No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF WATER RESOURCES AND IRRIGATION OF THE GOVERNMENT OF THE SOUTHERN SUDAN (MWRI / GOSS)

MINISTRY OF HOUSING, PHYSICAL PLANNING AND ENVIRONMENT OF THE GOVERNMENT OF THE SOUTHERN SUDAN (MHPPE / GOSS)

MINISTRY OF PHYSICAL INFRASTRUCTURE OF THE CENTRAL EQUATORIA STATE (MOPI / CES)

JUBA URBAN WATER SUPPLY AND CAPACITY DEVELOPMENT STUDY IN THE SOUTHERN SUDAN

FINAL REPORT (SUMMARY)

SEPTEMBER 2009

TOKYO ENGINEERING CONSULTANTS CO., LTD. (TEC)
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PREFACE

The Government of Japan decided to conduct “Juba Urban Water Supply and Capacity Development Study in the Southern Sudan” and entrusted it to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a Study Team headed by Mr. Hirotaka Sato of Tokyo Engineering Consultants from August 2008 to August 2009. The team held discussions with the officials concerned of the Ministry of Water Resources and Irrigation as well as other officials concerned, and conducted field surveys. Upon returning to Japan, the team prepared this final report to summarize the results of the study.

I hope that this report will contribute to development in the Republic of the Sudan, and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Sudan for their close cooperation extended to the Study Team.

September 2009,

Mr. Toshiyuki Kuroyanagi
Director General
Economic Infrastructure Department
Japan International Cooperation Agency

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Director General
Economic Infrastructure Department
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Dear Sir,

Letter of Transmittal

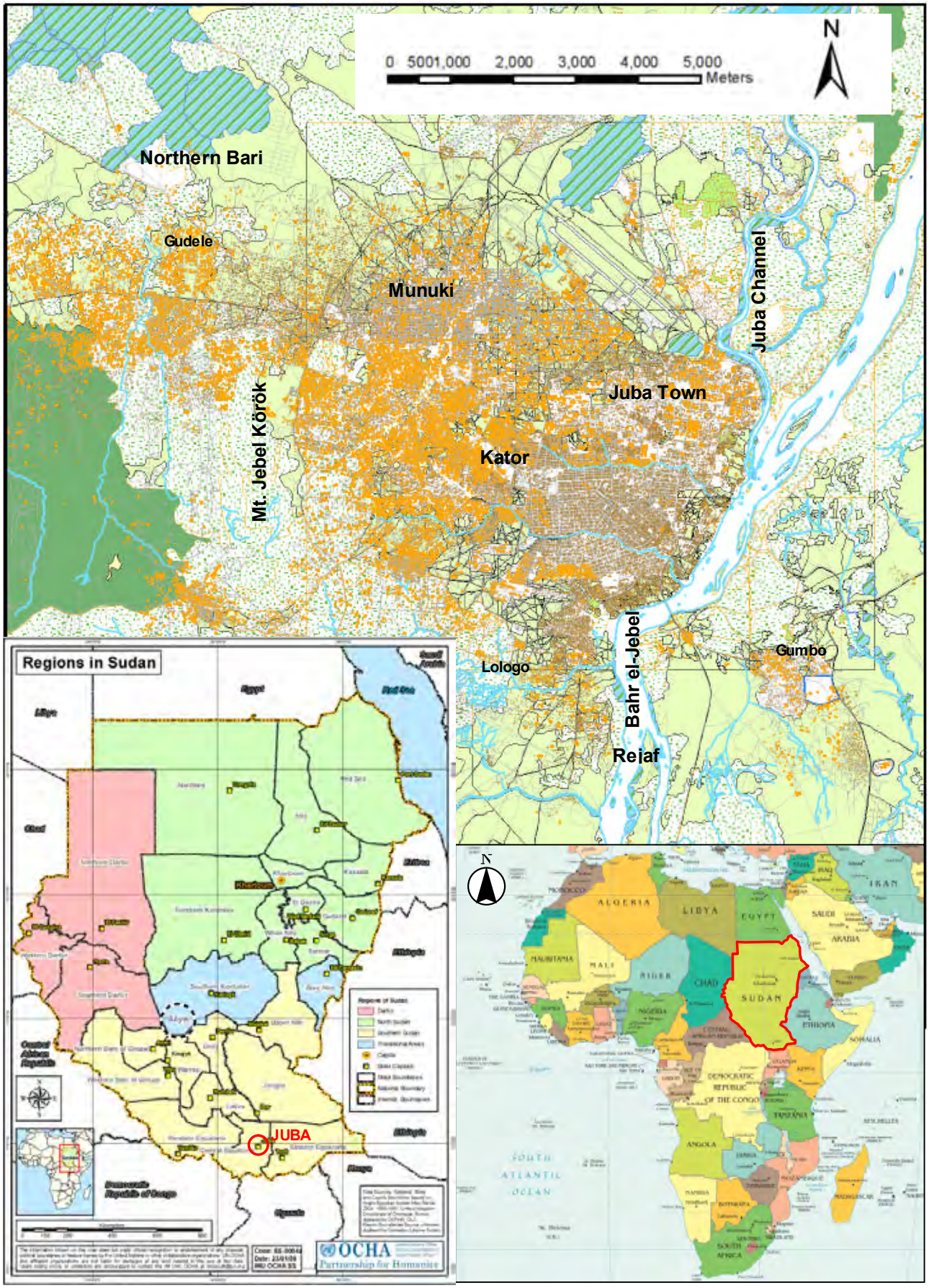
We are pleased to submit herewith the Final Report of "Juba Urban Water Supply and Capacity Development Study in the Southern Sudan". The report compiles the results of the Study and includes the advices and suggestions of the authorities concerned of the Government of Japan and your agency as well as the comments made by the Ministry of Water Resources and Irrigation and other authorities concerned in the Southern Sudan.

The Study was carried out for the purpose of formulating a plan to improve the water supply of Juba and developing the capacity of the water sector in the Southern Sudan. The report includes the existing water supply conditions of Juba, the contents of the master plan and the results of a feasibility study carried out on the priority project. We are truly sure that the results of the Study shall contribute to improving the current severe water supply conditions of Juba.

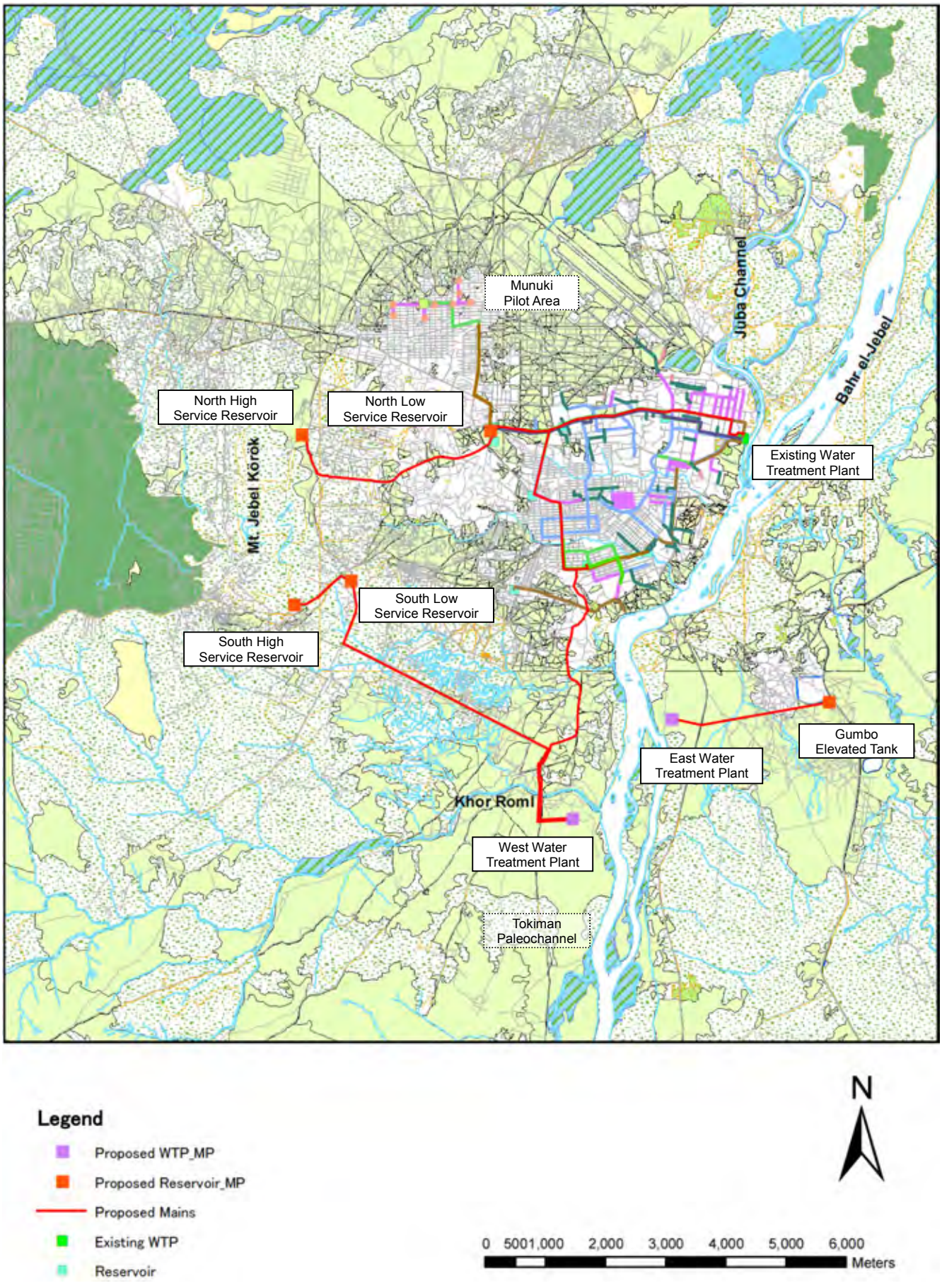
We wish to take this opportunity to express our sincere gratitude to your agency and the Ministry of Foreign Affairs. We also wish to express our deep gratitude to the Ministry of Water Resources and Irrigation as well as other Governmental Agencies concerned in the Southern Sudan for their close cooperation and assistance extended to us during the Study. We hope this report will contribute to the development of the Southern Sudan.

Very truly yours,

Mr. Hirotaka Sato
Team Leader,
Juba Urban Water Supply and Capacity
Development Study in the Southern Sudan



LOCATION MAP



PROPOSED MAIN WATER SUPPLY FACILITIES IN MASTER PLAN

EXECUTIVE SUMMARY

INTRODUCTION

After the end of long duration of civil wars, Juba became the capital of Southern Sudan in September 2005. For more than 20 years in the wars, no adequate investment and maintenance have been carried out in the water supply sector in Southern Sudan. Therefore, most of the facilities in Juba are in dilapidated state and in urgent need of rehabilitation and construction of new water supply system to meet increased large water demand.

To improve this situation, the Government of Southern Sudan (GOSS) requested the Government of Japan to carry out "Juba Urban Water Supply and Capacity Development Study (the Study). The purpose of the Study is to formulate a water supply master plan for Juba to a target year of 2025 and to carry out a feasibility study for priority projects. In the course of the Study, capacity development for the water sector of Southern Sudan was also implemented.

CURRENT WATER SUPPLY CONDITIONS

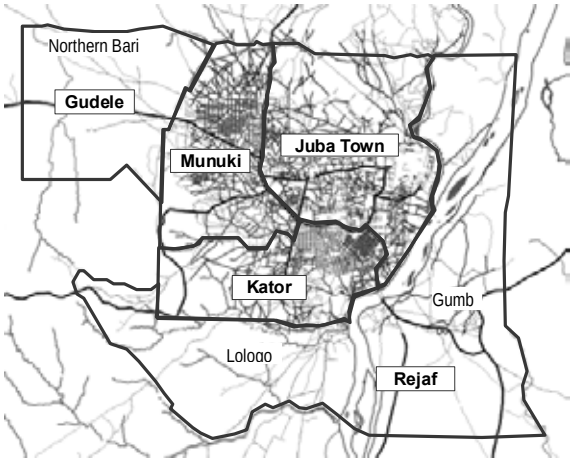
The people in Juba obtain water by means of house connection or public tap of Urban Water Corporation (UWC), public wells equipped with hand pumps, private venders by water tanker or jerry can venders, and private wells.

Before the completion of the rehabilitation of the existing treatment plant in May 2009, it was not possible for the people in Juba to obtain safe and clean water. After the completion, according to the estimate by the Study Team, about 8 % of the population can have access to safe and clean water. However, most of the people still use untreated river water or high salinity groundwater, which have unhygienic and inadequate quality for human consumption.

Out of many problems that households in Juba are facing after the end of the wars, according to a household sample survey by the Study Team, the severest problem relates to water supply, and almost all sampled households expressed dissatisfaction with current water supply in terms of water quality, quantity, supply hours and/or price. Out of these water supply dissatisfactions, water quality was answered as the biggest issue. The current average water consumption is about 30 L/c/d and the average fetching time of water is more than 1 hour every day. The households pay very expensive charge to private water venders; the average household expenditure for water is 132 SDG/month. Reflecting the current high expenditure for water, the willingness to pay for improved water supply services of households is quite high; i.e., 110 SDG/month for satisfied water supply service and 134 SDG/month for satisfied continuous water supply service.

TARGETS OF WATER SUPPLY MASTER PLAN

The target service area of the Master Plan is composed of Juba Town, Kator, Munuki Payams, Gumbo and Lologo in Rejaf Payam and Gudele in Northern Bari Payam. The overall target of the Master Plan is that all population in Juba can have access to safe and clean water by 2025 by means of house connection, public tap stand or water tanker supplying treated water. The target figures of the Master Plan are presented in the table below. The estimated water demands on daily maximum basis are 69,000 m^3/d in 2015 and 237,000 m^3/d in 2025.



Target Service Area of Water Supply

Target Figures of Water Supply Service in Master Plan

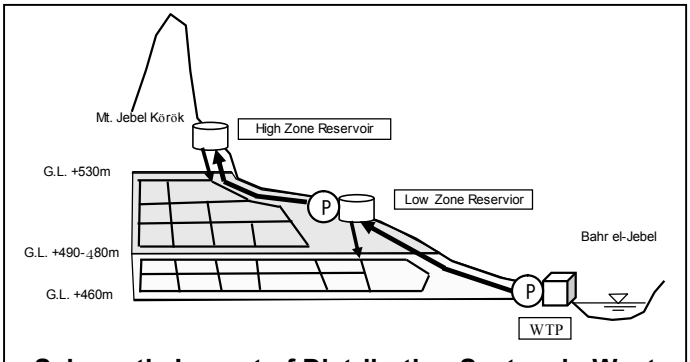
Item	2009 (present)	2015	2025
Future total population (persons)	406,000	680,000	1,161,000
Target coverage for access to safe and clean water supply (%)	8.4 (estimate)	80	100
Service population (persons)	Est. 34,000	544,000	1,161,000
Design domestic per capita consumption (L/c/d) - for house connection - for public tap stand/water tanker	 26 (53)* 34	 90 40	 120 40
Average daily water demand (m^3/d)	7,200 (capacity)	58,000	197,000
Maximum daily water demand (m^3/d)	7,200 (capacity)	69,000	237,000

Note: * It is adjusted based on increased capacity of the treatment plant after the completion of the MDTF project.

PROPOSED WATER SUPPLY SYSTEM IN MASTER PLAN

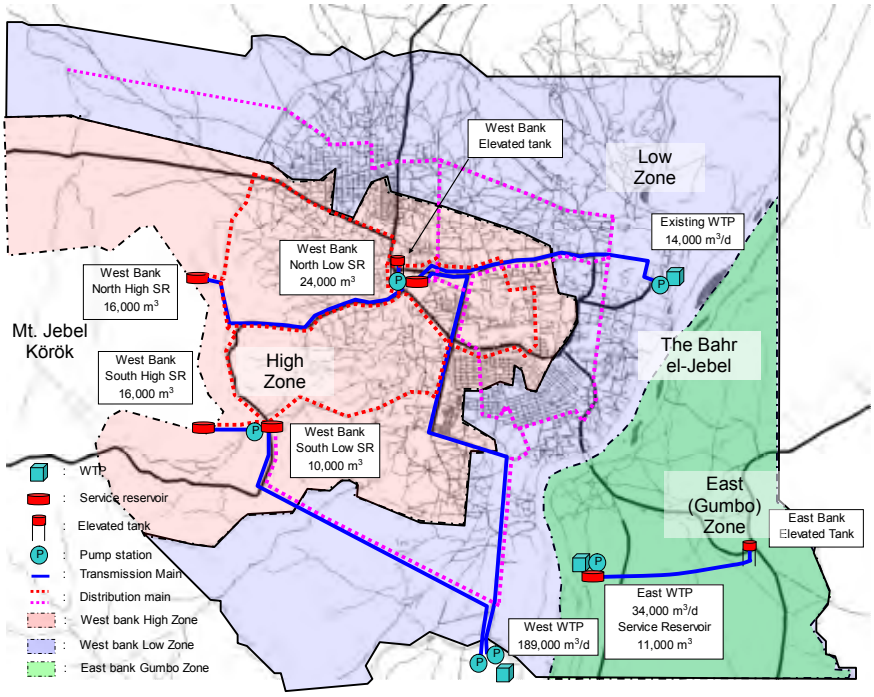
The Bahr el-Jebel is selected as a water source and the location of new intakes shall be at the upstream of the confluence of the Khor Ramla (Jondoru) river to avoid the impact of potential leach from the city dumping site, which is located in the watershed of the Khor Ramla river.

The water supply system proposed in the Master Plan envisages the existing water treatment plant being expanded to twice of its existing capacity and two water treatment plants will be newly constructed in the west and east banks, separately. Three distribution zones (high and low zones in the west bank and Gumbo zone in the east bank) are proposed to supply water by gravity from service reservoirs. The proposed water



Schematic Layout of Distribution System in West

distribution zoning system and major facilities in the Master Plan are presented in following figure.



Major Proposed Facilities and Distribution Zones in Master Plan

A part of the components proposed in the Master Plan was selected as "priority project," which should be implemented by 2015 with a higher priority. The following table outlines the major facilities in the Master Plan and priority projects. A feasibility study on the priority project was carried out in the Study.

Major Facilities in Master Plan and Priority Project

Category	Facility	Existing	Priority Project by 2015	Master Plan by 2025
Production	Water treatment plant (m^3/d)	1) 7,000	1) Existing WTP: 7,000 2) Expansion of existing WTP: 7,000 3) West WTP: 63,000	1) Existing WTP: 7,000 2) Expansion of existing WTP: 7,000 3) West WTP: 189,000 4) East WTP: 34,000
	Total capacity	7,000	77,000	237,000
Transmission and distribution	Transmission pumping station	1) PS in existing WTP	1) PS in existing WTP 2) West WTP PS 3) North Low PS	1) PS in existing WTP 2) West WTP PS 3) North Low PS 4) East WTP PS 5) South Low PS
	Service reservoir (m^3)	-	1) North Low: 10,000 2) North High: 10,000	1) North Low: 24,000 2) North High: 16,000 3) South Low: 10,000 4) South High: 16,000
	Transmission line (km)	About 5	17.5	27
	Distribution network (km)	About 60	410	1,252
Service connections	House connections, public tap stands, water tanker stations	About 2,500 without meter	25,200 with meter 302 public tap stands/kiosks 7 stations	117,700 with meter 330 Public tap stands 7 stations

PROJECT COST ESTIMATION

The project costs for the priority project and the Master Plan project are summarized in the table below. The total fund requirements for the priority project and the Master Plan project are estimated as 184.7 million USD and 467.4 million USD, respectively.

Project Cost Estimation

(million USD)

Item		Priority project up to 2015	Master plan up to 2025
1	Water Treatment Plant	38.9	96.8
	Transmission Pipeline	20.7	32.9
	Transmission PS	2.7	6.3
	Distribution main facility	6.7	20.5
	Distribution main & sub	38.1	68.3
	Distribution network	17.4	53.9
	Construction Cost	124.5	278.7
2	Administration Cost	2.5	5.5
3	Engineering Cost	12.5	27.9
4	Physical Contingency	13.9	31.2
5	Price Escalation	31.3	124.1
	Sub-total	60.2	188.7
	Total Project Cost	184.7	467.4

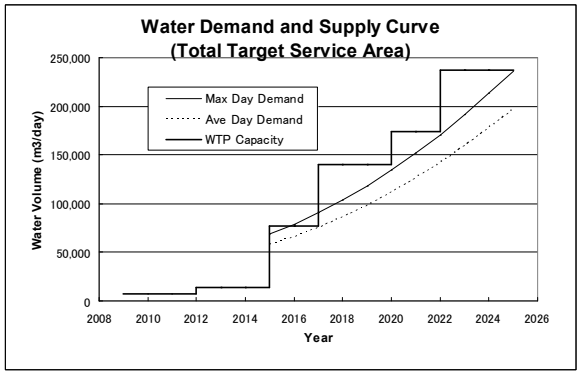
IMPLEMENTATION PLAN

The implementation of the Master Plan project is planned to comprise four phases. The concept of phased implementation, major facilities, total production and project cost by phases are presented in the table below. The phase-1 and phase-2 are planned to be implemented as the priority project.

Implementation Concept, Proposed Facilities, Total Production and Project Cost by Phase

Phase	Period	Implementation concept	Major proposed facilities	Total production (m^3/d)	Project cost by phase (million USD)
1	2010-2012	Improvement of existing system	1. Expansion of exist. WTP 2. Const. of North Low Service Reservoir and transmission mains 3. Full replacement of existing network	14,000	40.4
2	2013-2015	Initiation of setup of new West Water Supply System in the west bank	1. Const. of West WTP (1st stage) 2. Const. of North transmission system in the west bank 3. Expansion of distribution network	77,000	144.4
3	2016-2020	Expansion of West Water Supply System and setup of East Water Supply System	1. Expansion of West WTP (2nd stage) 2. Expansion of South transmission system and distribution network in the west bank 3. Const. of East WTP, transmission system and distribution network	174,000	178.9
4	2020-2025	Expansion and completion of the Master Plan	1. Expansion of West WTP (3rd stage) 2. Expansion of distribution network	237,000	103.7

Based on the implementation plan prepared in the Master Plan, the relation of the estimated water demand with the expansion plan of water treatment plant is shown in the right figure.



Water Demand vs. Water Treatment Capacity

MANAGEMENT, OPERATION & MAINTENANCE PLAN

The management targets and indicators for the Master Plan are summarized in the table below, followed by explanation of the outline of management, operation and maintenance plan.

Summary of Management Targets and Indicators

Item	2009 (current)	Target in 2015	Target in 2025
Service population (coverage)	Est. 34,000 (13%)	544,000 (80%)	1,161,000 (100%)
Nos. of connections	About 2,500	25,200	117,700
Target management status	・ No autonomy ・ Subsidized ・ Weak financial basis	・ Transition to self-sustaining organization with limited autonomy ・ Moderate financial basis	・ Self-sustaining organzaition with full autonomy ・ Strong financial basis
Total nos. of staff (staff efficiency)	167 (68 staff /1000 connect)	378 (15 staff /1000 connect)	808 (7 staff /1000 connect)
Target of internal management	・ No delegation of responsibility to departments ・ Very low O&M capacity	・ Delegation of responsibility to departments ・ Managed by internal profit units ・ Improved O&M capacity ・ Managed by performance indicators	・ Delegation of responsibility to departments ・ Managed by internal profit units ・ Competent O&M capacity ・ Managed by performance indicators
Annual O&M cost	USD 0.55 million/year	USD 6.8 million/year	USD 21.8 million/year
O&M cost/revenue water	0.64 USD/m^3 (exclude personnel cost by subsidy)	0.52 USD/m^3	0.41 USD/m^3
Annual subsidy	est. SDG 2.0 million/year	nil	nil
Annual revenue	SDG 0.38 million/year (USD 0.18 million) in 2007	USD 8.7 million/year	USD 51.6 million/year
Average monthly water charge for average income household	13.3 SDG (average of domestic customers)	29.5 SDG/household (2.5 % of household expenditure)	- (2.5 % of household expenditure)
Non-revenue water ratio (%)	60 % (estimation)	44 %	28 %
Involvement of private sector	Not involved although private sectors play important role in water supply without regulation	Shall be involved or promoted: ・ Community based water management committee ・ Authorized water vender (e.g. water kiosk) ・ Licensed water tanker	

The main management policies for UWC are established in the Master Plan as follows.

- To be a self-sustaining organization with autonomy
- To concentrate and unify decision making system
- To improve work efficiency
- To enhance fund-raising capacity

Financial strengthening is identified as a primary important management policy for UWC. Under this perspective, following targets are proposed.

- Establishment of increasing block tariff to cover all operating expenses
- Upgrading of billing and revenue collection system based on metering system
- Enhancement of customer service and reduction of non-paying customers
- Strengthening of debt management

The organization reform for UWC is proposed that the management will be made by internal profit units of production and customer service. Each business unit shall be granted with discretion as well as profit responsibility and be linked to each other by internal profit relationship. Partnership with the private sector is also recommended as water supply by public taps (including water kiosk) and water tankers should play important roles in supplying treated water of UWC.

Non revenue water (NRW) management is one of the most important elements of waterworks management. The current NRW ratio is roughly estimated as 60 % and it should be reduced to 28 % by 2025. To achieve the target, following measures shall be implemented.

- Replacement of entire existing distribution network until 2015
- Planning of NRW management measures
- Continuous implementation of NRW management activities

Water quality management and water distribution management should be focused in operation and maintenance of water supply system as the core value of water supply services. In addition, strengthening of customer services is primarily emphasized as the number of customers are planned to increase drastically toward the year 2015.

The annual operation and maintenance (O&M) costs for the proposed water supply system are estimated at 6.8 million USD in 2015 and 21.8 million USD in 2025 with the estimated unit cost per revenue water at 0.52 USD/m^3 and 0.42 USD/m^3, respectively.

The capacity of UWC has been identified as very weak at all staff levels and in all aspects. A plan of capacity development is proposed as shown in following table, in which the initial capacity development activities were carried out in the Study.

Capacity Development Action Plan

Capacity development items	Proposed implementation scheme
1) Initial capacity development ・ Seminar on waterworks management ・ Waterworks management training (Japan) ・ Study tour in neighboring countries (Kenya) ・ Training in neighboring countries (Kenya) ・ Preparation of O&M manuals and document management	Completed in the Study
2) Water treatment plant operation and maintenance 3) Water quality control	To be implemented in trial operation by MDTF
4) Water charge billing and collection system 5) Water distribution system management 6) Leakage control/non revenue water management 7) Plumbing technique 8) Public relation activities	Technical assistance by JICA

PROJECT EVALUATION

Increased block tariff with base tariff by customer category was proposed as a new water tariff structure in consideration of affordability of customers, sustainability of waterworks and fairness among customers.

The financial internal rate of returns (FIRR) of the Master Plan project and the priority project resulted in 10.5 % and 8.8 %, respectively, by which it is judged that the projects are financially viable.

The economic internal rate of returns (EIRR) of the priority project resulted in 24.7%, owing to considerably high willingness to pay for improved water supply services. Therefore, the priority project is judged as quite viable from the national economic perspective.

As a result of an initial environmental examination (IEE) and a preliminary environmental impact assessment (pre-EIA), two major impacts were identified as follows.

- Land acquisition for the proposed facilities is the most concerned issue from social view point, although it is not likely to cause serious impact because all proposed sites do not involve with resettlement, but adequate compensation shall be required.
- Increase of wastewater discharge to living and natural environment due to increase of water supply amount may cause water pollution and deterioration of living environment. This is the most significant possible negative impact of the implementation of the Master plan. The countermeasures for wastewater increase should be made in advance.

The implementation of the Master Plan will materialize the access to safe and clean water supply to the people in Juba, give many direct and indirect benefits to Southern Sudan, and contribute to the Millennium Development Goals (MDGs) of Southern Sudan.

MUNUKI PILOT PROJECTS

Two pilot projects; water management committee and school latrine and compost gardening projects, were carried out in Munuki Payam in the course of the Study. In project evaluation, it is realized that management of public tap stands by forming a community based organization is a difficult task in the urban settlements like Munuki but business based management is probably more suitable in this setting. School latrines were constructed and the use of the latrines was just initiated, but composting and its gardening use has not yet started. Hygiene education was also carried out in the Study through the formation of a school WASH committee.

RECOMMENDATIONS

Capacity development is identified as significantly important for UWC and should be implemented in parallel with infrastructure project. Utilization of foreign technical assistance is recommended for implementation of the proposed capacity development plan.

Financial improvement of UWC is of vital importance for sustainability of water works management and the measures such as water tariff reform based on metering policy and debt management should be carried out at the first instance.

Fund procurement is one of the most critical issues to realize the Master Plan. To encourage financing the proposed project, basic requirements such as preparation of financial statements according to International Accounting Standard along with achievement of sound financial and technical status of UWC should be met through capacity development.

Public taps, water kiosks and water tanker venders in addition to house connections will play a key role in supplying the treated water to the residents, especially in the initial stage, and they are important sources of revenue for UWC. Therefore, a system to manage these facilities and customers along with customer service department should be established.

Preparation of wastewater management plan and its implementation are required to mitigate the impact of increased water supply volume by the implementation of the Master Plan. The acquisition process for the land of the proposed facilities should be followed immediately after the Study, especially for priority project facility sites.

Two Munuki pilot projects initiated by the Study Team still need continuous supports to acquire valuable knowledge and information and to convert them a successful model.

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Acronyms and Abbreviations

CD	Capacity Development	MOH	Ministry of Health
CES	Central Equatoria State	MOPI	Ministry of Physical Infrastructure
CPA	Comprehensive Peace Agreement	M/P	Master Plan
DIP	Ductile iron pipe	MWRI	Ministry of Water Resources and Irrigation
DMA	District Metered Area	NRW	Non-revenue water
DSSGDW	Draft Southern Sudan Guidelines for Drinking Water Quality	O&M	Operation and maintenance
EC	Electrical conductivity	P, PS	Pump station
EIA	Environmental Impact Assessment	PCM	Project Cycle Management
EIRR	Economic internal rate of returns	PTA	Parent-Teacher Association
ET	Elevated tank	PVC	Polyvinyl chloride
F/S	Feasibility study	ROS	Republic of Sudan
FIRR	Financial internal rate of returns	SDG	Sudanese Pond
GI	Galvanized iron	SR	Service reservoir
GOJ	Government of Japan	SSUWC	Southern Sudan Urban Water Corporation
GOSS	Government of Southern Sudan	SWL	Static Water Level
GTZ	German Technical Cooperation	SWOT	Strength, Weakness, Opportunity and Threat
GV	Guideline Value	TDS	Total dissolved solid
IDP	Internally Disturbed Population	USD	United States dollars
IEE	Initial environmental examination	USAID	United States Agency for International Development
IFRC	International Federation of Red Cross	UNICEF	United Nations International Children's Emergency Fund
JICA	Japan International Cooperation Agency	UWC	Urban Water Corporation
MC&RD	Ministry of Cooperatives and Rural Development	WASH	Water, Sanitation and Hygiene
MDTF	Multi Donor Trust Fund	WHOGDW	WHO Guidelines for Drinking Water Quality
MDG	Millennium Development Goal	WTP(s)	Water treatment plant(s)
MOFEP	Ministry of Finance and Economic Planning	WtoP	Willingness to pay
MHPPE	Ministry of Housing, Physical Planning and Environment		

Unit

d	day	L/h/d	liter per household per day
h	hour	L/min	litter per minute
hh	household	m^3/d	Cubic mater per day
L	liter	mg/l	milligram per liter
L/c/d	liter per capita per day	y	year
L/hh	liter per household		

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

After the end of long duration of civil wars, Juba became the capital of the Southern Sudan in September 2005. For more than 20 years due to civil wars, no adequate investment and maintenance of urban infrastructures have been carried out in the water supply sector. Therefore, most of the facilities are dilapidated and in an urgent need of rehabilitation or reconstruction to bring them to their normal condition of operation.

Reconstruction of existing water treatment plant was completed in May 2009 with the design capacity of 7,200 m^3/d funded by Multi-Donor Trust Fund (MDTF) and the Government of Southern Sudan (GOSS). However, there still exists a large gap between the current water demand and the water supply capacity. In addition, water distribution network mostly composed of aged asbestos pipes causes high leakage. The water treated in the water treatment plant is supplied to only a small fraction of government offices and households. Most of the households rely on wells and water tankers. Since groundwater in most of the wells in Juba is high in salinity and some of wells are polluted, the use of groundwater becomes difficult for a urban water supply source. Also the water tankers selling water to people is mainly raw river water that is not suitable for human consumption.

To improve this situation, GOSS has recognized that increase of water treatment plant capacity by provision of a new intake and treatment plant located upstream of Juba in the Bahr el-Jebel and rehabilitation and expansion of distribution network are urgently required.

Based on the results of the Emergency Study implemented by Japan International Cooperation Agency (JICA), GOSS has requested the Government of Japan (GOJ) implementation of this "Juba Urban Water Supply and Capacity Development Study (hereinafter referred to as "the Study")."

1.2 Objectives of Study

The objectives of the Study are:

- to formulate a water supply master plan covering the examination of alternative water sources,
- to conduct a feasibility study for prioritized projects, and
- to support the capacity development of Southern Sudan Urban Water Corporation (SSUWC), UWC-Juba Station and other organizations concerned, and support to community-based water projects.

1.3 Study Area and Schedule

Juba Town is located in Central Equatoria State in Southern Sudan. The Study covers Juba Town and its surrounding areas extending through an area of about 40 km^2 and having a population of 250,000 in 2005.

Juba County located in Central Equatoria State comprises of 11 payams. Out of those payams, the Study Area is formed by the existing major urban area including Juba Town, Kator and Munuki payams, and future expected urban areas including the parts of Rejaf and Northern Bari payams.

The Study started in August 2008 and completed in September 2009.

1.4 Relevant Organizations of the Study

This study was initiated by Ministry of Housing, Lands & Public Utilities (MHLPU/GOSS). However, according to the Presidential Decree on 28 July 2008, the responsible organization of urban water supply was changed from MHLPU to Ministry of Water Resources and Irrigation (MWRI), and the title of Ministry of Housing, Lands & Public Utilities was also changed to Ministry of Housing, Physical Planning, and Environment (MHPPE). Accordingly, MWRI became the overall responsible agency of the Study. The following are counterpart agencies along with MWRI.

- Southern Sudan Urban Water Corporation (SSUWC)
- Ministry of Physical Infrastructure of Government of Central Equatoria State (MOPI/CES)

CHAPTER 2 ASSESSMENT OF EXISTING CONDITIONS

2.1 Current Population Estimation

Population census for Southern Sudan had not been conducted for long time since 1983. Finally, in March, 2008, the national census survey was conducted. However, publication of the result of the census was delayed considerably.

Since the complete result of the census was not been published as of May 2009 and there was no reliable data, the current population in the Study Area has been estimated in the Study through sample population counting by the Study Team and multiplying the area of residential zones by average population density in the sample areas. Consequently, the total population of the Study Area was estimated as 406,000 in 2009, as shown in Table 2.1, along with the population estimation by payam in 2005 and 2009. During this period, the urban area has mainly extended westward, especially to the west of Munuki, and a new settlement has come up in Rejaf and Gudele.

Table 2.1 Population Distribution by Payam in 2005 and 2009

(thousand)

Items	Juba	Kator	Munuki	Rejaf	Gudele	Total
Population in 2005	103	69	78	-	-	250
Population in 2009	117	79	117	31	62	406

Finally, a preliminary result of the 5th Sudan Population and Housing Census conducted in March 2008 was published in July, 2009, according to which, the population of the Study Area is 250,000 to 280,000, which is less than that of the Study Team estimate.

The population to be considered for this Study was discussed in the fourth Steering Committee Meeting, and the GOSS and all other members agreed that the Study Team should continue with its own population estimates for the Study.

2.2 Assessment of Water Sources

2.2.1 Groundwater Sources

The result of the hydro-geological survey by International Federation of Red Cross (IFRC) in 2006 indicated that paleochannel in Tokiman, Rejaf Payam may have high potential of groundwater development. To confirm the survey result, the Study Team carried out groundwater survey in the

Tokiman Paleochannel through construction of three test wells and two observation wells, and investigated geological conditions and groundwater quantity and quality for planning as an alternative water source for Juba urban water supply.

Based on the result of the survey, groundwater in the area is distributed in three aquifers; aquifer 1, 2 and 3, and the characteristics of groundwater of Tokiman Paleochannel are given in Table 2.2. As a result, following main points have been found in the Study.

- There is no such aquifer that has thickness of more than 150 m and consists of alluvial deposits with high potential of groundwater discharge directly connected to the Bahr el-Jebel.
- The yield of the groundwater is very low and the water quality is totally not suitable for human consumption in the aquifer 1 and 3 as it exceeds the guideline values to a large degree.

As a result, the groundwater present in the area is not recommended as a source of urban water supply.

Table 2.2 Groundwater Characteristics of Tokiman Paleochannel

Aquifer	Aquifer 1	Aquifer 2	Aquifer 3
Groundwater type	Unconfined groundwater	Confined groundwater and fissure water	Unconfined groundwater and fissure water
Approx. depth	Less than 50 m	100 m	200 m
Yield	Q = 230 L/min	Q = 30 L/min	Q = 220 L/min
Groundwater quality	Iron, manganese, antimony, sodium and TDS values exceed the guideline values.	Iron, antimony and nitrate values exceed the guideline values.	EC, antimony, chloride, hardness, nitrate, sodium, sulfate and TDS values exceed the guideline value.

2.2.2 Surface Water Source

The Bahr el-Jebel passes through Juba. The river is a main tributary of the White Nile. In the strict meaning, “White Nile” refers to the river formed at Lake No at the confluence of the Bahr el-Jebel and the Bahr el Ghazal. In the wider sense, “White Nile” refers to the approximately 3,700 kilometers of rivers draining from Lake Victoria into the White Nile proper.

The river flow rates of the Bahr el-Jebel have been measured by Dam Implementation Unit (DIU) since January 2008. In Juba, the location of monitoring point is upstream of Juba Bridge. The Study Team collected 45 measured river flow data between January and September in 2008 at this point. The minimum and maximum flow rates during this period are 1,125 m^3/s or 97.2 million m^3/d and 1,742 m^3/s or 150.5 million m^3/d, respectively.

As estimated in the Master Plan, the water demand of the Target Service Area in 2025 is estimated as

237,000 m^3/d. This amount is equivalent to 0.25 % of the lowest flow rate of the river, which is a very small fraction of the river flow. Therefore, raw water can be constantly withdrawn from the river for urban water supply in the Target Service Area without impairment of the river flow.

In order to evaluate water quality of the river in the Study, water sampling was carried out at following 3 locations of the Bahr el-Jebel:

1) Juba channel of the Bahr el-Jebel at the intake of the existing water treatment plant
2) The Bahr el-Jebel near Juba Bridge
3) The Bahr el-Jebel upstream of Juba at Tokiman area (Proposed new water treatment site)

The samples collected several times in the rainy and dry seasons were analyzed in laboratories and by field kit. The results of water quality analysis were compared with the WHO guidelines and (WHOGDW) and draft Southern Sudan guidelines (DSSGWQ) for drinking water quality. In general, the qualities of surface water at 3 sampling points indicate that the water is good as a source for conventional water treatment, although the following parameters exceed the guideline values.

- Aluminum at all 3 sites in rainy season
- Antimony at the existing water treatment plant sites
- Iron at the existing water treatment sites in rainy season

The concentration levels of aluminum and iron could be reduced below the guideline values after conventional water treatment using coagulation, sedimentation and rapid filtration. Antimony exceeds DSSGWQ but does not exceed WHOGDW except one sample in the rainy season.

2.3 Existing Water Supply Conditions

2.3.1 Existing Condition of Water Supply Service

In the Study Area, following types of water supply services are utilized by the residents.

- Water supply by house connection (UWC)
- Water supply by public tap (UWC: water source is piped water)
- Public well equipped with hand pump
- Private water venders
  - ✧ Water tanker
  - ✧ Jerry can vender by bicycle
- Private well

The overall water supply scheme in the Juba urban area is summarized in Table 2.3. According to this estimate, 56 % is supplied by public wells; the highest coverage. The ratio of the piped water supply service of UWC is 13 %. The existing water supply facilities along with water tanker supply stations

along the river side are shown in Figure 2.1.

Table 2.3 Estimated Overall Water Supply Scheme in Juba

Type	Description and assumptions for estimated supply capacity	Approx. estimated net supply for domestic users (m^3/d)	Estimated service population	Ratio
Water supply by pipe (UWC)	Before the completion of MDTF project in May 2009 ・The source of water is the river. ・The actual capacity of WTP is 3,500m^3/d. ・Old WTP was not functioned and treated water was not drinkable. ・Service population was estimated using 26 L/c/d (JICA household survey), 50% of effective water rate and half volume supplied for domestic users.	875 (1,750 for all users)	34,000	13 %
	After the completion of MDTF project in May 2009 ・The capacity of WTP is 7,200m^3/d. ・The service population is assumed same as before the inauguration of WTP.	1,800 (3,600 for all users)	34,000	13 %
Public well	・The source of water is groundwater. ・The water in many wells is of high salinity. ・There are approximately 400 wells (Only 150 wells are acceptably operational). ・Assuming 70 % of wells are operational. ・30 L/c/d is assumed.	4,410	147,000	56%
Water tanker	・The source of water is the river without treatment. ・7 intake stations. ・400-650 tankers/d x 4 ~5 m^3 (1,600-2,600m^3/d). ・Assuming 80 % is supplied to the domestic users. ・30 L/c/d is assumed. ・Free chlorination is provided.	2,080 (2,600 for all users)	69,000	26%
Jerry can vender	・The source of water is the river without treatment. ・3 intake stations and on average 5,000 cans per day. ・The total quantity is estimated as 100 - 135 m^3/d. ・Free chlorination is provided. ・10 L/c/d is assumed.	135	14,000	5%

Note: Total of the estimated service population is not same as the current total population estimated in the Study.

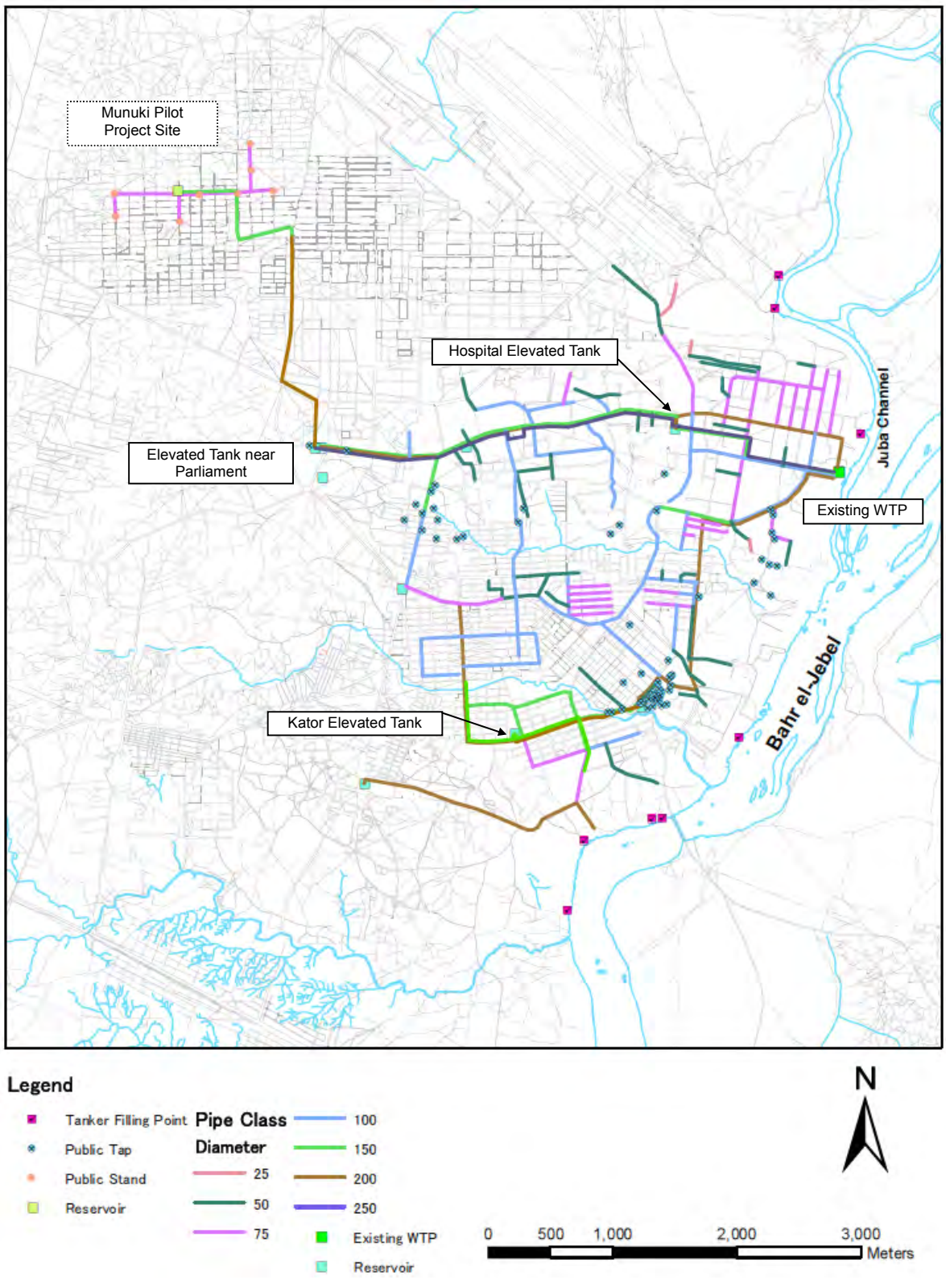


Figure 2.1 Existing Water Supply Facilities and Water Intake Station of Water Venders

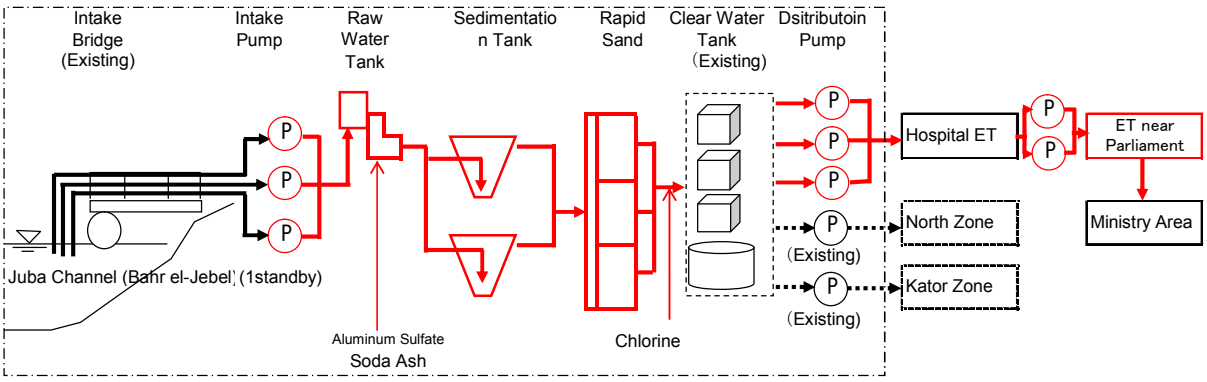
2.3.2 Existing Water Supply System

In 1972-1983, the Government of Sudan with other international agencies like GTZ carried out the improvements of the water treatment facilities and distribution networks, which increased the capacity of the water supply to 5,200 m^3/d and covered almost the entire old Juba Town (Malakia, Hai Jalaba, Amarat, Kosti, Nimara Talata and Atlabara). This water supply conditions had continued during war until the signing of CPA.

The rehabilitation of the existing water supply system including renewal of treatment plant with a capacity of 7,200 m^3/d, and the construction of transmission facilities to supply the water to the government area were implemented by the MDTF fund. The construction of these facilities was completed and became operational at the end of May in 2009. The information on newly constructed facilities is summarized below:

- Water treatment plant: 7,200 m^3/d including raw water pump, chemical building, distribution pump
- Pump station in Hospital and booster pump
- Elevated tank in the John Garang Memorial Site near the Parliament (250m^3)
- Transmission pipelines (WTP – Hospital – Parliament: dia. 300 mm*5 km)

The flow of the water supply system of MDTF fund along with existing facilities is shown in Figure 2.2 and the schematic layout of the existing transmission system and supply zones is shown in Figure 2.3.



Note: Red and black colors indicate the water supply facilities constructed by MDTF fund and the existing facilities, respectively.

Figure 2.2 System Flow of Water Supply System (as of May 2009)

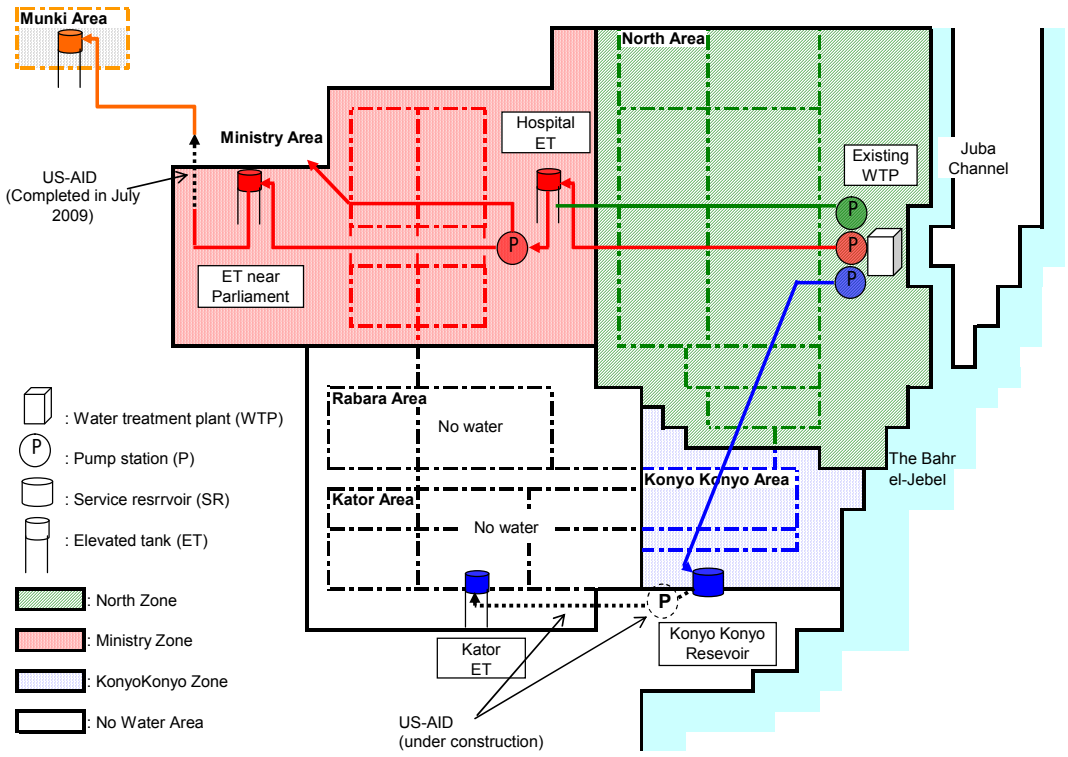


Figure 2.3 Systematic Layout of Existing Transmission System and Supply Zones

Elevated tanks, which are located near the hospital and parliament, are operational, but the other old tanks and reservoirs are not functional. The total length of distribution network is about 60 km. The majority of network was installed before 1972 and is composed of asbestos pipes, except a few PVC and GI pipes. Those pipes have trouble with frequent leakage due to fragility to shock and their installation at shallow depth.

2.3.3 Results of Socio-Economic Survey on Water Use

A Socio-economic study was carried out through a household questionnaire survey in 5 communities, i.e. Juba Town, Kator, Munuki, Lologo and Gumbo in October 2008. Based on the answers obtained from 269 households, the findings of the survey are summarized below.

<Average family size>

The average family size in the interviewed household is 7.8 person/hh; the range is from 2 persons to 22 persons per household, and a large proportion of interviewed households have a family size of 6 persons.

<Income of household>

Average monthly income of household is 1,257 SDG/month/hh and the minimum and maximum monthly incomes are 150 SDG/month and 14,000 SDG/month, respectively. Two thirds of all the households fall in the range between 500 SDG/month and 1,749 SDG/month.

<Major problems of household>

Related to the question of what kind of problems their family is facing, 57 % of households responded that the significant problem they were facing relates to water supply, for example access to safe water, and it is presumed that the demand for water supply improvement are very high. The second in series of problems are lack of development of road and electricity and the third problems are low income and lack of medical facilities.

<Water sources>

Most of the households are using private water tankers as water source, followed by public borehole with hand pumps. 61% of households are using both of these water sources. Some of the households are using the rain water and river water to cover shortage in water available to them.

<Water consumption>

Estimated average unit water consumption is summarized in Table 2.4 and Table 2.5. Average unit consumption per capita is 30 L in rainy season and 36 L in dry season with average of 33 L. A household additionally wants 146 L, equivalent to 19 L/c/d. The estimated total water requirements per person is 52 L daily. Water is mostly fetched by wife and daughter in household.

Table 2.4 Estimated Average Unit Water Consumption for Household and Person

Item	Unit	Rainy season	Dry season	Annual ave.	Additional water requirement	Total water requirement
Water consumption /household	L/hh/d	232	286	259	146	405
Water consumption per capita	L/c/d	30	36	33	19	52

Table 2.5 Estimated Water Consumption Per Capita by Type of Water Supply

(L/c/d)

Main water source	Dry season	Rainy season	Average
House connection	29	23	26
Public taps	37	28	32.5
Tanker truck	38	33	35.5
Average	36	30	33

<Water supply service hour>

The average time of households using UWC supplied water is 7 hours. The service hours of public tap and bore hole with hand pump is also restricted depending on community. The average distance to water sources from household is 281 m, and the average fetching time is 66 minutes. The water tanker's selling hour is also unscheduled, and the purchase of water may not be possible sometimes. Consequently, many households have storage tanks in the form of drum (200L) or plastic container which are used to store the water.

<Supply water quality>

Approximately, 70% of households replied that their main water sources are unclean. The water quality problems which the customer identified are color, unclean, smell and taste.

< Problems of water supply service>

Over 90% of the households expressed dissatisfaction with the current water supply conditions of both main and supplemental water sources. The water tanker's cost ranges between 4 SDG/200L and 7 SDG/200L (Ave. 5 SDG/200L and 0.5-1.0 SDG/one Jerry can (20L)) which is also reflected by the results that almost half of the households expressed the cost was high.

Table 2.6 Problems of Water Supply Services (Main water sources)

Items		Nos.	Ratio of respondent
Water supply quantity/service pressure		69	26%
Service hour		134	50%
Served water quality	Unclean	190	71%
	Taste(high salinity)	36	13%
	Color	39	13%
Water Tariff		120	45%
Distance of water sources		151	56%

Note: Multiple answers

<Drinking water>

To the question about pre-treatment of drinking water, 142 households responded that they drank water after addition of chlorine tablets and powder. It may be attributed to the outcome of free distribution of chlorine and public awareness activities by NGO and other donors. However, 30 % of the households responded that they used drinking water without any treatment.

<Current water cost and willingness to pay for water supply services>

The average monthly cost on water for household is 132 SDG. The average willingeness to pay by water supply services with different service levels are summarized in Table 2.7.

Table 2.7 Summary of Average Willingness to Pay and Current Water Cost

Water supply service level	Willingness to pay (SDG/hh/month)
1. For water supply under current condition	80
2. For satisfied water supply service (clean, safe and enough amount)	110
3. For satisfied continuous water supply service (clean, safe and enough amount of water through pipe for 24 hours)	134
4. Average current water cost (actual)	132

<Health>

Only 3 % of the households responded that they had not been infected with any of water related diseases or malaria during the year of 2008. The members in 91% of the households have been infected with malaria. In 51% of the households, the members had contacted diarrhea, and in 35% of the households, the members had contacted typhoid. The average medical related costs for hospital, medicine and transportation was 333 SDG/hh/year.

2.4 Existing Organizations and Operation and Maintenance

2.4.1 Institution and Organization

(1) Water Supply related Organizations and Institutions

Urban and rural water supply is administrated by Ministry of Water Resources and Irrigation (MWRI/GOSS) after GOSS ministries were reformed in July 2008. Main roles of MWRI are policy making, planning and investment on water supply and sanitation. Ministry of Health (MOH/GOSS) also takes a role of hygiene promotion from viewpoint of public health. In the state level, Ministry of Physical Infrastructure (MOPI/CES) is the implementing organization under the GOSS policy.

(2) Southern Sudan Urban Water Corporation

Under MWRI, Southern Sudan Urban Water Corporation (SSUWC) is mandated as the official urban waterworks of Southern Sudan and the organization responsible for providing water supply services to urban citizens of Southern Sudan. The organization comprises headquarters office and three branch

offices of Juba, Malakal and Wau. The Board of Directors is formed in SSUWC headquarters to draw general policy and supervise the SSUWC.

(3) Southern Sudan Urban Water Corporation –Juba Station

Public water supply services for urban part of Juba are performed by SSUWC - Juba Station, which is located in the premises of existing water treatment plant. For carrying out activities related to water supply, SSUWC-Juba has five (5) departments including purification, distribution, financial, human resources, and administration headed by Area Manager and altogether has a total of 167 staff members as of September 2008. The organization structure of UWC-Juba Station is given in Figure 2.4.

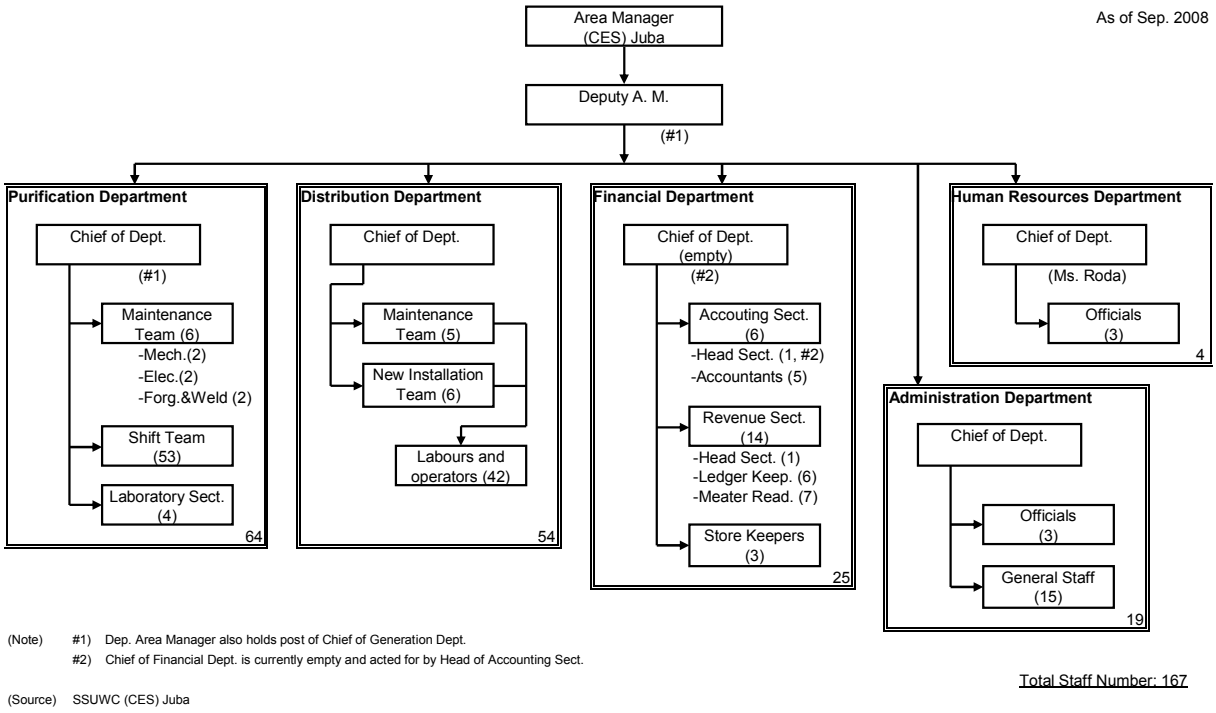


Figure 2.4 Organization Chart of UWC-Juba Station

2.4.2 Operation and Maintenance of Existing Water Supply Facilities

The existing water supply facilities are very old although some of the pumps have been replaced in last few years under assistance of overseas development funds and appropriate maintenance has not been undertaken during the period of internal disturbances for long time. Only reactive (crisis) maintenance is carried out and there is no preventive (routine) maintenance works in practice. In distribution system, leakage is often observed and due to poor maintenance, sometimes the pipelines could be seen above the ground level along the road.

At the end of May, 2009, a new water treatment plant, pumping stations, transmission lines and elevated tank constructed under MDTF and GOSS funding has been inaugurated. On completion of the construction, the water treatment facilities is being operated and maintained by the Contractor for a period of one year. During this period, the operators and engineers of UWC are to be trained in all aspects of the operation and maintenance of the water treatment plant. The Contractor shall also prepare a comprehensive Operation and Maintenance Manual and the facilities shall be operated in accordance with this Manual. As of June 2009, the operation and maintenance manual and as built drawings are still under preparation.

The water quality parameters have been measured by the Study Team at different process of treatment facilities and at the demand points in the city. It can be observed that treated water quality parameters in new water treatment plant are almost within the WHO guidelines for drinking water quality.

The existing water supply facilities and equipment in Juba are obsolete and inadequate at present and the operation and maintenance system is not functioning properly due to insufficient technical capacity of staff of UWC, education/trainings, regulation and planning for operation and maintenance without O&M manuals and procedures.

2.4.3 Capacity Assessment of Urban Water Corporation

A capacity assessment on UWC management was carried out through a SWOT (Strength, Weakness, Opportunity and Threat) analysis and the results are summarized in Table 2.8. UWC is generally characterized by institutional weakness, inefficient O&M, insufficient infrastructure and severe financial constraints.

Table 2.8 SWOT Analysis of UWC

	Positive factor	Negative factor
Internal environment	**S**TRENGTH S-1 Well functioning command line S-2 Staff responsibility and loyalty S-3 Training demand and potential leader S-4 Technical appropriateness S-5 Low language barrier	**W**EAKNESS W-1 Dependent constitution (lack of autonomy) W-2 Insufficient O&M practice W-3 Inefficiency in business process W-4 Financial weakness W-5 Poor human resources development
External environment	**O**PPORTUNITY O-1 Institutional setup O-2 Government commitment O-3 Donor assistance O-4 Intensive water demand O-5 Friendly relations with neighboring countries	**T**HREAT T-1 Lack of laws and regulation T-2 Insufficient involvement of state and Payam authorities T-3 Public awareness T-4 Political unrest

2.4.4 Financial Conditions of UWC-Juba Station

UWC earns income from water sales and installation fee for new connection. These incomes are paid into a government pool account managed by Ministry of Finance and Economic Planning (MOFEP) and SSUWC is financially dependent on subsidy from GOSS. Subsidies are received by SSUWC headquarters office and transferred to each branch office upon request. UWC depends on government subsidy which covers mostly personnel expenses.

The tariff system is a fixed charge by user category and water meter is not installed. In the law, tariff should be proposed by UWC and approved by the Board of Directors of SSUWC. Then it would be taken into effect after decision by the Assembly.

The number of current subscribers is 2,467 (excluding 467 new connections). UWC has a plan to install about 2,000 customer water meters which have been provided by MDTF.

According to the financial department of UWC, only approx. 50% of customers respond to the bill on time. Hence, considerable amount of arrears by the remaining half of customers continue as account receivable, which is a depressing cash flow for UWC. Although there is a regulation of penalty in the form of the customer who does not pay bills for three months would be fined and disconnected, disconnection is hardly carried out. It is more difficult to handle the situation due to inadequate power of UWC. Also, there are many cases in which customers refuse to receive bills for insufficient water supply condition. In that case, bill amount is discounted upon negotiation, which may often cause record errors in water ledger because the ledger is maintained manually.

CHAPTER 3 MASTER PLAN

3.1 Planning Basis

3.1.1 Master Plan Targets

The overall target water supply service of the Master Plan until 2025 is set as follows.

Target Water Supply Services

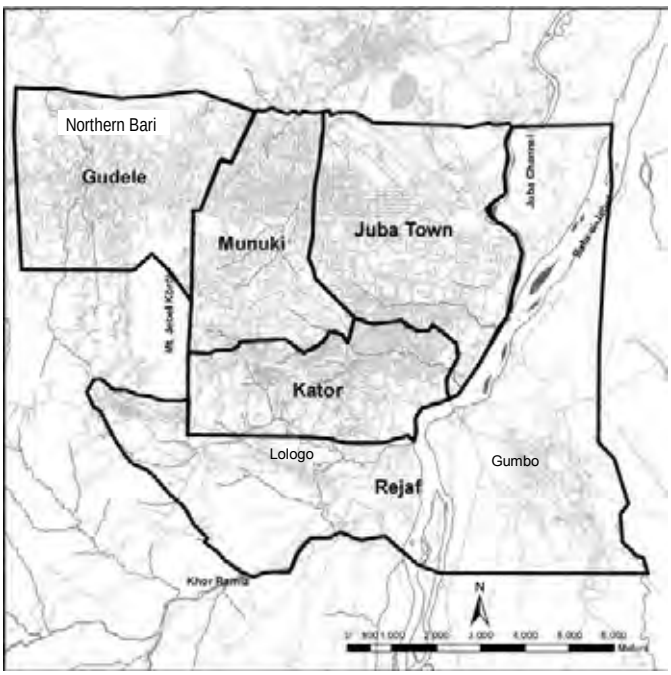
All the people in Juba can access safe and clean water supply by 2025 by means of house connection, public tap or private water vender with following target coverages. Safe and clean water means adequately treated water for human consumption and of potable quality.

Target Coverage of Water Supply

	2009	2015	2020	2025
Target Coverage	**Est. about 8 %**	**80 %**	**90 %**	**100 %**

The target area of water supply service is set as the existing major urbanized area including Juba Town, Kator and Munuki, and future expected urbanized areas including Rejaf and Gudele.

Target Service Area of Water Supply



3.1.2 Population and Water Demand Projections

(1) Population Projection

The population in the Target Service Area in 2009 is estimated as 406,000 and the past populations are summarized in Table 3.1. The estimated population in the Target Service Area has increased at the rate of 12.9 % per annum after 2005. This drastic increase is attributable more to the socio-dynamic patterns than to natural causes as many refugees and internally displaced persons (IDPs) have returned to Southern Sudan, especially to Juba area, after the signing of CPA.

Table 3.1 Past Population and Estimated Growth Rate

	1977	1994	2005	2009
Population	71.5 *1	156 *2	250 *3	406 *4
Annual growth rate (%)	4.7%	4.4%	12.9%	

Source:
*1: JICA Emergency Study
*2: United Nations head count census
*3: Juba Assessment Town Planning and Administration, USAID
*4: The Study Team estimate

The Study Team assumed that the current trend of high population increase will not continue after 2012 because the recent drastic increase is attributed mainly to the migration or returnees. The growth rate will eventually drop to the level of natural increase similar to the trends in the cities of the neighboring countries. Three growth scenarios have been assumed for the future population growth rate for Juba. Based on these growth scenarios, the future population has been estimated and presented in Table 3.2. The Study Team and Southern Sudan side agreed to adopt the high estimate as the future population for Juba. Consequently, the adopted population of the Target Service Area in 2015 and 2025 are 680,000 and 1,161,000, respectively.

Table 3.2 Future Population Forecast with Different Growth Trends

(thousand persons)

Scenario	2010	2015	2020	2025
High estimate (adopted)	**459**	**680**	**910**	**1,161**
Medium estimate	459	655	836	1,017
Low estimate	459	631	768	890

(2) Water Demand Projection

The design or target water consumption per capita for domestic users is set as shown in Table 3.3,

considering those of other areas in Sudan and other countries.

Table 3.3 Design Domestic Water Consumption per Capita

(L/c/d)

Service level	Current water use	Target in 2015	Target in 2020	Target in 2025
- House connection	26 (53)*	90	105	120
- Public tap	32.5	40	40	40
- Water tanker	35.5	40	40	40

Note: * 26 L/c/d, which is estimated from the results of socio-economic survey by the Study Team, is the consumption level before the rehabilitation of the existing water treatment plant and 53 L/c/d is estimated as the consumption level after the rehabilitation.

The ratio of water consumption of domestic and non-domestic users for 2025 are set as 70 % and 30 %, respectively. The service coverage for 2015 and 2025 is assumed as presented in Table 3.4 and Table 3.5.

Table 3.4 Service Coverage Assumption for 2015 and 2025

Year	Service Coverage Assumption
2015	• The border of the covered area of water distribution network is delineated along the existing organized urban area and its surrounding. • In the network covered area, existing and potential organized urban area is supplied by house connection and unorganized urban area is supplied by public taps. The water source for both types of supply is piped water. • The area outside of the covered area is supplied by tanker. The water source in this case is also piped water.
2025	• The coverage of house connection in the existing main city areas (Juba Town, Kator and Munuki) will be 80 % and that of the remaining area (Rejaf and Gudele) will be 60 %.

Table 3.5 Service Coverage Projection

Item	2015				2025			
	House connection	Public tap	Water tanker	Non-treated	House connection	Public tap	Water tanker	Non-treated
Service coverage	28 %	22 %	30 %	20 %	70 %	15 %	15 %	0 %
Population covered	188,000	150,900	204,400	136,300	811,300	174,900	174,900	0

Other assumptions and conditions of demand estimation are summarized in Table 3.6.

Table 3.6 Estimation Assumptions and Conditions of Water Demand

Factors	Assumptions/ Conditions
1) Continuous use of existing wells	It is assumed that even after 2015, the part of existing wells equipped with public tap will be continuously used by the users.
2) Leakage ratio	The leakage ratio in 2015 is set as 20 % after the rehabilitation of the existing network, and after 2015 the leakage ratio is assumed to be maintained at 20 %.
3) Seasonal peak /daily maximum factor	Considering very hot dry season in Juba, the maximum daily water demand coefficient is set as 1.2.

The future water demands are estimated up to 2025 at 5 year interval and distributed over the Target Service Area. The result is shown in Table 3.7. The maximum daily water demand in 2015 and 2025 is estimated as 69,000 m^3/d and 237,000 m^3/d, respectively. In 2015, the water demand of Juba is the largest and that of Gudele is the smallest. Toward the year 2025, the increase in water demand of Rejaf and Gudele are getting significant and that of Juba, Kator and Munuki is getting smaller.

Table 3.7 Average and Maximum Daily Water Demand Estimation

(m^3/d)

Payam	Average daily demand			Maximum daily demand		
	2015	2020	2025	2015	2020	2025
Juba	20,900	29,200	41,000	25,000	35,100	49,300
Kator	10,900	18,300	29,400	13,100	21,900	35,300
Munuki	13,400	22,900	36,300	16,100	27,500	43,600
Rejaf	8,300	26,700	59,300	9,900	32,100	71,100
Gudele	4,100	14,100	31,000	4,900	16,900	37,200
Total	**57,600**	**111,200**	**197,000**	**69,000**	**133,500**	**236,500**

3.1.3 Selection of Water Supply Source

Based on the evaluation result, the surface water is feasible as urban water supply source but the groundwater in Tokiman Paleochannel is not feasible in terms of water quality and quantity. Groundwater of existing wells that complies with the draft Southern Sudan guidelines for drinking water can be used as a supplemental water source for urban piped water supply.

3.1.4 Basic Policy of Water Supply Facility Planning

The basic policies of water supply facilities planning are outlined as follows.

(1) Ensuring Reliability of Water Supply and Lowering Risk of Failures

Water is an essential element for city activities including living and business activities and water

supply system is one of the most important infrastructures in a city. Without it, all city activities could be stopped, especially when the city residents rely mainly on water supply system. Therefore, it is of vital importance to consider preventive measures against failure of water supply system such as large pipe breaks.

In order to strengthen the water supply system against failure and enhance the reliability of the system, following measures or concepts are effective and shall be adopted for planning policy.

- Usage of gravity water distribution
- Introduction of multiple transmission systems and mutual backs-ups, if one system fails
- Decentralization of water supply facilities
- Introduction of District Metered Areas (DMAs) and mutual backs-up among DMAs
- Selection of water intake to water pollution free location in future

(2) Other Key Policies for Planning

The following are considered as other key policies for master planning.

- Staged facility construction to save initial construction cost
- Adoption of gravity distribution of water utilizing topographic advantage
- Separation of distribution network from transmission line
- Use of hierarchy of distribution zoning and relevant water supply facilities

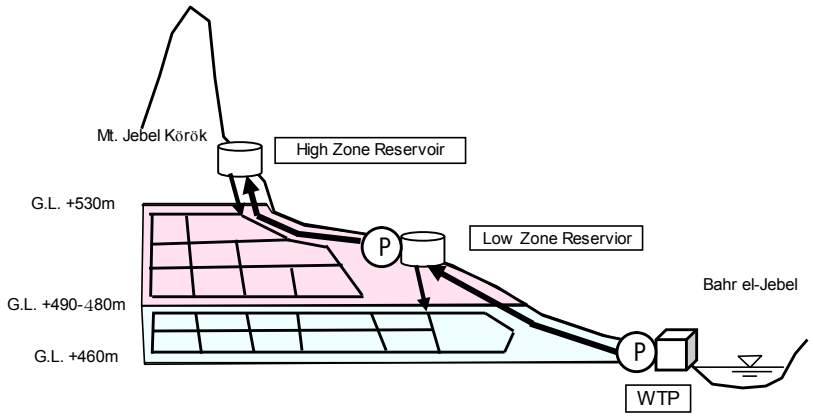
3.2 Water Supply Facility Plan

3.2.1 Distribution Zoning

Water distribution zoning system is planned considering the topography of the area concerned. In the Target Service Area, the following two salient features of topography are considered:

- Separation by the Bahr el-Jebel into two area (west and east bank)
- Elevation difference in the west bank (slop down from Mt. Jebel Körök to the Bahr el-Jebel)

Two distribution zones in the west bank and one zone in the east bank are adopted for a new distribution system for the Target Service Area. The vertical schematic layout is shown in Figure 3.1 and the delineation of 3 large distribution zones is shown in Figure 3.2.



(Two Gravity Distribution Zones)

Figure 3.1 Vertical Schematic Layout of Distribution Zoning in the West Bank

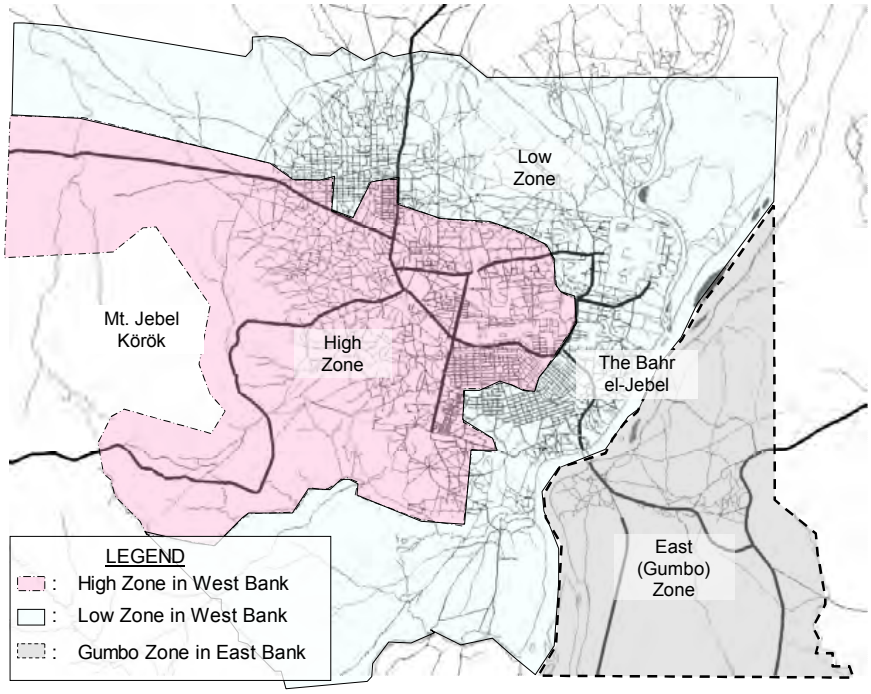


Figure 3.2 Layout of Large Distribution Zoning

Water demand by zone is calculated as shown in Table 3.8. The maximum daily water demand in 2025 has been estimated as 236,600 m^3/d including 96,300 m^3/d for the High Zone, 106,500 m^3/d for Low zone in the West Bank, and 33,800 m^3/d for the Gumbo zone in the East Bank.

Table 3.8 Water Demand by Zone

Area	Average Daily Water Demand			Maximum Daily Water Demand		
	2015	2020	2025	2015	2020	2025
West bank						
West High Zone	25,300	46,400	80,300	30,300	55,700	96,300
West Low Zone	26,900	50,700	88,800	32,300	60,800	106,500
Sub-total	52,200	97,100	169,100	62,600	116,500	202,800
East bank						
Gumbo Zone	5,300	14,100	28,200	6,400	16,900	33,800
Total	**57,500**	**111,200**	**197,300**	**69,000**	**133,400**	**236,600**

Based on the estimated maximum daily water demand, the required total capacity of proposed major water supply facilities (water treatment plant and service reservoir) in 2025 is calculated as shown in Table 3.9. The total required capacity of water treatment plant is 237,000 m^3/d composed of 203,000 m^3/d and 34,000 m^3/d for the West Bank and the East Bank, respectively. The total required capacity of service reservoir is 79,000 m^3 composed of 68,000 m^3 and 11,000 m^3 for the West and East Banks, respectively.

Table 3.9 Required Capacity of Proposed Major Water Supply Facilities in 2025

Facility	Unit	West Bank			East Bank	Total
		High Zone	Low Zone	Sub-total	Gumbo Zone	
Water Treatment Plant	m^3/d	96,000	107,000	203,000	34,000	237,000
Service Reservoir	m^3	32,000	36,000	68,000	11,000	79,000

3.2.2 Water Treatment Plant

(1) Site for Surface Water Intake and Water Treatment Plant

As a result of the evaluation of site for water treatment plants, the following 3 locations are selected.

- Existing water treatment complex for expansion of the existing plant: 7,000 m^3/d
- Tokiman area in Rejaf for West Water Treatment Plant
- Gumbo area in Rejaf for East Water Treatment Plant

The Study Team had a site survey to confirm whether any potential pollution sources is located in the upstream of the Khor Ramla (Jondoru) River and found that the existing dumping site of the Juba urban area is located in the upstream of the watershed of the river. To avoid any potential pollution for the source of water supply and by considering land acquisition easiness, the intake site has been selected. The land shown in Figure 3.3 is selected as new water treatment sites.

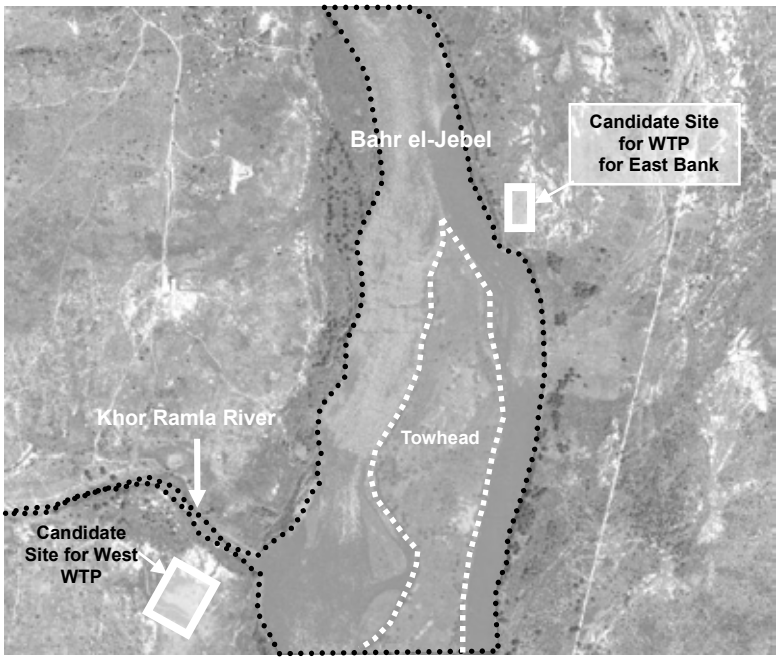


Figure 3.3 Sites for New Water Intake and Water Treatment Plant for West and East Banks

(2) Expansion of Existing Water Treatment Plant

The existing water treatment method is high rate coagulo-sedimentation with rapid filtration, which requires comparatively smaller area. Considering the limited land and consistency of operation and maintenance with the existing water treatment plant, a process of high rate coagulo-sedimentation and rapid filtration is adopted as the treatment method of expansion plant and water treatment facilities of the same capacity as the existing water treatment plant is expanded.

(3) Proposed New Water Treatment Plant for West and East Banks

The following four treatment methods were evaluated for adoption of proposed new water treatment plant.

- Slow sand filtration with sedimentation
- Rapid sand filtration with one of the following sedimentation methods
  - High rate coagulo-sedimentation basin
  - Horizontal flow sedimentation basin
  - Horizontal flow sedimentation basin with baffle plate

As a result of comparison, rapid sand filtration with horizontal flow sedimentation is selected as the treatment method for proposed new water treatment plant considering following advantages.

- Operation and maintenance difficulty is fair.
- It is adaptable to any turbidity level of raw water.

- It is robust in the fluctuation of turbidity of raw water
- It is the most conventional method of rapid sand filtration

(4) Summary of Planned Water Treatment Plants

The capacity of the proposed water treatment plants is summarized in Table 3.10 and general layout of water treatment plants are shown in Figure 3.4 and Figure 3.5. The water treatment plant for west bank is assumed to be constructed in 3 series. The capacity of one series of the water treatment plant for the west bank is 63,000 m^3/d.

Table 3.10 Summary of Proposed Water Treatment Plants

Item	Expansion WTP	West WTP	East WTP
Series/construction stages	1	3	1
Capacity of 1 series (m^3/d)	7,000	63,000	34,000
Total capacity (m^3/d)	7,000	189,000	34,000
Treatment process	High rate coagulo sedimentation and rapid sand filter	Horizontal flow sedimentation and rapid sand filter	Horizontal flow sedimentation and rapid sand filter

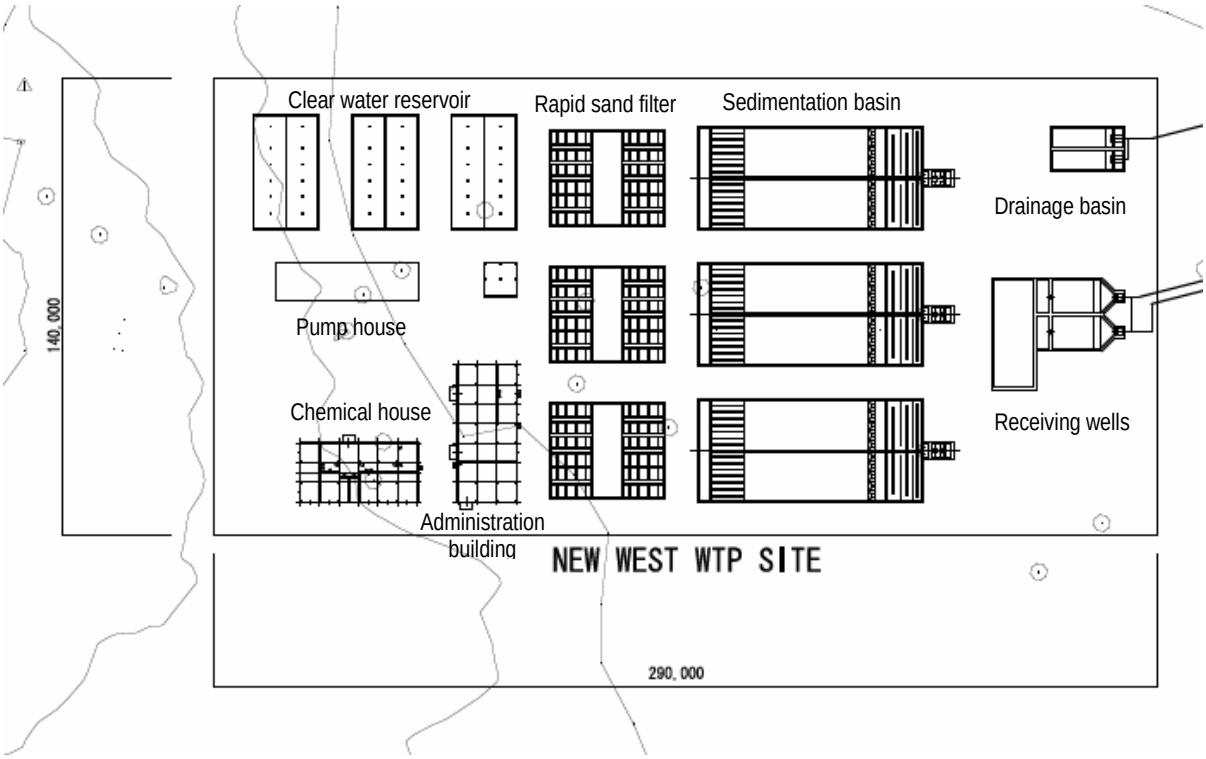


Figure 3.4 General Layout of Water Treatment Plant for West Bank

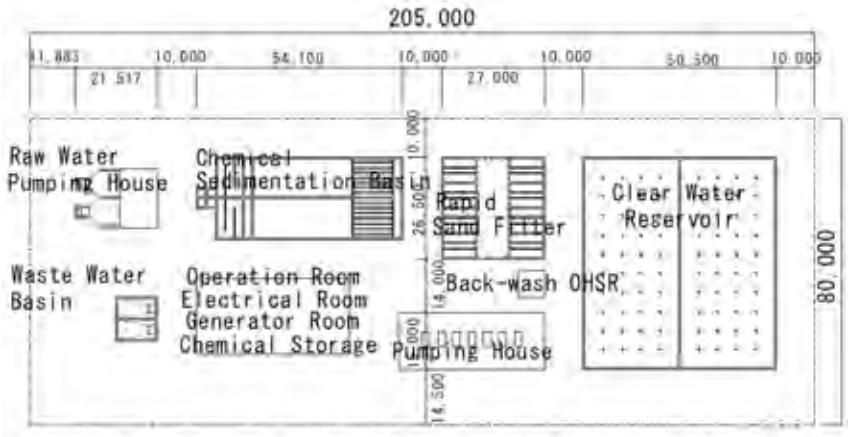


Figure 3.5 General Layout of Water Treatment Plant for East Bank

3.2.3 Transmission and Distribution System

(1) Planning Conditions

Design of transmission and distribution main system is carried out based on hydraulic analysis adopting design criteria shown in Table 3.11.

Table 3.11 Design Criteria for Transmission and Distribution Facilities

Facility	Adopted design criteria	Remarks
Design of transmission pipeline	Maximum daily demand in 2025	Daily peak factor = 1.2
Design of distribution pipeline	Maximum hourly demand in 2025	Hourly peak factor = 1.65 in 2025
Minimum hydraulic pressure in distribution network	1.5 kgf/cm^2 in distribution main pipe and 1.0 kgf/cm^2 in service connection.	2 story building can receive water supply by tap directly.
Reservoir capacity	Volume equivalent to 8 hours of maximum daily demand	

(2) Locations of Service Reservoirs

1) High Distribution Zone in West Basin

The optimum ground level of reservoirs for high distribution zone is around 540 m to supply water with appropriate water pressure to the area. The sites for service reservoir to serve high zone are limited at the foot of the Mt. Jebel Körök. One reservoir in this area could supply water to entire area of the high zone. However, after a detailed comparison, two reservoirs system is selected to supply

water to two directions; i.e. north and south separately, considering the expansion of the urban area toward south in future and mutual backup between two reservoirs is possible in case of accident and during repair work of each service reservoir and relevant pipelines.

2) Low Distribution Zone in West Basin

The optimum ground level of service reservoirs for low distribution zone is around 515 m. This level is equivalent to the ground level of the site of the exiting elevated tank in the John Garang Memorial Site near the Parliament. This site is suitable for reservoir to supply water in low zone considering the elevation and the location of the distribution area. This site is located at the center of the existing urbanized area so that water can be distributed to any direction of the current urbanized area in the low zone. However, considering future expansion of urbanized area, it is highly possible that one reservoir cannot cover the entire area of the low zone due to the distance from service reservoir and tract of the low zone. The two sites were studied as potential sites for additional reservoirs considering the direction of expansion of the urbanized area. After the comparison of the alternatives, two reservoirs system is selected for the low zone.

3) Gumbo Zone in East Bank

The topography of the east zone is relatively flat with an elevation range from around 460 m to 480 m and there is no appropriate location for ground service reservoir from which water can be distributed by gravity. Therefore, a system comprised of an elevated tank and a service reservoir connected by transmission mains is proposed to distribute water in this zone. The location of an elevated tower is planned at the highest point in the zone, which is almost the center of the service area of the east zone.

(3) Transmission System in West Bank

Two alternatives are compared for transmission system in the west bank and following system is selected as an optimal system. This alternative is advantageous in terms of backup; each transmission system can be mutually backed up in case of accident and during repair work of the other system.

- Treated water is firstly transmitted from the West Water Treatment Plant to both low service reservoirs separately, from where the part of water to meet the high zone demand is pumped up to two high zone reservoirs, separately.

(4) Distribution System

Based on hydraulic analysis, the distribution main network was designed for 2025. The total length of required distribution mains including sub-mains in 2025 is 169 km.

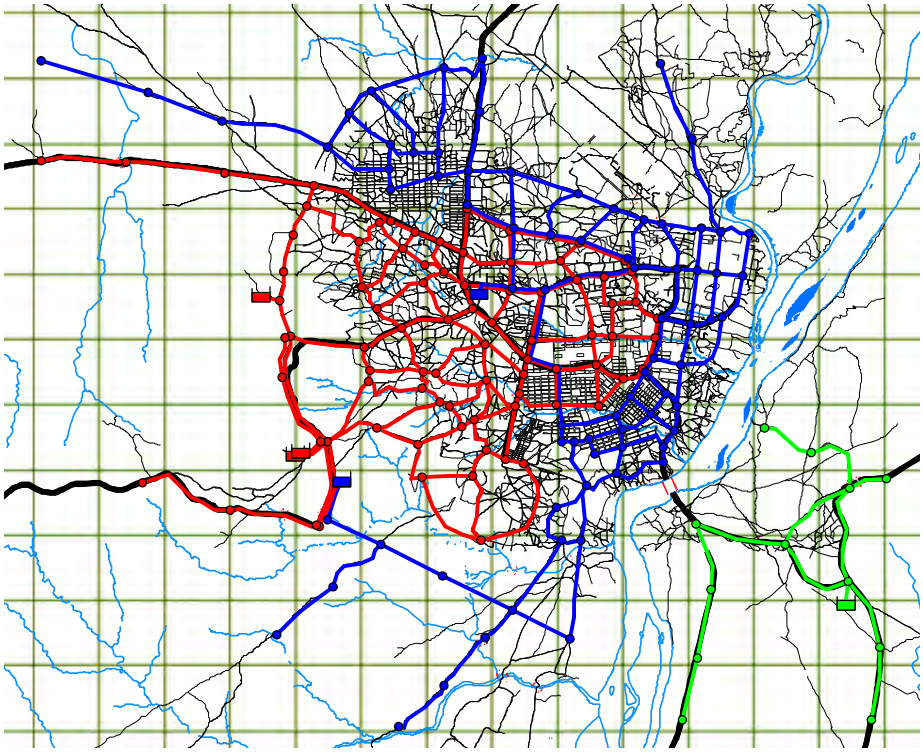


Figure 3.6 Water Distribution Main System in 2025

Table 3.12 Estimated Length of Distribution Mains up to 2025

(m)

Diameter (mm)	West High Zone	West Low Zone	Gumbo Zone	Total
200 - 1000	80,000	74,600	14,100	168,800

Distribution tertiary pipelines are designed by adopting the concept of district metered area (DMA). The required length and diameter of tertiary pipelines are estimated by calculation of pipe density of the model DMA area. The length of tertiary network by diameter in 2025 is estimated as shown in Table 3.13 and the estimated total length is 1,083 km.

Table 3.13 Estimated Length of Distribution Tertiary by Diameter up to 2025

(m)

Zone	Diameter		Total
	150 mm	100 mm	
High	66,900	378,900	445,800
Low	75,900	430,100	506,000
Gumbo	19,700	111,600	131,300
Total	162,500	920,600	1,083,100

3.2.4 Proposed Water Supply System

A general layout of major water supply facilities in 2025 together with the targeted service zones and capacity of major water supply facilities is shown in Figure 3.7. A schematic elevation map of proposed water supply system in 2025 is shown in Figure 3.8. The summary of the components and capacity of the Mater Plan project is given in Table 3.14.

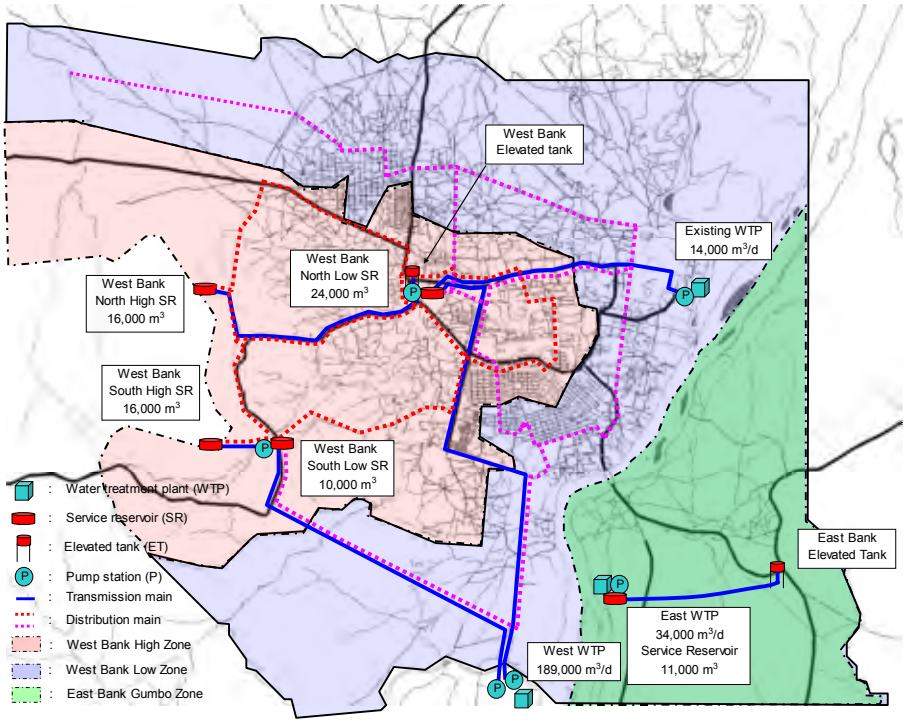


Figure 3.7 General Layout of Water Supply Facilities in 2025 and Capacity of Major Facilities

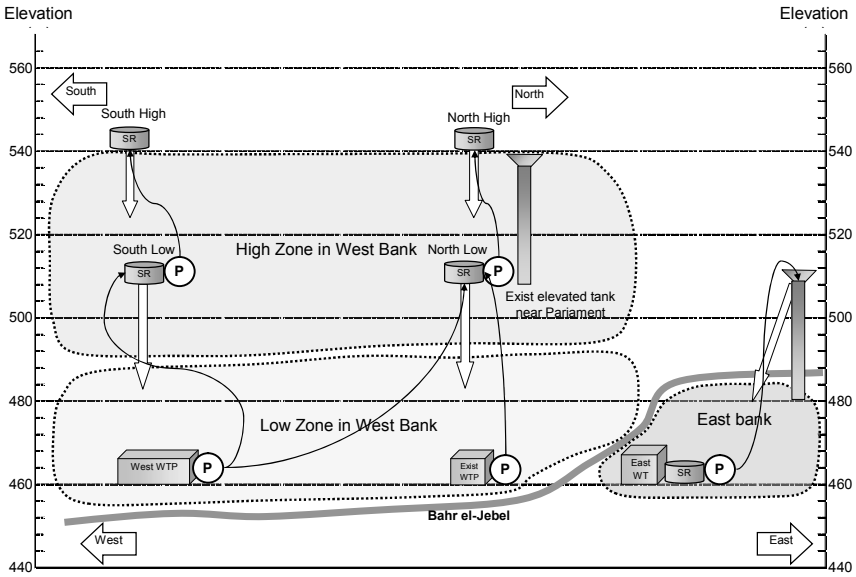


Figure 3.8 Schematic Elevation Map of Water Supply System in 2025

Table 3.14 Components and Capacity of New Facilities in Mater Plan

System component	Facility	Name/Location/Route	Capacity/Specifications
1. Production system	Water Treatment Plants	Expansion of the existing WTP	7,000 m^3/d
		New West WTP	189,000 m^3/d
		New East WTP	34,000 m^3/d
Total			230,000 m^3/d
2. Transmission System	Transmission pump stations	North Low SR site	48,000 m^3/d x 50 m head
		South Low SR site	48,000 m^3/d x 40 m head
	Transmission pipelines	Existing WTP - North Low SR	Dia. 500 mm x 4.45 km
		New West WTP - North Low SR	Dia. 1000 mm x 9.10 km
		North Low SR - North High SR	Dia. 700 mm x 3.75 km
		New West WTP - South Low SR	Dia. 900 mm x 5.86 km
		South Low SR - South High SR	Dia. 700 mm x 1.54 km
		New East WTP - Gumbo ET	Dia. 800 mm x 2.55 km
	Total		Dia. 500 -1000 mm, 27.25 km
3. Distribution System	Service reservoirs	North High SR	16,000 m^3
		North Low SR	24,000 m^3
		South High SR	16,000 m^3
		South Low SR	10,000 m^3
		Gumbo SR in East WTP	11,000 m^3
		Gumbo Elevated Tank	1,300 m^3
	Total (except ET)		Capacity = 77,000 m^3
	Distribution Network(High zone)	Distribution main & sub-main	Dia. 900 - 200 mm x 80.0 km
		Distribution tertiary pipelines	Dia. 150 - 100 mm x 445.8 km
	Distribution Network (Low zone)	Distribution main & sub-main	Dia. 1000 - 200 mm x 74.7 km
		Distribution tertiary pipelines	Dia. 150 - 100 mm x 506.0 km
	Distribution Network (Gumbo zone)	Distribution main & sub-main	Dia. 800 - 200 mm x 14.0 km
		Distribution tertiary pipelines	Dia. 150 - 100 mm x 131.3 km
	Total		Dia. 150-1000 mm x 1,251.8 km

3.3 Development Schedule of Water Supply System

3.3.1 Concepts of Phased Implementation

The concept of phased implementation of the proposed project components under Master Plan, comprising four phases, is prepared in Table 3.15.

3.3.2 Water Demand and Proposed Water Production Capacity Curve

Based on the principle of developing water supply system, in which water supply system will be expanded according to increase of the water demand, water treatment plant expansion plan is prepared as shown in Figure 3.9.

Table 3.15 Concept of Phased implementation of the Master Plan

Phase	Concept	Project components	Total production capacity
Phase-1 (-2012)	This phase is regarded as an emergency improvement phase, in which a small project is implemented to give larger benefits with small investment. The project includes increasing production capacity of the existing WTP and rehabilitation of the existing network to supply the limited water efficiently to the target customers.	・ Expansion of the existing WTP ・ North Low Service Reservoir ・ Transmission pipeline from the existing WTP to North Low Service Reservoir ・ Full replacement of the existing network	14,000 m^3/d
Phase-2 (-2015)	This phase is regarded as the initiation of development of new water supply system of the M/P. The project aims to increase water treatment capacity drastically and mainly supply water to the existing urban area with adequate amount of water.	・ Construction of stage 1 of New West WTP ・ Construction of the first transmission and distribution main system ・ Expansion of distribution network	77,000 m^3/d
Phase-3 (-2020)	This phase is regarded as the intermediate term of development of the new water supply system. The water supply system will be developed in the east bank. The frame of the main water supply system will be formulated.	・ Construction of stage-2 of New West WTP ・ Construction of new East WTP ・ Second transmission and distribution main system ・ Expansion of distribution network	174,000 m^3/d
Phase-4 (-2025)	This phase is the final phase of development of the new water supply system in the M/P. At the end of this phase, distribution network will be developed in the most of the Target Service Area.	・ Construction of stage-3 of New West WTP ・ Expansion of distribution network.	237,000 m^3/d

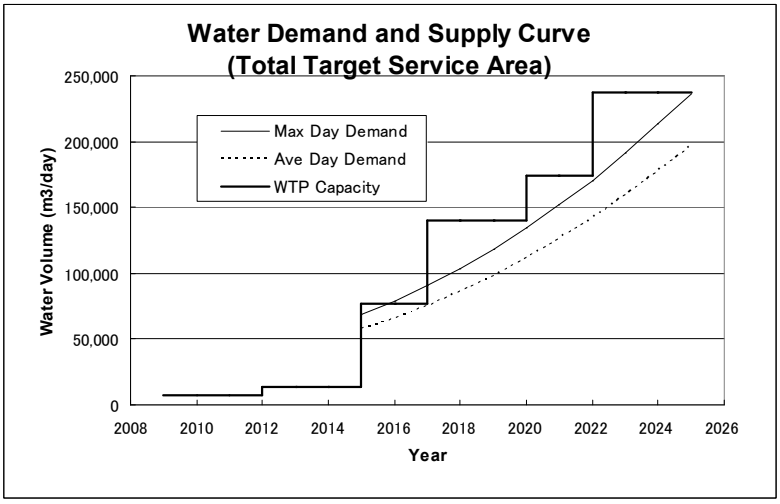


Figure 3.9 Estimated Water Demand and Proposed Expansion of Water Treatment Plant

3.3.3 Expansion Plan of Water Supply System

(1) Treatment Plant

The expansion plan of the water treatment plants through phase-wise construction is prepared and presented in Table 3.16. Regarding the water treatment plant for the east bank, considering its scale of capacity, its construction can be undertaken in one phase, i.e. in the phase 3 and all components of the facilities in the east bank will be constructed in this phase.

Table 3.16 Expansion Plan of Water Treatment Capacity by Construction Phase

(m^3/d)

Term	Existing WTP site		West WTP	East WTP	Total capacity
	Existing	Expansion			
Urgent improvement (phase 1)	7,000	7,000	-	--	14,000
New system construction (phase 2)	-	-	63,000	-	77,000
New system construction (phase 3)	-	-	63,000	34,000	174,000
New system construction (phase 4)	-	-	63,000	-	237,000

(2) Transmission System

The expansion plan of transmission system is shown in Table 3.17 and the expansion plan of service reservoir up to 2025 is given in Table 3.18.

Table 3.17 Expansion Plan of Transmission Pipeline by Construction Phase

Term	Exiting WTP – North Low SR	West WTP – North Low SR – North High SR	West WTP – South Low SR – South High SR	East WTP – Gumbo ET
Urgent improvement (phase 1)	Dia.500mm x 4.45km			
New system construction (phase 2)		Dia.1000mm x 9.1km Dia.700mm x 3.75km		
New system construction (phase 3)			Dia.900mm x 5.86km Dia.700mm x 1.54km	Dia.800mm x 2.55km

Note: The development of transmission main system is planned to complete in the phase-3.

Table 3.18 Expansion Plan of Service Reservoir by Construction Phase

(m^3)

Term	West Bank				East Bank	Total capacity
	North High	North Low	South High	South Low	Gumbo	
Urgent improvement (phase 1)	-	5,000	-	--		5,000
New system construction (phase 2)	10,000	5,000	-	-		15,000
New system construction (phase 3 and 4)	6,000	14,000	16,000	10,000	11,000	57,000
Total	16,000	24,000	16,000	10,000	11,000	77,000

Note: The capacity of 2,000 m^3/d is covered by the reservoir cum clear water tank in West WTP.

3.4 Management, Operation and Maintenance

3.4.1 Management Policy and Concept

To operate and maintain an expanded large water supply system and manage a large number of future customers and UWC staff itself, UWC is required to develop its capacity to perform the works efficiently. Furthermore, the required budget scale of UWC of Juba will increase significantly in future. Given these conditions, UWC should move to a self-sustaining entity with adequate financial conditions and autonomy for future. A concept of management restructuring of SSUWC for future is outlined in Figure 3.10. Other measures are also proposed as management policies such as concentrated and unified decision making system, improvement of work efficiency, and enhancement of fund-raising capacity.

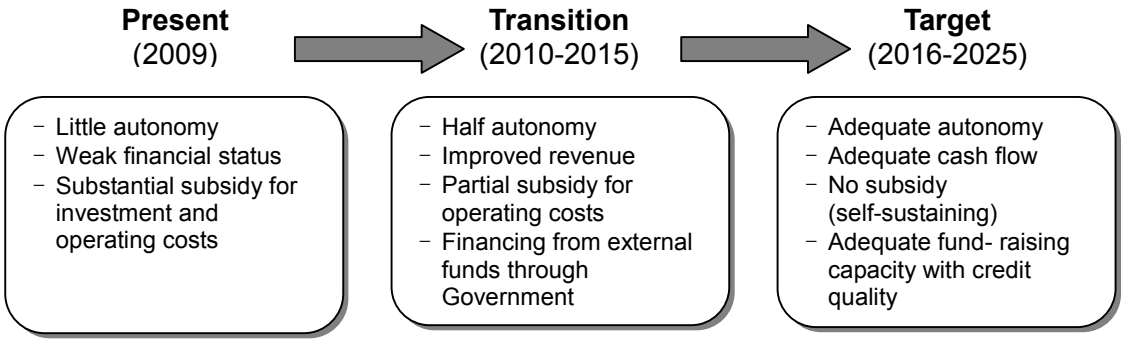


Figure 3.10 Management Status of SSUWC

3.4.2 Organization Plan

Workforce outlook in 2015, 2020 and 2025 is estimated to be 378, 714 and 824 respectively, by assuming adequate staff efficiency. A future organization structure is proposed to suit future business practices and organizational needs. At that time, redefinition of business units is recommended, which have internally independent account. Each business unit shall be granted with discretion as well as profit responsibility and be linked to each other by internal profit relationship. The concept and proposed organization structure by profit unit is illustrated in Figure 3.11.

Establishment of customer service offices is proposed, at least one office in each administrative area of Juba, Kator, Munuki, Rejaf and Gudele, in order to work closer to customers. Involvement of the private sectors shall be encouraged by means of licensed private vendors including water kiosk managers, water tankers.

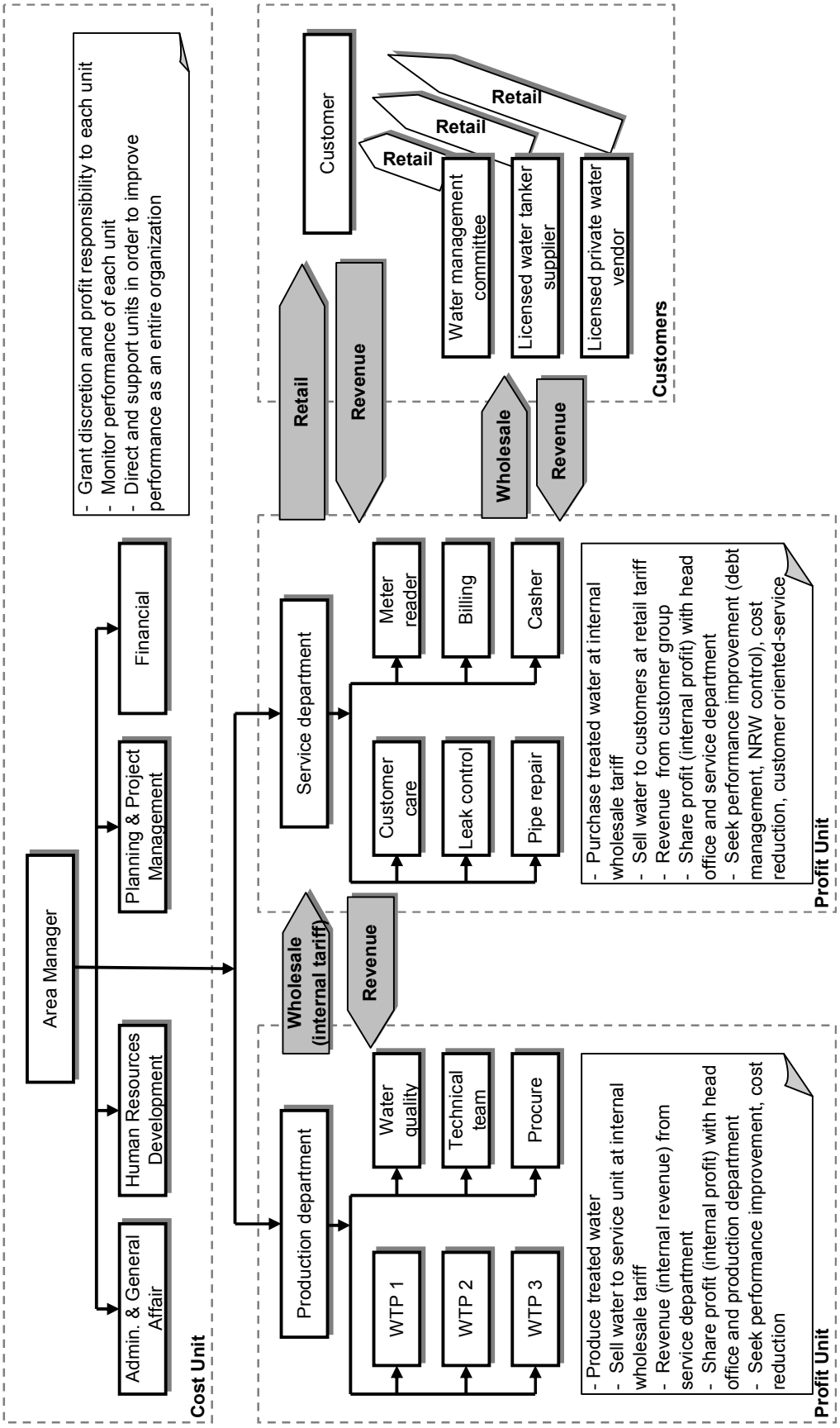


Figure 3.11 Concept of Redefinition of Proposed Organization by Internal Profit Unit

3.4.3 Operation and Maintenance of Proposed Facilities

(1) Objectives of Operation and Maintenance (O&M)

The main function of waterworks is to provide safe and sufficient water to the consumers and the main purposes of operation and maintenance of water supply systems to meet this function are:

- To ensure continued and sufficient water supply at sufficient pressure and of good quality to consumers
- To operate facilities in cost efficient way
- To increase service life

Broad categories of operation activities include routine jobs, measurement and tests, monitoring and reporting. Maintenance includes activities that could be broadly categorized as preventive maintenance, reactive maintenance, important repairs and overhauling, and stores and purchases. Preventive maintenance, including inspection, cleaning, lubrication, consists of the systematic routine actions needed to keep the utility plant in good condition. It also includes minor repairs and replacement as dictated by the routine examination. Reactive maintenance normally occurs as a result of reported pipe breaks and the malfunctioning or breakdown of equipment.

In O&M, the role of managers is to provide directions, make decisions, and control. The roles of operators are to maintain quality of output and match rate of working with requirements. Maintenance staff members are responsible for carrying out repair or replacement of worn or defective components to ensure continued satisfactory level of services.

Each water treatment plant, pumping stations and reservoirs should have its own team of O&M staff and they should report to the head office periodically. There should be inspectors for transmission and distribution networks. At each water treatment plant, there should be laboratory to take care of water quality analysis and management.

(2) Operation and Maintenance Manuals, Records and Reporting

To operate and maintain the facilities appropriately by experts and skilled workers, an efficient and effective O&M system along with the development of the technical capacities of staff is required. The O&M system includes O&M manuals, recordings and reporting. The list of deliverables for proper O&M is shown in Table 3.19.

Table 3.19 List of Deliverables Related to O&M Manuals

Category	Contents
Operation and maintenance manuals	• Design criteria and their implications, with technical detail including ratings and significant dimensional parameters • Operational procedures, supported manufacturer's instructions for all machinery and equipment • Maintenance, similarly supported by manufacturer's instructions and parts lists
Tasks and flow charts of operation and maintenance	• Tasks for water quality control in water supply • Tasks for operation of WTP and pumping stations • Tasks for maintenance of WTP, pumping stations and distribution networks • Flow chart showing steps for water quality control • Flow chart showing steps for operation of water supply facilities • Flow chart showing steps for maintenance of water supply facilities
Records and reports	• Operating records • Daily logs • Monthly operating report • Annual reports • Maintenance report • Cost accounting

3.4.4 Non Revenue Water Management

Non revenue water (NRW) management is one of the most important elements of the overall plan for improvement of any water supply system. The current leakage and NRW ratios of UWC are roughly estimated at 40 % and 60 %, respectively. The targets of NRW management plan are set as follows, based on the Japanese experience and international best practices:

- NRW and leakage ratios will be reduced to 44 % and 20 % by 2015, respectively, after the entire existing network is replaced.
- NRW ratio will be further reduced to 28 % and the leakage ratio will be maintained at 20 % by 2025

To achieve the targets, following measure shall be implemented.

- Replacement of entire existing distribution network until 2015
- Planning of NRW management measures
- Continuous implementation of NRW management activities

3.5 Capacity Development Plan

Based on Project Cycle Management (PCM) workshops organized for UWC-Juba, a capacity development (CD) plan was proposed with appropriate target group as shown in Figure 3.12.

The operation and maintenance system should also be improved and modernized for efficient and effective O&M through the following capacity building measures focusing on the selected strategies.

- Establishment of adequate O&M system

- Database development and management
  - Datasheet for record keeping and work process flow
  - Application of GIS for water supply management
  - Preparation of customer database
- Ensuring adequate budget for O&M
- Organization of training and establishment of training facilities

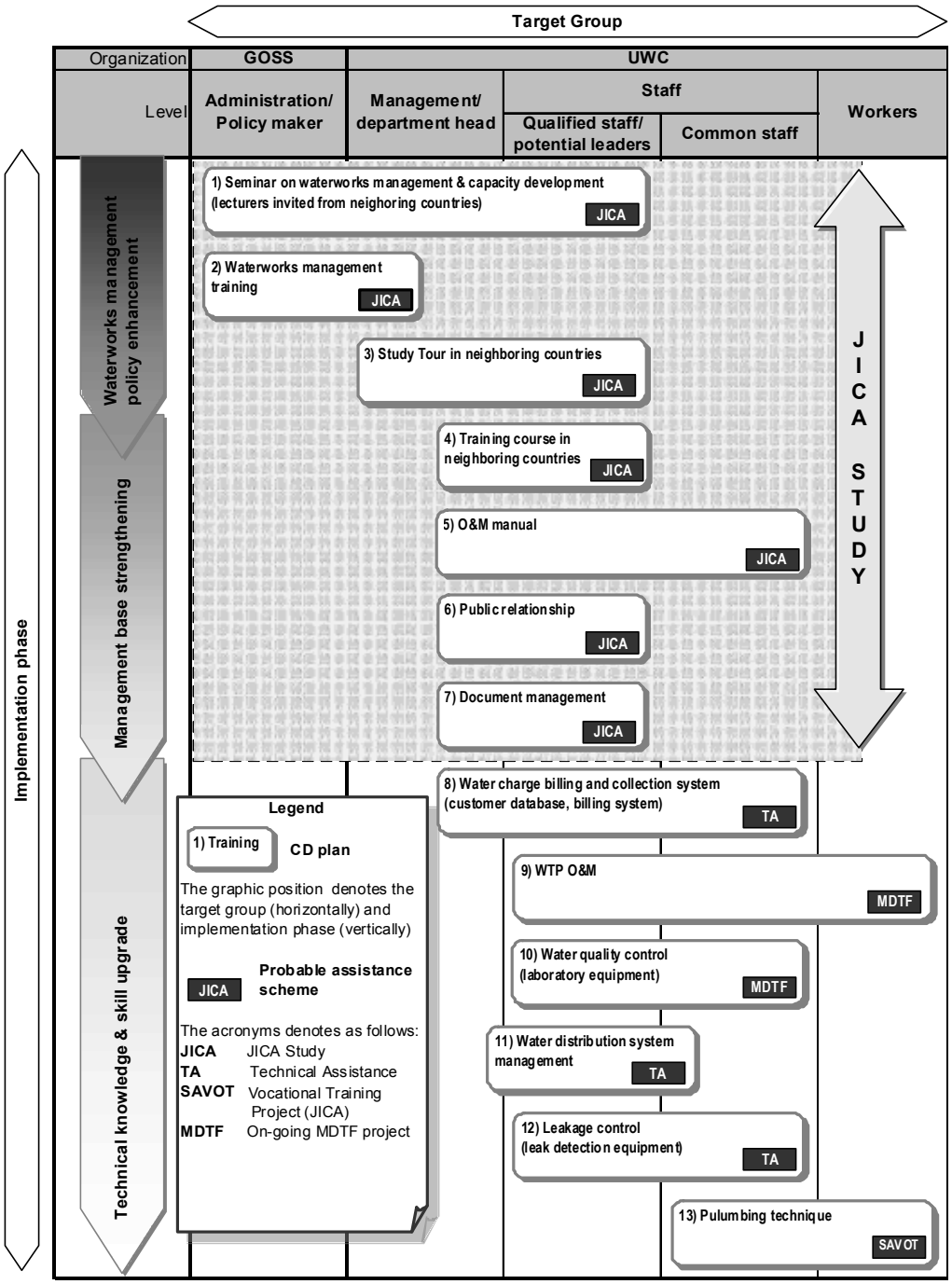


Figure 3.12 Proposed Capacity Development Plan by Implementation Phase and Target Group

3.6 Project Cost Estimation

3.6.1 Conditions of Cost Estimation

The cost is estimated based on the following conditions and assumptions:

- The base year of cost estimation: 2009
- Exchange rate of Sudanese Pound to USD: SDG 2.21
- Project administration cost of the Southern Sudan side: 2 % of construction cost
- Engineering cost: 10 % of construction cost
- Physical contingency: 10 % of total of construction cost, administration and engineering costs
- Price contingency: 7.0 % per year for local currency portion and 4.1 % for foreign currency portion
- Phased construction schedule is assumed
- The cost is estimated by local and foreign currency potions separately. Local and foreign currency potions indicate the goods and labors which are procured in local market and foreign market, respectively.

3.6.2 Estimation of Project Cost

The estimated project costs for the Master Plan are summarized in Table 3.20, the estimated costs by phase are shown in Table 3.21, and the breakdown of the estimated construction cost is summarized in Table 3.22.

Table 3.20 Project Cost and Fund Requirements

(thousand USD)

No.	Item	Local currency	Foreign currency	Total
1.	Construction cost	48,151	230,508	278,659
2.	Administration cost	936	4,610	5,573
3.	Engineering cost	4,815	23,051	27,866
4.	Physical contingency	5,393	25,817	31,210
5.	Price contingency	35,158	88,904	124,062
	Total	94,480	372,890	467,370

Note: Local and foreign currency potions: the goods and labors which are procured in local market and foreign market, respectively.

Table 3.21 Project Cost by Phase

(thousand USD)

Phase	Construction cost	Project cost	Fund requirement
1	29.5	36.4	40.4
2	95	117	144.4
3	103.6	127.7	178.9
4	50.5	62.2	103.7
Total	278.6	343.3	467.4

Table 3.22 Breakdown of Construction Cost for Master Plan

Facility	Specifications	Cost (thousand USD)	Percentage (%)
1. Water Treatment Plant (WTP)			
1.1 Expansion of Existing WTP	7,000 m^3/d	5,538	2.0
1.2 West WTP	189,000 m^3/d	68,087	24.4
1.3 East WTP	34,000 m^3/d	23,146	8.3
Sub-total		**96,771**	**34.7**
2. Transmission Pumping Station (T-P/S)			
2.1 T-P/S in North Low SR	Q=48,000 m^3/d, H=50 m	3,408	1.2
2.2 T-P/S in South Low SR	Q=48,000 m^3/d, H=40 m	2,881	1.0
Sub-total		**6,289**	**2.3**
3. Service Reservoir (SR)			
3.1 North Low SR	24,000 m^3	7,072	2.5
3.2 North High SR	16,000 m^3	4,603	1.7
3.3 South Low SR	10,000 m^3	2,482	0.9
3.4 South High SR	16,000 m^3	5,206	1.9
3.5 Elevated Tank in Gumbo Zone	1,300 m^3	1,159	0.4
Sub-total		**20,522**	**7.4**
4. Transmission Pipeline			
4.1 Transmission Pipeline	DIP, DN200-1000mm x 27.3 km	32,892	11.8
Sub-total		**32,892**	**11.8**
5. Distribution Main & Sub-main			
5.1 Low Zone	DIP, DN200-1000m x 74.7km	32,435	11.6
5.2 High Zone	DIP, DN200-900m x 80.0km	29,040	10.4
5.3 Gumbo	DIP, DN200-800m x 14.0km	6,817	2.4
Sub-total		**68,292**	**24.5**
6. Distribution Tertiary			
6.1 Low Zone Network	PVC, Dia.100-150 x 506.0km	23,776	8.5
6.2 High Zone Network	PVC, Dia.100-150 x 445.8km	20,947	7.5
6.3 Gumbo Network	PVC, Dia.100-150 x 131.3km	6,170	2.2
6.4 Kiosk/Water Tanker Feeding Station		3,000	1.1
Sub-total		**53,893**	**19.3**
Total		**278,659**	**100.0**

Note: The total is not 100 % due to rounding.

3.6.3 Operation and Maintenance and Capacity Development Cost

The operation and maintenance (O&M) cost is estimated as shown in Table 3.23. The cost for

capacity development is assumed to be additional 10 % of the personnel cost every year which should be allocated for staff training and expenses for training facilities.

Table 3.23 Summary of Cost Estimation of O&M by Target Year

Year	Annual revenue water (m^3/year)	O&M Cost (thousand USD/year)							O&M cost per revenue water (USD/m^3)
		Personnel	Electricity	Chemical	Spare parts	Staff training	Others	Total	
2009	851,667	0.0 (0%)	165.7 (30%)	86.0 (16%)	158.5 (29%)	0.0 (0%)	135.1 (25%)	545.3	0.64 (SDG1.41)
2012	2,044,000	630.4 (40%)	463.0 (29%)	172.0 (11%)	106.5 (7%)	63.0 (4%)	143.5 (9%)	1,578.5	0.77 (SDG1.70)
2015	13,115,667	1,899.0 (28%)	2,696.6 (40%)	946.1 (14%)	421.5 (6%)	189.9 (3%)	615.3 (9%)	6,768.3	0.52 (SDG1.15)
2020	33,872,000	3,995.7 (25%)	6,989.0 (44%)	2,137.8 (14%)	783.1 (5%)	399.6 (3%)	1,430.5 (9%)	15,735.8	0.46 (SDG1.02)
2025	51,903,000	5,749.1 (26%)	9,519.5 (44%)	2,911.9 (13%)	1,066.6 (5%)	574.9 (3%)	1,982.2 (9%)	21,804.2	0.42 (SDG0.93)

3.7 Project Evaluation

3.7.1 Water Tariff Setting

In designing water tariff system, three principles are taken into account; affordability, sustainability and fairness. As a result, a tariff structure of increased block with base tariff is proposed by customer category, as shown in Table 3.24.

Table 3.24 Proposed Water Tariff Structure

Type of customer	Base (SDG/month)	Block 1 (SDG/m^3)	Block 2 (SDG/m^3)	Block 3 (SDG/m^3)
Domestic		(0 - 15 m^3)	(15 - 30 m^3)	(> 30 m^3)
House connection	10.0	0.7	1.5	2.0
Public tap	0	0.7	0.7	0.7
Water tanker	0	0.7	0.7	0.7
Commercial/ Industrial	30.0	(0 - 50 m^3) 3.7	(50 - 100 m^3) 4.5	(> 100 m^3) 5.2
Institution	30.0	(0 - 50 m^3) 2.2	(50 - 100 m^3) 3.0	(> 100 m^3) 3.7

Note: Base price level is in March 2009.

It is also recommended to increase tariff to secure financial soundness of UWC for future. The tariff is assumed to increase at 3 % per annum after 2015 until 2025. In addition, inflation adjustment to the tariff should be made periodically.

Monthly household expenditure for water in 2015 is estimated to examine appropriateness of water tariff for household. Three cases are assumed for examination; (I) minimum, (II) average and (III) high consumption cases. As a result, the estimated water charges in these cases fall in the adequate

percentage of the household expenditure (below 3 %) and therefore, the proposed tariff structure is regarded as appropriate and reasonable.

3.7.2 Project Financial Evaluation

Free cash flows for the period of 40 years are analyzed, in which investment cost of phase 1 is deducted from the cash flow since that portion is assumed to be financed by grant aid. The calculated cash flow returns 10.5% of financial internal rate of returns (FIRR), which can be considered as a reasonable rate for water supply project.

The profit and loss statement until 2050 based on the calculation above is projected, which shows break-even point would be year 2015. This is considered as early thanks to sufficient revenue generated from increasing water sales.

The entire operation and maintenance costs and all or a part of depreciation can be covered by water revenue through the project period. The proposed water tariff would be acceptable from the viewpoint of affordability. Consequently, it is judged that the project is financially viable.

3.7.3 Project Benefits

Through implementation of the Master Plan, safe and clean water supply is materialized and following direct and indirect benefits are expected.

1. The service population provided with treated clean water shall be drastically increased.
2. The current very low water consumption per capita will be increased.
3. The quality of supplied water will be improved.
4. Improvement in water supply conditions mentioned above shall contribute to reduction of occurrence of water related diseases such as cholera, typhoid and diarrhea, and skin & eye diseases and is expected to improve health conditions of the people.
5. Water use will be more convenient, i.e., 24 hours supply with sufficient quantity in case of house connection.
6. Water fetching time and efforts, especially of women and children, will be reduced and mitigated. As a result, working and education opportunity for them will be enhanced.
7. Internally displaced persons (IDPs) are located in the service area and the improvement of the water supply service will contribute to improved living conditions of these disadvantaged people. This will further contribute to the stabilization of people's livelihood in the area and political stability.
8. Working opportunities will be created during construction and operation & maintenance of water supply facilities

9. The industry and business that are now affected by dirty water supply will be activated and contribute to the development of the country.
10. The current cost for obtaining water will be significantly reduced and the household expenditure on water will be reduced, which will indirectly contribute to improvement in the livelihood of the people.

The benefits of UWC are identified as follows:

1. The current degraded distribution network, which results into high percentage of water loss, will be rehabilitated and leakage will be reduced. This has benefits in terms of increasing water supply volume and improving revenue. In addition, leakage repair works will be mitigated.
2. The capacity of UWC will be developed by implementation of capacity development program.
3. Revenue of UWC will be enhanced to a great extent and UWC will be self-sustaining entity under the implementation of tariff system reform with meter system.
4. Image of UWC will be improved through the implementation of public awareness campaign.
5. Involvement of the private sector will ease UWC management burden.

3.8 Key Environmental Issues for the Master Plan

As a result of an initial environmental examination (IEE), there are two major issues; land acquisition and increased wastewater due to increase of water supply volume. Land acquisition for the proposed facilities during planning and construction phase is the most concerned issue from social viewpoint, although it is not likely to cause a serious impact as resettlement would not be involved in land acquisition. Increase of wastewater discharge in the residential area and environment may cause water pollution and deterioration of living environment. This may be the most significant negative possible impact of the implementation of the Master Plan.

3.9 Munuki Community Water and Sanitation Management

In the course of the Study, following two pilot projects were implemented in Munuki.

- Establishment of water management committee for public taps
- School sanitation project

3.9.1 Water Management Committee in Munuki

(1) Background of Water Management Committee

JICA constructed a pilot scaled water supply system in Munuki from 2006 to 2007 as a part of the previous JICA Emergency Study. One elevated water storage tank, distribution lines and eight (8) tap stands were constructed. The location of the project is shown in Figure 3.13.

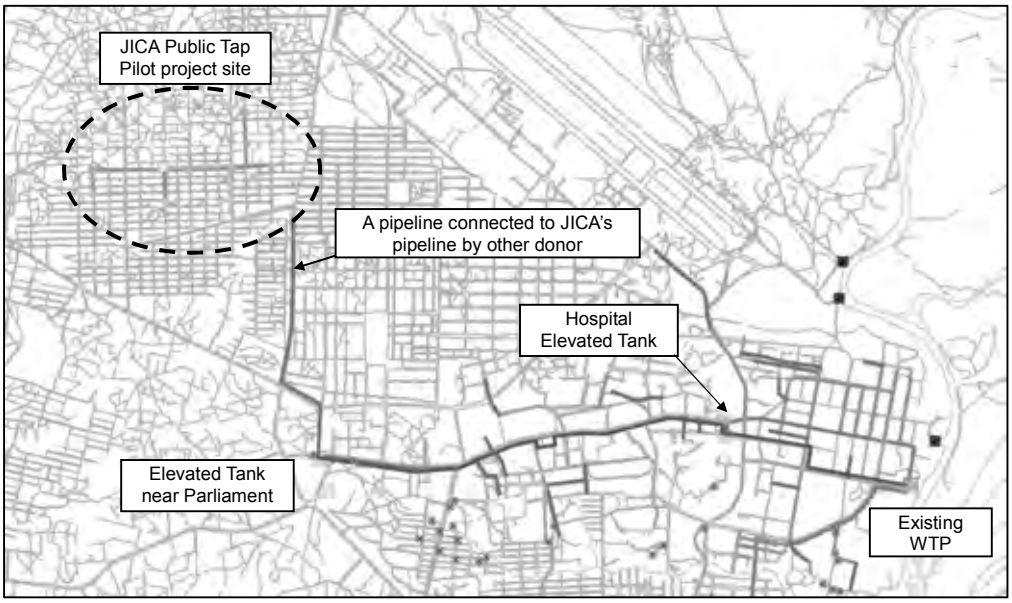


Figure 3.13 Project Site Location

The groundwater extracted through two deep wells which were developed by the pilot project was, however, found to be contaminated with naturally existing toxic mineral, Arsenic. The idea of using well was abandoned for health concern.

Since the water was not supplied to the tap stands, responsible body to manage and operate the water distribution system was not formulated. Meanwhile road rehabilitation project had laid a road in such a manner that seven of the tap stands is situated in the middle of the road and became a road hazardous.

The next opportunity to provide water to the pilot project site arose in 2009 after a while. GOSS and MDTF commenced the rehabilitation work of the existing water treatment plant and the transmission system in 2007 and would completed in 2009, and USAID commenced construction of a transmission main from the existing water supply system to the Munuki transmission main in 2008. Coordinating with completion of these facilities, JICA also initiated to improve the current situation by moving and restoring the tap stands and completed it in April 2009.

(2) Overall Plan of Activities

Activities carried out in Munuki pilot project in the Study are shown below.

1. Assistance to establish water management committee and formulate action plan on operation and maintenance
2. Public awareness survey for water tariff
3. Preparation of operation and maintenance manual
4. Assistance and training to prepare activity schedule on sanitation and hygiene education program
5. Evaluation and workshop

(3) Situation Analysis

Despite all the trainings, campaigns, study tours, meetings and dialogues, the water management committee did not gain recognition and support from the community. Weak office enforcement power, lack of motivation, and conflict of interests are thought to be major factors of difficulty in formulating an active water management committee.

(4) Lessons Learned

The concept of "community base" and dependency to the community's good will and solidarity might be applicable to a remote agricultural community where community's kinship and daily life are closely tied and no other managerial service to a water system is available. Munuki is growing to be part of capital city's function where many private services and economic activities are taking place. People are not heavily depending on each other or a single water source. On the other hand, it was observed that people are willing to pay for convenience, such as buying water for delivery by water tanker, and has financial capacity in some extent. For example, people in Munuki prefer to pay 5 SDG for 200L from tanker than paying 3 SDG tariff for 200L at the tap stands. It can be said that a private company to sell and manage water is more suitable in Munuki.

(5) Suggestions and Recommendations

- UWC needs to establish a function that channels to water users in order to ensure well management of a community based water supply system (such as tap stands) and to collect tariff.
- Business based water supply O&M in city setting like Munuki is encouraged.
- It should target women if it has to be community based but needs an intensive training, long term support from public funding such as UNICEF and frequent follow ups.

3.9.2 School Sanitation Pilot Project

(1) Overall Plan of Activities

FFEDA Basic School located in Munuki was selected for the pilot project for school sanitation since this school did not have a proper hygiene and sanitation facility such as hand washing basin and hygienic latrine. The activities at the school are summarized below.

- Construction of facilities for hygiene and sanitation
  - 6 composting latrines
  - Hand washing facility& rain water harvesting system
- Latrine walls painting
- Formulating manuals and training to use them
  - Composting latrine
  - Hygiene and sanitation
  - WASH club manual
  - Urine& compost-fed gardening workshop
  - Formulation and training of WASH club

(2) Preliminary Evaluation and Lessons Learned

- Insufficient time: Teacher's training, formulation of WASH committee not accomplished
- Teachers are not available / dependable and often absent except the school master.
- Degree of teachers' commitment and ability to educate students is insufficient
- Students and PTA to be the target of hygiene and sanitation promotion activities
- The design of latrine (followed by manuals of UNICEF, MIWR) needs to be improved: ventilation, more lights sources, easier access to vaults, vaults to 2 latrines were missing
- The latrine slab is very small; difficult to use for anyone taller than 160 cm and adults

(3) Suggestions and Recommendations

The following actions are suggested.

- Observation and follow up for a long time of period
- Need to formulate WASH committee (PTA and other stake holders) to support WASH club
- Support to the WASH club by receiving technical support from and tapping into UNICEF& MOH's School hygiene program
- Input of a specialist for the urine and compost fed school gardening and operation of the urine diversion composting latrine
- Support to the teachers to develop skills to carry out hygiene education program and students-led

school activity

3.10 Conclusions and Recommendations

The Water Supply Master Plan for the Juba urban area targeting the year 2025 has been formulated and the conclusions and recommendations on the Master Plan are given as follows:

3.10.1 Conclusions

1. The planning area or the Target Service Area of the Master Plan is composed of Juba urban areas including Juba Town Payam, Kator Payam, Munuki Payam, Gumbo and Lologo in Rejaf Payam and Gudele in Northern Bari.

2. The current estimated population in the Target Service Area is 406,000 in 2009 and the future population in 2025 is projected as 1,160,000. The target of the Master Plan is that all population can access safe and clean water supply by means of house connection, public taps/kiosk or water tanker by 2025.

3. It is concluded that the groundwater in Tokiman Paleochannel is not a feasible source as water supply for the Juba urban area in terms of water quality and quantity. On the other hand, it is confirmed that the surface water of the Bahr el-Jebel is a feasible source considering long-term perspectives. Therefore, the Bahr el-Jebel is selected as water supply source for the Juba urban area.

4. The current treatment capacity is 7,200 m^3/d. The projected total water demand and the proposed treatment capacity in 2025 are planned as 237,000 m^3/d.

5. The major components of the Master Plan project are as follows:
   - Expansion of existing water treatment plant (7,000 m^3/d)
   - Construction of a water treatment plant in the west bank (189,000 m^3/d)
   - Construction of a water treatment plant in the east bank (34,000 m^3/d)
   - Construction of 4 service reservoirs (16,000 m^3, 24,000 m^3, 16,000 m^3, and 10,000 m^3)
   - Construction of transmission pipelines (27 km)
   - Construction of 2 transmission pump stations (48,000 m^3/d x 40 m head and 48,000 m^3/d x 50 m head)
   - Replacement and expansion of distribution network (1,252 km)

6. The following management policies are proposed for Urban Water Corporation (UWC) to be financially and technically sound organization.

- To be self-sustaining organization with autonomy
- To concentrate and unify the decision making system
- To improve work efficiency
- To enhance fund-raising capacity

7. Management targets are proposed as follows:
   - Staff efficiency improvement defined as staff number per 1,000 connections
   - Redefining of business units of UWC for seeking internal profit responsibility
   - Establishment of customer service office to improve customer services
   - Involvement of the private sectors including water kiosk management and private water venders

8. Operation and maintenance plan including work process flow, record keeping formats and reporting system is formulated in the Master Plan.

9. Non-revenue water (NRW) control plan is formulated to increase revenue and improve efficiency of water supply services. The ratio of NRW is projected to be reduced to 28% in 2025 from the current estimated high ratio (60 %).

10. The capacity of all staff levels in UWC including administration, policy making, management, and workers have been identified as very weak. An action plan of capacity development for the year 2025 is proposed to improve management policy, management base and technical knowledge and skills by target group.

11. The construction cost up to 2025 is estimated at 278.6 million USD, project cost including administration and engineering and physical contingency is estimated at 343.3 million USD, and the total fund requirement including price contingency is estimated at 467.4 million USD.

12. The annual operation and maintenance cost in 2009 is 545,300 USD with the estimated unit cost of per revenue water at 0.64 USD/m^3. The current cost does not include personnel costs, which is currently paid by GOSS. The annual operation and maintenance cost in 2025 is estimated as 21,804,000 USD with the estimated unit cost per revenue water at 0.42 USD/m^3.

13. New water tariff is proposed in consideration of affordability of customers, sustainability of waterworks and fairness among customers. As a result, increased block tariff with base tariff by customer category is proposed.

14. Financial internal rate of returns (FIRR) of the Master Plan project resulted in 10.52 %. The breakeven point in a profit and loss projection will be in 2015. The entire operation and

maintenance costs and all or a part of depreciation can be covered by water revenue through the project period. The proposed water tariff would be acceptable from the viewpoint of affordability. Consequently, it is judged that the project is financially viable.

15. As a result of an initial environmental examination (IEE), two major impacts were identified; land acquisition and increased wastewater due to increase of water supply.
    - Land acquisition for the proposed facilities is the most concerned issue from social view point, although it is not likely to cause serious impact, as all proposed sites are not involved with resettlement.
    - Increase of wastewater discharge to the living and natural environment may cause water pollution and deterioration of living environment, which may be the most significant negative possible impact of the implementation of the Master Plan.

16. Two pilot projects; water management committee and school latrine and compost gardening projects, were carried out in Munuki Payam. In the projects evaluation, it is understood that management of public tap stands by forming a community based organization was a difficult task, but business based management is probably more suitable in the urban settlements like Munuki. School latrines were constructed and the use of the latrines was just initiated, but the gardening has not yet started. Simultaneously, hygiene education was carried out in the Study, forming a school WASH club.

17. The Master Plan contributes to eight goals in the Millennium Development Goals (MDGs) of Southern Sudan; i.e., eradicate extreme poverty and hunger, achieve universal primary education, promote gender equality and empower women, reduce child mortality, improve maternal health, combat HIV/AIDS, malaria and other diseases, ensure environmental sustainability, and develop a global partnership for development, directly and indirectly.

3.10.2 Recommendations

1. Capacity development is identified as significantly important for Urban Water Corporation. To implement the proposed capacity development plan effectively, foreign technical cooperation should be invited. In training of the staff, also, training resources in Khartoum or neighboring countries such as Kenya and Uganda that have similar background and experiences on the improvement of water supply sector should be utilized.

2. Fund procurement will be one of the most critical issues to realize the project. The Government of Southern Sudan should seek for funding source. Practically, soft loan offered by external official funds is most preferred. To encourage financing, basic requirements such as financial statements according to International Accounting Standard should be prepared along with sound

financial and technical conditions. In addition, external private fund should be considered as the second option.

3. Preparation of wastewater management plan and its implementation is required to mitigate the impact of increased water supply volume.

4. The acquisition process of the land for the proposed facilities sites should be followed immediately after the Study.

5. Both Munuki pilot projects have been just initiated by the Study Team. Further supports are required for both Munuki pilot projects to be a successful model.

CHAPTER 4 FEASIBILITY STUDY

4.1 Scope of Feasibility Study

4.1.1 Selection of Priority Project for Feasibility Study

The water supply master plan for the Juba urban areas targeting the year 2025 (the Master Plan) was formulated, and development of the water supply system with four phases are prepared according to priority and importance of the components of master plan facilities.

A part of the components proposed in the Master Plan is selected as "priority project," which will be required to be implemented by 2015 with a higher priority than other components. The components included in the first and second phases of the Master Plan were selected as priority project. A feasibility study was carried out for the priority project in the Study.

4.1.2 Target Water Supply Service of Priority Project

(1) Target Year

The target year of the priority project is set as the year 2015. By the selected components, the target water supply services in 2015 should be materialized.

(2) Target Service Area

The target area of water supply service for priority project is set as the existing major urbanized area including Juba Town, Kator and Munuki payams, and future urbanized areas including Rejaf and Gudele, which is the same area as set in the Master Plan.

(3) Overall Target Service Coverage

The overall target service coverage is set as 80 % in 2015 (Table 4.1) and should be met by means of house connection, public taps/ water kiosk connected to the distribution network and private venders supplying water manually and by water tanker. The source of water for all supply methods should be safe and clean water that is adequately treated in the proposed water treatment plant.

Table 4.1 Overall Target Service Coverage in 2015

Item	2009 (base year)	2015 (target year)
Treated water supply coverage	8.4 %	80 %
Total population	406,000	680,000
Service population	34,000	544,000

(4) Target Service Coverage

The target major service area by supply method of house connection and public taps /water kiosks is shown in Figure 4.1, as the pipe network area. The outside of this area, treated water is supplied by water tankers. The target service coverage by means of water supply method and by payam in 2015 is estimated in Table 4.2.

Table 4.2 Service Coverage Projection for 2015

Payam	House connection	Public tap	Water tanker	No coverage
Juba Town	57 %	24 %	11 %	8 %
Kator	42 %	34 %	14 %	10 %
Munuki	37 %	50 %	8 %	5 %
Rejaf	0 %	0 %	60 %	40 %
Gudele	0 %	0 %	60 %	40 %
Total	28 %	22 %	30 %	20 %
Population covered	188,000	151,000	205,000	136,000

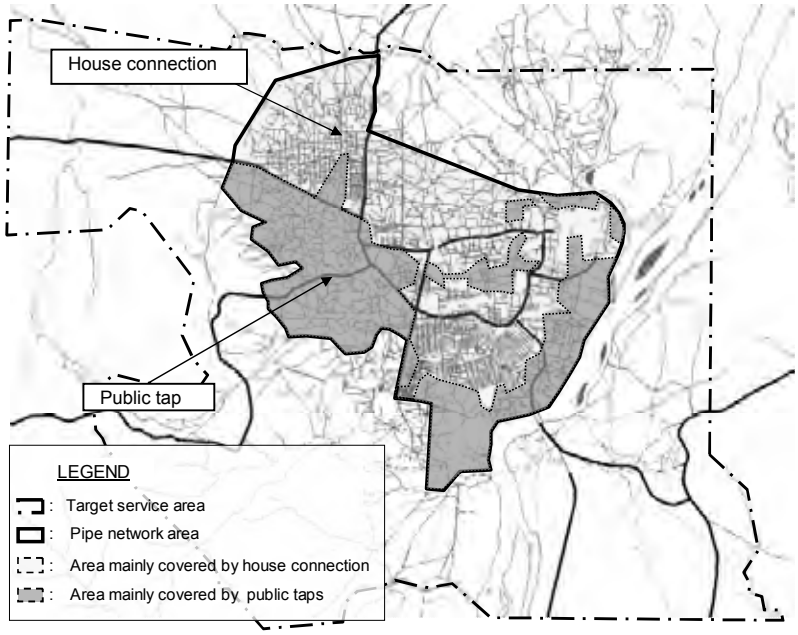


Figure 4.1 Target Service Area

4.1.3 Water Demand Estimation for 2015

The average and maximum daily water demands by payam in 2015 along with the net daily water demand are estimated as shown in Table 4.3. The total average and maximum daily water demands are 57,500 m^3/d and 69,000 m^3/d, respectively.

Table 4.3 Net Average, Average and Maximum Daily Water Demand Estimation for 2015

(m^3/d)

Payam	Net daily demand	Average daily demand	Maximum daily demand
Juba	16,700	20,900	25,000
Kator	8,700	10,900	13,100
Munuki	10,700	13,400	16,100
Rejaf	6,600	8,200	9,900
Gudele	3,300	4,100	4,900
Total	46,000	57,500	69,000

The water demand by distribution zone is estimated as shown in Table 4.4. The estimated maximum daily water demands in 2015 are 62,600 m^3/d in the West Bank and 6,400 m^3/d in the East Bank, respectively.

Table 4.4 Water Demand by Zone in 2015

(m^3/d)

Zone	Average daily water demand	Maximum daily water demand
West Bank		
West High	25,300	30,300
West Low	26,900	32,300
Sub-total	52,200	62,600
East Bank		
Gumbo	5,300	6,400
Total	57,500	69,000

4.1.4 Proposed Water Supply System for Priority Project

The facilities in the proposed water supply system for the priority project are listed below and shown in Figure 4.2. The capacity of the proposed main facilities of the priority project is summarized in Table 4.5.

1) Expansion of the existing water treatment plant
2) West Water Treatment Plant (1st stage of 3 stages)
3) North Low Service Reservoir
4) North High Service Reservoir

5) Transmission pump stations in water treatment plant and North Low SR
6) Transmission mains for West North System
7) Distribution network in high and low zones

In addition to these major water supply facilities, following demand points will be installed in the system.

1) Service connections / house connections
2) Water tanker supply stations
3) Public stand with taps / water kiosks

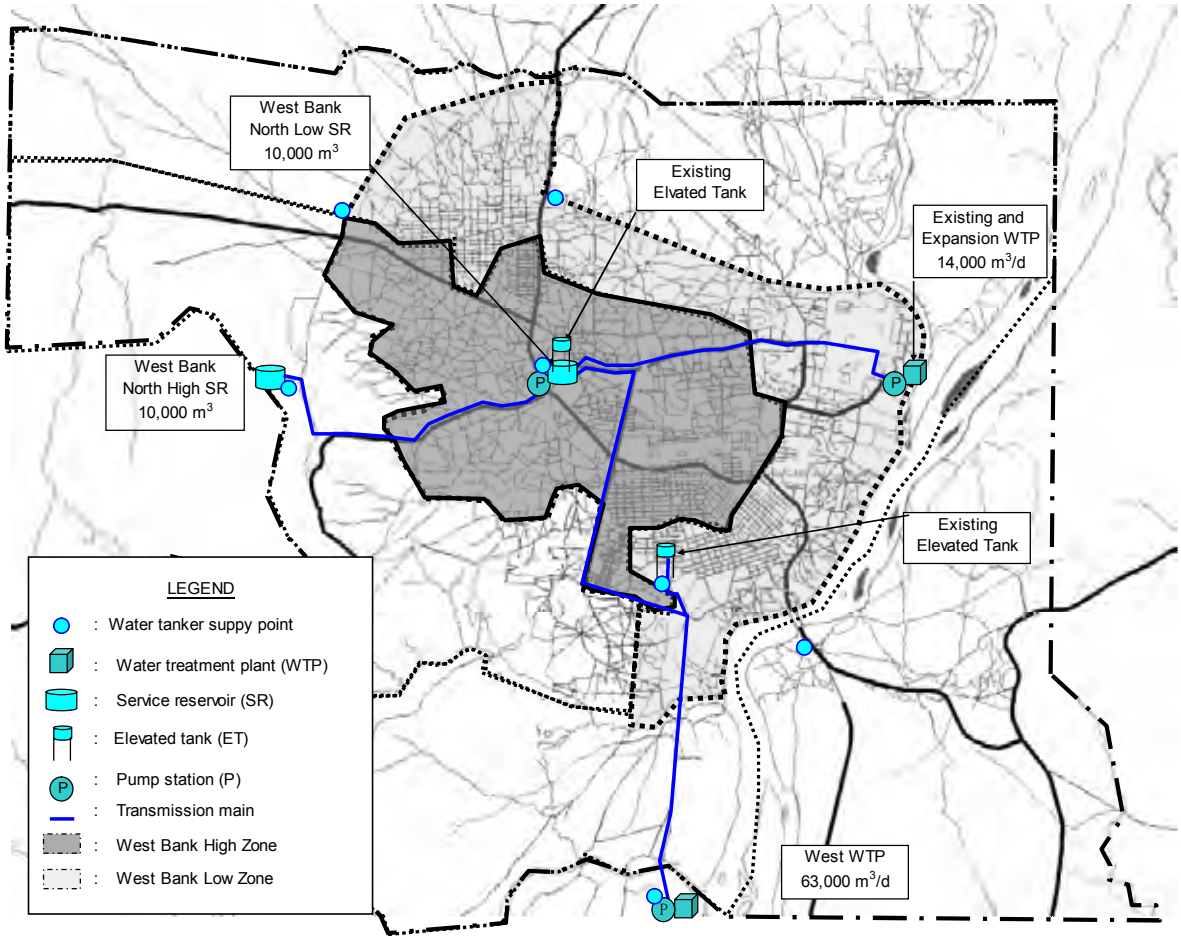


Figure 4.2 Proposed Water Supply Facilities for Priority Project in 2015 along with Service Area

Table 4.5 Summary of Capacity of New Water Supply Facilities for Priority Project

System	Facility	Category / Facility name	Capacity/ Quantity
1. Production	Expansion of exiting WTP	-	7,000 m^3/d
	New West WTP	Stage-1/3 of New West WTP	63,000 m^3/d
Total			70,000 m^3/d
2. Transmission	Pump station in North Low SR	Stage-1/2 of pump station	30,000 m^3/d x 50 m head
	Transmission pipelines	Existing WTP - North Low SR	Dia. 500 mm x 4.45 km
		New West WTP - North Low SR	Dia. 1000 mm x 9.10 km
		North Low SR - North High SR	Dia. 700 mm x 3.75 km
		Branch to existing Kator ET	Dia. 200 mm x 0.20 km
	Total		17.5 km
3. Distribution	Service reservoirs	North High Service Reservoir	10,000 m^3
		North Low Service Reservoir	10,000 m^3
	Total		20,000 m^3
	Distribution network (High zone)	Distribution main & sub-main	Dia. 900 - 200 mm x 53.7 km
		Distribution tertiary pipelines	Dia. 150 - 100 mm x 102.6 km
	Distribution network (Low zone)	Distribution main & sub-main	Dia. 1000 - 200 mm x 49.6 km
		Distribution tertiary pipelines	Dia. 150 - 100 mm x 203.8 km
	Total		409.7 km
4. Supply points	House connections	-	24,100 connections
	Public taps	-	302 stands
	Water tanker supply points	-	7 points with 8 pipes per point

4.2 Facility Design

4.2.1 Production System

(1) Expansion of the Existing WTP

The capacity of expansion of existing WTP is decided as 7,000 m^3/d considering the available land for expansion in the existing site and exiting capacity (7,200 m^3/d) by rounding off to nearest thousand. The same treatment process as the existing plant is adopted so as to operate both plants coherently with the same procedure and technology.

Some of the existing facilities are proposed to be utilized as common facilities for existing and proposed plant in the consideration of cost and space saving and centralized operation. The general layout of expansion facilities is shown in Figure 4.3.

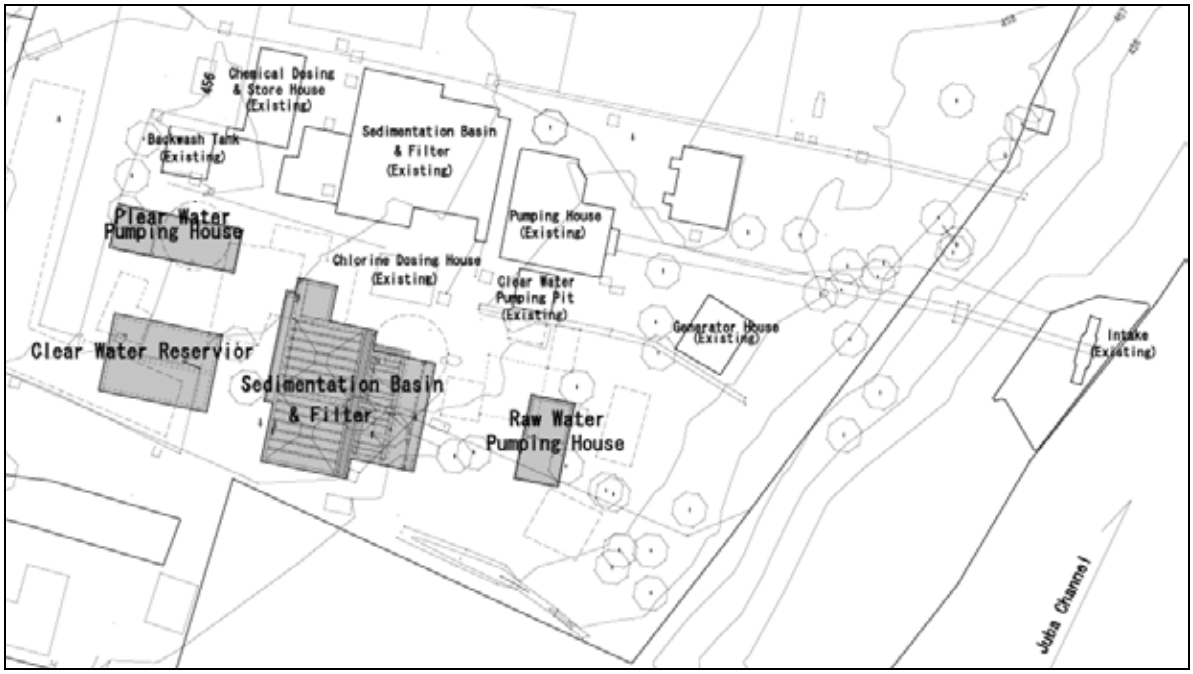


Figure 4.3 General Layout of Expansion Facilities in Existing WTP

(2) West Water Treatment Plant in West Bank

Conventional treatment process with horizontal flow sedimentation and rapid sand filter is adopted for West WTP as decided in the Master Plan. The total capacity of West Water Treatment Plant proposed in the Master Plan is 189,000 m^3/d, which is proposed to be constructed in 3 stages. In the priority project, one series with a treatment capacity of 63,000 m^3/d will be constructed.

Intake facility of raw water is planned to be located upstream of the confluence of Khor Ramla river in the Bahr el-Jebel to avoid any potential risk of future contamination from Khor Ramla river, the catchment of which includes a city waste dumping site. The exact location of treatment plant is decided in the available land considering stability of soil.

Discharged sludge from sedimentation basin and wastewater of back wash from rapid sand filter shall be retained in drainage basin and discharged to the Bahr el-Jebel. The discharged water contains high concentration of suspended solid and aluminum but do not contain any harmful matter. Therefore, its discharge to a large flow of the river does not result in negative impact on the river. However, if it is discharged to the bank, the stagnant high concentrated wastewater and sludge along the river bank may give a bad aesthetic view. To avoid this negative environmental impact, the discharge point should be at the center of the river so that sludge can diffuse instantly. For this purpose, the discharge pipe shall be extended to the center of the river.

A general layout of the West Water Treatment Plant is given in Figure 4.4. The specification of the

components of the proposed facilities is summarized in Table 4.6.

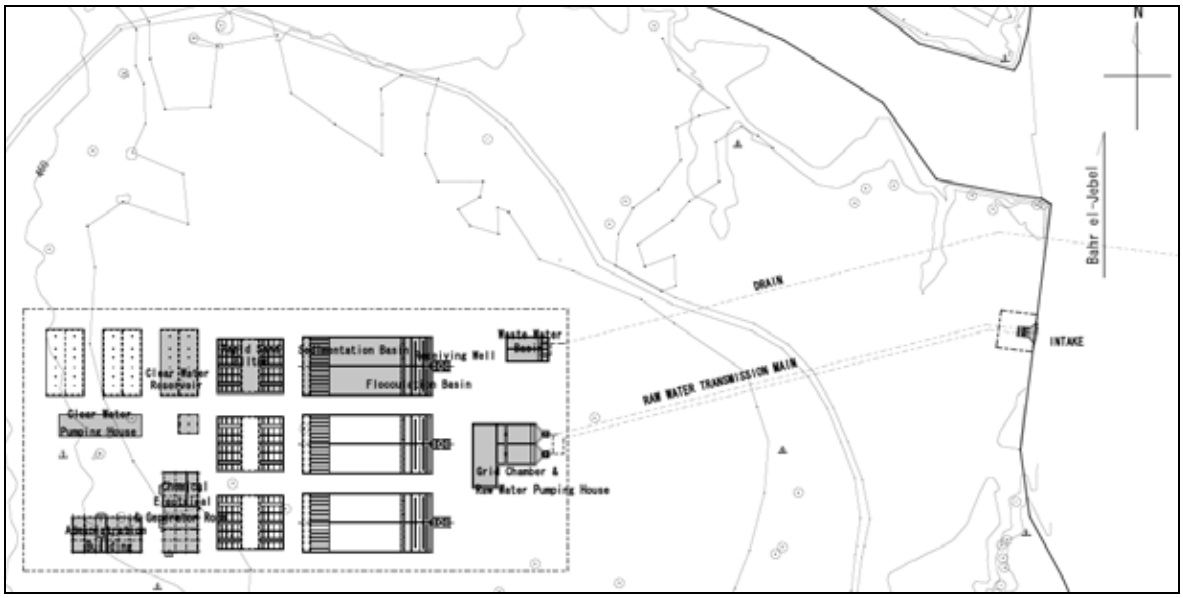


Figure 4.4 General Layout of West Water Treatment Plant for Priority Project

Table 4.6 Specification of Facility Component of West WTP for Priority Project

No.	Facility	Specification
1.	Intake facility	W2.0m * H4.1m * 2 series
2.	Grit chamber	W10.0m*L19.0m*H6.7m*2 series
3.	Raw water pump house Raw water pump	394m^2 * 2floor Q43.7m^3/min * H10.0m * 110kw * 2 (1) nos.
4.	Receiving well	W4.0m * L2.0m * H5.1m * 1 series
5.	Mixing tank	Mechanical type W4.0m * L4.0m * H3.3m * 1 series
6.	Flocculation basin	Tapered horizontal flow W15.0m * L13.8m * 2 series
7.	Chemical sedimentation basin	Horizontal flow with mechanical sludge collector W15.0 * L50.3m * 2 series
8.	Rapid sand filter	Gravity flow (Back and surface wash) W9.0 * L12.0m * 6 basin
9.	Elevated tank for backwash	W10.0 * L10.0 * He4.0m
10.	Clear water reservoir	W10.0m * L35.0m * He4.0m * 2 tanks V=2,8000m^3
11.	Transmission pump house Transmission pump Backwash pump Surface wash pump	440m^2 * 2floor Q37.2m^3/min * H90.0m * 750kw * 3 (1) nos. Q13.3m^3/min * H25.0m * 75kw * 2 (1) nos. Q13.0m^3/min * H25.0m * 75kw * 2 (1) nos.
12.	Wastewater basin	W 6.0 m * L 16.0 m * 2 series
13.	Administration building	648 m^2 Office, laboratory, control room, meeting room etc.
15.	Utility building	756 m^2 Chemical dosing, electrical, generator room Diesel Generator 1,500 kVA * 1 no.

Note: ( ) indicates the number of stand-by.

4.2.2 Transmission Facilities

(1) Pump Station in North Low Service Reservoir

The specification of facilities and equipment required for the target year of 2015 summarized in Table 4.7.

Table 4.7 Specification of Transmission Pump Station in North SR for Priority Project

Facilities	Specification in 2015
Building	Pump, generator, electricity and office rooms (RC Structure = total space 384 m^2)
Pump	Q = 16.7 m^3/min (24,000 m^3/d) , H = 50 m, motor = 200 kW 2 sets (one as standby)
Generator	Diesel engine generator (Capacity = 300 kVA) 1 set

(2) Transmission Pipelines

The proposed alignment of transmission pipelines are shown in Figure 4.5. Routes of transmission pipelines are selected considering the existing roads and alignment, along which a route survey was conducted in the feasibility study for preparing a plan for transmission pipelines.

The existing transmission main (dia. 300 mm) constructed by MDTF will be converted into distribution main and new transmission mains (dia. 500 mm) that can transmit the doubled capacity of the existing water treatment plant shall be constructed.

4.2.3 Distribution Facilities

(1) Service Reservoirs

North High SR and North Low SR will be constructed with a storage capacity of 10,000 m^3 each for high or low zone, respectively in the priority project. General layout of service reservoirs are shown in Figure 4.6 for North High SR and in Figure 4.7 for North Low SR.

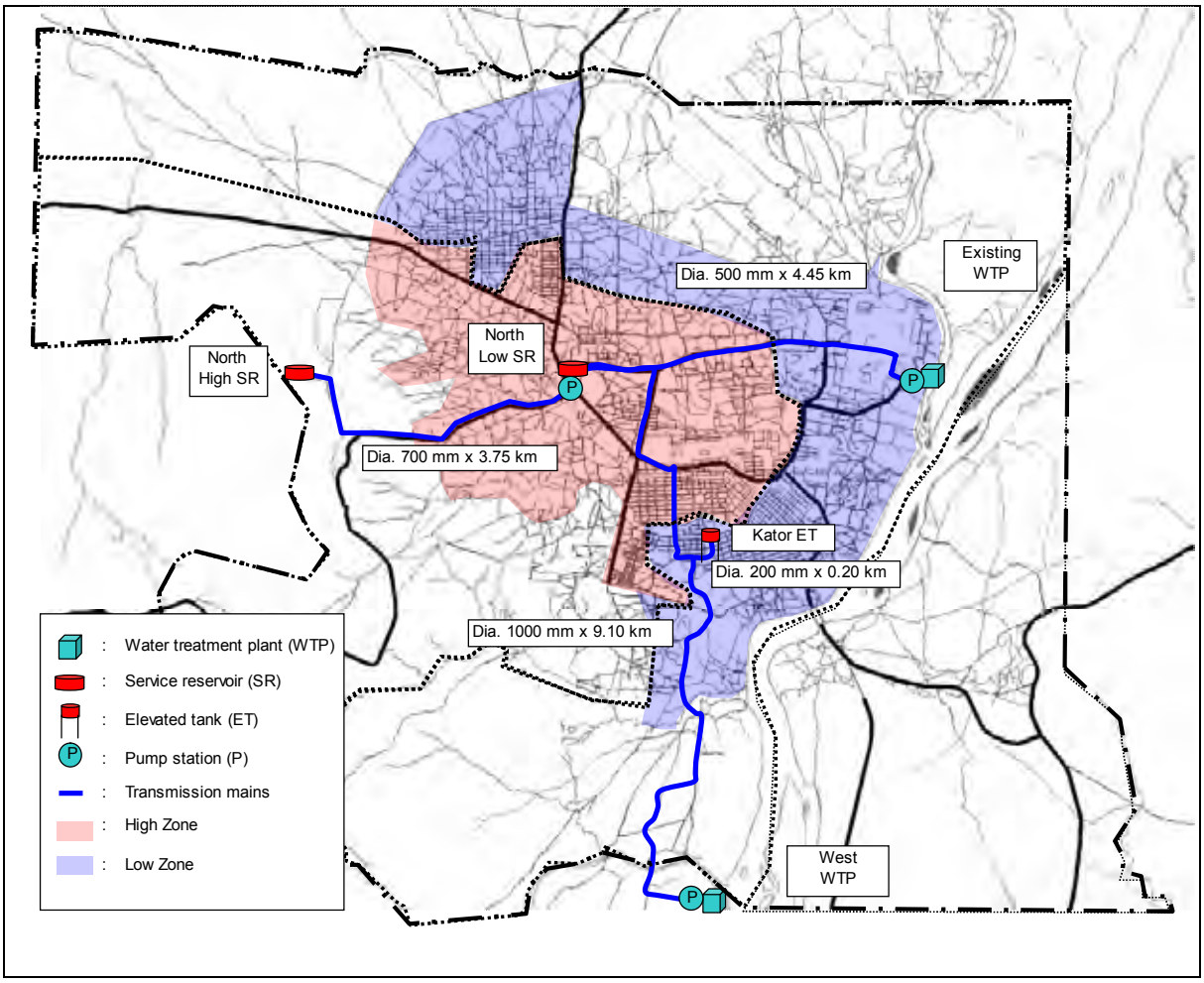


Figure 4.5 Alignment of Transmission Pipelines

Figure 4.6 General Layout of North High Service Reservoir

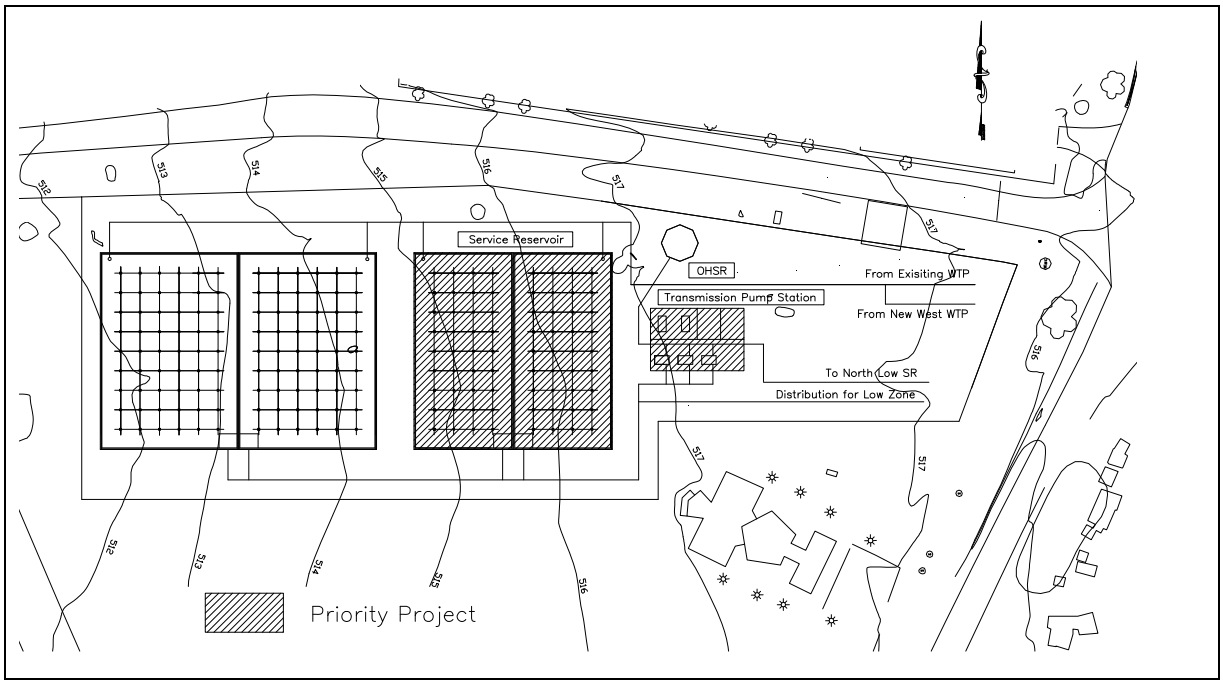


Figure 4.7 General Layout of North Low Service Reservoir

(2) Distribution Network

The total length of distribution network required in 2015 is 409 km, which are comprised of 103 km of distribution main and sub-main and 306 km of distribution tertiary pipelines. A summary of required length and diameter of distribution network are shown in Table 4.8.

Table 4.8 Summary of Distribution Network in 2015

Category	Diameter (mm)	High Zone (km)	Low Zone (km)	Total (km)
Distribution main & sub-main	200- 1000	53.7	49.6	103.3
Distribution tertiary pipeline	150-200	102.6	203.8	306.4

(3) Public Tap Stand and Water Supply Point of Water Tanker

The net water demand for 2015 by user type is estimated as shown in Table 4.9. In 2015, the net water supplies of 7,900 m^3/d and 10,700 m^3/d should be covered by public taps /water kiosk, and water tanker. To meet these water demands, the number of the required facilities is estimated in Table 4.10, and supply points for tanker is preliminarily decided as shown in Figure 4.2.

Table 4.9 Net Water Demand Estimation for 2015 by User Type

Item	House connection	Public tap	Water tanker	Total
Population covered	188,000	151,000	204,000	543,000
Per capita consumption (L/c/d)	90	40	40	-
Net domestic demand (m^3/d)	16,900	6,000	8,200	31,100
Local well use (m^3/d)	0	-1,800	-2,500	-4,300
Net domestic use excluding local use (m^3/d)	16,900	4,200	5,700	26,800
Non-domestic (%)	38	38	38	-
Net non-domestic demand (m^3/d)	10,400	3,700	5,000	19,100
Net total demand (m^3/d)	27,300	7,900	10,700	45,900

Table 4.10 Demand Points by Service Level in 2015

Item	Nos. of connections, tap stands or tanker supply points
House connections	25,200 connections
Public tap stand	302 stands
Tanker supply point	7 points with 8 pipes per point (56 pipes)

4.3 Management, Operation and Maintenance

4.3.1 Management Policy and Target

UWC of Juba aims at being a self-sustaining organization with autonomy in future. To that end, financial strengthening should be primarily focused for capacity development of UWC as the financial constrain is the biggest constraint of water works management. The following measures should be taken.

- New water tariff set up to cover operating expenses and a part of depreciation
- Upgrading billing and revenue collection system based on metering system.
- Enhancement of customer service and authorization to disconnect
- Strengthening of debt management

4.3.2 Performance Target

To improve business performance, performance indicators (PIs) are recommended to use, which are published by ISO/TC224 and other water associations like JWWA (Japan Water Works Association).

Typical PIs are selected in consideration of four domains of management focus: service, operational process, finance and human resource. The position of each PI is illustrated in Figure 4.8.

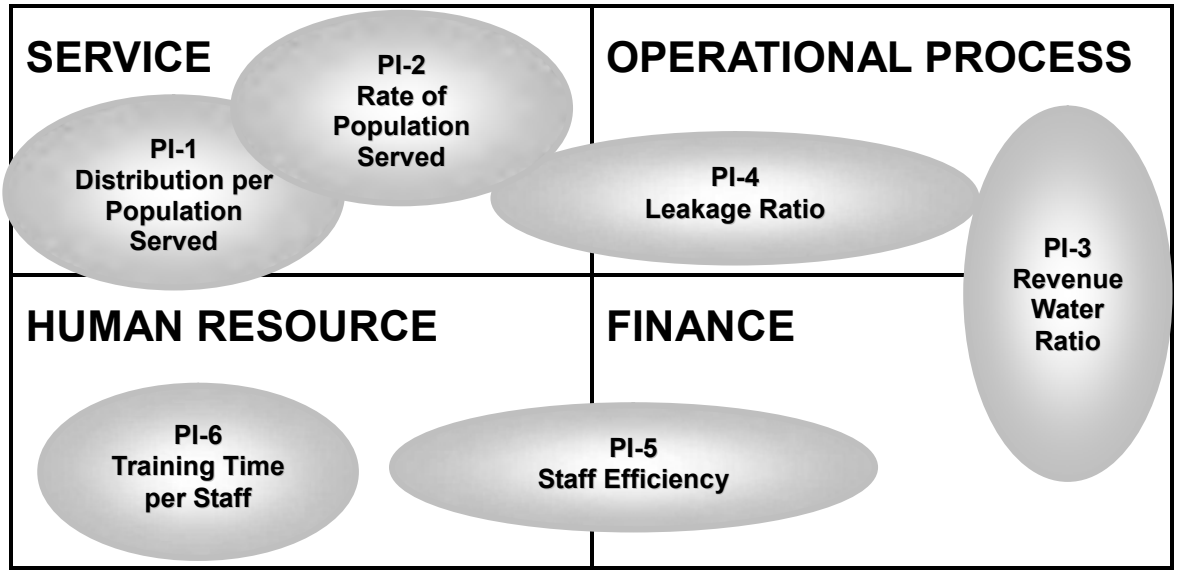


Figure 4.8 Position of Performance Indicators in Four Management Domains

4.3.3 Organization Plan

Workforce in 2015 is estimated to be 378 persons assuming that staff efficiency will be 15 staff-members per 1000 connections. Given this, organization reform is proposed by redefining internal profit units as illustrated in Figure 4.9.

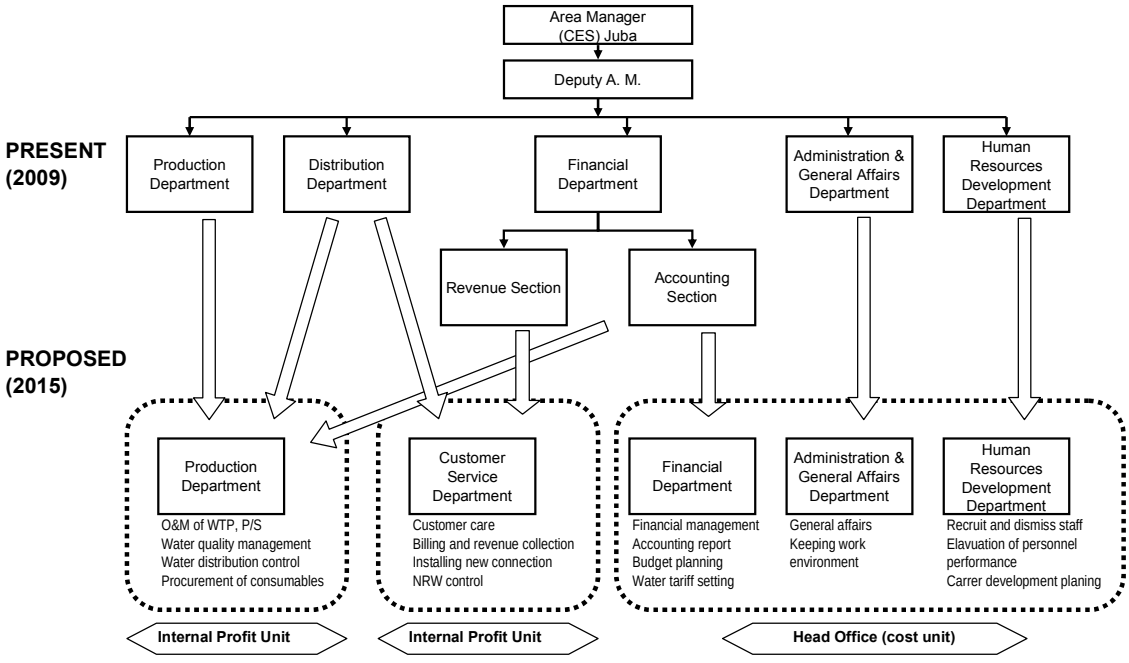


Figure 4.9 Proposed Organization Structure in 2015

Customer service offices should be established and involvement of the private sectors is also recommended, since water supply by public tap (including water kiosk) and water tanker will take important roles. In that case, private vendors should be granted with license by UWC in order to ensure that the water quality and official retail price set by UWC is maintained by the venders.

4.3.4 Operation and Maintenance Plan

The core value of water supply services is supply of safe and clean water in sufficient volume, which should be ensured through appropriate O&M practices. In other words, water quality management and distribution control should be performed appropriately.

Water quality management is a practice to ensure water quality at the tap end to be always potable by means of monitoring and controlling water quality from the water source to the tap end. The following activities are required to ensure proper water quality management.

- To monitor water quality of water source and distributed water
- To control chemical dosing in the treatment process according to the raw water quality
- To prevent water from contamination in the distribution system

Distribution control is a practice to ensure water flow, pressure and quality of treated water to be transmitted to the place of demand. Distribution control includes the following tasks:

- To keep water flow and pressure at the required level by operating pumps and valves
- To set up management system to take necessary measures to handle emergency (accidental) cases
- To maintain drawings of the facilities for proper asset management
- To protect treated water from contamination

4.3.5 Customer Services

Activities of customer services include acceptance of application for new connections, meter reading, billing and revenue collection, customer management and complaint processing. The number of customers is projected to be over 25,000 in 2015, which is about ten times more than existing number of customers. In addition, considering that flat rate is currently applied and revenue collection ratio is quite low, priority of customer services strengthening is very high. Necessary measures to be taken are as follows:

- Enacting new tariff policy
- Improvement of work process
- Debt management
- Authorization to water suspension
- Complaint processing

4.3.6 Non Revenue Water Management (NRW)

By 2015, the most distribution system is planned to be replaced with new pipes. Leakage ratio (physical loss) is planned to be 20 % at that time and the commercial loss (apparent loss) is planned to be 24 %. With the short term perspective, NRW management should focus on commercial loss reduction, which consists of customer meter inaccuracies, unauthorized consumption; illegal connections, theft and fraud, customer data base errors, data collection and transfer errors.

After installation of customer meters, district metering is recommended by installing a bulk meter to the inlet and outlet of the district metered area (DMA), which enables to measure the water flow of DMA. Then the water balance in a DMA should be assessed by comparing the total water consumption of the area and measurement of minimum night flow. Based on the assessment, appropriate measures for NRW reduction should be planned and implemented.

4.3.7 Action Plan of Capacity Development for Priority Projects

Capacity development plan for the priority project is proposed in consideration of the required capacity to achieve the target of priority project. The objectives of the proposed capacity development plan are summarized in Table 4.11.

Table 4.11 Summary of Objectives of Proposed Capacity Development Plan by 2015

Category	Objective
Autonomy	• Autonomy of UWC is enhanced for higher management efficiency
Organization	• Roles and responsibilities of UWC and each section are clarified • Private sectors are involved in public water supply • Business activities are monitored by performance based evaluation
O&M	• O&M work is done properly according to O&M manuals • Required water volume is produced and distributed
Finance	• O&M cost is recovered without the government subsidy • Bad debt is reduced
Human resources development	• Knowledge and skill of UWC staff is improved
Public relations	• Public awareness on water supply is raised

4.3.8 Recommended Capacity Development Project

On recognition that management capacity of UWC should be primarily developed, the project objective is set as management capacity strengthening of urban water sector in Southern Sudan. In this case, the target group should include not only UWC-Juba but also personnel engaged in urban

water sector in Southern Sudan as a whole, as development of Juba water supply is recognized as a model case to imitate in other urban center of the nation. Field activities, such as in-house training and pilot project, will be limited to Juba but training opportunity should be given to personnel of the other urban centers. For implementation of the plan, foreign technical assistant program is recommended.

4.4 Implementation Plan and Cost Estimation of Priority Project

4.4.1 Implementation Plan of Priority Project

(1) Implementation Strategy

The strategy of implementation of the priority project is shown in Figure 4.10. In the implementation of the project, facility and non-facility (management) measures shall be simultaneously implemented to strengthen water supply services and capacity of UWC. Through the phase-1 project using grant aid, management fundamentals of UWC should be established and existing facilities should be rehabilitated. Based on the fundamental established, a new water supply system should be implemented through phase-2 project as loan.

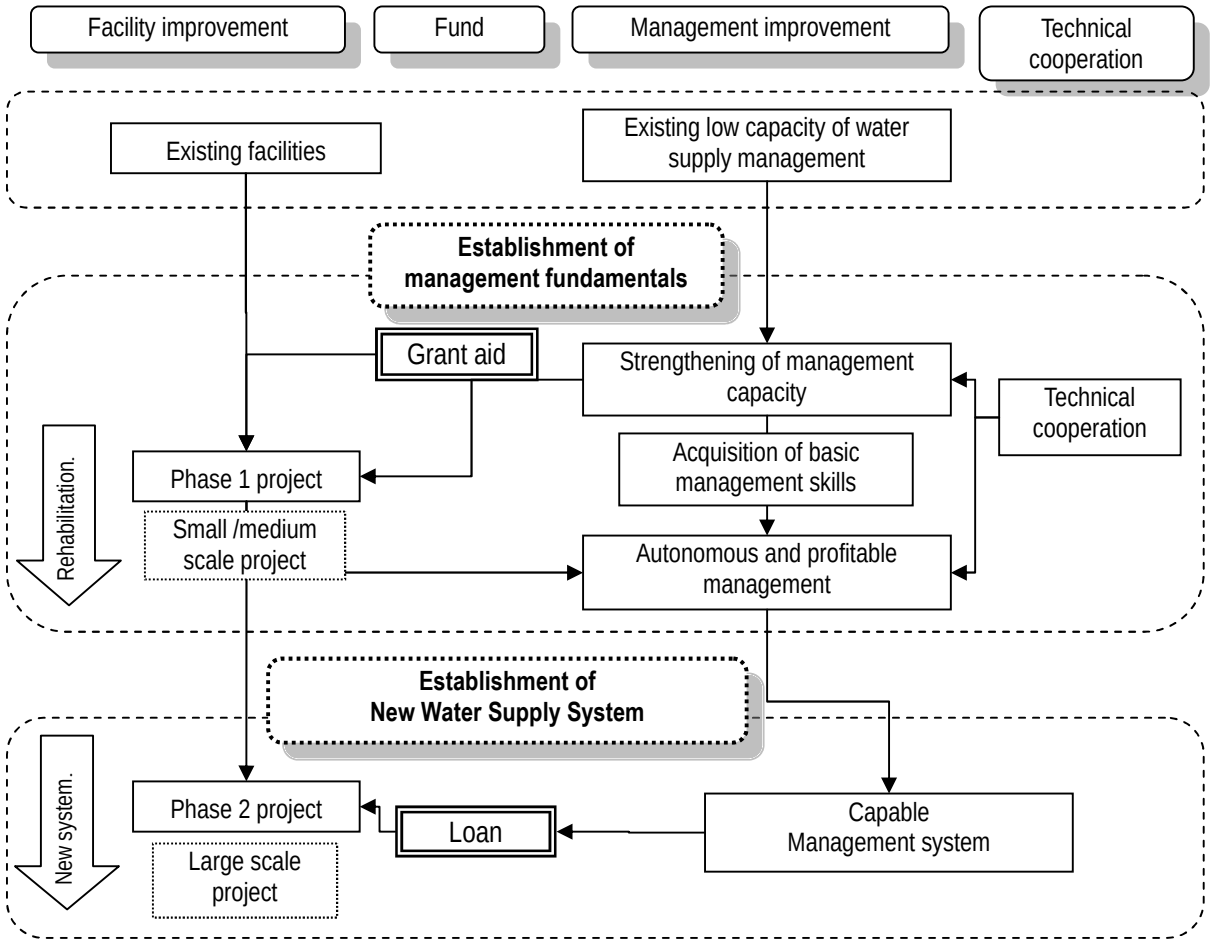


Figure 4.10 Implementation Strategy of Priority Project

Table 4.12 Concept of Implementation of Priority Project

Phase	Concept	Facilities	Total Production
1	This phase is an emergency improvement phase, in which a project is implemented to give larger benefits with small investment. This phase includes expansion of exiting WTP and replacement of existing distribution network aiming to distribute limited water effectively and equitably to users through improved network in the existing urban center including the residential area of Juba Town and Kator and governmental and commercial area.	Package-A ・ Expansion of the existing WTP by 7,000 m^3/d ・ North Low service reservoir ・ Transmission pump station ・ Transmission pipeline from the existing WTP to North Low SR Package-B ・ Distribution main & sub-main (22.7km) ・ Distribution tertiary (73.6km) Package-C ・ Distribution main & sub-main (13.0km) ・ Distribution tertiary (66.5km)	14,000 m^3/d
2	This phase is an initiation of construction of the new water supply system of the M/P. The project aims to increase water treatment capacity drastically and mainly to supply water to the existing urban area with adequate amount of water.	・ Stage-1 of West WTP ・ North High Service Reservoir ・ Transmission pipelines from new West WTP to North Low SR / from North Low SR to North High SR ・ Expansion of distribution main and network to realize targeted water supply service coverage	77,000 m^3/d

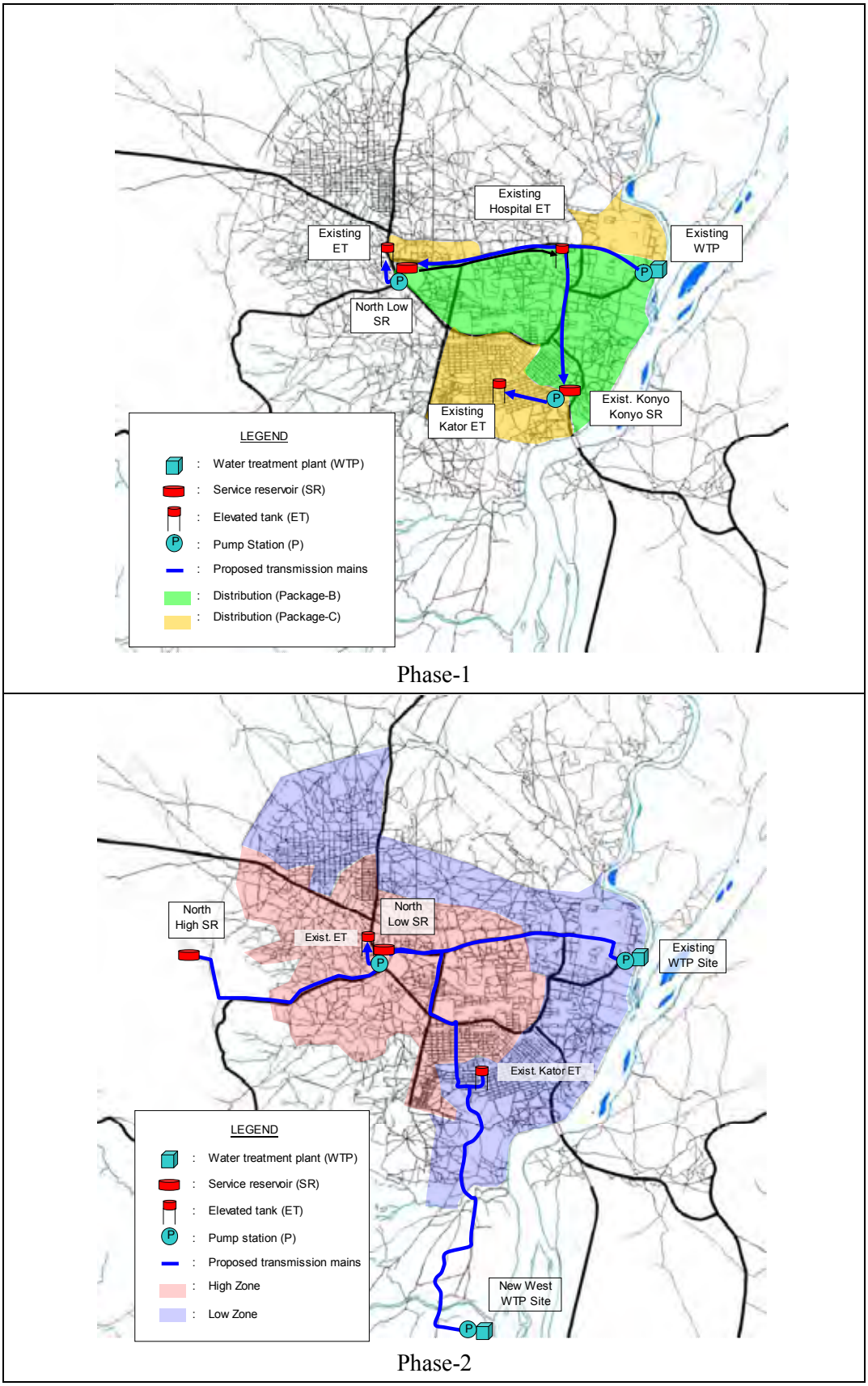


Figure 4.11 Major Facilities and Service Zones of Priority Project by Phase

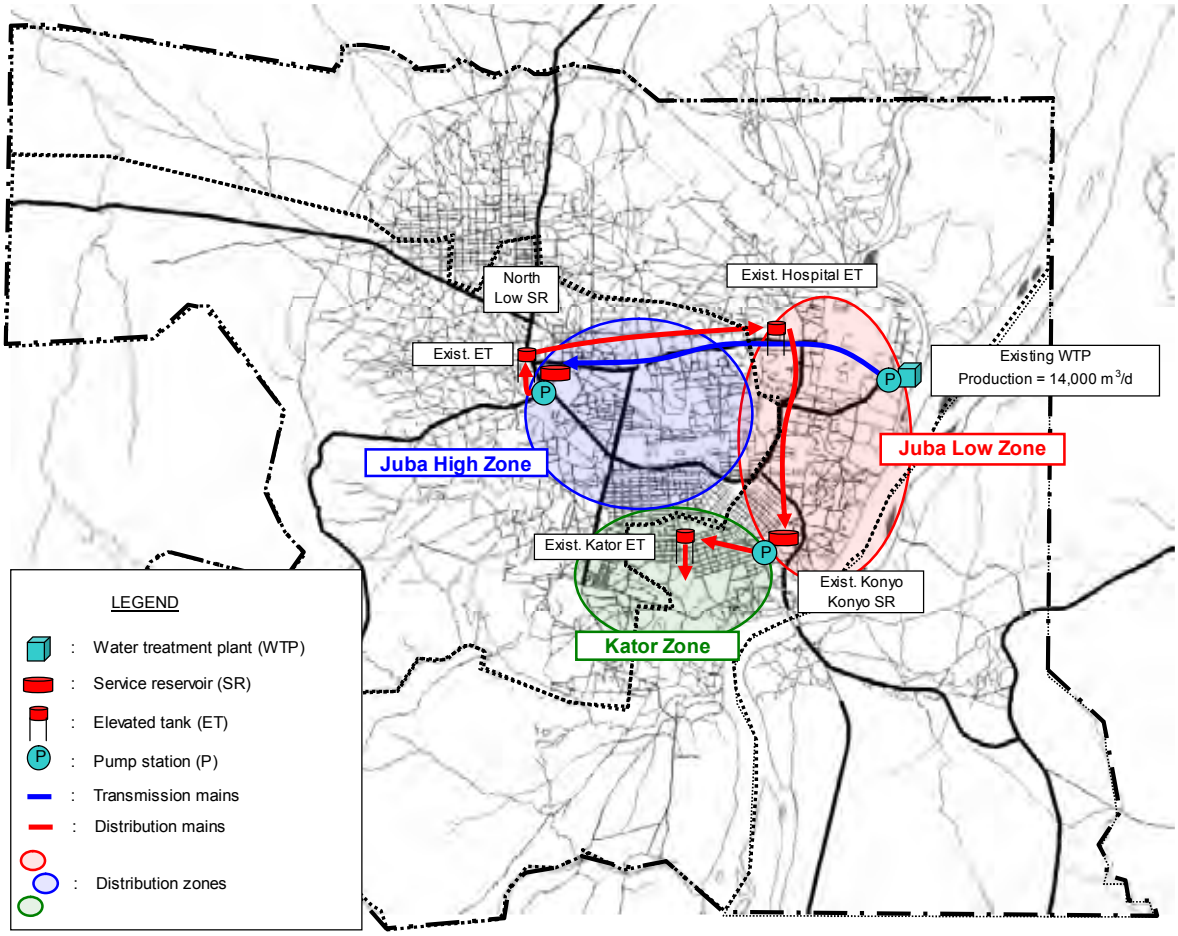


Figure 4.12 Water Supply System in Phase-1

4.4.2 Cost Estimation

(1) Conditions of Cost Estimation and Implementation Schedule

The capital cost of the priority project is estimated based on the same conditions of the Master Plan. The same implementation schedule as the Master Plan until target year of 2015 is assumed.

(2) Estimation of Project Capital Cost

The capital cost for the priority project is estimated and summarized in Table 4.13.

Table 4.13 Capital Cost Estimation of Priority Project

(thousand USD)

No.	Item	Local currency	Foreign currency	Total
1.	Construction cost			
1.1	Water treatment plant	7,167	31,734	38,901
1.2	Transmission pipeline	1,944	18,770	20,714
1.3	Transmission pump station	242	2,416	2,658
1.4	Distribution main facilities	1,445	5,304	6,749
1.5	Distribution main & sub-main	6,644	31,470	38,114
1.6	Distribution network	2,634	11,762	14,396
	Sub-total	23,076	101,456	124,532
2.	Administration cost	462	2,029	2,491
3.	Engineering cost	2,308	10,146	12,454
4.	Physical contingency	2,585	11,363	13,948
5.	Price contingency	9,209	22,145	31,354
	Sub-total	14,564	45,683	60,247
	Total	37,640	147,139	184,779

The capital cost by construction phase and package of the priority project is estimated as shown in Table 4.14.

Table 4.14 Estimated Capital Cost by Construction Stage of Priority Project

(thousand USD)

No.	Local currency	Foreign currency	Total
Phase - 1 (Package-A)	2,549	15,183	17,732
Phase - 1 (Package-B)	2,844	10,666	13,510
Phase - 1 (Package-C)	1,920	7,196	9,116
Total of Phase - 1	7,313	33,045	40,358
Phase - 2	30,327	114,094	144,421
Total	**37,640**	**147,139**	**184,779**

(3) Operation and Maintenance and Capacity Development Costs

The annual operation and maintenance cost for the proposed water supply system is estimated based on the same condition of the Master Plan as summarized in Table 4.15.

Table 4.15 Annual Operation and Maintenance Cost

Year	Annual revenue water (m^3/year)	O&M Cost (thousand USD/year)							O&M cost per revenue water (USD/m^3)
		Personnel	Electricity	Chemical	Spare parts	Staff Training	Others	Total	
2009	851,667	0.0 (0%)	165.7 (30%)	86.0 (16%)	158.5 (29%)	0.0 (0%)	135.1 (25%)	545.3	0.64 (SDG1.41)
2012	2,044,000	630.4 (40%)	463.0 (29%)	172.0 (11%)	106.5 (7%)	63.0 (4%)	143.5 (9%)	1,578.5	0.77 (SDG1.70)
2015	13,115,667	1,899.0 (28%)	2,696.6 (40%)	946.1 (14%)	421.5 (6%)	189.9 (3%)	615.3 (9%)	6,768.3	0.52 (SDG1.15)
2020	14,989,333	1,876.0 (28%)	2,696.6 (40%)	946.1 (14%)	421.5 (6%)	187.6 (3%)	612.8 (9%)	6,740.6	0.45 (SDG0.99)
2025	16,863,000	1,985.1 (29%)	2,696.6 (39%)	946.1 (14%)	421.5 (6%)	198.5 (3%)	624.8 (9%)	6,872.5	0.41 (SDG0.91)

(Price level of March 2009)

4.5 Project Evaluation

4.5.1 Financial Evaluation

Water tariff, revenue forecast, project costs and O&M costs are estimated based on same conditions of the Master Plan. Free cash flow until year 2050 is calculated, in which investment cost of the phase 1 is deducted from the cash flow since that portion is assumed to be financed under grant aid.

The profit and loss statement of the priority project is projected until year 2050. The result shows that break-even point is estimated as the year 2019, which is a little late mainly due to early start of depreciation. Although operating ratio, the ratio of O&M plus depreciation costs to revenue, will exceeds 100% during 2013-2018, entire O&M costs and a part of depreciation can be covered throughout the project period. After 2019 when the project profit will become surplus, the profit performance will be favorable owing to sufficient revenue generation by increased tariff and higher revenue collection ratio.

Applications and sources of funds are projected until the year 2050, on assumption that reinvestment will be made after 30 years. Overall, the table implies smooth cash flows throughout the project period and re-investment after 2041 could be financed under the retained financial profits without external funds.

Water tariff is selected for sensitivity analysis as it is the most influential factor for revenue increase. FIRR has been calculated at various level of water tariff by changing ratio to the proposed water tariff, and presented in Table 4.16.

The average water charge and ratio of the water charge to monthly expenditure is also presented in the

Table, as the normal case of middle income class household with house connection.

Table 4.16 Sensitivity Analysis of FIRR

	Multiplier factor of water tariff							
	x 0.6	x 0.8	x 1.0 (Base)	x 1.2	x 1.4	x 1.6	x 1.8	x 2.0
FIRR (%)	2.17	5.80	8.79	11.51	14.13	16.72	19.35	22.05
Average water charge of typical case (SDG/month)	17.7	23.6	29.5	35.4	41.3	47.2	53.1	59.0
Ratio of water charge to total monthly household expenditure (%)	1.5	2.0	2.5	3.0	3.4	3.9	4.4	4.9

The proposed priority project resulted in reasonable FIRR of 8.79 %, owing to assumption of deducting investment cost of phase 1 which is assumed to be financed under grant aid. The repayment of the loan principal and interest can be covered by the anticipated free cash flows. The suggested water tariff table could be accepted from the viewpoint of affordability. Therefore, from the results of these analyses, the priority project is financially viable.

4.5.2 Project Benefits and Economic Evaluation

Economic analysis is carried out by calculating economic internal rate of returns (EIRR) of the project based on the economic project costs and benefits, by assuming following conditions:

- Economic Benefits:

The willingness to pay (WtoP), which was obtained from the socio-economic survey in the Study, is used to estimate economic benefits. The net economic benefits per household per month are estimated as the deduction of the WtoP for the current water supply service from the WtoP for the improved services. The service population is used to estimate beneficial households.

- Economic Costs:

To convert the project cost into the economic cost, all distorted factors in the costs shall be removed. The prices of goods and services are distorted by many factors such as government regulations and these distorted prices shall be converted into economic price. In the Study, physical and price contingencies are excluded in analysis.

The calculated EIRR resulted in sufficient value of 24.7 %, owing to considerably high WtoP for improved water supply services. Hence, from the national economic perspectives, the viability of the priority project is quite high.

4.6 Preliminary Environmental Impact Assessment

As a result of preliminary environmental impact assessment (pre-EIA) carried out using JICA EIA regulations, it is identified that 10 impact items below have some negative impacts caused by the implementation of the priority project. Out of these impacts, land acquisition for the proposed facilities sites and water pollution by increased wastewater are identified as major negative impacts of the priority project.

1. Resettlement (or loss of properties/land acquisition)
2. Land use and local resources utilization
3. Sanitation
4. Infectious diseases such as HIV/AIDS
5. Traffic accidents
6. Biota and ecosystems
7. Air pollution
8. Water pollution (increase of wastewater)
9. Noise and Vibration
10. Bottom sediment in the sea and rivers

Proposed mitigation measures and monitoring items for land acquisition and water pollution by stage are presented in Table 4.17.

Table 4.17 Proposed Mitigation Measures and Monitoring Items for the Priority Projectoring Items for the Priority Project

Items	Mitigation Measures	Monitoring Items
1. Resettlement (or loss of properties/ land acquisition)	[**This Study**] • Stakeholder meetings were held for information disclosure and confirmation of the agreement with stakeholders of the project. [**Basic design**] • The holding of stakeholder meetings for information disclosure and confirmation of the agreement with stakeholders. • The establishment of a community coordination committee for smooth land acquisition and required compensation. • Proponent shall take a law-based process for land acquisition and compensation. [**Detailed design and construction**] • Detailed measurement survey shall be done. • Proponent shall complete land acquisition and compensation.	[**Detailed design and construction**] • Observation of adequate land acquisition process and compensation
2. Water pollution	[**Basic design**] • Backwashed drainage and sludge should be discharged at the center of the river shall be adopted in design • Formulation of wastewater management plan. [**Detailed design, construction and post construction**] • Construction of drainage and sewerage system. • Establishment and enforcement of regulations of effluent standards from industries and commercial.	[**Post construction**] • Water quality survey and monitoring

4.7 Conclusions and Recommendations

4.7.1 Conclusions

1. A part of the components proposed in the Master Plan is selected as "priority project," which will be required to be implemented by 2015 with a higher priority. The components included in the first and second phases of the Master Plan were selected as priority project. A feasibility study was carried out for the priority project in the Study.

2. The target service area of the priority project is the same as the Master Plan. The target service coverage is set as 80 % of the population in the service area, who can access safe and clean water supply by means of house connection, public taps/kiosk or water tanker by 2015. The total population in 2015 is projected at 680,000 and the service population is set at 544,000.

3. The projected total water demand and proposed treatment capacity in 2015 are 69,000 m^3/d and 77,000 m^3/d, respectively.

4. The major components of the priority project are as follows:
   - Expansion of existing water treatment plant (7,000 m^3/d)
   - Construction of a water treatment plant in the west bank (63,000 m^3/d)
   - 2 service reservoirs (North Low SR (10,000 m^3) and North High SR (10,000 m^3))
   - Transmission pipelines (17.5 km)
   - A transmission pump station (30,000 m^3/d x 40 m head)
   - Replacement and expansion of distribution network (409.7 km)

5. Financial strengthening is identified as a primary management policy for UWC to be a self-sustaining organization. Under this perspective, following management targets are proposed.
   - Establishment of new increasing block water tariff to cover operating expenses and depreciation
   - Upgrading of billing and revenue collection system based on metering system.
   - Enhancement of customer service and authorization to disconnect
   - Strengthening of debt management

6. The workforce of UWC in 2015 is estimated to be 378 persons on assuming the staff efficiency of 15 staff-members per 1,000 connections. Given this, organization reform is proposed by redefining internal profit units of production and customer service departments. Involvement of the private sectors is also recommended for water supply management, as public taps (including water kiosk) and water tankers will take important roles in supplying treated water of UWC. In

this case, license will be granted by UWC to communities and private vendors to ensure water quality and retail price of the supplied water.

7. Water quality management and distribution management should be focused in operation and maintenance of the water supply system as the core value of water supply services. In addition, the importance of customer services is primarily emphasized as the number of customers will increase drastically by 2015.

8. Implementation of a capacity development plan by 2015 is proposed to strengthen management capacity of the urban water sector through foreign technical assistance programs. The proposed outputs of the plan are as follows:
   - Improvement of management practices of UWC related to basic waterworks management skills and revenue collection
   - Construction and management of public taps stands /water kiosks and tanker stations as pilot project
   - Reduction of non-revenue water in the pilot area

9. The strategy of implementation of the priority project is developed. To facilitate the development of water supply system at the initial stage, the phase-1 project is formulated to give larger benefit with relatively small scale of investment. Furthermore, phase-1 project is divided into 3 small packages for further facilitation of the project implementation.

10. In implementation of the priority project, non-facility (management) measures as well as facility measures should be implemented for UWC to become a capable organization. Small or medium scale grant aid project for rehabilitation of the existing water supply system along with technical cooperation to strengthen the management capability shall be invited at the initial stage of the priority project. Through the implementation of rehabilitation project along with technical cooperation project, UWC should establish sound management fundamentals and become a capable organization to attract large investment irrespective of public or private fund to materialize the new water supply system proposed in the phase-2. Based on the established sound management fundamentals, UWC could manage a large project, expand the service area, and improve their services.

11. The construction cost up to 2015 is estimated at 124.5 million USD and total fund requirement including indirect costs consisting of administration and engineering costs and contingencies is estimated at 184.8 million USD.

12. The annual operation and maintenance cost for the water supply system in 2015 is estimated at 6,768,000 USD with the estimated unit cost per revenue water at 0.52 USD/m^3.

13. New water tariff structure is proposed in the Master Plan should be adopted for the priority project in consideration of affordability of customers, sustainability for waterworks and fairness among customers.

14. The priority project returns reasonable FIRR of 8.8 %. The repayment of the loan principal and interest can be covered by the anticipated free cash flows. The proposed water tariff would be acceptable from the viewpoint of affordability. Consequently, it is judged that the priority project is financially viable.

15. The EIRR of the priority project resulted in 24.7%, thanks to considerably high willingness to pay for improved water supply services. Therefore, the priority project is quite viable from the national economic perspective.

16. As a result of preliminary environmental impact assessment (pre-EIA), land acquisition and increased wastewater due to increase of water supply are identified as main impacts of the priority project.

4.7.2 Recommendations

1. The Government of Southern Sudan and UWC should address financial issues of water works management, such as enacting water tariff reform based on metering policy and debt management which can be done within their current capability. In this regard, water meters procured under the project of the multi donor trust fund (MDTF) should be installed as early as possible.

2. In addition to house connections, public taps, water kiosks and water tanker venders play a key role to supply the treated water to the residents, especially at the initial stage of the priority project, and they are important sources of revenue of UWC. UWC should establish a system to manage these customers. While selecting public taps or water kiosks, UWC should decide the appropriate management organization, by a careful assessment on the involvement of community or private business based management.

3. As the necessity of technical assistance for capacity development is quite high to ensure the sustainability of the priority project, it should be implemented in parallel with infrastructure investment.

4. Small package projects were prepared in the feasibility study. These projects shall be requested as grant aid project along with a foreign technical cooperation project to improve water supply services and management fundamentals of the waterworks.

5. The acquisition process of the land for following proposed facilities should be followed immediately after the Study.
   - West Water treatment Plant in Tokiman, Rejaf
   - North Low Service Reservoir and Pump Station in the John Garang Memorial Site
   - North High Service Reservoir at the foot of Mt. Jebel Körök