB and NARWASSCO will finally decide the sludge disposal site in accordance with the relevant Kenyan law and regulation, and inform JICA Kenya Office of the decision.

④ Disposal Site of Construction Waste Soil Generated with laying of Distribution Pipelines

According to NEMA, construction waste soil generated from excavation for laying distribution pipelines can be disposed to general waste disposal site that is managed by the Town Council. However, the transport of these waste materials for disposal needs the permission of NEMA and an application letter will have to be submitted to gain permission.

General Waste Disposal Site

Narok Town Council owns the general waste disposal site (Quarry Disposal Site) in Olpopongi area of Narok Town and if necessary, the project can use adjacent land as waste disposal site. Outline of the waste disposal site is shown in **Table 1-3-7** and its location in **Figure 1-3-1**. According to Town Council, the local government owns only one waste collection vehicle, a seven-ton trailer that collects wastes only in the Town center and its disposal amount is 14 tons/day.

Table 1-3-7 General Waste Disposal Site in Narok Town

No	Details of Disposal Site	
1-1	Name of disposal site	Old quarry site
1-2	Owner	Narok Town Council
1-3	Construction year	1980
1-4	Area	5 acre（20,234 m^2）
2-1	Name of disposal site	Adjacent area of old quarry site
2-2	Owner	Narok Town Council
2-3	Area	250 acre（1,011,715 m^2）

Source: Narok Town Council、Waste Management Section

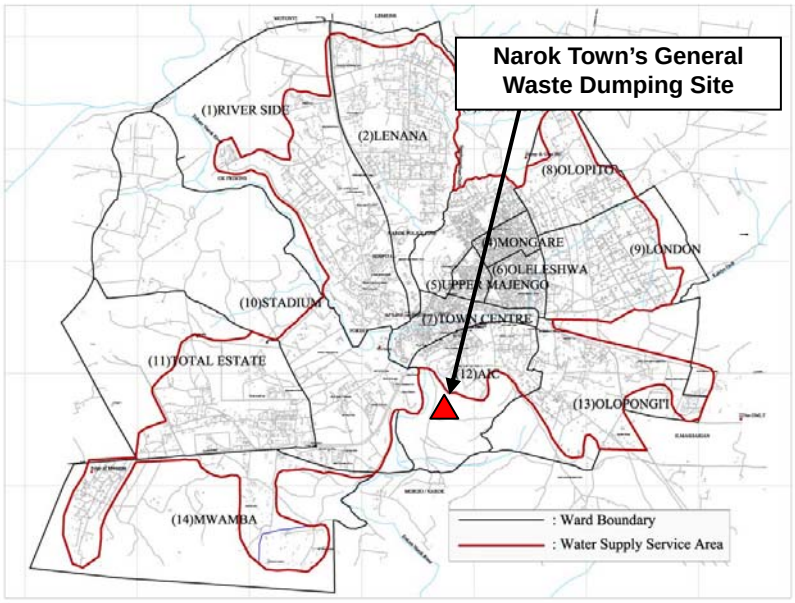


Figure 1-3-1 Location of General Waste Disposal Site Owned by Narok Town Council

1-3-1-5 Environmental Management Plan and Monitoring Plan

(1) Monitoring System by Implementation Organization

NEMA evaluates and supervises monitoring results. Imposed conditions with EIA approval include detailed instructions on monitoring items, its frequency, and the submission of reports to NEMA. Monitoring is actually carried out at the sites by proprietors (NARWASSCO) and Contractors at construction stage and by management utility (NARWASSCO) at operation stage. Monitoring fees are shouldered by these interested parties. Water analysis is limited to only registered laboratories to NEMA.

The NEMA office in Narok Town has one environmental management inspector and if necessary, he carries out environmental management inspection by visiting field sites for environmental management and audit.

(2) Monitoring System at Construction Stage

The aim of safety management (safety traffic control and laborers' safety working) in sites is to avoid injuries arising from construction activities, produce a healthy working environment, and create fewer disturbances to the public. An Environmental Management Program shall be implemented in order to protect all personnel and the public at site, and minimize the risk of accidents and incidents and ensure the health of the working personnel at work locations and the public in the construction vicinity and ensure the minimum damage to the environment. The safety

measures shall be continuously implemented throughout the duration of the construction works. Environment management shall be conducted at the site and work areas outside the site such as equipment and material storage sites and construction sites. Special care shall be paid to traffic control during the time of construction.

The project manger employed by the contractor who controls construction works must select and arrange for an Environmental Officer under the Site Manager. He shall select a knowledgeable and experienced engineer as the Environmental Officer from the engineering staff and must engage in safety environmental management for whole construction works. The Environmental Officer should plan for safe environmental management by checking site environment of construction sites, establishing necessary plan, discussing Project Manager and Site Manager, and notifying necessary safety environmental management countermeasures to all the workers. **Figure 2-2-10** shows environmental management system in the construction site. The Consultant Supervisor must safely implement the construction works by adequately discussing with Contractor's Project Manager (and/or Environmental Officer) and implementation agency.

(3) Submission of Monitoring Report

Environmental regulations have detailed description and guidelines on the monitoring system. Thus, monitoring system information was obtained by the interview to Narok regional director of NEMA. NARWASSCO conducts monitoring as routine works during construction stage and collects the necessary data and quarterly submits monitoring report to NEMA. On the environmental audit, there are public audit by NEMA and self audit by implementation organization. NARWASSCO conducts self audit and after two years from operation of new water supply system, its organization must submits yearly reports to NEMA.

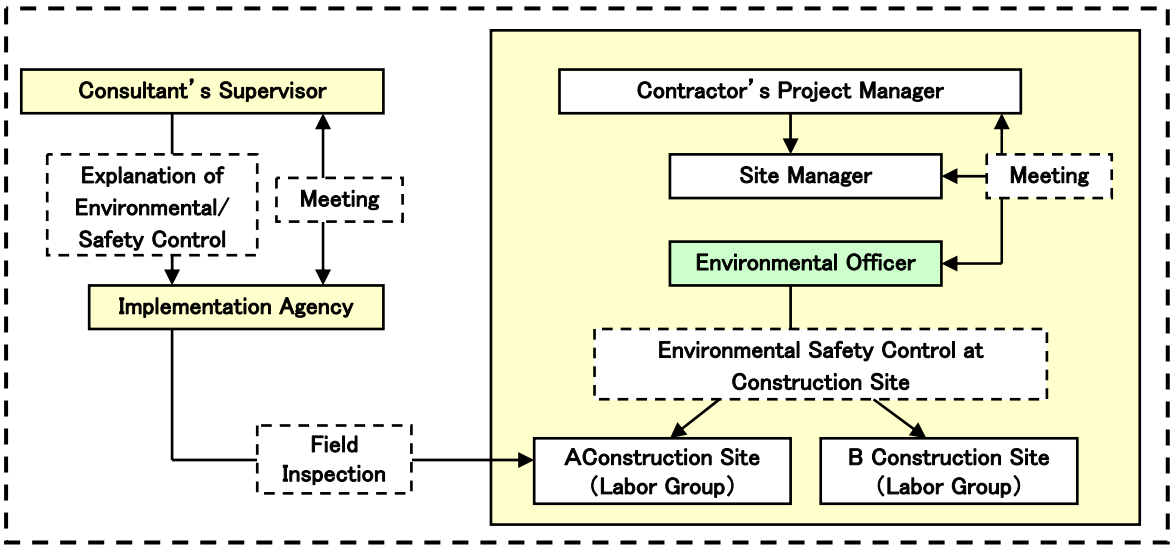


Figure 1-3-2 Environmental Management Systems in Construction Site

(4) Monitoring Plan

Adverse impacts and mitigation measures at the construction and operation stages and the monitoring plan for environmental protection are shown in **Table 1-3-8**. Monitoring results should be recorded and stored by format papers.

Table 1-3-8 Monitoring Plan for Environmental Protection in Construction and Operation Stages

No	Adverse Impact and Countermeasures	Monitoring Parameters	Monitoring Locations	Monitoring Manners	Frequency	Responsibility of Monitoring
Construction Stage						
1	Erosion by land cut and fill and temporary sedimentation of water course in the river	Soil erosion and turbidity of surface water	Downstream point near construction site of intake weir and of outlet of discharge pipelines	Measure of turbidity	During construction Three times/ week	Environmental officer , Consultant、NARWASSCO (NEMA)*
2	Adverse impacts on surface hydrology and mitigation countermeasures	Disturbance to flowing course of the river	Downstream point near construction site of intake weir and of outlet of discharge pipelines	Physical observation	During construction Once/week	-Ditto-
3	Ground and surface water contamination by oil, grease and fuel	Ground and surface water contamination by oil, grease and fuel	Downstream point near construction site of intake weir and of outlet of discharge pipelines	Physical observation	During construction Once/week	-Ditto-
4	Dumping of surplus excavation soils caused by pipe laying	Keeping safety and sanitary dumping site	Dumping site (Public general waste dumping site)	Physical observation	During construction Once/week	-Ditto-
5	Protection from noise and vibration pollution at the time of pipe laying and construction of WTP, and distribution reservoir, and water intake facility, etc.	Noise and vibration	All construction sites	Complaints by people	During construction	-Ditto-
6	Protection from fog and dust during construction works	Fog and dust	All construction sites	Complaints by people	During construction	-Ditto-
7	Protection of traffic accidents and disturbance during pipe laying works in roads	Adequate safety traffic control manners	All pipes laying work sites	Physical observation	During construction Two times/ week	Environmental officer , Consultant、NARWASSCO (KeRRA, KENHA)*
8	Protection from accidents by entrance and exit of construction vehicles at construction sites	Adequate safety traffic control manners	Entrance and exit points for construction of new WTP, distribution reservoir,	Physical observation	During construction Two times/ week	-Ditto-

No	Adverse Impact and Countermeasures	Monitoring Parameters	Monitoring Locations	Monitoring Manners	Frequency	Responsibility of Monitoring
			transmission pipelines, and water intake weir			
9	Protection of polluted roads caused by soil on vehicle tires, traffic accidents casued by fallen objects from vehicles during transportation of equipment and materials and surplus excavation soils	Dirty grade of roads	Road used by construction vehicles in transporting equipment and materials, and surplus excavation soils	Physical observation	During construction Two times/ week	-Ditto-
10	Discharge of wastewater generated by construction works and its countermeasures	Confirmation of adequate discharge countermeasures of wastewater	All construction sites	Physical observation	During construction Once/week	Environmental officer , Consultant、NARWASSCO (NEMA)*
11	Waste water and solid waste generated by construction sites and camps and its treatments	Adequate treatment of wastewater and solid wastes	All construction sites, laborers' camps and its neighboring areas	Physical observation	During construction Once/week	-Ditto-
12	Safety control of construction workers	Wear safety shoes and hats and observe safety control procedures at construction sites	All construction sites,	Physical observation	During construction Once/week	Environmental officer , Consultant、NARWASSCO (Ministry of labor)*
Operating Stage						
1	Disposal of sludge generated from WTP	Proper delivery and transportation procedures by contractor licensed by NEMA for disposal of sludge	Water treatment plant	Physical observation	At the transportatio n time of sludge	NARWASSCO (NEMA)*

（Note）(-------)* indicates responsible authorities which directly or indirectly supervise and monitor

Noise issue of water supply facilities at operation stage was omitted as there are no houses near the construction sites.

1-3-1-6 Stakeholder Meeting

This project does not have any resettlement issues since the areas where the WTP and distribution reservoir are to be constructed are public lands and its public lands are covered by bush trees.

Stakeholder meeting held at Narok Town Hotel's conference room on April 13, 2012 were attended by

about 30 interested persons from related government agencies, representatives from the Town's zone, chamber of commerce and industry, and water user association. The meeting was hosted NARWASSCO with assistance of JICA study team. In the meeting, the current status of water supply conditions and issues, project objectives and design plans, environmental management plan, future implementation schedule etc. were presented. Agenda and attendance list are shown in the attachment.

Participants offered the following comments:

We appreciated that Japanese Government assists Narok Town's water supply system. Community's people desire that piped water supply system is installed. Though some issues such as utilization of private lands may be brought up, the community people will cooperate to provide their lands for water supply system. In the stakeholder meeting, more interested persons shall be invited for discussion.

In this response, NARWASSCO replied as follows:

Not only land acquisition, but there also several issues with the progress of the project and, we will solve these issues step by step. As this is the first stakeholder meeting, this time we could not collect more attendees. We would like to announce the project information to town's people with as many occasions as we can.

1-3-2 Land Acquisition and Resettlement

The Narok Town Council controls the public lands where the water facilities are planned to be constructed. The public lands occupy a wide area on the left bank from the river bank of the Enkare Narok River to national road C 57 running in the NS directions and its land area is almost 2.4 km^2. **Figure 1-3-3** shows the extent of public lands. In addition, the river bed of the Enkare Narok where intake facility is planned is managed by WRMA. Planned intake facility can be constructed by an authorization letter for water permit.

Though the topography is almost flat land, the area has fairly steep slopes. In some places on the way to the river, a valley with steep slopes is formed. A weir is installed in the Enkare Narok River, and a small pump house on valley slope. Near and along national road C 57, a WTP of about 16,000 m^2 and a ground reservoir with capacity of 2,000 m^3 are to be constructed. Intake and water treatment facilities shall be connected by transmission pipelines. The transmission pipelines will be installed on ground surface in case of exposure of hard rocks, and below ground in case of no exposure of hard rocks.

In the public lands, there are no residential housing units.. Thus, there also is no compulsory land acquisition and resettlement. According to register officer belonging to Department of Land, the Ministry of Land, the public land is sometimes used as pasture for cattle, although public lands are not originally grazing lands. As for compensation, the administration office has no official recognition as pasture lands in other areas such as loiter etc. Furthermore, distribution pipelines are planned to be installed along the roads and supply facilities. Thus, the project will not require compulsory land

acquisition and resettlement.

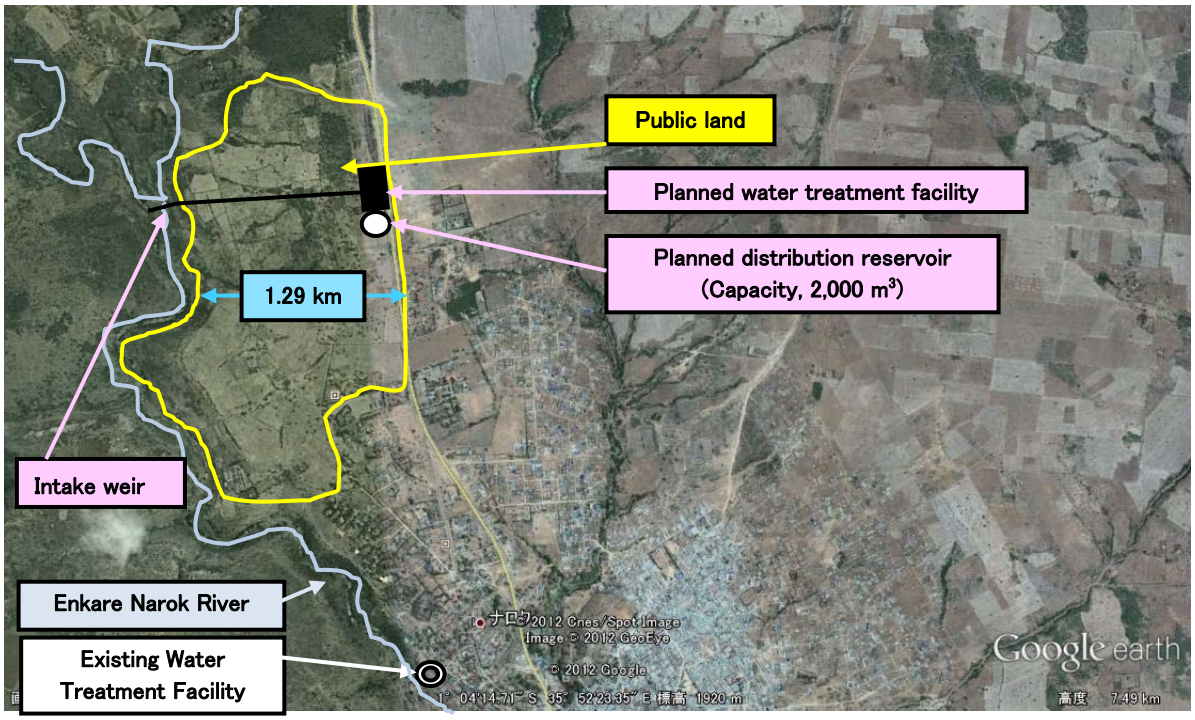


Figure 1-3-3 Proposed Construction Sites of Planned Water Supply Facilities and Public Lands

1-3-2-1 Progress of Land Acquisition

(1) Issuance of Minutes and Authorization Letter for Land Acquisition by Narok Town Council

To implement the project, a WTP and a distribution reservoir with capacity of 2,000 m^3, and a transmission pipeline, and intake facility are planned to be constructed in public lands which are controlled by Narok Town Council. Land acquisition is presently under process. The JICA study team received minutes dated on April 12 from Narok Town Council to give the 10 acres (40,460 m^2) of public lands to NARWASSCO from the Enkare Narok Rivers and Famers Training Center (FTC). In this land, planned water supply facilities sites are proposed to be constructed. Necessary land for construction of water supply system is 32,350 m^2 in total as shown in **Table 1-3-9.** Thus, adequate space / land for the construction of water supply system have been acquired.

Furthermore, as the minutes did not clearly show the alloted number for land acquisition, NARWASSCO applied for land that included the number from Narok Town Council with the submission of a survey map of the proposed sites for the water supply facilities and the plan chart of the new WTP. As a result, Narok Town Council issued an authorization letter on the acquisition of allotment number of Zone FTC/360 to NARWASSCO on April 12, 2012. By this letter, NARWASSCO was formally authorized on land acquisition for construction of water supply system by Narok Town Council. The Minutes and authorization letter for land acquisition are shown in the

attachment.

Table 1-3-9 Necessary Land Areas for Planned New Water Supply Facilities

No	Planned New Water Supply Facility	Size and Area (m^2)
1	Intake Facility	30 m×30 m = 900 m^2
2	Transmission Pipeline	10 m×(1,275 +270 m) = 15,450 m^2
3	Water Treatment Facility, Distribution Reservoir with capacity of 2,000 m^3, and Drain pond	100 m×160 m = 16,000 m^2
Total		32,350 m^2 (3.235 ha)

(2) Formal Permission on Acquisition of Public Land for Construction of New Water Supply System

There is a two-step procedure to get the permission in acquiring public lands for the construction of new water supply system. The first step is getting the authorization of land acquisition from the Town Council, and second step is the formal approval for land acquisition by the Ministry of Land.

NARWASSCO has successfully gone through the first step, and the next remaining procedure is the approval by the Ministry of Land and National Land Commission (NLC). The documents submitted to Town Council have been submitted to the Ministry of Land. After review by the Ministry of Land, the Ministry announces the agreement for land acquisition in the newspaper and publishes the notice in the official gazette. After these procedures, the Minister of the Ministry of Land, permanent secretary, and commissioner of NLC finally signs their approval, and land acquisition procedures will be substantially completed.

The approval procedures will be followed up by relevant government authorities by the time when the procedures are finalized. The availability of the land for construction will be confirmed in writing to the Ministry of Land and NLC by relevant government authorities by the end of November 2012, although MWI has told that the construction of the New Water Supply can be commenced with the permission of land acquisition from the Town Council.

1-3-2-2 Monitoring Form and Environmental Checklists

(1) Monitoring Form

This section shows only the monitoring forms which relate to compliance with conditions required in connection with EIA approval. The draft monitoring forms are shown in the **Appendix 6-15.**

(2) Environmental Checklists

Environmental checklists are shown in the **Appendix 6-16.**

1-4 Others

1-4-1 Climate Change and Significance of Implementation of the Project

It has recently been reported that global warming has progressed with the increasing release of greenhouse gases (CO_2) due to unabated industrial development and decreasing forest cover. As mentioned previously, Kenya has the wet season of long rainfall period from January to May and short rainfall period from August to December, and the dry season. This seasonal fluctuation originates by the seasonal shifting of the Intertropical Convergence Zone (ICZ) caused by general air circulation in global scale. Seasonal shifting of the ICZ depends on the emergence and the strength of the El Nino event with high water temperature at the eastern part of the Pacific Ocean, and the La Nina event with low water temperature at the same eastern part. The emergence of the El Nino event relates to warm event in global scale and it gives more rainfall than its average amount in short rainfall period and on the other hand, the emergence of the La Nina event provides stronger dry conditions than its average one in dry seasons.

According to UNDP Climate Change Country Profile, it is anticipated that average air temperature trend in Kenya is becoming higher in the future, and frequency of humid nights and hot days will increase. In addition, though it has no significant trend, yearly average rainfall is anticipated to increase every year and number of occurrences of storms shall also increase.

Recently, seasonal climate change has already given significant social impacts in Kenya and this tendency is expected to be stronger in the future. Droughts presently cause the decrease of the production of crop and livestock, hydropower, industrial manufacturing, drinking water, and occurrence of forest fire, and these have huge effect on economical activities. In addition, risks of flood occurring also increases. Recently, severe drought occurred in the periods of 1998 to 2000, 2004 to 2005, and 2009 and deluges came up in the periods of 1997 to 1998 and 2006.

The implementation of the project will augment water quantity and improve water quality for Narok Town with the construction of a new water treatment facility plus distribution pipelines. It will therefore achieve a safe and stable water supply for the service area. In addition, the project will ensure adequate water supply in times of rainfall fluctuations or droughts thus alleviating social impacts and stabilizing social conditions. On the other hand, the increased risk on occurrence of flooding shall be managed by the design policy against flooding (refer to **2-2-1** Design Policy).

1-4-2 Influence to Climate Change by Implementation of the Project

The project is an augmentation scheme of water supply facilities in Narok Town and it has no special facilities and equipment to give benefit to climate change. The intake facility takes raw water of 4,300 m^3/ day and conveys its water to new WTP, but the plant location is higher by about 80 m than that of intake point. Thus, it must be pumped up by intake pump. Adversely, consumable electric charge is estimated to become 119.5 kWh with the operation of WTP and it is to indirectly release bicarbonate

gas estimated at about 48.1 CO_2 tons/ month, and about 585.2 CO_2 tons/year.

(Note, as conversion coefficient from electric charge to CO_2 gas amount is not announced in Kenya, it was estimated by using alternative conversion factor (0.000559t-CO_2/kWh) which was described in "Reporting Manual for Calculation of Emission Amount of Greenhouse Gas (April 2011)" issued by the Ministry of Environment and the Ministry of Economy, and Trade and Industry in Japan.)

Table 1-4-1 Consumable Electric Charge of Planned Water Supply System

No	Equipment Name	Motor (kW)	Quantity	Sub-total (kW)
Planned Intake Facility				
1	Intake Pump	45	2	90
Planned Water Treatment Plant				
1	WTP Pump	7,5	1	7.5
2	Distribution Pump	5.5	1	5.5
3	Blower	7.5	2	15
4	Drain Pump	0.75	2	1.5
Total				119.5

1-4-3 Protection of Aquatic Ecology in the River

The Enkare Narok River from where raw water shall be drawn for water supply in Narok Town, joins together with other tributaries to become the Enkara Ngiro River, which empties into Lake Natron located away about 120 km in the SSE direction of Narok Town. Lake Natron is a famous as flamingo birds' habitat and is located in the border of Tanzania. It is also designated as a registration land dated on July 2001 by the Ramsar Convention.

As Lake Natron is located quite far away, the drained water will have no impact against the environment of Lake Natron. However, the direct discharge of backwashing water from the new WTP involves the risk to negatively affect the aquatic ecology in the natural river because the water contains a high concentration of chlorine. To protect the aquatic ecology in the river, the drained water shall be stored initially in a drain pond, which will see chlorine release naturally into the atmosphere. Then, the water will then be discharged into the river. The volume of the drain water is about 180 m^3/day.

Chapter 2

Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

The Kenyan national development plan Vision2030 looks at "water supply and sanitary service as one of the development tasks", with the objective of "improving water service rate in the rural areas from 40% to 59%, and the reducing NRW ratio from 60% to 30%".

In the future, industrial and tourism growth is expected in Narok Town, thus it was selected as one of 15 towns prioritized for water system development. Though the existing Central WTP has been constructed and expanded three times, from 1930's and 1980's, the plant capacity has decreased from the design capacity of 2,500m^3/day to its current capacity of 1,500m^3/day because of deterioration of its facilities. In addition, most of the existing pipelines within the town's boundaries were installed in the 1930's and the aged pipelines caused numerous pipe leaks contributing to very high NRW of 54% in 2010. Operation of the existing Central WTP in overloaded, treated water quality is below potable water standard

The purpose of this project is to supply safe drinking water to the residents by the construction and rehabilitation of water supply facilities. Service population will increase from the present 18,000 to 49,980, and water supply amount will increase from 2,000m^3/day to 5,000m^3/day.

The outline of the water supply system development plan to be implemented through this project is shown in **Table 2-1-1** and **Figure 2-1-1.**

Table 2-1-1 Outline of the Project

	No.	Project Component	Specifications	Quantity
Facility Construction	1	Construction of new water intake facilities	Intake pumps, etc	1 unit
	2	Raw water transmission pipe installation	ϕ 200mm	1.5km
	3	Rehabilitation of the existing Central WTP	1,000m^3/day	1 set
	4	Construction of new North WTP	4,000m^3/day	1 set
	5	Clear water transmission pipe installation	ϕ 250mm	3.8km
	6	Construction of new clear water reservoir	2,000m^3	1 unit
	7	Rehabilitation of the existing reservoirs		7 units
	8	Distribution main/branch pipe installation	ϕ 50mm～300mm	80km
	9	Construction of Chemical Room		1 lot
Material and Equipment Procurement	10	Chemical dosage equipment and water quality analysis equipment		1 lot
	11	Computer		5 units
	12	Printer		4 units
	13	House connection pips		16km
	14	Water meter		1,600 pcs
Soft Component (Capacity Development)	15	O&M of Water Supply Facility		1 lot
	16	Upgrading Supervising Capacity of Pipe Installation		1 lot
	17	Strengthening Managerial Capacity of Water Supply Undertaking		1 lot

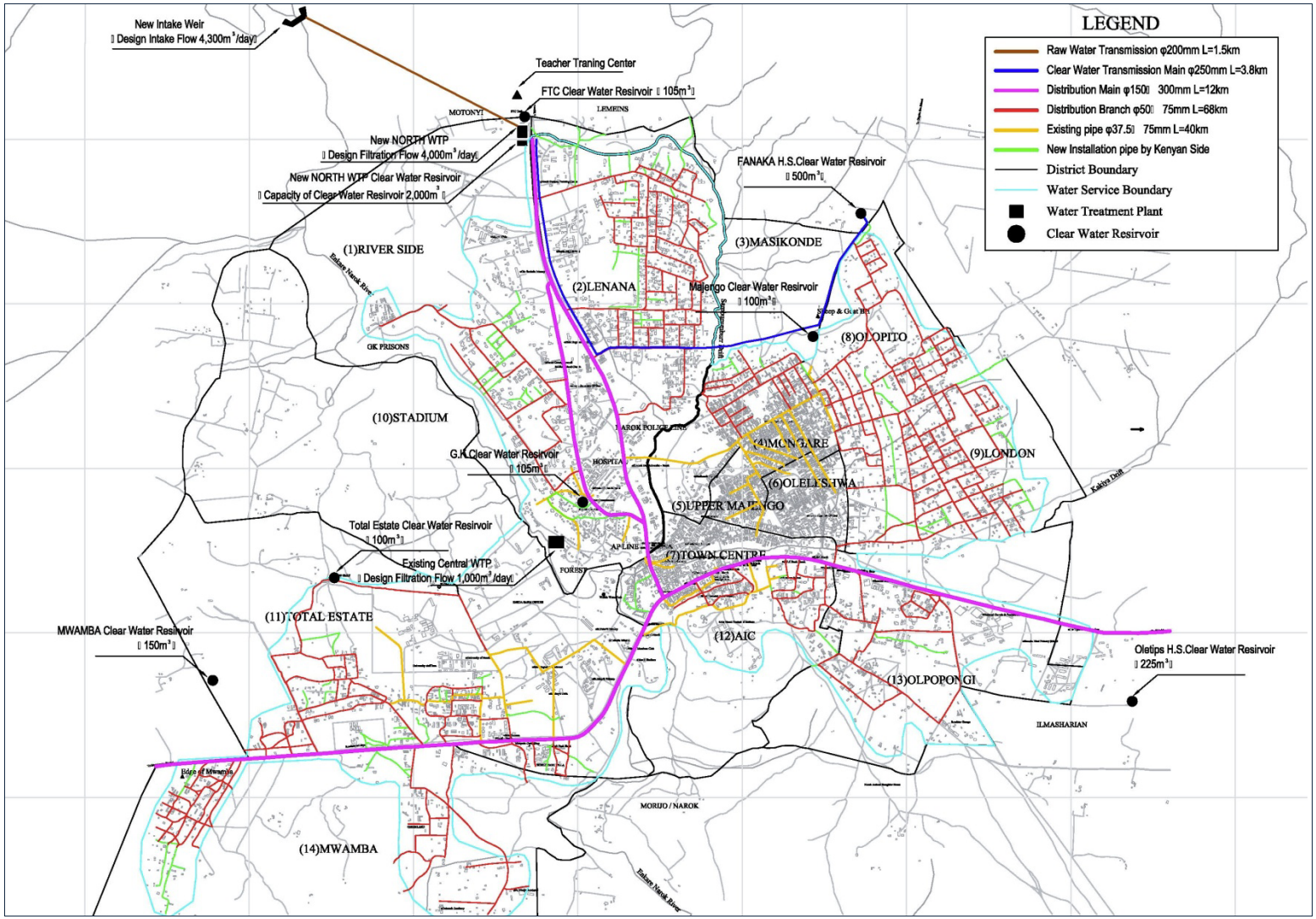


Figure 2-1-1 Outline Drawing of the Project

2-2 Outline Design of Japanese Assistance

2-2-1 Design Policy

(1) Basic Policies

Target year for this project was set for 2020. The basic policies were confirmed as follows:

① Facility design shall be carried out based on the Kenyan Practical Manual for Water Supply Services in Kenya, October 2005, MWI. (hereafter "Kenyan Practical Manual")

② The existing Central WTP is to be operated even after the completion of the proposed North WTP.

③ Water intake facility will be constructed 3km upstream of the existing intake point along the Enkare Narok River. Intake water will be sent to the proposed North WTP by pumping. To remove sand and to prevent inflow of floating leaves, desiltng facilities and screen will be installed at the inlet of water intake facilities.

④ Raw water transmission pipe installation route shall be a linear one, connecting the proposed water intake facility with the proposed North WTP (ϕ200mm×1.5km). The raw water transmission pipe shall be buried under the ground. The raw water transmission pipe material is DI pipe.

⑤ The proposed North WTP and clear water reservoir shall be constructed at the high elevation area, and basically distribute water to the service area by gravity.

⑥ Water treatment process will conform to the WHO drinking water standard and Kenyan water quality standard. The optimum treatment method with minimum required equipment, minimum power requirement, and easy O&M will be selected. Automatic control will be minimized, and plant will be manually operated.

⑦ The clear water transmission pipe is a gravity flow system. The clear water is transmitted from the clear water reservoir constructed in the proposed North WTP site to the existing Fanaka high school tank (250mm×3.8km). The pipe route shall be the same as the existing transmission pipe.

⑧ According to "Kenyan Practical Manual", the capacity of a clear water reservoir is set at 2,000m3 for 12 hours. The new clear water reservoir shall be constructed in the North WTP site.

⑨ The clear water distribute from the clear water reservoir in the proposed North WTP site to water service area in Narok Town by gravity.

(2) Policies on Natural Conditions

In 2011, temperature fluctuated from 9℃ to 27℃ and annual average was below 20℃. Monthly average rainfall in Narok Town ranged from 11.0mm to 113.8mm, while the annual average rainfall was 762.4mm.

There are two rainy seasons a year in the project area, with long-term rainy season from March to May and short-term rainy season from November to December. During the long-term rainy season, intense rain accompanied by thunder comes mainly in the night time, while temperate rain comes mainly in the early evening during the short-term rainy season.

Therefore, the implementation schedule shall be planned properly, particularly when securing materials, equipment and transportation for soil excavation work, concreting and so forth, which should take into consideration the long-term rainy season.

Geology of ground surface in the service areas is of reddish-brown or gray-brown lateritic soil, weathered silty or clayish fine grained soil and below this soil layer, volcanic vomit which ranges from tuff, breccias tuff and welded tuff. Tuff is exposed at basaltic lava at the river side and roads. Heavy weathering rock is observed near ground surface.

(3) Policies on Socio-Economic Conditions

Saturdays and Sundays are commonly two-day weekends off in Kenyan governmental agencies. According to labor regulations, there are 45 labor hours per workweek. The 45 hours are comprised of eight hours during weekdays and five hours on Saturdays. There are more than 10 national holidays, but if any of these holidays falls on Sunday, the next Monday is converted to compensation holiday. Most Muslims also take several days off after Ramadan. All these labor conditions shall be taken into account in the preparation of the project implementation plan.

(4) Policies on Laws, Institutions and Regulations

1) Water Right

Water right is granted to water-use public organizations by WRMA after examination on water use purpose, water intake amount, planned water intake facility, and water intake capacity. Agreement of Water Resources Users Association (WRUA) is also needed to issue water right. WRMA's regulations regulate to take the period of 6 months for procedures of water right and to need the charge of 90,000 Kshs in case of the Enkare Narok River. The charge rate is different at every river.

Further, WRMA collects the usage charge of the water source depending on water intake amount and NARWASSCO now has water right amount of 5,000m^3/day for the existing facilities and it has paid 1,250,000 Kshs in total every year as the usage charge of water source to WRMA. The payment is actually paid by dividing the year into second phases: the first half is from January to June, and the second half is from July to December.

Water right for the proposed North WTP will be secured by NARWASSCO. Its designed water intake amount is 4,300m^3/day, including water treatment loss. The detail is described in the **1-3-1-1**

2) Land Lease Right

Since supervisory authority of the rivers is with WRMA, its approval is needed for the construction of

the water intake facility in the river. In the left bank of the Enkare Narok River, there are wide public lands which are managed by Narok Town and the proposed North WTP is planned to be located in a part of the public lands. The public lands are leased by way of grant to a public utility organization such as Farmers Training Center (FTC) and the Teachers Training Center (TTC) for its high priority. As the proposed WTP construction site is located within the public lands, NARWASSCO shall apply to obtain the authorization letter for land acquisition from Narok Town and the formal approval will be from the Ministry of Land and the National Land Commission.

3) Management of Public Roads

All Kenyan roads are managed by Road Authorities in accordance with road classifications. The Kenyan National Highway Authority (KNHA) carries out road planning, implementation and O&M on Class A: national roads connecting to national border, Class B: trunk domestic roads and Class C: general domestic roads. As to Class D to E city roads, road planning and implementation are covered by Kenya Rural Roads Authority (KeRRA), while O&M activities are undertaken by the County Council or Town Council. Pipe installation routes, road crossing points and pipe installation methods shall be proposed in consultation with the Town Council. According to Kenyan pipe installation regulations, pipes shall be installed at minimum clearance of 1.0 to 2.5m from private housing border(s) and shall be installed in unpaved utility space available on both sides of the paved road. Minimum earth cover shall be 1.0m. Pavement restoration can be undertaken by the Contractor or carried out by Road Authorities in charge by paying due cost. The implementation plan shall be prepared taking into consideration these safety measures for residents.

(5) Policies on Application of Local Contractors and Local Materials

Similar water supply sector projects have already been implemented in Kenya such as in Embu Town, Meru Town and Kapsabet Town. Thus, the availability of local contractors has been confirmed. For simple construction work, manual labor is strongly recommended by GoK. NARWASSCO has been installing pipe-laying works using manual labor instead of large-scale construction machineries.

The study team has confirmed that three local contractors available in Narok Town and unskilled laborers are available at cheap cost and that no issues were found in labor supply. Under the project, local contractors shall be employed and their implementation abilities upgraded through the construction supervision by a Japanese contractor. In the future, NARWASSCO can contract out any construction works to local contractors, and can also do the supervision works from the experience gained from this project. Major construction and architectural materials such as cement, stone, gravel, sand, squared and board timber, petrol and oil are available in Kenya.

Although minor electrical devices used for building services are available in Kenya, the electrical and instrumentation equipment shall be imported from Japan or from industrialized third countries to secure the continued functioning of the proposed North WTP and the water intake pump station.

(6) Policies on O&M Capacity of Project Executing Agency

Current number of NARWASSCO staff is 23 personnel, who belong to technical and financial/ management departments. The existing water supply facilities are as follows:

① WTP..... Existing 1 unit
② Reservoirs .....7 units including 3 units under construction
③ Distribution pipe .....Total length of 40km
④ Served HHs.....2,131 HH
⑤ KIOSKs ..... 7 units
⑥ Yard taps .....5 units

The existing water supply system in Narok Town cannot meet the current and future water demand, since all the components of the system are old and deteriorated. This problem refers not only to water production and distribution facilities, but also to the aspect of planning, operation and maintenance, financial management, customer service and over-all utility management. It is expected that more staff will be required to operate and maintain the new system since water production is going to double after project completion.

Although NARWSSCO is a mature organization, there is still a need to train current staff on operation and maintenance work to ensure the continued operation of the new water supply facilities. Newly recruited staff should possess not only the required educational qualifications, but also relevant experience. Various training methodologies should be utilized such as on-the-job training, competency-based experiential training, hands-on and lecture-based training on the different functional areas of water utility management as well as operation and maintenance. All these shall be included in the Soft Component Programme that will enable NARWASSCO to become a quality water service provider with satisfied customers and operating a self-sustainable system by target year of 2020.

(7) Policies on Facility and Equipment Grade Setting

The optimum water treatment methods can generate treated water of quality that complies with WHO and Kenyan potable water quality guideline. Automatic control shall be minimized and basically, facilities shall be manually operated. All mechanical and electrical equipment shall be Japanese made with high reliability.

Pipe materials for core elements of the system, such as raw water transmission pipe, clear water transmission pipe and distribution main pipes shall be adopted DI pipe which has been applied in past Japan Grant Aid projects in Kenya. For other distribution branch pipes with diameters ranging 50mm to 75mm, Kenyan uPVC pipe is that upgraded by recent technical innovation shall be employed. However, for pipes to be installed in inferior road conditions where washout and vehicle load are high, Kenyan GI pipe is to be adopted.

(8) Policies on Facility Construction, Material/ Equipment Procurement and Work Terms

As proposed facilities are reinforced concrete structures and no specialized construction methods are needed, there will be no issues in the implementation by Kenyan local contractor. However, as water-tightness in concrete tank structure must be secured, concrete quality shall be strictly controlled by Japanese contractors. Rock exposure is often observed in sites and thus, excavation shall be done by a parallel use of specialized heavy machinery and manpower. Excavated surplus soil cannot be directly reused for backfilling. Contained stone, gravel and foreign objects other than soil shall be removed in advance and only good quality soil can be used for backfilling.

The construction materials for the civil and superstructure works are basically proposed from the local market while mechanical and electrical equipment for the water intake pump station and the proposed North WTP, and materials are not available in local market shall be imported from Japan or third countries. The organization and number of work teams shall be established considering the aforementioned natural conditions, the socio-economic conditions. Tight quality control and safety control shall be planned as well.

Water intake facility construction work shall be executed during dry seasons. Since it takes some time for imported DI pipes to be transported to Kenya and then cleared by Customs, it is preferable to install the uPVC pipes and GI pipes available locally before the DI pipe installation works.

2-2-2 Basic Plan (Construction Plan /Equipment Plan)

(1) Basic Policies

1) Target Water Supply Service Area

Target water supply service population and its area have been studied based on 2009 Census population provided by Kenya National Bureau of Statistics, and the latest topographic map from the Survey of Kenya. According to these data, the central area of Narok Town is divided into 14 districts, River Side, Lenana, Masikonde, Mongare, Upper Majengo, Oleleshwa, Olopito, London, Stadium, Town Centre, Total Estate, Aic, Olpopongi, Mwamba, with the area of approximately 20.36km^2 and the population of 36,797 in 2009. Target water service area is densely populated Total area for the proposed service district is 11.27km^2.

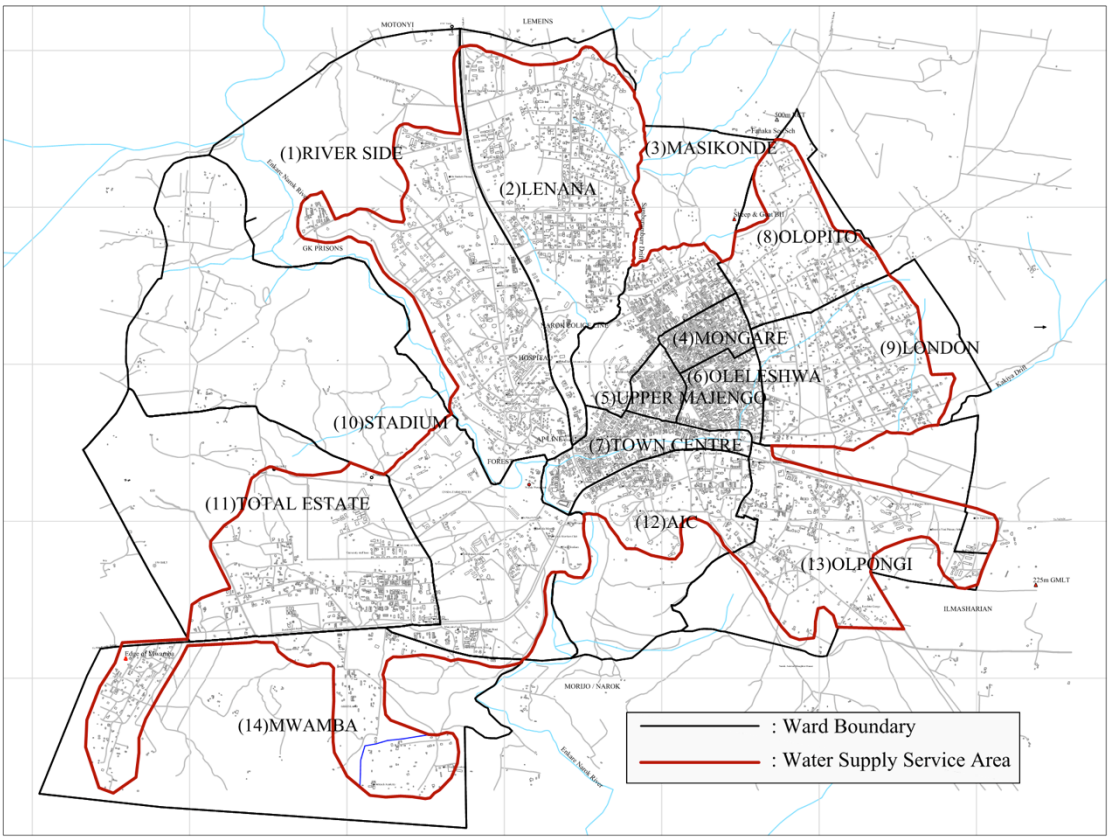


Figure 2-2-1 Target Water Supply Service Area

2) Distribution Pipe Installation

As shown in **Figure 2-2-2**, distribution pipes shall be installed only in the densely populated area. Less dense areas shall be excluded from the service area and distribution pipes will not be installed by this project. The Kenyan side shall cover the said excluded areas in the future, after residential areas are developed. Valves shall be fixed at the end of pipes for future extension.

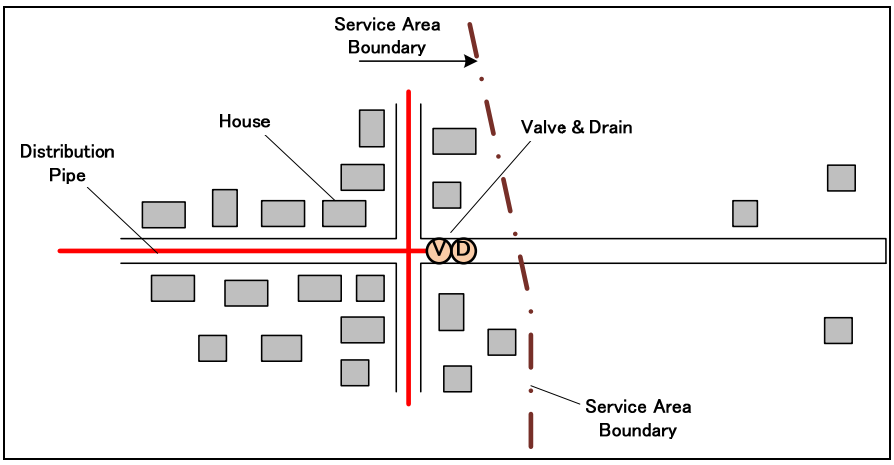


Figure 2-2-2 Distribution Pipe Installation

3) Service Population

Census is conducted every 10 years since 1969, and population in target year of 2020 was estimated based on census data carried out in September 2009.

In Narok Town, population growth was significant in areas located along with the trunk road, National Road B3 completed in 2010 and especially in districts of Stadium, Total Estate and Mwamba. Their population was increased to several-times in recent few years. Conversely, in the districts of Mongare, Upper Majengo and Oleleshwa, there was a slight decrease attributable to saturation.

Narok Town can thus be classified into three cases according to population:

Case A: Areas along with National Road B3 where rapid population growth is anticipated
Case B: Areas that are densely inhabited
Case C: Areas where natural population growth is expected by on-going residential area development

The population increase rates vary by area classification. Considering these conditions, population in 2020 is estimated by the following manner:

i) Case A: Districts where general population growth is expected (7 districts)

① Districts as Case A

1. River Side, 2. Lenana, 3. Masikonde, 8. Olopito, 9. London, 12. Aic and 13. Olpopongi

② Current status

1. River Side, 2. Lenana, 3. Masikonde, 8. Olopito and 9. London

These districts have lower housing density. As some houses are now under construction, they have vast open land for housing development. Narok Town Council has prepared land readjustment plan for these districts and future population growth is anticipated as per the plan. However, as these areas are located far from National Road B3, rapid population growth cannot be assumed. Accordingly, the population growth in these areas will not occur in a few years.

12. Aic and 13. Olpopongi

These districts are located along with National Road B3, but have partially gone slum. Though a few vacant lands are available for housing, rapid future population growth is not anticipated.

③ Population projection method

As to these districts, the adoption of natural population increase rate established by Kenyan Census, Narok North District and Narok Statistic Office seems appropriate. The following **Table 2-2-1** shows the population increase rates.

Table 2-2-1 Population Increase Rate in Statistics

	Source	Increase Ratio	Reference
1	Kenya Population & Housing Census *1	3.0%	Increase Rate 1999 to 2009
2	Narok North District Development Plan*2	3.3%	
3	Narok District Statistic Office	4.6%	

**1: 2009 Kenya population and Housing Census Volume II, August 2010*
**2: NAROK NORTH DISTRICT DEVELOPMENT PLAN 2008-2012 (KANYA VISION 2030, Towards a Globally Competitive and Prosperous Kenya, June 2009)*

Considering the current population growth trend in the target districts, the population increase rate of 3.3% projected by Narok North District is adopted for the following reasons:

- Narok District Statistic Office estimated 4.6% targeting all 14 districts in Narok Town. Since Case A is only targeting abovementioned seven districts, the other districts where rapid population growth is expected shall be excluded –Stadium, Total Estate and Mwamba. Thus, 4.6% seems to be overestimated.
- Narok North District Development Plan uses the projected population increase rate of 3.3%. Considering that the recent population increase rate is Narok Town is higher than other cities and towns in Kenya (owing to its fame as tourism and traffic key spot), this figure may be slightly higher than increase rate calculated in Kenya Population and Housing Census, but for this project, it seems adequate.

ii) Case B: Districts where rapid population growth is anticipated (3 districts)

① Districts as Case B

10. Stadium, 11. Total Estate, 14. Mwamba

② Current status

Population in the above-mentioned districts has dramatically increased after completion of National Road B3 in 2008. Several hundred housing units have been built in some districts where there was only an open space 10 years ago. In these locations, there are new housing units and on-going housing construction work.

Furthermore, even in open lands where there are no housing units yet, public utilities such as power cables are already in place to support the housing boom. One of these lands is proposed in the regional development project, thus future housing and population growth are assured.

③ Population growth projection

As population in these districts dramatically increased after the completion of National Road B3 in 2008, population increase rate calculated by available Census data from 1999 to 2009 cannot be applied because the 1999 population was too small.

Narok Town development plan is not prepared at present. But housing numbers are estimated by Narok Town Council for Stadium district which located the center of Narok

Town. As shown in **Table 2-2-2,** population increase rate is 8.0%/year in Stadium district. To estimate the population in Stadium, Total Estate and Mwamba for the year of 2020, a comparison between housing number in 2008 and design housing number in 2020 was made.

Table 2-2-2 Housing Number of Stadium District

	2008	Design value in 2020
Housing number in Stadium District	316	799
Population increase rate	799/316= 2.53 ⇒ **8.0%/year**	

iii) Case C：Districts where no population growth is anticipated（4 districts）

① Districts as Case C

4. Mongare, 5. Upper Majengo, 6. Oleleshwa, 7. Town Centre

② Current status

These four districts are recognized as congested housing area. As there are many tenement-type housing occupied by many families. The entire area is densely populated, and saturated. Therefore, there is no room for future expansion, and the future population may only slightly increase or decrease, which is almost negligible.

③ Population growth projection

Considering the population growth from 1999 to 2009, current housing density and no vacant land for new housing / buildings. Future population growth is unlikely. Thus, population in 2009 is to be directly adopted as 2020 population without modification.

Table 2-2-3 Projection of served population in 2020

District Name		All Area (km^2)	Service Area (km^2)	All Area Population		Pop Ratio of (SAP/AAP) *)	Service Area Population		Estimation from 2009 to 2020	
				1999	2009		2009	2020		
①	River Side	3.01	1.57	2,371	2,631	97.1%	2,554	3,660	Case-A	3.3%: NAROK NORTH District development Plan
②	Lenana	1.75	1.65	770	3,694	99.6%	3,680	5,260	Case-A	3.3%: NAROK NORTH District development Plan
③	Masikonde	1.07	0.51	1,322	4,732	98.0%	4,639	6,640	Case-A	3.3%: NAROK NORTH District development Plan
④	Mongare	0.17	0.17		4,420	100.0%	4,420	4,420	Case-C	Use 2009 Population
⑤	Upper Majengo	0.12	0.12	2,093	2,909	100.0%	2,909	2,910	Case-C	Use 2009 Population
⑥	Oleleshwa	0.24	0.24	6,200	5,232	100.0%	5,232	5,240	Case-C	Use 2009 Population
⑦	Town Centre	0.35	0.35	2,502	2,387	100.0%	2,387	2,390	Case-C	Use 2009 Population
⑧	Olopito	0.75	0.65		1,129	96.6%	1,091	1,560	Case-A	3.3%: NAROK NORTH District development Plan
⑨	London	1.20	0.99		2,097	99.5%	2,086	2,990	Case-A	3.3%: NAROK NORTH District development Plan
⑩	Stadium	3.48	1.18	512	1,378	71.4%	984	2,480	Case-B	8.0%: Estimated

District Name		All Area (km^2)	Service Area (km^2)	All Area Population		Pop Ratio of (SAP/AAP) *)	Service Area Population		Estimation from 2009 to 2020	
				1999	2009		2009	2020		
										based on Present/ Scheme in Stadium
⑪	Total Estate	2.37	1.30		2,512	95.2%	2,390	6,020	Case-B	8.0%: Estimated based on Present/ Scheme in Stadium
⑫	Aic	1.12	0.54		955	97.0%	926	1,330	Case-A	3.3%: NAROK NORTH District development Plan
⑬	Olpopongi	1.82	1.06	1,068	1,793	98.6%	1,769	2,530	Case-A	3.3%: NAROK NORTH District development Plan
⑭	Mwamba	2.91	0.95		1,109	91.2%	1,012	2,550	Case-B	8.0%: Estimated based on Present/ Scheme in Stadium
Total		20.36	11.27	16,838	36,978	-	36,079	**49,980**		

*) SAP/AAP : (Service Area Population) / (All Area Population)

4) Water Demand Projection

i) Domestic water

According to the "Kenyan Practical Manual", unit water consumption rate in the urban area depends on the income level. It is stipulated in the "Kenyan Practical Manual" that the unit water consumption rate shall be 250 LPCD, 150 LPCD and 75 LPCD for the high income group, the middle income group and the low income group, respectively. However, considering infrastructure and living level of Narok Town, the urban infrastructure design for a big city like Nairobi cannot be fully adopted to Narok Town.

The water demand for the proposed service area can be estimated according to the unit water consumption rate stipulated in the "Kenyan Practical Manual" as the applicable figure for the rural area, and according to the result of the social survey conducted in each district. .

a. Unit consumption rate of domestic water

The social survey on water consumption was conducted in the water-served districts. Unit water consumption rate stated in "Kenyan Practical Manual" is shown in **Table 2-2-4** and results of social environmental survey on unit rate with water supply hours exceeding 10 hours are shown in **Table 2-2-5.**

Table 2-2-4 Domestic Water Unit Consumption Rate stated in "Kenyan Practical Manual"

Consumer	Unit	Rural Areas			Urban Areas		
		High potential	Medium potential	Low potential	High potential	Medium potential	Low potential
People with Individual Connections	LPCD	60	50	40	250	150	75
People without Individual Connections	LPCD	20	15	10	-	-	20

Source: Practice Manual for Water Supply Service in Kenya, October 2005, MWI

Table 2-2-5 Unit Domestic Water Consumption Result of Social Environmental Survey

District Name	Water Volume (LPCD)	Supply Hour (hour/day)	To equivalent for 24hr *) (hr)	Water Volume (Equivalent 24hr) (LPCD)	Average (LPCD)
River Side	16.7	12	1.5	25.0	**17.0**
	7.5	11	1.5	11.3	
	11.1	12	1.5	16.7	
	10.0	10	1.5	15.0	
Lenana	7.5	10	1.5	11.3	**62.6**
	10.7	12	1.5	16.1	
	75.0	24	1	75.0	
	40.0	24	1	40.0	
	83.3	24	1	83.3	
	150.0	24	1	150.0	
Majengo	13.3	12	1.5	20.0	**35.0**
	20.0	12	1.5	30.0	
Oleleshwa	60.0	24	1	60	**41.7**
	30.0	12	1.5	45	
Total Estate	20.0	24	1	20.0	**35.0**
	50.0	12	1.5	75.0	
	10.0	24	1	10.0	

*) The areas where 24 hours water supply conducted multiple 1.5 for equivalent 24 hours water supply

Although the current unit water consumption rate recorded in Lenana slightly exceeds the rate described in the column of High Potential of Rural Area in the "Kenyan Practical Manual", the others, including the survey conducted in Majengo, Oleleshwa and Total Estate are less than 60 LPCD corresponding to High Potential of Rural Area in the "Kenyan Practical Manual".

Residents in the districts of River Side, Lenana, Masikonde, Olopito, London, Stadium, Total Estate, Aic, Olpopongi and Mwamba are classified to relatively higher income group so 60 LPCD is adopted for these districts.

Districts of congested housings, namely Mongare, Upper Majengo and Oleleshwa are full of tenement-type housings and low income housing area. Several low income families are served by one faucet. Compared with the ordinary housing, individual connection in this area is much less, and thus, Low Potential rate of 40 LPCD is employed for this area.

Though most of Town Centre district is a slum area, several housing units have shop/restaurant with accommodation, so the rate of 60 LPCD used shop/ restaurant with dwelling is adopted.

b. Domestic water demand

Domestic water demand is calculated by district-wise design service population and unit water consumption rate as shown in **Table 2-2-6.**

Table 2-2-6 Water Amount for Domestic Use（2020）

District Name		Area (km^2)	Population (2020)	Per Capita Flow (LPCD)	Water Amount (m^3/day)
①	River Side	1.57	3,660	60	220

District Name		Area (km^2)	Population (2020)	Per Capita Flow (LPCD)	Water Amount (m^3/day)
②	Lenana	1.65	5,260	60	316
③	Masikonde	0.51	6,640	60	398
④	Mongare	0.17	4,420	40	177
⑤	Upper Majengo	0.12	2,910	40	116
⑥	Oleleshwa	0.24	5,240	40	210
⑦	Town Centre	0.35	2,390	60	143
⑧	Olopito	0.65	1,560	60	94
⑨	London	0.99	2,990	60	179
⑩	Stadium	1.18	2,480	60	149
⑪	Total Estate	1.30	6,020	60	361
⑫	Aic	0.54	1,330	60	80
⑬	Olpopongi	1.06	2,530	60	152
⑭	Mwamba	0.95	2,550	60	153
Total (I. Domestic Water Use)		**11.27**	**49,980**	**-**	**2,748**

ii) Water demand in other use

a. Fundamentals

Water demand in other usage is to be estimated based on field survey results, as follows:

- Numbers of students and teachers are quoted from data published by the Narok District Education Office.
- Increasing rate in numbers of hospital beds, students and teachers of elementary, junior/senior high school is set by 3.3%/year, the same as population increase rate.
- Water demand growth in Narok University is set at 3.0%/year, based on interview survey with the university.
- Numbers of livestock shall be estimated based on data obtained from Narok District Livestock Marketing. It is assumed that tap water consumption by livestock will remain at the current volume even if livestock population will increase in the future. It is proposed to use 20% of the calculated amount since most of livestock don't use tap water.
- Population increase rate of 3.3%/year is also proposed for the demand increase rate in industrial and commercial use.

b. Unit water consumption rate and water demand

Unit water consumption rate is established as shown in **Table 2-2-7** which can be referred to the "Kenyan Practical Manual".

Table 2-2-7 Unit Water Consumption Rate

Consumer		Unit	LPCD
Livestock Unit		L/head/day	50
Boarding Schools		L/head/day	50
Day Schools	with WC	L/head/day	25

	without WC	L/head/day	5
Hospitals	Regional	L/bed/day	
	District	L/bed/day	200
	other	L/bed/day	100
Dispensary and Health Center		L/day	5,000
Hotel	High Class	L/head/day	600
	Medium Class	L/head/day	300
	Low Class	L/head/day	50
Administrative Office		L/head/day	25

Source: Practical Manual for Water Supply Service in Kenya, October 2005, MWI

① Elementary school, junior/senior high school

Every elementary school, junior/senior high schools are equipped with toilets but this is not the flushing type. Showers are not available. In the interview survey, the unit rate was one to two LPCD. This is because students bring their drinking water and water usage in school for hand washing is strictly limited. Upon completion of this project, potential water consumption might increase but considering current consumption rate and toilet type, a big increase is not expected. Thus, unit rate for schools is set by 20 LPCD, which is the intermediate value of "school with toilet" and "school without toilet" tabulated in the "Kenyan Practical Manual". This rate is common to both student and teacher.

② Dormitory (Elementary school, junior/senior high school)

According to questionnaire survey results, the water supply and toilet facilities are different for boy and girl dormitory students, thus, each unit rate is also different.

Student	Shower	Toilet	Unit Rate
Boy Dormitory Student	None	No-flushed	20 LPCD
Girl Dormitory Student	Available	Flushed	70 LPCD

As ratio of boy and girl is 45:55, the average rate is calculated as follows:

20 LPCD × 45%＋70 LPCD × 55%＝47.5 ≒ 50 LPCD

③ Narok University

Narok University is the sole university in Narok Town. The total number of students is 1,886 and 908 are dormitory students. The total number of teacher and staff is 611. All toilets are of the flush type. According to questionnaire survey results, monthly water consumption including dormitory is 4,632m^3/month or ÷ 155m^3/day. Annual water consumption increase rate is set by 3.0% of student increasing rate forecasted by the university. Water demand in 2020 is to be estimated by this increase rate.

④ Narok District Hospital

Narok District Hospital is the only District Hospital in Narok Town and is equipped with 150 beds. The daily average number of patients is 200, and the total doctor and staff numbers is 174. All toilets in the hospital are of the flush type toilet.

Monthly water consumption is 864m^3/month ÷ 30m^3/day. Water consumption in 2020 is to be projected by applaying 3.3%/year of the same rate as the population growth.

⑤ Other hospitals

Considering the current status of other existing hospitals, 100 L/bed/day stated in "Kenyan Practical Manual" seems unsuitable. The rate is estimated by using school rate, 15 LPCD adopted in this study and rate stated in the "Kenyan Practical Manual", 25 LPCD:

100 (L/Bed/day) × 15/25 (LPCD) ＝ 60 L/Bed/day

⑥ Hotels

Hotel rate of 50 LPCD belongs to Low Class Hotel described in the "Kenyan Practical Manual" is to be uniformly adopted.

⑦ Industrial and commercial water demand

The only factory currently operating in Narok Town is a cereal factory in Olpopongi located along with National Road B3. There are 40 staff and more than 100 non-regular staff working for the factory and the water demand is 2,000 L/day. Commercial facilities such as Bank, Post Office, Financing Company also exist totaling around 30. In each office, 10 to 30 office workers are employed, and the water demand is in range of 300 to 500 L/day. Thus, industrial and commercial water demand is estimated as follows:

500 L/day ×30 Companies＋2,000 L/day ＝17,000 L/day ＝17 m^3/day

⑧ Prison

The prison has 700 prisoners, plus 500 guards and staff. Shower and flush toilet are available and consumption is 70 LPCD. However, since rate of 70 LPCD confirmed by interview survey exceeds the hotel rate described in the design manual, it is not realistic based on the current water supply situation in Narok Town. Therefore, 50 LPCD is applied. The 500 guards and staffs are comprised of 100 full-time workers and 400 shift-workers. Their rate is set as the following:

- Full-time (day work) worker rate：25 LPCD
- 4 shift (including night work) guard rate：25 LPCD

c. Other water demand

Based on the abovementioned field survey results, design frame values in 2012 are converted to 2020 as shown in **Table 2-2-8** and other water use demand in 2020 is estimated by applaying each unit water consumption rate as shown in **Table 2-2-9.**

Table 2-2-8 Basic Data of Other Water to be Estimated from 2012 to 2020

Items		Unit	Q'ty	
			2012	2020
II-1	**Primary, Secondary & High School**		*Growth Ratio:*	*3.3%*
(1)	Student	person	11,518	15,000
(2)	Teacher and Staff	person	430	600
(3)	Dormitory	person	3,920	5,100
(4)	Other School Student	person	696	1,000
(5)	Other School Teacher and Staff	person	62	100

Items		Unit	Q'ty	
			2012	2020
II-2	**Narok University**		*Growth Ratio:*	*3.0%*
	Water Amount (Student, Dormitory, Teachers, Staff)	m^3/day	155	200
II-3	**Hospital**		*Growth Ratio:*	*3.3%*
(1)	Narok District Hospital	m^3/day	30	40
(2)	Other Hospital (Number of Beds)	bed	15	20
II-4	**Public Facility**		*Growth Ratio:*	*3.3%*
(1)	Government and Municipal Office	person	700	910
(2)	Police	person	68	90
(3)	Army (Estimation by Actual Data)			
II-5	**Hotel**		*Growth Ratio:*	*3.3%*
(1)	Major Hotel (Number of Room)	room	250	330
(2)	Other Hotel (Number of Room)	room	200	260
II-6	**Prison**			
(1)	Prisoner	person	700	700
(2)	Staff	person	500	500
	Considered that imprisonment and staff will not be increased.			
II-7	**Commercial, Factory**		*Growth Ratio:*	*3.3%*
(1)	Estimation by Actual Data	m^3/day	17	30
II-8	**Live Stock**		*Growth Ratio:*	*3.3%*
(1)	Goat, Sheep		2,000	2,600
(2)	Chicken		60,000	77,800

Table 2-2-9 Water Amount for Other Water Use（2020）

Items		Q'ty (2020)	Per Capita Flow (LPCD)	Water Amount (m^3/day)
II-1	**Primary, Secondary & High School**			
(1)	Student	15,000	20	300
(2)	Teacher and Staff	600	20	12
(3)	Dormitory	5,100	50	255
(4)	Other School Student	1,000	20	20
(5)	Other School Teacher and Staff	100	20	2
	Sub-Total I-1 (Primary, Secondary and High School)			589
II-2	**Narok University**			
(1)	Water Amount (Student, Dormitory, Teachers, Staff)			200
II-3	**Hospital**			
(1)	Narok District Hospital			40
(2)	Other Hospital (Number of Beds)	20	80	2
	Sub-Total II-3 (Hospital)			42
II-4	**Public Facility**			
(1)	Government & Municipal Offices	910	25	23
(2)	Police	90	25	2
	Sub-Total II-4 (Public Facility)			25
II-5	**Hotel**			
(1)	Major Hotel (Number of Room)	330	50	17
(2)	Other Hotel (Number of Room)	260	50	13
	Sub-Total II-5 (Hotel)			30
II-6	**Prison**			
(1)	Prisoners	700	50	35
(2)	Staff	500	25	13
	Sub-Total II-6 (Prison)			48
II-7	**Commercial & Factory**			
(1)	Estimation by Actual Data			30
II-8	**Live Stock**			

Items		Q'ty (2020)	Per Capita Flow (LPCD)	Water Amount (m^3/day)
(1)	Goat, Sheep	2,600	20	52
(2)	Chicken	60,000	0.4	24
	Sub-Total II- (Live Stock)			76
Considered that water amount is set 20% of above, since most of livestock don't use tap water				15
Total (II. Other Water Supply)				**978**

iii) NRW ratio

As to NRW amount, this includes pipe leakages and operating waste by O&M activities, WSP plan*) and new pipe installation of with total length of 80km by this project shall be taken into account. It is estimated that 25% of supplied water is NRW amount. **) Strategic Plan 2010-2015 (NARWASSCO)*

iv) Design water supply amount

Design water supply amount including NRW amount is shown in **Table 2-2-10.** Total amount is estimated as 5,000m^3/day in target year of 2020.

Table 2-2-10 Water Supply Amount（2020）

Designed Water Supply Items		unit	Water Amount
I.	**Domestic Water Use**	**m^3/day**	**2,748**
II.	**Other Water Use**	**m^3/day**	**979**
II-1	Primary, Secondary and High School	m^3/day	589
II-2	Narok University	m^3/day	200
II-3	Hospital	m^3/day	42
II-4	Public Facility	m^3/day	25
II-5	Hotel	m^3/day	30
II-6	Prison	m^3/day	48
II-7	Commercial and Factory	m^3/day	30
II-8	Livestock	m^3/day	15
Water Demand (I+II)		**m^3/day**	**3,727**
III.	**Non Revenue Water**		
	Ratio	%	25
	Non Revenue Water	m^3/day	1,243
	roundup	m^3/day	**1,273**
Total Water Supply Amount (I+II+III)		**m^3/day**	**5,000**

5) Comparison of Project Alternatives

① Alternative 1 (proposed by the F/S Report)

Alternative 1 plans only water intake facility 5km upstream of the existing Central WTP. Raw water transmission pipes with diameter of 200mm are planned to be installed along the river to transmit raw water to the existing Central WTP by gravity.

② Alternative 2

Alternative 2 plans the proposed North WTP and water intake facility in the future expansion land

of the existing Central WTP. A clear water reservoir is to be constructed in the upstream site to supply water supply by gravity.

③ Alternative 3 (proposed by this study)

Same as the F/S Report, Alternative 3 plans to install water intake facility 5km upstream of the existing Central WTP. In this case, the proposed North WTP and a reservoir are planned in the upstream site to supply water only by gravity.

Table 2-2-11 shows alternative comparison and three alternatives' validity in terms of workability, necessary area for WTP, environmental impacts and O&M cost is evaluated. **Alternative 3 is adopted as the optimum plan.**

【Reasons for Adoption】

1. As distance between water intake facility and the proposed North WTP is only 1.5km, a combination of direct raw water intake by pumping and raw water transmission by gravity makes power consumption relatively lesser
2. Since water intake facility is planned upstream, raw water quality is better than that of the existing Central WTP
3. Plain open public land along with National road C 57 has sufficient extent for facility planning aimed at systematic operation and management
4. The existing Central WTP is not to be abolished but to be efficiently operated after minor repairs. By this arrangement, the proposed North WTP capacity and construction cost can be reduced. Furthermore, two WTPs enable flexible water supply operation in emergency cases.

Table 2-2-11 shows the outline of the alternative water supply plans and **Table 2-2-12** indicates evaluation results of the alternative plans.

Table 2-2-11 Outline of Water Supply Alternative Plans

Alternative Plan	**Alternative Plan 1** Water Supply and Sanitation Improvement (F/S) project for 13 towns financed by AfDB	**Alternative Plan 2**	**Alternative Plan 3** Adopted plans for the project
Plan contents and characteristic	1) Only water intake facility is to be constructed at upper stream away about 5km from the existing Central WTP. 2) A new WTP is proposed to be constructed in the future augmentation land adjacent to the existing Central WTP. 3) Raw water transmission pipelines are to be installed along the river in the distance of intake facility to a new WTP and raw water is transmitted from water intake facility to a new WTP by gravity. 4) A clear water reservoir is proposed to be installed at the upper stream and treated water is transmitted by booster pumps from the new WTP to	1) Raw water for a new WTP is taken by utilization of the existing water intake facility near the existing Central WTP. 2) A clear water reservoir is proposed to be installed at the upper stream and treated water is boosted up from a new WTP by booster pumps. 3) A new WTP is to be constructed at the adjacent augmentation site of the existing Central WTP. 4) Supplaying water from the existing Central WTP, in addition to a new WTP for water supply to Narok Town	1) A new water intake facility, a new WTP, and new clear water reservoir are to be constructed at the upper stream away about 5km from the existing Central WTP. 2) Raw water is to be transmitted from water intake facility to a new WTP; treated water is to be distributed from new clear water reservoir for water supply to Narok Town by gravity. 3) Allotment of distribution area: A part of the existing Central WTP is rehabilitated and its treated water is used for water supply to Narok University and the treated water by a new WTP is distributed for water supply to

Alternative Plan	**Alternative Plan 1** Water Supply and Sanitation Improvement (F/S) project for 13 towns financed by AfDB	**Alternative Plan 2**	**Alternative Plan 3** Adopted plans for the project
	the new reservoir. 5) Supplaying water from the existing Central WTP in addition to a new WTP for water supply to Narok Town is distributed.	is distributed.	Narok Town.
Outline of facility	1) Construction of a new water intake facility 2) Rehabilitation of the existing Central WTP (1,000m^3/day) 3) Construction of a new WTP (4,000m^3/day) 4) Construction of a new clear water reservoir (2,000m^3) 5) Laying of raw water transmission pipelines (DI), diameter 200mm, length 5.0 km 6) Laying of clear water transmission pipelines (DI), diameter 150mm, length 2.6km 7) Laying of distribution pipelines (uPVC), diameter 100mm, length 25km 8) Construction of maintenance road, length of 5km	1) Improvement of the existing water intake facility 2) Construction of a new WTP (4,000m^3/day) 3) Rehabilitation of the existing Central WTP (1,000m^3/day) 4) Construction of a new clear water reservoir (2,000m^3) 5) Laying of raw water transmission pipe (DI) diameter of 200mm, length of 0.3km 6) Laying of clear water transmission pipe (DI), diameter of 150mm, length of 2.6km 7) Laying of distribution pipelines (uPVC) with diameter of 100mm, and length of 25km	1) Construction of a new water intake facility 2) Construction of a new WTP (4,000m^3/day) 3) Rehabilitation of the existing Central WTP (1,000m^3/day) 4) Construction of a new clear water reservoir (2,000 m^3) 5) Laying of raw water transmission pipe (DI), diameter of 200mm, length of 1.5km 6) Laying of clear water transmission pipe (DI), diameter150mm, length 1.0km 7) Laying of distribution pipe (uPVC), with a diameter 100mm, and length of 25km 8) Construction of maintenance road, length of 1.5km

Table 2-2-12 Evaluation Results of Water Supply Alternative Plans

Evaluation criteria and evaluation and reason		**Alternative Plan 1** Water Supply and Sanitation Improvement (F/S) project for 13 towns financed by AfDB	**Alternative Plan 2**	**Alternative Plan 3** Adopted plans for the project
Difficulty of construction works	Evaluation	Bad	Good	Good
	Reason	In the plan, connecting the new water intake facility located at the upper stream with the new WTP downstream by 5km of transmission pipelines will be done along the river. Pipe laying is very difficult due to exposure of hard rock along the river.	Construction works will not be difficult in rehabilitating and improving the existing intake facility.	A new water intake facility and a new WTP are connected by raw water transmission pipe with about 1.5km, and in exposed portion of hard rock, pipes are laid by open plumbing and in no hard rock portion, pipes are laid by underground piping. The plan has not so big difficulty in construction works.
Availability of land space and topography of construction site of a new WTP	Evaluation	Bad	Bad	Good
	Reason	In the plan, the proposed new WTP site for constructing a new WTP in the prepared future augmentation land space (10,000m^2) adjacent to the existing Central WTP site (4,000m^2) has almost flat topography. Water amount increases due to increasing of water service population from F/S	The same as left	There is almost flat and vacant public land space along the national road C57 and it has sufficient space to construct a new WTP and a new clear water reservoir (2,000 m^3). In addition, new water intake facility and raw water transmission pipe can be also constructed in

		study. There is not enough space for constructing a new WTP and also, adjacent area has no additional vacant land space.		public lands.
Land use	Evaluation	Good	Good	Good
	Reason	The proposed land is used as a part of the existing Central WTP sites.	The same as left	Vacant area with scattered bush trees.
Possibility of river flood	Evaluation	Bad	Good	Good
	Reason	Raw water Transmission pipe installed along the river may be broken due to river flood.	Comparatively safe from flood	The same as left
Population density	Evaluation	Good	Good	Good
	Reason	Low	The same as left	The same as left
Vegetation	Evaluation	Good	Good	Good
	Reason	No important vegetation	The same as left	The same as left
Operation cost (electricity charge)	Evaluation	Not good	Not good	Good
	Reason	Electric charge for facility operation is estimated to be Kshs 16,386,000/year and it will become heavy burden.	The same as left	Electric charge for facility operation is estimated to be Kshs 14,176,000/year and its operation cost is cheaper compared with other options or plans and it will be appropriate for the project.
Comprehensive evaluation	Evaluation	Bad	Bad	Good
	Reason	The plan has difficulty in construction works and not enough land area for a new WTP. These become critical issues.	Though environmental conditions are satisfied, the plan does not have enough land area for a new WTP. Thus, it becomes a critical issue.	In all the evaluation conditions including difficulty of construction works, availability of land space and topography for a new WTP, O&M cost, and environmental conditions, the plan has appropriateness and satisfies construction plan.

(Note) Operation cost was evaluated only by using electric charge because concrete F/S plan including chemical injection was not clear.

(2) Water Intake Facility Plan

1) Selection of Intake Point

Proposed intake point is located 3km upstream of the existing Central WTP, which is the confluent point of the Enkare Narok River and the Enkare Ngosorr river. There are rocks exposed on the river surface which makes for easy weir construction.

2) Possible Intake Amount

i) Necessary Intake Amount

Design water intake amount after implementation of this project is 4,300m^3/day in the proposed North WTP, 1,050m^3/day in the existing Central WTP and total water intake amount of 5,350m^3/day is to be diverted from the Enkare Narok River.

ii) River flow amount measured by field survey

To confirm flow amount of the Enkare Narok River, river flow amount measurements were carried out on 26 March 2012 at the proposed intake point. Narok Town was in fine weather without rainfall.

Rock exposure is found at the river crossing and rock exposure level is lowest at the center.

Figure 2-2-3 shows cross section of river at the proposed intake point. Flow velocity measurement was conducted three times and average velocity was V=0.57m/sec. River flow cross section area is 0.29m^2, so the flow amount is 0.29×0.57m/sec=0.165m^3/sec=142,819m^3/day. Aforementioned total intake amount of 5,350m^3/day corresponds to 3.7% of this river flow amount and this intake amount seems feasible.

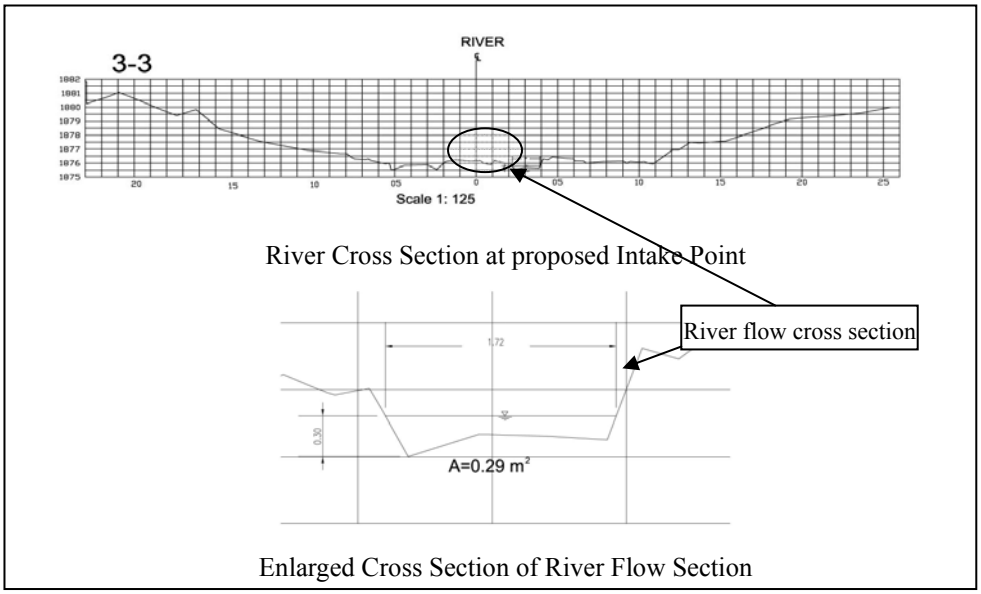
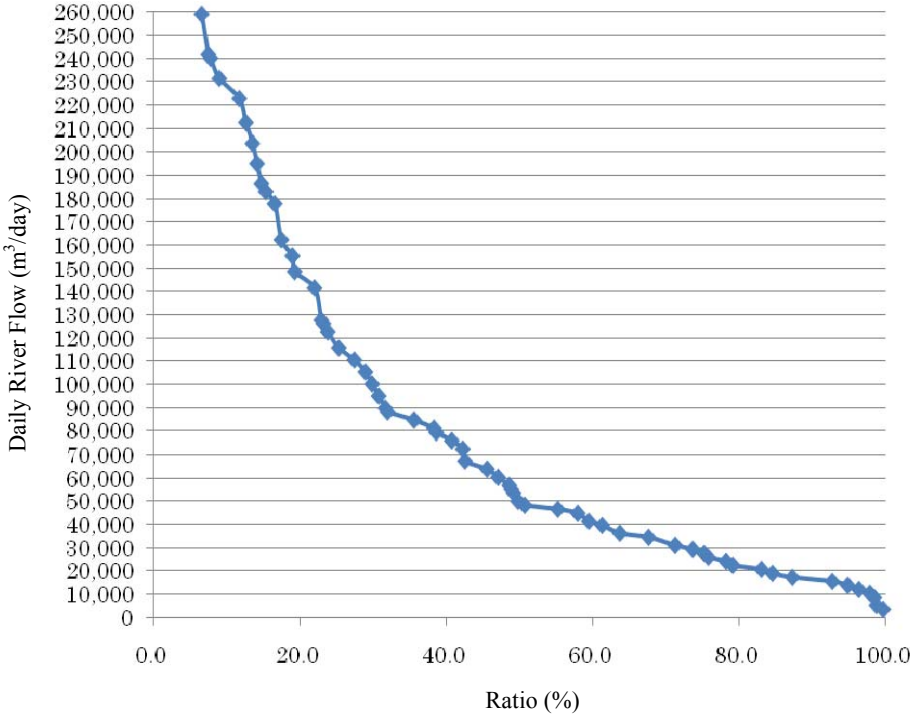


Figure 2-2-3 River Cross Section at River Flow Measurement (Proposed Intake Point)

iii) Confirmation of the minimum monthly river flow amount of 95% probability

Analyzed the Enkare Narok River flow amount data recorded for 31 years from 1980 to 2012 by WRMA. River surface level data was converted into river flow amount data to estimate the monthly minimum river flow amount. Flow duration curve was prepared as shown in **Figure 2-2-4**. By this curve, the minimum monthly river flow amount of Q=13,495m^3/day in 95% probability was assumed. Proposed total intake amount for the existing Central WTP and the proposed North WTP, 5,350m^3/day corresponds to 39% of said minimum monthly river flow amount of Q=13,495m^3/day with 95% probability.



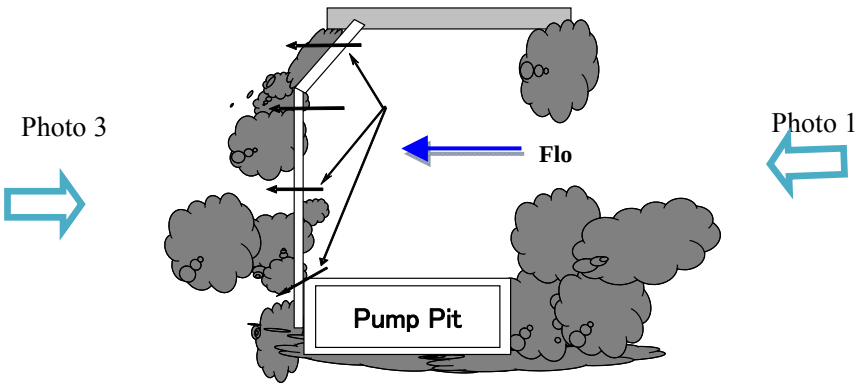
Note) Minimum monthly river flow amount data duration: January 1981 to January 2012,
River flow amount measurement station No. 2K03

Figure 2-2-4 Flow Duration Curve in Enkare Narok River

3) Water Intake Facility

i) Water Intake Method

Stagnant river water will flow through the intake weir to be built in the crossing direction of the river, and raw water is withdrawn by intake pumps that are installed in the pump pit. The pump pit shall be installed upstream of the river adjacent to intake weir. A plan of proposed intake facility, field photos and the photo of similar weir are shown in **Photo 2-2-1**.



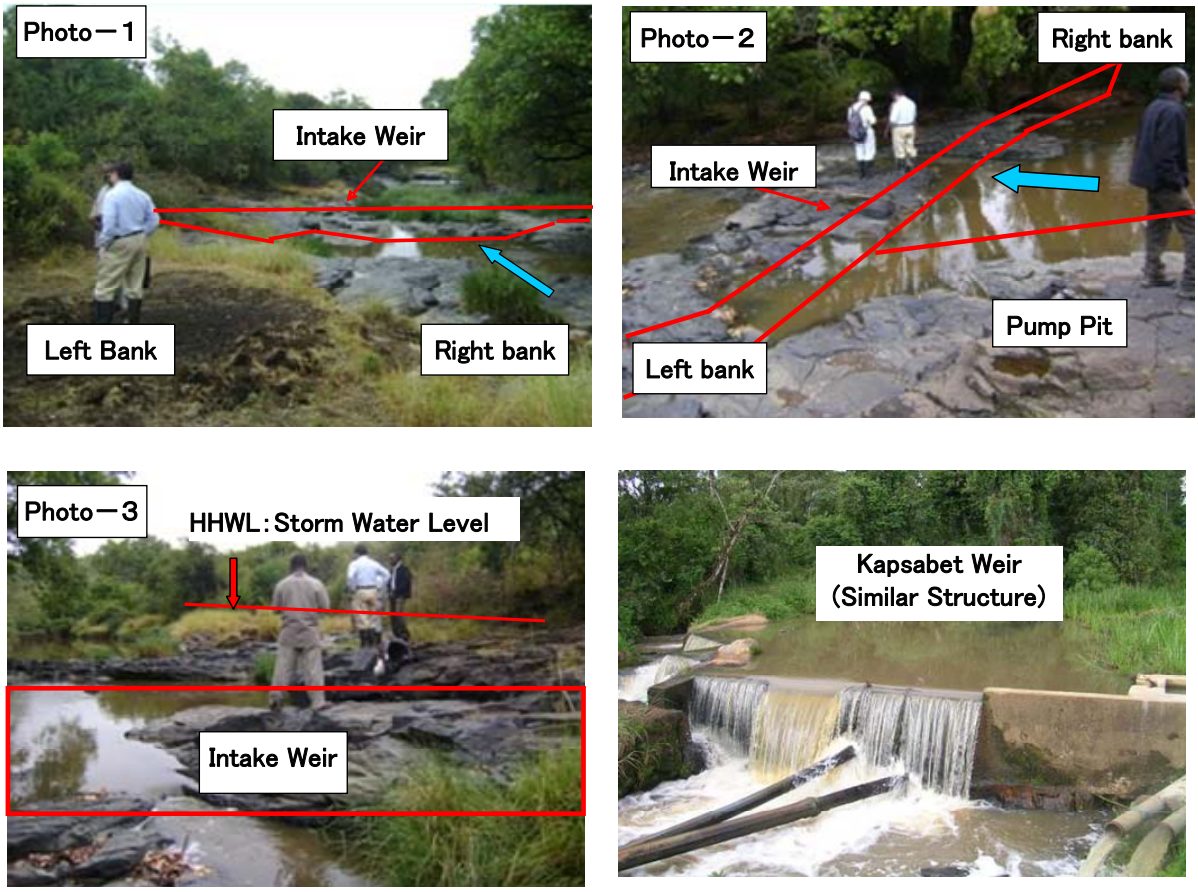


Photo 2-2-1　Proposed Construction Site of Water Intake Facility

ii) Intake weir

The intake weir shall be a robust structure effectively utilizing the exposed rooks. Weir top height shall be about 80cm considering river water levels at floods. The cross section of the intake weir is shown in **Figure 2-2-5**.

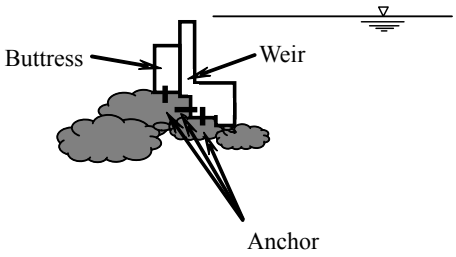


Figure 2-2-5　Cross Section of Intake Weir

iii) Pump Pit

As shown in **Figure 2-2-6**, the pump pit is to be installed upstream of the intake weir. Two pit inlet weirs with a width of 1m are planned, where the weir top level will be 20cm lower than intake weir top level. A screen will be installed in front of the pit inlet weir to prevent inflow of floating objects. Desilting of sediments accumulated in the pit bottom will be conducted by two desilting

pipes. Desilting shall be done continuousely to avoid accumulation of settling sand. Since the installation of motor on the slab top of pump pit is planned, the top slab level shall be higher than intake weir level + 1m.

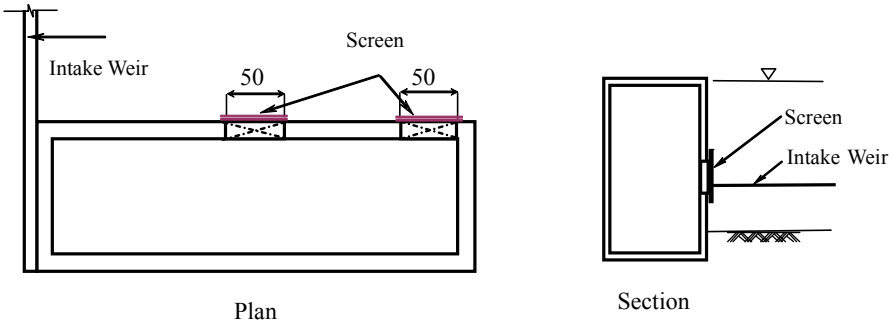


Figure 2-2-6 Plan and Section of Intake Pump Pit

(3) Raw Water Transmission Pipe

1) Pipe Route

Pipe installation route shall be a linear one connecting between the proposed intake facility and the proposed North WTP. Basically, the raw water transmission pipe shall be buried under the ground.

2) Setting Pipe Diameter

The elevation of the proposed water intake facility and the proposed North WTP is shown in **Table 2-2-13** and **Figure 2-2-7**. The distance between them is 1,540m while the elevation difference is 80m.

Table 2-2-13 Elevation Difference of Conveyance Pipe

Elevation	Intake	North WTP	Elevation Difference
	+1,877m	+1,957m	80m

The designed raw water transmission amount becomes 4,300m^3/day, 0.04977m^3/sec includng treatment loss in the proposed North WTP. The following Hazen-Williams Formula was applied in the raw water transmission pipe diameter calculation:

$$H=10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$

where: H : Head Loss (m)
C : Velocity Coefficient (130)
D : Diameter (m)
Q : Flow Amount (m^3/sec)
L : Pipe Length (m)

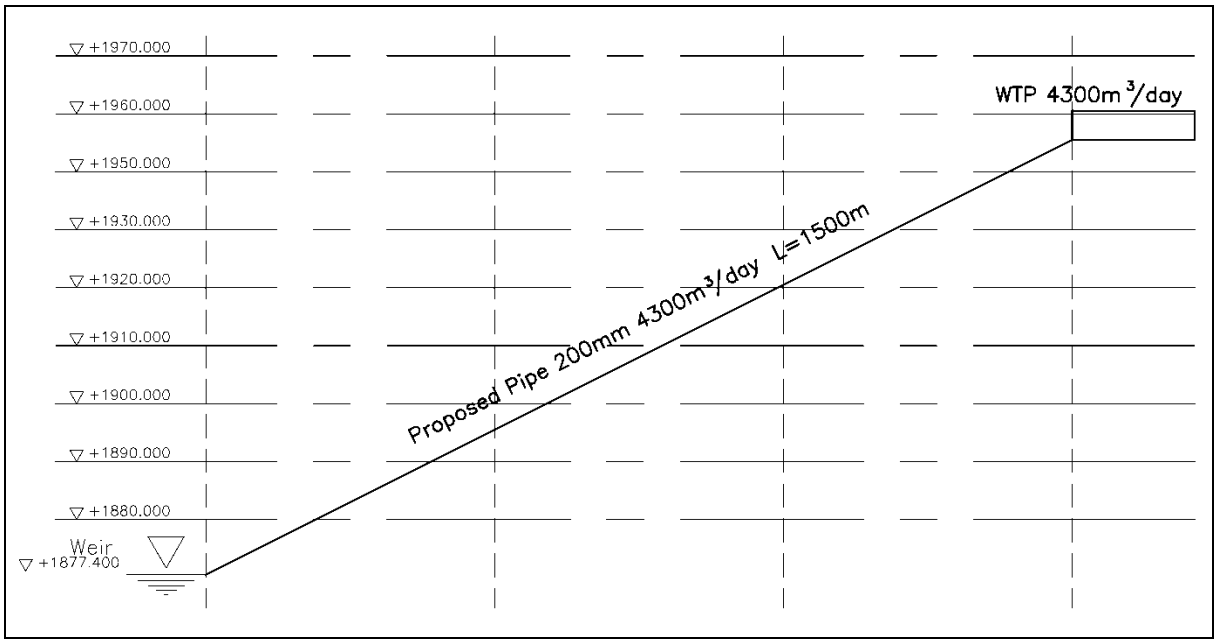


Figure 2-2-7 Elevation of Raw Water Transmission Pipe

Since raw water is pumped from the proposed water intake facility to the proposed North WTP, head loss and velosity shall be properly maintained. Because of the difference of elevation, the interval between the proposed water intake facility and the proposed North WTP is 80m, which is large. Head loss shall be minimized and velocity shall be within the range of 1.0m/sec to 3.0m/sec, which is regarded as the appropriate pumping velocity.

Raw Water Transmission Pipe Diameter：200mm
Raw Water Transmission Pipe Material：DI Pipe

(4) Water Treatment Plant（Proposed North WTP）

The location of the proposed North WTP shall be properly selected from several candidate construction sites where gravity water supply is possible, and therefore, the site with the highest elevation area is selected. Designed treatment amount is set by 4,000m^3/day, design treatment water amount of the existing Central WTP, 1,000m^3/day from design distribution amount, 5,000m^3/day.

1) Water Treatme

During field survey, soil investigation was carried out in one point at the intake facility, five points at WTP site to confirm the soil condition. Soil spread in water intake facility and WTP site is mainly composed of silty clay. Since N values in one to 2m depth groom ground surface reached 50, the ground has quite firm nature. Therefore, mat foundation is proposed for water treatment facilities.

2) Water Treatment Process and Facility Plan

The water treatment process selected for the proposed North WTP is the same as the existing

Central WTP, which is coagulated sedimentation and rapid filter system. Water tretament process is comprised of injection of coagulant, alminium sulfate , flocculation basin, sedimantation tank and rapid sand filtration. Lime is used as alkali conditioner and granule calcium hypochlorite is adopted as sterilizer and their solution is injected to a chlorine disinfection basin. Upon backwashing of rapid filter, two methods are conducted in parallel, namely air backwashing by blower/compressor and backwashing by gravity flow fed from elevated backwash tank. Sludge generated in sedimentation tank is treated by a drying bed. Wastewater generated in each facility including filter backwashing wastewater is drained to a drainage pond and after settling the suspended solids, only the supernatant is discharged to the Enkare Narok River. Overflow from each basin is collected by a yard drainage channel and discharged to the road drainage of C57 Road. The treatment flow diagram of the proposed North WTP is shown in **Figure 2-2-8** and facility plan is described in **Table 2-2-14**.

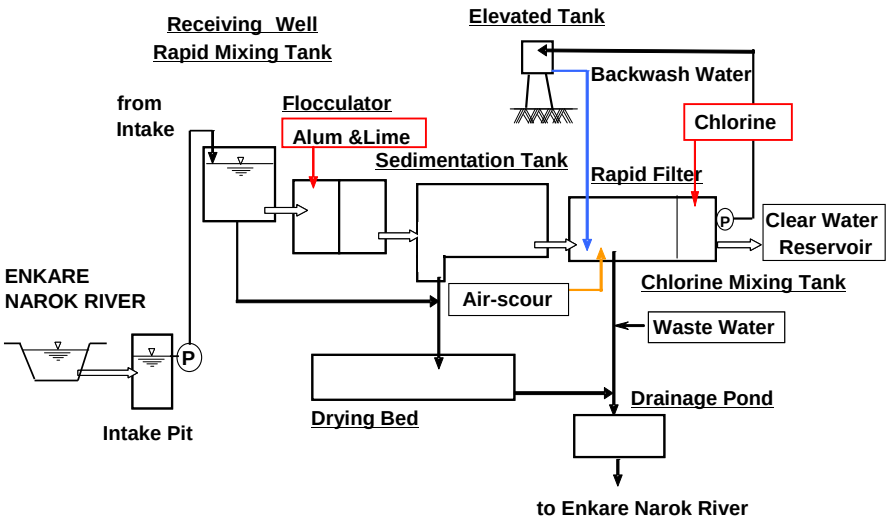


Figure 2-2-8 Treatment Flow Diagram of the Proposed North WTP

Table 2-2-14 Proposed North WTP Facility Plan

Facility/ Equipment	Facility Plan
Receiving Well/ Rapid Mixing Basin	Receiving well detention time is 10 minutes. Mixing is conducted by gravity fall from overflow weir.
Flocculator	Temperate agitation is carried out by gravity flow generated by horizontal baffled channel. Retention time is 20 minutes.
Sedimentation Tank	Horizontal flow-type sedimentation tank. Surface load is 16mm/min. Sludge is executed by gravity to drying bed.
Rapid Filter	Gravity filter. Filtration rate is 120m/day. Filter backwashing is conducted by gravity backwashing fed by elevated backwash tank and air backwashing in parallel.
Chemical Dosing Equipment	Aluminum Sulfate, calcium hypochlorite and lime solution is injected by gravity. Hand mixer is used for chemical solution.
Drying Bed	Drying of generated sludge
Drainage Pond	Settling turbid materials contained in wastewater generated from backwashing, discharge supernatant to the Enkare Narok River.

3) Equipment Plan

Raw water pumped by the water intake facility will be transmitted into the receiving well and will flow through each treatment facility by gravity making use of the facility's difference in elevation and will be finally discharged into clear water reservoir. The optimum treatment method with minimum required equipment, minimum power requirement, and easy O&M will be selected. Automatic control will also be minimized and plant will be manually operated.

Rapid filter backwashing will be conducted by manual open-close operation of valve handles consolidated on top slab of rapid filter. A distribution pump shall transmit clear water to residents nearby, and plant water pump shall transmit clear water to elevated backwash tank. Since raw water contains much clayish materials, turbidity might increase during rainy season. Considering such conditions, three blowers, including one stand-by are planned and a combination of backwash and air scouring is recommended.

Chemical equipment will be installed on the second floor and chemical solution will be injected by gravity. Injection rate will be controlled manually without using power-consuming devices. Coagulant dosing rate will be set based on the results of jar test and to cope with fluctuation of raw water turbidity, chemical injection equipment with dosing capacity with range of minimum 20mg/L to maximum 150mg/L is planned. Alkaline agent dosing equipment to increase pH lowered by coagulant and chlorine dosing equipment for clear water disinfection is also planned. Refer to **Appendix 6-12:** Examination on Chemical Injection Rate in WTP.

4) Outline of Facilities

The outline of the proposed North WTP facilities is shown in **Table 2-2-15**.

Table 2-2-15 Outline of the Proposed WTP Facilities

Facility/Equipment	Dimensions and Specifications	Remarks
Civil and Architectural		
1. Receiving Well/ Rapid Mixing Chamber	RC structure Width 1.8m×Length 1.5m×Depth 3.0m ×1 unit	
2. Flocculation Basin	RC structure Width 5.0m×Length 8.35m×Depth 1.0～1.3m ×2 units	Baffled channel flow type
3. Sedimentation Tank	RC structure Width 5.5m×Length 17.0m×Depth 3.0m×2 units	Horizontal flow type
4. Rapid Filter	RC structure Width 2.5m×Length 3.6m×4 units Sand layer thickness：1.0m Under drain system：1 set Air backwashing system：1 set	Gravity filtration Filtration rate: 120m/day
5. Rapid Mixing Tank	RC structure Width 4.0m×Length 3.6m×Depth 1.15m×1 unit	
6. Elevated Backwash Tank	RC structure Width 4.5m×Length 4.5m×Depth 4.0m×1 unit	For filter backwashing and in-plant watering
7. Drying Bed	RC structure Width 8.0m×Length 15.0m×Depth 1.0m×4 units	

Facility/Equipment	Dimensions and Specifications	Remarks
8. Drainage Pond	Unlined earth pond （Embankment is protected by gabion） Width 14.0m×Length 25.0m×Depth 2.0m×2 units	
9. Chemical House	Stone block structure Width 7.2m×Length 12.85m Dissolution tank：2.5m^3 ×6 units	Chemical storage room is secured Aluminum Sulfate, lime, calcium hypochlorite
10. Operation Building	Stone block structure Width 10.0m×Length 10.0m Office：50m^2 Operation room, Laboratory, kitchen, toilet, etc.: 50m^2	
11.Generator and Electrical House	Stone block structure Width 10.0m×Length 10.0m	
12. In-plant Piping	Piping work: 1 set	
13. In-plant Landscaping	Landscaping work: 1 set	
Mechanical Equipment		
1. Coarse Screen	Stainless punching metal Opening 15mm × 2 units	
2. Fine Screen	Stainless punching metal Opening 5mm × 1 unit	
3. Grit Chamber Inlet Gate and Outlet Gate	Cast iron manual gate W 500mm×H 500mm×4 units	
4. Intake Pump	Vertical shaft mixed flow pump Dia.150mm×4 units	
5. Discharge Valve	Automatic sluice Valve Dia. 150mm×4 units	
6. Pump Hoist Device	Manual chain block 1ton×1 unit	
7. De-sludge valve	Manual butterfly valve Dia 150mm x 4 units, with head stock	
8. Rapid Filter Inlet Gate	Manual butterfly valve Dia.200mm×4 units, with head stock	
9. Rapid Filter Backwash Drain Valve	Manual sluice valve Dia.250mm×4 units, with head stock	
10. Rapid Filter Outlet Valve	Manual butterfly valve Dia.300mm×4 units, with head stock	
11. Rapid Filter backwash Valve	Manual butterfly valve Dia.250mm×4 units, with head stock	
12. Rapid Filter Air Scour Valve	Manual butterfly valve Dia.250mm×4 units, with head stock	
13. Plant Water Pump	Horizontal shaft volute pump 1.0m^3/min × 20m× 7.5kW × 2units (1 unit stand-by)	
14.Water Supply Pump	Portable engine-driven pump, 1 unit	
15. Blower	Roots blower 4.5m^3/min × 35kPa × 7.5kW × 3 units (1 unit stand-by)	
16. Drainage Pump	Non-clog submergible pump 0.2m^3/min × 10m × 0.75kW × 4 units (1 unit stand-by)	
17. Pump Hoist Device	Manual chain block 1 ton×1 unit	
18. Alum Injector	Hand mixer×2 units Storage tank×1 unit Manual adjustment gravity dosing charger×2 units (1unit stand-by)	
19. Soda Ash Injector	Hand mixer×2 units Storage tank×1 unit Manual adjustment gravity dosing charger×2 units (1unit stand-by stand-by)	

Facility/Equipment	Dimensions and Specifications	Remarks
20. Chlorine Injector	Hand mixer×2 units Storage tank×1 unit Manual adjustment gravity dosing devise×2 units (1unit stand-by SB)	
21. Chemical Lift Equipment	Electrical chain block, 0.25t×1 unit	
22. Drain Pump	Portable, engine-driven pump, 1 unit	
23. Mechanical Flow Meter	Turbine flow meter, 11 units	
24. Mechanical Water Level Control Valve	Float valve, 1 unit	For elevated backwash tank
25. Mechanical Water Level Indicator	Site reading type scale, 1 unit	For elevated backwash tank
26. In-door Piping, Valves	Chemical room, pump room, etc 1 set	
Electrical Equipment		
1. Incoming Panel (Meter Panel)	Steel plate in-door wall mounted type 600W×600H×300D×2unit	
2. Power Receiving Panel	Steel plate in-door self-standing type 1,000W×2,300H×1,000D×2 unit	
3. Clear Water Transmission Pump Panel	Steel plate indoor self-standing type 1,000W×2,300H×1,000D ×4 units	No. 1～4 clear water transmission pump
4. Low Voltage Panel Feeder	Steel plate indoor self-standing type 1,200W×2,300H×1,000D ×1 unit	
5. Instrumentation Panel	Steel plate in-door self-standing type 1,000W×2,300H×1,000D×1 unit	
6. Local Control Panel	In-door wall mounted type 500W×700H×300D ×3 units 600W×800H×300D ×2 units 600W×700H×300D ×1 units	For No.1 to 4 clear water transmission pumps, No.1 to 3 Blowers No1, 2 plant water pumps
7. Diesel Generator sets	100kVA x 1 set at WTP	
8. Switch Box	Indoor wall mount type 500W×600H×300D ×1 unit	
9. Magnetic Flow Meter	Φ250mm×2 unit	
10. Turbine-type Flow Meter	φ150mm × 1 unit φ80mm × 1 unit, ϕ 75mm × 5 units	
11. Pressure Meter	2 unit	
12. Float-type Water Level Meter	6 units	
13. Level Switch	3 units	
14. Communication Device	Main and branch unit, 1 set	
15. Pipes and Cables	Pump rooms and outdoors, 1 L.S.	

(5) Existing Central WTP Rehabilitation Plan

1) Design Plant Capacity

A capacity of 1,300m^3/day is expected for the existing Central WTP, referred to in **Table 2-2-16**. This is in accordance to the facility capacity evaluation on major facilities of Sedimentation Tank and Rapid Sand Filter, which is based on the "Kenyan Practice Manual" as well as on the Japanese water supply system design guideline.

The target area has undulating topographic features, however, the service areas shall be divided into right bank side and left bank side of the Enkare Narok River flowing through Narok Central area, from the viewpoint of energy efficiency. Therefore, the service area of the existing Central WTP

shall be on the right bank corresponding to Total Estate district and Mwamba district. The target water distribution amount is set by the design water demand in target service area of 1,000m^3/day.

Table 2-2-16 Capacity Evaluation on the Existing Central WTP

Design Indices	Standards	Dimensions	Facility Capacity
A. Chemical Sedimentation Tank (9 units×30m^2/tank, overflow weir length 4.3m)			
＜Kenyan Practice Manual＞			
Surface load	1m^3/m^2-hr	30m^2/tank	720m^3/day/tank
＜Japanese water supply system design manual＞			
Surface load	15 ～ 30mm/min	30m^2/tank	650～1,300m^3/day/tank
In-tank velocity	Less than 0.3m/min	8.6m^2	3,715m^3/day/tank
Effluent weir load	Less than 500m^3/m	4.3m	2,150m^3/day/tank
B. Rapid Filter（2 units×7.0m^2/filter）			
＜ Kenyan Practice Manual ＞			
Filtration rate	5m^3/m^2-hr	7m^2/filter	840m^3/day/filter
＜Japanese water supply system design manual＞			
Filtration rate	120 ～ 150m/day	7m^2/filter	840～1,050m^3/day/filter
C. Treatment Capacity Evaluation			
Kenyan Practical Manual: Chemical sedimentation tank capacity is adopted 720m^3/day/tank×2 tanks=1,440m^3/day			
Japanese water supply system design manual: Rapid sand filter capacity is adopted 650～1,050m^3/day/filter × 2 filters = 1,300m^3/day～ 2,100m^3/day → 1,300m^3/day			

2) Rehabilitation Plan

The current status of the existing central WTP (Phase 3 facility, constructed in 1980's) was evaluated based on field survey results.

Floc carry over at the chemical sedimentation tank and scarce turbidity removal at rapid filter were confirmed through a field survey and these are the major issues in the present plant's operation. These issues were supposedly caused by over loading operation, filter sand thickening resulting in malfunctions, and the improper chemical dosing rate control. Drastic plant capacity upgrading is not necessary, so, the scope of works shall be limited to needed rehabilitation works to maintain the current total plant capacity. The following are proposed as rehabilitation targets.

i) Replacement of Filter Media

Target raw water contains much clayish particle materials and its turbidity rises during the rainy season. As the current fitration method is surface filtration, small particle filter sand is likely to generate into a mudball that clogs filtration. Accordingly, the existing filter sand shall be replaced with larger particle size and lower uniformity coefficient to perform depth filtration.

Based on the interview survey, the current layer thickness of filter media is comprised of a sand layer in 60cm and a gravel layer in 15cm. Considering some allowance, thickness of the layer of the sand and the gravel are set by 70cm and 20cm, respectively.

ii) Chemical Dosage Equipment and Chemical Storage Room

Since it is observed that the existing chemical dosage equipment and its storage space are

inappropriate for O&M activities and are no longer feasible to rehabilitate, it is desirable to replace this with a new system. Installation of a dosage equipment for alminium sulfate, calcium hypochlorite and pH adjuster and lime is planned .

iii) Water Quality Analysis Equipment (Equipment Procurement)

Water quality analysis equipment is absolutely needed for proper plant management and thus, it shall be provided through equipment procurement. Since the proposed North WTP will become the largest WTP in Narok Town after its commissioning, said equipment shall be supplied to the proposed North WTP. Together with this, the following water quality analysis equipment needed in daily plant management shall be procured for the existing Central WTP – jar tester, turbidity meter, chroline meter, pH meter and balance for chemical measurement.

3) Existing Central WTP Rehabilitation Work Items

Table 2-2-17 shows the summary of field survey findings and rehabilitation work items of the existing Central WTP. Work delineation has been determined considering work scale, level of work difficulty, and availability of material and equipment in Kenya.

Table 2-2-17 Current Status of the existing Central WTP and Rehabilitation Work Items

Facility Name	Rehabilitation Work Items	Work Demarcation		Remarks
		Kenya	Japan	
Intake Pit	Replacement of steel screen	●		
Intake/Conveyance Pump and related Equipment	Replacement of 1 unit of the existing malfunctioning pump	●		Install water meter on raw water transmission pipe for raw water intake amount measurement
Chemical Sedimentation Tank	-	-	-	Constant floc carry over from this tank was observed. After provision of chemical dosage equipment, chemical dosing status shall be reconfirmed and necessary countermeasures shall be taken
Rapid Sand Filter	Replacement of filter media (sand and gravel)	-	●	
Clear Water Reservoir	-	-	-	
Backwash Water Tank	-	-	-	
Chemical Dosage Equipment and Chemical Storage Room	Construction of new chemical storage room and installation of chemical dosage equipment of Aluminum Sulfate, Calcium hypochlorite and Lime		●	Demolish existing building and abolish existing chemical dosing equipment. Build temporally storage room during construction work
Water Quality Analysis Equipment	Jar tester, turbidity meter, chlorine meter, pH meter, chemical balance 1 set of glassware		●	Repair work for ceiling of the existing laboratory and power line setting work shall be undertaken by Kenyan side

(6) Clear Water Transmission Pipe Plan

Basically, the clear water transimission pipe plan is by gravity flow system from the proposed 2,000m^3 clear water reservoir to the 500m^3 Fanaka high school Tank.

1) Pipe Installation Route

Pipe route will commence from the proposed 2,000m^3 clear water reservoir to be constructed in the

proposed North WTP to the existing 100m^3 Majengo reservoir. This shall be the same as the existing one crossing Lenana and Samburumburr Drift. The pipe is planned to be laid along the public road from Majengo reservoir to the existing Fanaka 500m^3 high school reservoir.

2) Pipe Material and Diameter Selection

As shown in **Table 2-2-18**, the elevation difference between the proposed 2,000m^3 clear water reservoir to be constructed in the proposed North WTP and the existing 500m^3 Fanaka high school reservoir is 4m. Distance between these two reservoirs is 3,780m.

Table 2-2-18 Elevation Difference of Clear Water Transmission Pipe

Elevation	Amsl at New WTP Reservoir	Amsl at Fanaka High School Reservoir	Elevation Difference
	+1,952m	+1,948m	4m

Currently, φ75mm uPVC pipe is installed from the existing FTC reservoir to the existing Fanaka high school reservoir. However, as shown in **Figure 2-2-9**, after completion of the prposed 2,000m^3 clear water reservoir planned in the proposed North WTP, transmission volume will increase, and accordingly, the transmission volume from new reservoir to the existing Fanaka high school reservoir will also increase.

If the existing pipes are used, pipe friction loss will be higher than the current status due to increased transmission flow. Therefore, it is desirable to install a new clear water transmission pipe between the proposed reservoir and the existing reservoir at Fanaka high school.

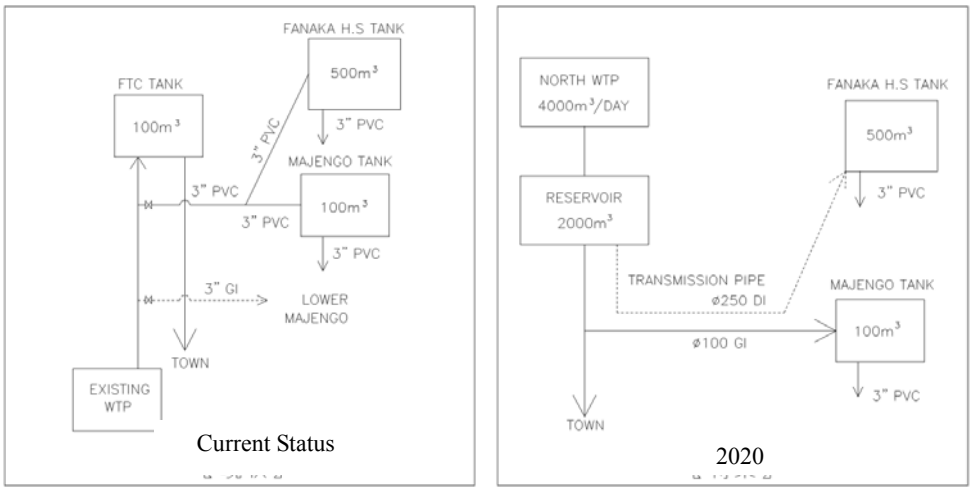


Figure 2-2-9 Schematic Drawing of Clear Water Transmission Pipe Layout

In examining the design of optimizing transmission pipeline system, daily maximum water demand for transmission is used, and the capacity of Fanaka high school reservoir (500m^3) is assumed to be able to store 12 hours' equivalent amount of daily maximum water demand and its capacity is set by 1,000m^3/day (0.01157m^3/sec). The following Hazen-Williams Formula is applied in hydraulic calculation:

$H=10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$

where: H：Head Loss (m)
C：Velocity Coefficient (=130)
D：Diameter (m)
Q：Flow Amount (m^3/sec)
L：Pipe Length (m)

The head loss of the pipe with 200mm is less than the elevation difference with 4m obtained from the topographic survey, still the pipe diameter with 250mm is adopted taking into consideration marginal factor allowance. Compared with the existing clear water transmission pipe, both pipe diameter and length become larger. The clear water transmission pipe should be durable and sustainable, and careful selection of the pipe should be made. Considering these, the DI pipe is adopted.

Diameter of Clear Water Transmission Pipe ：250mm
Material of Clear Water Transmission Pipe：DI Pipe

(7) Distribution Facility Plan

1) Water Distribution Method

Treated water is to be distributed from the clear water reservoir to the target service area by gravity. As to Olopito and London, water is served by the existing Fanaka reservoir. The Olpopongi district is served by the existing Oletips high school reservoir and Mwamba district is served by the existing Mwamba reservoir, respectively.

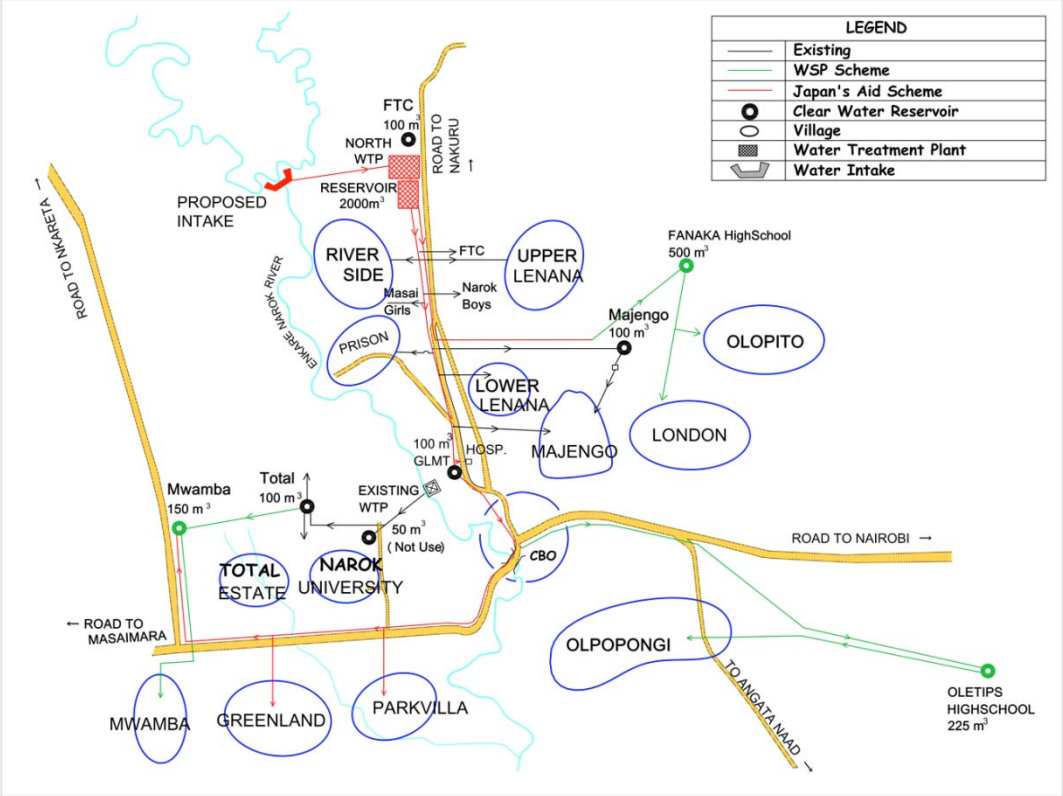


Figure 2-2-10 Schematic Plan of Water Distribution System (2020)

2) Reservoir

i) Proposed Clear Water Reservoir

According to the "Kenyan Practical Manual", the capacity of a gravity supplied reservoir is set as 12 hours the volume of daily maximum water supply amount, which also corresponds to the Japanese water supply system design guideline.

＜Reservoir Capacity Calculation by Japanese Water Supply System Design Guideline＞

Providing for the daily maximun water supply amount hour will continue until total daily maximum water supply amount is consumed, necessary reservoir capacity is calculated as:

Hourly Peak Factor	α	
Hourly an amount of Daily Maximum Water Supply Amount	q_0	(m^3/hr)
Hourly Maximum Water Supply Amount	$\alpha \cdot q_0$	(m^3/hr)
Daily Maximum Water Supply Amount	$Q_0=24\ q_0$	(m^3/day)
Successive hours of Daily Maximum Water Supply	$t = Q_0/(\alpha \cdot q_0) = 24\ q_0/(\alpha \cdot q_0) = 24/\alpha$ (hr)	

$$Vmax = \alpha \cdot q_0 \cdot t - q_0 \cdot t$$
$$= (\alpha-1) \cdot q_0 \cdot 24/\alpha$$
$$= 24(1-1/\alpha)\ q_0$$

*Water amount deducting distribution amount from transmission amount during "t" hours

As Vmax＝12 hours, since design daily water supply amount is 4,000m^3/day, required reservoir capacity is 2,000m^3.

Proposed Clear Water Reservoir in the North WTP Capacity: 2,000m^3

ii) Rehabilitation of the Existing Facilities

The existing reservoirs are rehabilitated by internal water-proof painting using epoxy paint and external painting. Areas that require painting are as follows:

Table 2-2-19 Required Painting Area of existing Reservoirs

Reservoir Name	Reservoir Capacity
G.K. Reservoir	105m^3
FTC Reservoir	105m^3
Total Estate Reservoir	100m^3
Majengo Reservoir	100m^3

3) Water Distribution Pipe

(i) Pipe Network

According to the distribution pipe network planning, the connection to the existing pipes shall be considered as premises for both new distribution main and distribution branch pipe. The definition of distribution main and distribution branch pipe is as follows:

- Distribution Main: Major distribution pipes excluding house connection pipes
- Distribution Branch: Pipes other than distribution main pipes

(ii) Pipe Materials and Diameter

The specifications for the distribution main and distribution branch pipes are stated as follows:

- Distribution Main pipe：DI pipe, φ300mm～φ150mm
- Distribution Branch pipe：GI pipe or uPVC pipe, φ75mm～φ50mm

(iii) Ancillary Facilities

- Install check valves other than branch points of distribution pipe where needed for proper O&M
- Install air valves and wash-out valves other than branch points of distribution pipe where proper O&M is needed
- Install at least one hydrant in each district

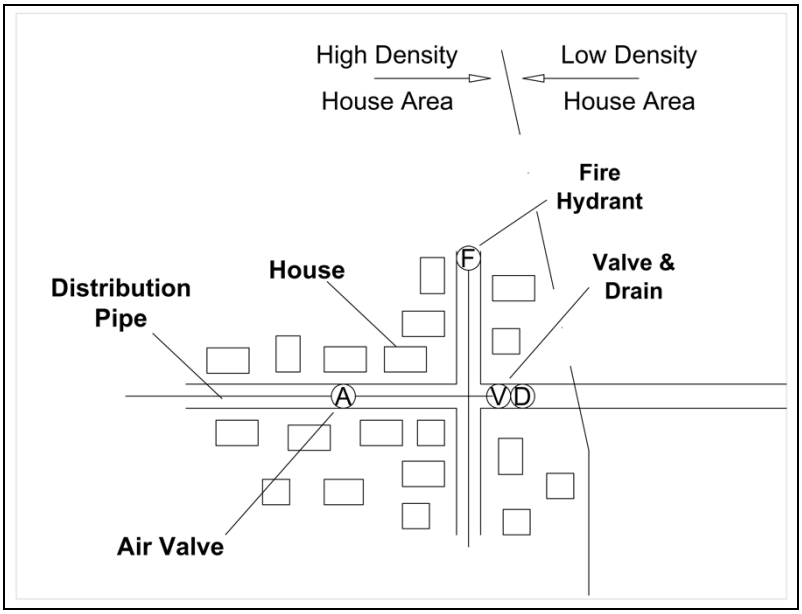


Figure 2-2-11 Manner of Distribution Pipe Installation

The distribution network shall be developed in areas currently congested with housing or areas where housing will be built until 2020. Network will not cover areas where housing is rare, as referred to **Figure 2-2-11**. Check valves and wash-out valves shall be placed at the pipe end of the distribution network for future network expansion by the Kenyan side.

4) House Connection Pipe

(i) House Connection

There are 2,131 existing water meters in Narok Town of which 956 units are currently non-functioning. According to population/housing numbers projection, the estimated number of water meter required within target service area in 2020 is 5,410 units, including the existing ones. Based on the following policy, the number of water meters to be procured by Japanese side is projected as 1,600 units:

- Replacement of 50% of water meters currently non-functioning and no longer serviceable
- Provide 50% of water meters to be installed on house connection pipes planned to be connected to the 80km distribution pipes will be installed by Japanese side

Water Meter : 1,600 units

(ii) House Connection Pipe

House connection pipes to be procured by the Japanese side to cover those branched from the proposed distribution pipe. House connection pipes to be covered are limited only from the branch point to the water meter. Based on the following conditions, the total proposed house connection pipe length is estimated as 16km.

- Number of water meter to be procured excluding malfunctioning to be replaced = 1,050 units

- House connection pipe length per house：15m/housing (based on field survey results)
- House connection pipe length：1,050 units (housings)×15m/housing＝15,750m≒16km

House Connection Pipe Length：16km

Figure 2-2-12 shows work demarcation between the Japanese side and the Kenyan side regarding the installation work of house connection pipe and water meter.

【Work demarcation in water distribution and house connection】

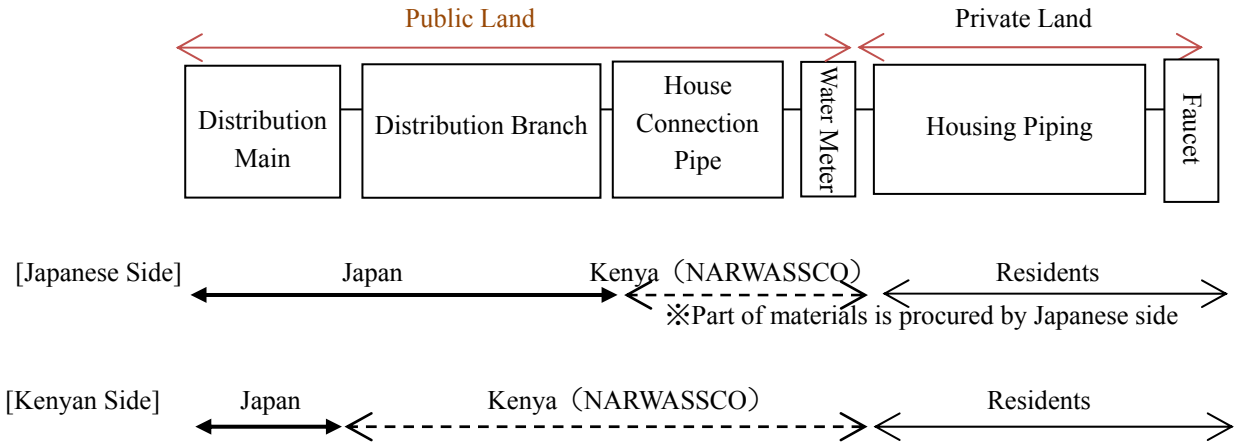


Figure 2-2-12　Work Demarcation between Japan and Kenyan Side

5) Outline of Water Distribution Facilities

Outline of water distribution facilities is shown in **Table 2-2-20.**

Table 2-2-20　Outline of Water Distribution Facilities

Name of Facility	Specifications/Dimensions	Remarks
1. Clear Water Reservoir in the Proposed North WTP		
Civil Works		
Clear Water Reservoir	RC Structure W 8.0m×L 20.0m×D 3.5m×2 units Capacity：1,050m^3 by 2 units	New construction
Mechanical/Electrical Works		
Water Level Control Valve	Float type eccentric valve Dia 300mm×2 units	
Power Receiving Panel	Steel plate in-door self-standing type 1000W×2300H×1000D ×1 unit	
Water Level Meter	Casting type, 1 unit	
Turbine-type Water Flow Meter	φ300mm ×1 unit	
Level Switch	1 set	
2. Distribution Pipe		
Civil Works		
Distribution Main	DI pipe Dia. 300～150 mm ×Length 12km approx.	New installation

Name of Facility	Specifications/Dimensions	Remarks
Distribution Branch	uPVC/Steel pipe Dia. 75～50 mm ×Length 68km approx.	
	Total 80km approx.	

(8) Materials and Equipment Procurement Plan

Procurement plan for the captioned project requested by GoK is as follows:

1) House Connection Pipes Materials and Fittings

Basically, the house connection pipes shall be uPVC pipe, but as to road crossing section where large vehicle load is expected and as to river/valley crossing with some midair sections, GI pipe with higher strength will be applied. Durable inner pressure for uPVC pipe shall be larger than 6 bar and that for GI pipe shall be larger than 10 bar.

Table 2-2-21 shows the list of provision material related to house connection. Provision of diversion saddle and repair valve is examined for smooth implementation of house connection work.

The accuracy of the water meter, and its easy maintenance are important for proper tariff collection. Currently NARWASSCO is mainly using Chinese-made water meters, which are cheap but easily malfunctions. This project will provide the water meters manufactured in Japan together with meter calibration devices.

Table 2-2-21 House Connection Pipes and Fittings to be procured

Classification	Specifications		
House Connection Pipes	Diameter（mm）	Pipe Materials	Length
	φ13	uPVC Pipe	16km
Fittings	Flow meter, check valve, air valve, wash-out valve		
Diversion Devices	Diversion saddle 1,600 units, Tapping machine for diversion saddle 2 units		
Repair Valves	1,600 units		
Water Meters	1,600 units (manufactured in Japan countries)		

Aside from visual inspection, water meter precision can be examined in more detail by meter calibration devices. This promotes removal/repair of malfunctioned water meters and function recovery confirmation on water meter after repair. Water meter calibration devices which are used in the Kapsabet and Embu projects shall be introduced and their operation shall be instructed through Soft Component assistance programme.

2) Water Quality Analysis Equipment

A laboratory is currently available at the existing Central WTP and this measures turbidity, pH, and residual chlorine of raw treated water in a simplified manner. However, equipment is quite inadequate and analysis is not reliable. In addition to this laboratory, water quality indices are analyzed in the MWI laboratory in Nakul twice a year. Considering such circumstances, provision of jar tester, turbidity meter, chlorine mater, pH meter, balance and one (1) set of glassware is proposed for the existing Central WTP.

A new laboratory will be built in the proposed North WTP where further broad range of water quality analysis functions shall be vested–not only general analysis by jar tester, turbidity meter and residual chlorine measurement. Thus, aside from basic equipment the introduction of spectrophotometer, incubator, and autoclave microorganism testing device and UV equipment are also needed.

3) O&M Equipment

At present, NARWASSCO owns only one unit of personal computer and one unit of printer for water tariff collection. Five (5) units of PC and four (4) units of printer shall be provided for the following purposes:

Table 2-2-22 Provision of Office Equipment for O&M

Offices	Purpose	Necessary Unit	
		Personal Computer	Printer
NARWASSCO Office	Sales and Promotion Section	1	1
NARWASSCO Office	Pipe Installation/Maintenance Works Supervision Section	1	1
Existing Central WTP	Plant O&M Section	1	1
Proposed North WTP	Plant O&M Section	2	1
Total		**5**	**4**