APPENDIX – B

WATER QUALITY ANALYSIS AND RIVER FLOW DATA

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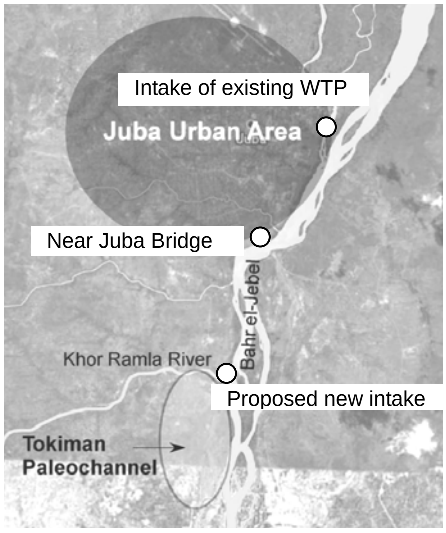
B.1 Water Quality Analysis

B.1.1 Scope of Water Quality Analysis in Laboratory

(1) Objectives and target water

Water quality analysis is being carried out for future water source candidates and existing water sources in Juba Town, and the suitability of these sources for drinking water from the perspective of water quality will be judged. The items included in water source study are as mentioned below.

- Surface water
  - Tributary of Bahr el-Jebel river at existing water treatment plants
  - Bahr el-Jebel river near Juba Bridge
  - Bahr el-Jebel river upstream of Juba Town at Tokiman (Proposed water treatment site)
- New ground water source candidates in paleochannel
- Existing wells



Furthermore, to understand the quality of water after it passes through distribution pipelines and water quality of treated water in the existing water treatment plants, water quality measurements shall be carried out for samples collected from taps of water supply and existing water treatment plants. The items to be measured for these samples shall include turbidity, residual chlorine and so on.

(2) Water Quality Analysis Parameters

Water quality analysis parameters are given below and in Table B.5 referring to the WHO water quality guidelines (3rd edition) for drinking water. As for agro-chemicals, major 7 agro-chemicals applied in Sudan and Uganda, which is located upstream of the Bahr el-Jebel, were selected from the following source:
Source: Kegley, S.E., Hill, B.R., Orme S., Choi A.H., PAN Pesticide Database, Pesticide Action Network, North America (San Francisco, CA, 2008), http:www.pesticideinfo.org.

The suitability of the water as drinking water shall be assessed from the results of water quality analysis comparing to the guidelines values in the WHO and Southern Sudan (draft).

- Parameter A: On-site analysis parameters
- Parameter B: General 27 parameters

- Parameter C: Agro-chemical 7 parameters
- Parameter D: Microbiological 2 parameters

(3) Sampling Frequency and Time

The only parameter of water quality that could vary significantly round the year is turbidity in case of rivers as water sources. In principle, the water quality shows practically no change throughout the year in case of groundwater. Accordingly, the frequency of water quality measurements considering the necessary minimum is fixed as once in the rainy season and once in the dry season. On the other hand, the frequency of water quality measurement for existing groundwater and shallow water wells is to be taken as once only, with the sole purpose of confirmation of water quality. The table below shows the plan of sampling time and the number of samples to be analyzed in laboratory.

Table B.1 Plan of Sampling Frequencies for Water Quality Study

Type of water source	Sampling location	WQ Parameters	No. of locations	Frequency	Total
Surface water	Intake point of existing water treatment plant	A, B, C, D	1	2 (1 each for rainy and dry seasons)	2
Surface water	Intake point of new water treatment plant	A, B, C, D	1	2 (1 each for rainy and dry seasons)	2
Surface water	Near Juba Bridge	A, B, C, D	1	2 (1 each for rainy and dry seasons)	2
Groundwater	Test wells in Paleochannel	A, B, C, D	3	2 (1 each for rainy and dry seasons)	6
Groundwater	Existing wells in the city	B, D	18	1 (in the dry season)	18

In actual, the original plan of sampling and testing frequencies and number of parameters were modified due to untested water parameters by equipment trouble and additional samples for analysis. The following two tables present original and modified number of samples analyzed in the laboratories.

Table B.2 The number of samples to be analyzed in laboratory and frequency

(Original)

Expecting Sampling Time	Parameter A (General parameters)		Parameter B (Pesticides)	
	Nos. of samples	Nos. of parameter A	Nos. of samples	Nos. of parameter B
Oct. 2008	3	27	3	7
Jan. 2009	3 18	27 27	3 -	7 -
Mar. 2009	3	27	3	7
Jun. 2009	3	27	3	7
Total	30	-	12	-

(Amended)

Sampling time	Parameter A (General parameters)		Parameter B (Pesticides)	
	Nos. of samples	Nos. of parameter A	Nos. of samples	Nos. of parameter B
Oct. 2008	3	27	3	5
Feb. 2009	3 18	27 27	3 -	7 -
May 2009	3	27	3	5
Jul. 2009	3	27	4	5
Jul. 2009	1	27	1	5
Total	31	-	13	-

(4) Water Quality Laboratory

The following water quality testing laboratories are used for analysis of water quality of the sampled water.

Parameter	Testing Laboratory	Sampling by
• General Parameters • Agro-chemicals	Central Water Testing Laboratory, Ministry of Water Resources and Irrigation, Government of Kenya, Nairobi	JICA Study Team
• Bacteriological	Sudanese Standards and Metrological Organization, Government of Sudan, Juba	Laboratory staff

(5) Water Quality Guidelines

The results of water quality analysis were compared with the guideline values of WHO and Southern Sudan (draft) for treated water.

B.1.2 Results of Water Quality Analysis by Laboratory

Water quality of surface water in the three locations was tested by potable water quality analysis kit and in Laboratory in Kenya. The results of the second analysis are tabulated in the following tables.

Table B.3 Sampling Data

Season	Sampling date	Sample water type	Nos. of samples			Table No.
			Parameter A General	Parameter B Pesticides	Parameter C Microbiology	
Rainy	Oct. 8th 2008	Surface water	3		-	Table B.5
	Oct. 8th 2008	Surface water	-	3	-	Table B.9
	Nov. 24th 2008	Surface water		-	3	Table B.10
Dry	Feb. 14th 2009	Surface water	3		-	Table B.6
	Feb. 14th 2009	Surface water	-	3	-	Table B.9
	Feb. 14th 2009	Existing well	18	-	-	Table B.6
	Feb. 14th 2009	Surface water	-	-	3	Table B.10
	Feb. 14th 2009	Existing well	-	-	18	Table B.10
	Apr. 26th 2009	Test well	3	-	-	Table B.7
	Apr. 26th 2009	Test well	-	3	-	Table B.9
	May 21st 2009	Test well	-	-	3	Table B.10
Rainy	Jun. 22nd 2009	Surface water	-	-	2	Table B.10
	Jun. 22nd 2009	Test well	-	-	1	Table B.10
	Jul. 2nd 2009	Surface water	2	-	-	Table B.8
	Jul. 2nd 2009	Surface water	-	2	-	Table B.9
	Jul. 2nd 2009	Treated water	1	-	-	Table B.8
	Jul. 2nd 2009	Treated water	-	1	-	Table B.9
	Jul. 10th 2009	Test well No.2	1	-	-	Table B.8
	Jul. 10th 2009	Test well No.2	-	1	-	Table B.9

B.1.3 Spot Analysis by Field Kit and in Laboratory

(1) Water Quality Parameters Analyzed by Field Kit

The Study Team tested the following water quality parameters using field kit.

- Temperature (ºC), pH, TDS (ppm), Salt (ppm), Conductivity (µS), Turbidity (NTU) and Residual Chlorine (ppm)

The following water quality analyses by filed kit or laboratory were carried out for purpose specified.

Table B.4 Sampling Data

Date	Parameters	Purpose	Table No.
Oct 8 2008 Nov. 24 2008 Feb. 14 2009 May 21 2009	Temperature, pH, TDS, Salt, Conductivity, Turbidity	To understand general characteristics of surface water quality and to decide water treatment process of new water treatment plant using turbidity.	Table B.10
In April, 2009	Temperature, pH, TDS, Salt, Conductivity, Turbidity	To understand salinity or TDS level of existing wells.	Appendix A
In May and June, 2009	Temperature, pH, TDS, Salt, Conductivity, Turbidity	To understand treatability of MDTF water treatment plant.	Table B.11
2nd July, 2009	Temperature, pH, TDS, Salt, Conductivity, Turbidity, Residual Chlorine	To understand water quality of source water and treated water	Table B.12
8th, 9th July, 2009	Temperature, pH, TDS, Salt, Conductivity, Turbidity, Residual Chlorine	To understand water quality of supplied water through tap.	Table B.13

Table B.5 Results of First Water Quality Analysis Compared with Guideline Values of WHO and Southern Sudan

No.	Parameter	Unit	WHO GV	Draft SS GV	Existing WTP	Near Juba Bridge	Tokiman -proposed WTP site
	Sampling No.				No. 1	No. 3	No. 2
	Sampling Time for Parameter A, B				10/8/08 9:00 hrs	10/8/08 12:15 hrs	10/8/08 10:30 hrs
1	Aluminum	mg/l	0.1-0.2	0.2	**0.40**	**0.62**	**0.52**
2	Ammonia	mg/l	NS	NS	0.03	0.03	0.03
3	Antimony	mg/l	0.02	0.005	**0.06**	Nil	Nil
4	Arsenic	mg/l	0.01	0.05	Nil	Nil	Nil
5	Barium	mg/l	0.7	0.7	Nil	Nil	Nil
6	Boron	mg/l	0.5	0.5	Nil	Nil	Nil
7	Cadmium	mg/l	0.003	0.003-0.005	Nil	Nil	Nil
8	Chloride	mg/l	250	200	7.0	6.0	5.0
9	Chromium	mg/l	0.05	0.05	Nil	Nil	Nil
10	Copper	mg/l	2	1.5	Nil	Nil	Nil
11	Cyanide	mg/l	0.07	0.05	Nil	Nil	Nil
12	Fluoride	mg/l	1.5	1	0.36	0.37	0.35
13	Hardness	mg/l	200	200	42	48	46
14	Hydrogen sulfide	mg/l	NS	NS	2	3	3
15	Iron	mg/l	0.3	0.5	**0.60**	0.48	0.48
16	Manganese	mg/l	0.4	0.4	0.01	0.01	0.01
17	Lead	mg/l	0.01	0.01	Nil	Nil	Nil
18	Mercury	mg/l	0.006	0.006	Nil	Nil	Nil
19	Molybdenum	mg/l	0.07	0.07	Nil	Nil	Nil
20	Nickel	mg/l	0.07	0.07	0.02	0.02	0.04
21	Nitrate	mg/l	50	30	0.40	0.98	0.84
22	Nitrite	mg/l	3	0.5	0.04	0.03	0.03
23	Selenium	mg/l	0.01	0.01	Nil	Nil	Nil
24	Sodium	mg/l	ND	100	15	15	16
25	Sulfate	mg/l	250	200	13.70	1.71	16.90
26	Total dissolved solids	mg/l	600	1000	92.9	90.5	88.8
27	Zinc	mg/l	3	3	0.04	0.03	0.03

Date of sampling: Oct. 8th 2008

Table B.6 Second Water Quality Analysis for Groundwater of Existing Wells and River Water

	No.				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21	20
	Type of water source				BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	BH	River	River	River
	Parameters	Unit	WHO GV	Draft SS GV	JP 001	JP 039	JP 048	JP 068	JP 110	JP 116	MP 032	RP 050	MP 046	MP 049	MP 063	MP 093	MP 127	MP 151	MP 008	RP 017	RP 012	MP 021	Existing WTP	Near Juba Bridge	Treatment proposed WTP site
1	Aluminium	mg/l	0.1-0.2	0.2	0.1	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.05	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.2	0.05	0.05
2	Ammonia	mg/l	NS	NS	0.03	0.03	0.08	0.08	0.05	0.05	0.05	0.03	0.03	0.05	0.05	0.03	0.03	0.08	0.08	0.05	0.08	0.05	0.1	0.1	0.1
3	Antimony	mg/l	0.02	0.005	0.01	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	**0.01**	Nil	Nil
4	Arsenic	mg/l	0.01	0.05	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
5	Barium	mg/l	0.7	0.7	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
6	Boron	mg/l	0.5	0.5	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
7	Cadmium	mg/l	0.003	0.003-0.005	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
8	Chloride	mg/l	250	200	**385**	115	125	155	120	130	35	**260**	39	170	25	**405**	50	41	26	3	20	20	8	5	5
9	Chromium	mg/l	0.05	0.05	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	Copper	mg/l	2	1.5	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
11	Cyanide	mg/l	0.07	0.05	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
12	Fluoride	mg/l	1.5	1	0.36	0.42	0.41	0.6	0.42	0.4	**1.1**	0.42	0.34	0.3	0.29	0.45	1.0	0.36	0.66	0.23	0.49	0.88	0.34	0.24	0.29
13	Hardness	mg/l	200	200	**446**	**370**	**230**	**296**	**202**	**310**	132	**340**	**308**	104	**218**	**426**	**226**	**234**	**220**	**322**	**532**	140	56	68	64
14	Sulfides	mg/l	NS	NS	1	1	2	1	1	2	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1
15	Iron	mg/l	0.3	0.5	0.25	0.12	0.08	0.12	0.08	0.15	0.18	0.2	0.18	0.24	0.12	0.38	0.11	0.14	0.11	0.16	0.21	0.15	0.28	0.22	0.24
16	Manganese	mg/l	0.4	0.4	0.01	0.01	Nil	Nil	Nil	0.01	0.02	0.01	Nil	0.02	Nil	0.08	Nil	Nil	Nil	0.01	0.02	0.01	0.01	0.01	0.01
17	Lead	mg/l	0.01	0.01	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
18	Mercury	mg/l	0.006	0.006	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
19	Molybdenum	mg/l	0.07	0.07	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
20	Nickel	mg/l	0.07	0.07	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.01	0.01	0.01
21	Nitrate	mg/l	50	30	30	18.5	20	25	8	5.4	9.8	**245**	9	0.44	0.64	**260**	22.1	3.3	0.9	0.12	0.14	0.32	0.19	0.19	0.21
22	Nitrite	mg/l	3	0.3	0.04	0.12	0.41	0.25	0.02	0.15	0.03	0.2	0.03	0.26	0.23	**0.62**	0.22	0.02	0.04	0.22	0.03	0.02	0.02	0.02	0.02
23	Selenium	mg/l	0.01	0.01	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
24	Sodium	mg/l	NS	100	**406**	**171**	**248**	**199**	64.3	**200**	**210**	**497**	50.7	**754**	35.5	**652**	**181**	**127**	**110**	36.8	**114**	**178**	21.3	12	17.5
25	Sulfate	mg/l	250	200	129	60	68.8	65.7	18.3	54.3	22.9	109	23.4	243	13.7	91.4	24.3	15.7	15.7	17.1	12.6	51.4	5.43	7.14	7.71
26	TDS	mg/l	600	1000	**1655**	929	961	911	423	929	732	**1773**	521	**2176**	369	**2300**	771	637	575	505	605	662	133	134	132
27	Zinc	mg/l	3	3	0.02	0.01	0.02	0.04	0.04	0.02	0.04	0.1	0.02	0.05	0.01	0.11	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02

Note: Bold figures indicate the values exceeding the Southern Sudan Water Quality Guidelines (Drinking Water); BH: Borehole
Date of sampling: Feb. 14th 2009

Table B.7 Results of Third Water Quality Analysis Compared with Guideline Values of WHO and Southern Sudan

No.	Parameter	Unit	WHO GV	Draft SS GV	Test Well 1	Test Well 2	Test Well 3
1	Aluminum	mg/l	0.1-0.2	0.2	0.10	0.10	0.05
2	Ammonia	mg/l	NS	NS	< 0.01	**0.4**	0.3
3	Antimony	mg/l	0.02	0.005	0.01	0.01	0.01
4	Arsenic	mg/l	0.01	0.05	Nil	Nil	Nil
5	Barium	mg/l	0.7	0.7	Nil	Nil	Nil
6	Boron	mg/l	0.5	0.5	Nil	Nil	Nil
7	Cadmium	mg/l	0.003	0.003-0.005	Nil	Nil	Nil
8	Chloride	mg/l	250	200	26	**410**	26
9	Chromium	mg/l	0.05	0.05	Nil	Nil	Nil
10	Copper	mg/l	2	1.5	Nil	Nil	Nil
11	Cyanide	mg/l	0.07	0.05	Nil	Nil	Nil
12	Fluoride	mg/l	1.5	1	0.1	0.52	0.39
13	Hardness	mg/l	200	200	32	**660**	120
14	Hydrogen sulfide	mg/l	NS	NS	**0.1**	**1.0**	**0.2**
15	Iron	mg/l	0.3	0.5	**2.96**	0.02	**0.52**
16	Manganese	mg/l	0.4	0.4	**1.2**	0.08	0.06
17	Lead	mg/l	0.01	0.01	Nil	Nil	Nil
18	Mercury	mg/l	0.006	0.006	Nil	Nil	Nil
19	Molybdenum	mg/l	0.07	0.07	Nil	Nil	Nil
20	Nickel	mg/l	0.07	0.07	Nil	Nil	Nil
21	Nitrate	mg/l	50	30	4.1	5.2	1.3
22	Nitrite	mg/l	3	0.5	0.25	0.01	**0.59**
23	Selenium	mg/l	0.01	0.01	Nil	Nil	Nil
24	Sodium	mg/l	ND	100	488	**775**	20
25	Sulfate	mg/l	250	200	0.3	**491**	7.8
26	Total dissolved solids	mg/l	600	1000	**1358**	**3677**	197
27	Zinc	mg/l	3	3	0.02	0.04	0.02

Date of sampling: Apr. 26th 2009

Table B.8 Results of Third Water Quality Analysis Compared with Guideline Values of WHO and Southern Sudan

No.	Parameter	Unit	WHO GV	Draft SS GV	Intake of Existing WTP	Treated Water at WTP	Proposed Intake Lologo	Test well No. 2
	Date of sample				2 July 2009			10 July
1	Aluminum	mg/l	0.1-0.2	0.2	0.05	0.02	0.02	0.1
2	Ammonia	mg/l	NS	NS	0.01	0.01	0.01	0.01
3	Antimony	mg/l	0.02	0.005	**0.01**	**0.01**	Nil	**0.01**
4	Arsenic	mg/l	0.01	0.05	Nil	Nil	Nil	Nil
5	Barium	mg/l	0.7	0.7	Nil	Nil	Nil	Nil
6	Boron	mg/l	0.5	0.5	Nil	Nil	Nil	Nil
7	Cadmium	mg/l	0.003	0.003-0.005	Nil	Nil	Nil	Nil
8	Chloride	mg/l	250	200	9	14	9	9
9	Chromium	mg/l	0.05	0.05	Nil	Nil	Nil	Nil
10	Copper	mg/l	2	1.5	Nil	Nil	Nil	Nil
11	Cyanide	mg/l	0.07	0.05	Nil	Nil	Nil	Nil
12	Fluoride	mg/l	1.5	1	0.45	0.32	0.46	**1.2**
13	Hardness	mg/l	200	200	52	58	54	42
14	Hydrogen sulfide	mg/l	NS	NS	0.1	<0.1	<0.1	0.1
15	Iron	mg/l	0.3	0.5	0.35	0.14	0.42	0.38
16	Manganese	mg/l	0.4	0.4	0.02	0.01	0.01	0.04
17	Lead	mg/l	0.01	0.01	Nil	Nil	Nil	Nil
18	Mercury	mg/l	0.006	0.006	Nil	Nil	Nil	Nil
19	Molybdenum	mg/l	0.07	0.07	Nil	Nil	Nil	Nil
20	Nickel	mg/l	0.07	0.07	Nil	Nil	Nil	Nil
21	Nitrate	mg/l	50	30	0.98	0.36	0.32	0.58
22	Nitrite	mg/l	3	0.5	<0.01	0.03	0.01	0.5
23	Selenium	mg/l	0.01	0.01	Nil	Nil	Nil	Nil
24	Sodium	mg/l	ND	100	18.4	16.9	23.2	94
25	Sulfate	mg/l	250	200	2.86	17.7	2.0	0.29
26	Total dissolved solids	mg/l	600	1000	121	122	136	311
27	Zinc	mg/l	3	3	0.03	0.02	0.03	0.03

Table B.9 Water Quality Analysis Results of Agro-Chemicals

No.	Parameter	Guidelines		Oct. 8th 2008			Feb. 14th 2009			Apr. 26th 2009			July 2nd 2009			
		Unit	WHO GV	Existing WTP	Near Juba Bridge	Tokiman -proposed WTP site	Existing WTP	Near Juba Bridge	Tokiman -proposed WTP site	Test Well 1	Test Well 2	Test Well 3	Existing WTP	Treated water	Tokiman -proposed WTP site	Test Well 2
1	Aldrin	mg/l	0.00003	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
2	Carbofuran	mg/l	0.007	NA	NA	NA	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
3	Chlordane	mg/l	0.0002	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	NA	NA	NA	NA	NA	NA	NA
4	DDT	mg/l	0.002	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
5	2,4-Dichlorophenoxyacetic acid (2,4-D)	mg/l	0.03	NA	NA	NA	<LOD	<LOD	<LOD	NA	NA	NA	NA	NA	NA	NA
6	Heptachlor	mg/l	0.00003	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOQ	<LOD	<LOD	<LOD
7	Lindane	mg/l	0.002	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD

LOD: limit of detection, LOQ: limit of quantitation
NA: not analyzed due to problem with the equipment.

Table B.10 Water Quality Analysis Results of Microbiological

	Parameter	Unit	WHO GV	Nov. 24th 2008			Feb. 14th 2009							
				Existing WTP	Near Juba Bridge	Tokiman -proposed WTP site	Jp66	Jp001	Kp050	Mp151	Mp093	Mp127	Jp039	Jp032
1	Total Coliform	count/100ml	0	900	1100	500	>18	>18	>18	>18	>18	>18	>18	>18
2	E Coli.		0	+	+	+	+	+	+	+	+	+	+	+

	Parameter	Unit	WHO GV	Feb. 14th 2009									
				Jp046	Jp118	Jp116	Mp068	Mp046	Mp049	Rp013	Rp013	Rp011	Rp021
1	Total Coliform	count/100ml	0	2	0	>18	>18	2	>18	>18	2	0	3
2	E Coli.		0	+	-	+	+	+	+	+	-	-	-

	Parameter	Unit	WHO GV	Feb. 14th 2009			May 21st 2009			Jun 22nd 2009		
				Existing WTP	Near Juba Bridge	Tokiman -proposed WTP site	Test Well 1	Test Well 2	Test Well 3	Existing WTP	Tokiman -proposed WTP site	Test Well 3
1	Total Coliform	count/100ml	0	>18	>18	>18	>180	25	>180	>18	>18	>18
2	E Coli.		0	+	+	+	+	+	+	+	+	+

+: positive

Table B.11 Spot Analysis by Field Kit (1)

Water Quality in the Bahr el-Jebel River in Juba City

Parameters	Tokiman -proposed WTP site	Near Juba Bridge	Existing WTP	WHO Guideline
Date of Sampling: Oct 8 2008				
Sampling Time	10:30 hrs	12:15 hrs	9:00 hrs	
Temperature (ºC)	28.1	28.3	27	-
pH	7.68	7.57	7.53	6.5-8.0
TDS (ppm)	87	84	128	600
Salt (ppm)	66	63	103	250
Conductivity (μS)	133	123	209	-
Turbidity (NTU)	**16.9**	**19.58**	**16.94**	5
Date of Sampling: November 24 2008				
Sampling Time	10:45	11:45	12:15	
Temperature (ºC)	29.2	29.5	29.3	-
pH	7.65	7.62	7.6	6.5-8.0
TDS (ppm)	152	202	210	600
Salt (ppm)	116	153	158	250
Conductivity (μS)	234	299	312	-
Turbidity (NTU)	**14.02**	**16.14**	**16.65**	5
Date of Sampling: February 14 2009				
Sampling Time	9:20	10:00	10:50	
Temperature (ºC)	28.9	29.4	29.4	-
pH	8.16	8.13	8.09	6.5-8.0
TDS (ppm)	180	261	188	600
Salt (ppm)	147	198	142	250
Conductivity (μS)	305	381	287	-
Turbidity (NTU)	**17.02**	**20.1**	**18.96**	5
Date of Sampling: February 14 2009				
Sampling Time	11:40	12:10	12:40	
Temperature (ºC)	30.3	31.1	30.4	-
pH	8.25	8.06	8.06	6.5-8.0
TDS (ppm)	144	215	228	600
Salt (ppm)	110	163	165	250
Conductivity (μS)	243	319	338	-
Turbidity (NTU)	**19.22**	**20**	**19.19**	5
Date of Sampling: May 21 2009				
Sampling Time	12:00		13:00	
Temperature (ºC)	28.3		27.7	-
pH	7.99		7.99	6.5-8.0
TDS (ppm)	134		130	600
Salt (ppm)	100		98	250
Conductivity (μS)	201		192	-
Turbidity (NTU)	**35.0**		**49.3**	5

Table B.12 Spot Analysis by Field Kit (2)

Water Quality at New Water Treatment Plant

Parameters	Raw Water	Receiving Tank	Post-sedimentation	Treated Water	WHO Guideline
Sampling Date and Time		1st June 2009 - 2:30pm			
Temperature	29.3	31.5	31.1	33.3	-
pH	8.00	7.94	7.43	7.73	6.5-8.0
TDS (ppm)	66	100	126	129	600
Salt (ppm)	44	76	128	103	250
Conductivity	98	154	188	208	-
Turbidity (NTU)	39.3	46.1	9.97	4.79	5
Sampling Date and Time		2nd June 2009 - 3:00pm			
Temperature	28.2	29.7	31.1	31.2	-
pH	7.98	7.53	7.53	7.59	6.5-8.0
TDS (ppm)	37	58	128	138	600
Salt (ppm)	29	47	86	109	250
Conductivity	63	72	186	226	-
Turbidity (NTU)	56.9	66.2	9.09	6.37	5
Sampling Date and Time		3rd June 2009 - 10:00am			
Temperature	29.4	32.4			-
pH	7.46	5.89			6.5-8.00
TDS (ppm)	90	157			600
Salt (ppm)	147	106			250
Conductivity	130	165			-
Turbidity (NTU)	34.7	51.9			5
Sampling Date and Time		4th June 2009 - 2:00pm			
Temperature	29.7	30.5	34.2	37.8	-
pH	6.18	5.39	7.30	6.95	6.5-800
TDS (ppm)	102	151	128	157	600
Salt (ppm)	100	109	102	120	250
Conductivity	140	225	207	216	-
Turbidity (NTU)	38.0	16.70	18.5	10.96	5
Sampling Date and Time		5th June 2009 - 1:00pm			
Temperature	32.8	32.2	32.3	32.1	-
pH	8.07	7.27	7.58	7.72	6.5-8.00
TDS (ppm)	158	69	99	106	600
Salt (ppm)	110	90	78	80	250
Conductivity	230	132	140	154	-
Turbidity (NTU)	26.1	32.4	12.79	3.50	5
Sampling Date and Time		9th June 2009 - 2:15pm			
Temperature	29.3	31.1	33.5	36.6	-
pH	7.72	7.64	7.38	7.83	6.5-8.00
TDS (ppm)	140	110	136	109	600
Salt (ppm)	130	78	107	83	250
Conductivity	115	163	228	160	-
Turbidity (NTU)	26.5	29.5	2.69	4.48	5
Sampling Date and Time		10th June 2009 - 4:00pm			
Temperature	29.3	31.1	33.5	36.6	-
pH	7.72	7.64	7.38	7.83	6.5-8.00
TDS (ppm)	140	110	136	109	600
Salt (ppm)	130	78	107	83	250
Conductivity	115	163	228	160	-
Turbidity (NTU)	26.5	29.5	2.69	4.48	5
Sampling Date and Time		11th June 2009 - 2:15pm			
Temperature	31.5	32.6	31.5	31.3	-
pH	7.84	6.76	7.26	7.71	6.5-8.00
TDS (ppm)	109	58	43	48	600
Salt (ppm)	180	38	54	36	250
Conductivity	120	83	75	63	-
Turbidity (NTU)	26.7	31.1	7.29	2.48	5

Table B.13 Spot Analysis by Field Kit (3)

Water Quality at WTP and in the Bahr el-Jebel River in Juba City

Date of Sampling: 2 July 2009

Parameters	Intake of Existing WTP	Treated Water at WTP	Proposed Intake Location Lologo	WHO Guidelines
Sampling Time	8:30	8:50	11:30	-
Temperature (ºC)	26.8	27.4	27.5	-
pH	8.1	7.78	8.02	6.5-8.0
TDS (ppm)	66	92	81	600
Salt	50	67	62	250
Conductivity (µS)	98	135	126	-
Turbidity	28.9	2.39	27.0	5
Residual Chlorine	-	1.97	-	-

Table B.14 Spot Analysis by Field Kit (4)

Water Quality at Public Taps

Parameter	Unit	Maximum allowable limit in Treated Water	Treated Water WTP	UWC Tap, Juba Payam	Public tap, Juba Payam	Sacred Heart Kindergarten, Juba Payam	Hai Amarat, Juba Payam	Hai Cinema, Juba Payam
Sampling Time and Date			10:15am 08 July 2009	10:55am 08 July 2009	11:30am 08 July 2009	2:59pm 08 July 2009	3:34pm 08 July 2009	3:00pm 09 July 2009
Water Temperature	°C			26.5	29.8	30.4	33.8	29
pH	-	6.0-8.5		8.05	7.93	8.03	5.88	7.7
Turbidity	NTU	5.0	5.93	5.34	9.37	2.1	5.8	15.26
Conductivity	µS	150.0		126	157	164	245	165
Total Dissolved Solids	mg/L	1000		87	106	104	158	112
Salinity				66	77	81	120	85
Residual Chlorine	mg/L		0.24	0.16	0.17	0.21	0.17	0.09

B.2 River Flow Data

Table B.15 Results of Water Flow Measurement by DIU at Juba in River Bahr el-Jebel

No. of measures	Date	Surface width m	Section area m^2	Mean velocity m/s	Max velocity m/s	Mean depth m	Max depth m	Mean gauge	Adjusted mean gauge	Total discharge m^3/s	Total discharge million m^3/d
1	30-Jan	298.4	1109	1.08	1.58	3.72	5.78	11.37	12.37	1190	102.82
2	6-Feb	282	1129	1.05	1.69	4.05	6.02	11.34	12.34	1179	101.87
3	27-Feb	256	1093	1.05	1.7	4.12	5.44	11.3	12.3	1145	98.93
4	3-Mar	257	1073	1.07	2.51	4.18	5.55	11.29	12.29	1144	98.84
5	6-Mar	250	1064	1.06	1.68	4.25	4.25	11.28	12.28	1129	97.55
6	10-Mar	256	1066	1.04	1.77	4.16	5.38	11.28	12.28	1137	98.24
7	13-Mar	257	1082	1.05	1.69	4.21	5.45	11.28	12.28	1136	98.15
8	17-Mar	256	1053	1.06	1.74	4.11	5.47	11.28	12.28	1120	96.77
9	27-Mar	255	1078	1.07	1.75	4.23	5.47	11.28	12.28	1153	99.62
10	31-Mar	257	1079	1.07	1.83	4.21	5.39	11.29	12.29	1152	99.53
11	3-Apr	258	1079	1.07	1.86	4.19	5.45	11.3	12.3	1150	99.36
12	7-Apr	260	1148	1.07	2.07	4.04	5.28	11.29	12.29	**1125**	**97.20**
13	10-Apr	259	1088	1.06	1.83	4.2	5.41	11.3	12.3	1154	99.71
14	14-Apr	260	1089	1.05	1.88	4.18	5.44	11.3	12.3	1145	98.93
15	17-Apr	260	1098	1.08	1.9	4.23	5.53	11.32	12.32	1183	102.21
16	21-Apr	257	1082	1.07	1.91	4.21	5.39	11.34	12.34	1158	100.05
17	24-Apr	259	1105	1.07	1.92	4.27	5.54	11.34	12.34	1186	102.47
18	28-Apr	260	1084	1.06	1.95	4.16	5.4	11.28	12.28	1150	99.36
19	1-May	264	1097	1.03	1.91	4.16	5.49	11.26	12.26	1132	97.80
20	5-May	261	1184	1.15	2.14	4.53	5.83	11.64	12.64	1360	117.50
21	8-May	259	1080	1.08	1.86	4.18	5.51	11.27	12.27	1163	100.48
22	12-May	261	1098	1.05	2.05	4.21	5.48	11.29	12.29	1157	99.96
23	15-May	257	1068	1.08	1.79	4.15	5.46	11.28	12.28	1150	99.36
24	19-May	260	1100	1.07	2.13	4.23	5.41	11.3	12.3	1172	101.26
25	22-May	256	1078	1.07	1.78	4.31	5.39	11.27	12.27	1148	99.19
26	26-May	259	1084	1.06	1.91	4.18	5.32	11.27	12.27	1147	99.10
27	29-May	258	1079	1.05	1.9	4.17	5.37	11.25	12.25	1133	97.89
28	2-Jun	258	1074	1.1	2.22	4.16	5.43	11.32	12.32	1184	102.30
29	5-Jun	258	1076	1.11	1.95	4.17	5.49	11.33	12.33	1192	102.99
30	9-Jun	258	1084	1.11	1.94	4.21	5.44	11.36	12.36	1201	103.77
31	16-Jun	259	1112	1.09	2.15	4.29	5.57	11.38	12.38	1214	104.89
32	7-Jul	262	1064	1.08	2.05	4.06	5.59	11.24	12.24	1149	99.27
33	10-Jul	256	1054	1.07	2.09	4.11	5.57	11.24	12.24	1129	97.55
34	14-Jul	259	1057	1.09	2.07	4.06	5.47	11.26	12.26	1149	99.27
35	24-Jul	259	1071	1.09	2.02	4.14	5.47	11.28	12.28	1170	101.09
36	28-Jul	259	1086	1.1	2.04	4.19	6.06	11.34	12.34	1197	103.42
37	31-Jul	259	1122	1.17	2.3	4.34	6.25	11.48	12.48	1314	113.53
38	4-Aug	257	1115	1.17	2.07	4.34	6.23	11.44	12.44	1300	112.32
39	7-Aug	256	1148	1.22	2.05	4.48	6.31	11.62	12.62	1401	121.05
40	11-Aug	260	1186	1.24	2.38	4.57	6.31	11.67	12.67	1468	126.84
41	14-Aug	257	1269	1.37	2.19	4.93	6.54	12.03	13.03	**1742**	**150.51**
42	21-Aug	259	1166	1.22	2.2	4.51	6.06	11.66	12.66	1417	122.43
43	1-Sep	257	1177	1.24	2.26	4.57	6.13	11.69	12.69	1462	126.32
44	8-Sep	262	1253	1.3	2.21	4.79	6.32	11.88	12.88	1634	141.18
45	15-Sep	260	1220	1.29	2.06	4.7	6.22	11.87	12.87	1575	136.08

Source: Dam Implementation Unit

APPENDIX – C

POPULATION AND WATER DEMAND PROJECTIONS

APPENDIX - C POPULATION AND WATER DEMAND PROJECTIONS

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C.1 Future Land Use Plan

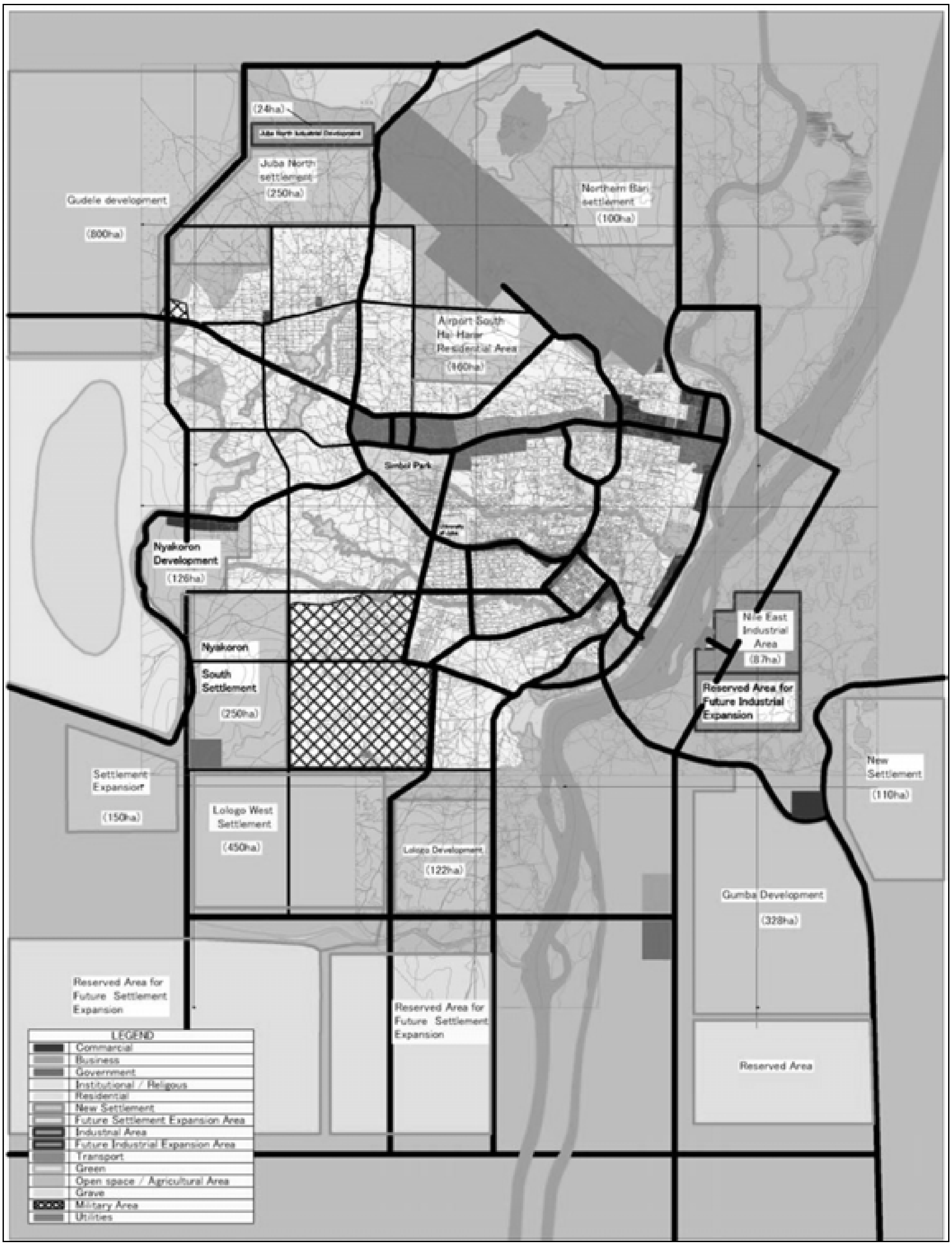
Juba is newly designated capital of Southern Sudan. Therefore, Juba will be not only a major city in the region but also the center of government, economic and cultural activities of Southern Sudan. In order to function as the capital, a drastic development is expected and infrastructure including water supply must be well coordinated with future land use plan. Considering the existing land use plan prepared in JICA Emergency Study and on-going JICA Transportation Study, a future land use plan is adopted for this Study.

(1) JICA Emergency Study

JICA Emergency Study Team along with the land department in Central Equatoria State proposed the future land use plan for 2015. The future land use in urbanized area by category was estimated as shown in Table C.1 and the conceptual future land use map is prepared as shown in Figure C.1.

Table C.1 Future Land Use in Urbanized Area by Category in 2015

No.	Land Use	Area	
		(ha)	(%)
1	Residential	3,290	42.4
2	Commercial	207	2.7
3	Business	152	2.0
4	Government	82	1.1
5	Military	280	3.6
6	Industry	129	1.7
7	Institutional	182	2.3
8	School / Clinic	204	2.6
9	Religious	29	0.4
10	Sport field / Public Facility	54	0.7
11	Road / Transport	1,488	19.2
12	Grassland / Agricultural	1,662	21.4
	Total	7,759	100.0



Source: JICA Emergency Study on the Planning and Support for Basic Physical and Social Infrastructure in Juba Town and the Surrounding Areas in the Southern Sudan

Figure C.1 Future Land Use in 2015

(2) JICA Transportation Study up to 2025

The JICA Transportation Study, which is currently undergoing, is proposing draft future land use and road network up to 2025 as shown in Figure C.2.

Figure C.2 Land Use Plan and Road Network Proposed by JICA Transportation Study

(3) Adopted Land Use Plan up to 2025

The conceptual future land use plan proposed in JICA Emergency Study has been authorized by the government of Central Equatoria State. Therefore, this future land use plan is also adopted for this Study. Secondly, the draft proposed road network plan proposed by JICA Transportation Study shall be used in the Study, especially for selecting pipeline routes.

The required total areas for each land use category such as institution, commerce, business, and industry, which are expected to be future users of public water supply, are estimated in the same manner used in JICA Emergency Study. The estimated total area by land use category is distributed to each sub-district in accordance with the allocation of the future land use plan in 2015.

C.2 Population Projections

C.2.1 Existing Future Population Forecast

(1) GIBB Africa estimate

GIBB Africa estimated future population in the report “Government of Southern Sudan, Urgent Infrastructure Needs Assessment Draft Report Sept 2005.” The estimation was made based on the following model assumption:

- The number of traditional migrants is not thought to be large.
- Juba offers attractions over other towns.
- The movement from towns too far away from Juba is discounted.
- Many of the refugees and IDP populations wish to return to Southern Sudan.

Migrants will move to towns and villages in Southern Sudan closest to the places they currently reside in, namely: refugees from Uganda, Kenya, and DRC to towns in Equatoria, and those in Ethiopia to Jonglei and Upper Nile Migrants in the southern parts of North Sudan (e.g. Korodofan) to places in the northern parts of Southern Sudan (e.g. Malakal and Bentiu).

The port towns along Nile and its tributaries (i.e. Juba as well as Malakal, Bor and Bentiu) are considered to be easier for IDPs in Khartoum to travel to than other cities only accessible by roads. The model considered the relative attractiveness of different towns and state capitals, and the likely migration not just to Juba but to all other large towns.

Based on the model they estimated the future population in Juba as shown in the following table. The following summarizes the findings in the model estimation:

- The population increase of 240,000-270,000 was forecasted over the period 2005 – 2011
- 80 % of increase is due to returnees and IDPs
- Juba urban population could exceed 500,000 within 6 years
- This represents 12 % AGR.

It seems very likely that Juba will be confronted with large number of migrants.

Table C.2 Population projection 2005 - 2011

Population increase, by Source	Estimated moving to Juba
Natural increase, 2005 -2011	45,900
Traditional Migration	1,900 – 3,700
Returnees from Neighboring Countries	96,900
IDPS Currently in Khartoum	63,300 – 92,000
IDPs Currently Elsewhere in the North	4,100
IDPs Currently in Southern Sudan	27,900
Total increase	240,000 – 270,500

(2) JICA Emergency Study

In the JICA Emergency Study, the population in Juba and the surrounding area in 2005 was estimated as 250,000 and the future population up to 2015 was forecasted based on the following approach.

Future population is projected considering two components; a) natural increase and b) social increase. The social increase in case of Juba consists of three types; 1) conventional migrants (the balance between in-migration and out-migration), 2) refugees from other countries and 3) internally displaced persons (IDPs). Accordingly, the future population in Juba is expected to increase from 250,000 in 2006 to 459,100 (low estimate) and 585,200 (high estimate) in 2015. Table C.3 shows the result of population forecast.

Table C.3 Future Juba Population in 2015 Projected by JICA Emergency Study

(Persons)

	Low Estimate	Medium Estimate	High Estimate
Population in 2006		250,000	
Natural Increase between 2006-2015	48,800	57,500	71,900
Conventional Migration *	6,800	12,700	19,900
Refugees from Neighboring Countries	89,000	94,700	109,000
IDPs from Khartoum and North Sudan	47,300	76,300	112,200
IDPs from South Sudan	17,200	18,800	22,200
Total Population in 2015	459,000	510,000	585,200

* Projected using the Migration Model prepared by GIBB Africa

C.2.2 Future Population Forecast

JICA Study Team forecasts the population in Juba up to 2025 to prepare a conceptual future water supply plan for the next 15 - 20 years, in addition to water supply master plan in 2015.

The estimated populations in 2005 and in 2009 were estimated to be 250,000 and 400,000, showing a rapidly increasing trend. This drastic population increase is attributable more to the socio-economic conditions than to natural causes. In the case of Juba, returnees of IDPs and refugees, and the newly designated capital are the major reasons. In this circumstance, it is rather difficult to estimate future population based on the past trend.

The current population in Juba (for 2009) estimated by JICA Study Team is 400,000 and the calculated average annual growth rate is 12.5 % during the period. This rate is the almost same as the estimation by GIBB Africa. Therefore, JICA Study Team assumes that the population growth up to 2011 can be explained by the GIBB Africa model, and the population until 2011 will be forecasted by following the GIBB estimate.

To forecast the future population after 2011, JICA Study Team assumes that the current drastic social migration, which is now dominant, will be ceased and natural population increase will be gradually dominant after 2011, and the forecast is guided by the population growth trend in other cities and countries nearby Juba as shown in Table C.4.

Table C.4 Past Population Growth Rates in Other Major Cities in Other Neighboring Countries

City	Annual Pop. Gr. Rate	Period	Population in Start Year	Population in End Year
Nairobi, Kenya	4.7%	1999-2006	2,143,254	2,948,109
Mombasa, Kenya	3.8%	1999-2006	665,018	862,092
Kampala, Uganda	3.7%	2002-2008	1,189,142	1,480,200
Addis Ababa	3.2%	1994-2006	2,112,737	2,973,000
Bangui, Central Africa	2.2%	1988-2003	451,690	622,771

The population growth rates of Nairobi and Mombasa, which are the capital of the neighboring countries, are 4.7 % and 3.7 %, p.a., respectively and show relatively high growth rates.

The following table shows the population growth in Nairobi and Mombasa between the period of 1969 and 2006. During this period, the population growth rate did not exceed 5 %. This indicates excluding very high social migration growth, basically, a growth rate of 5 % p.a. is an almost highest rate in population growth in this region of the world. Therefore, in the population forecast for Juba, the population growth rate shall not exceed 5 % in the long run.

Table C.5 Past Population Trend in Nairobi and Mombasa since 1969

(Persons)

	1969	1979	1989	1999	2006
Population in Nairobi	509,286	827,775	1,324,570	2,143,254	2,948,109
Population in Mombasa	247,073	341,148	461,753	665,018	862,092
Pop Growth Rate (p.a.) in Nairobi		5.0%	4.8%	4.9%	4.7%
Pop Growth Rate (p.a.) in Mombasa		3.3%	3.1%	3.7%	3.8%

The demographic indicators of the countries and cities nearby Juba along with Central Equatoria State and Southern Sudan are summarized in the table below. As shown in this table, the total fertility rates are very high as 6.7 but the mortality rate is also high; almost two times higher than those of Uganda.

Table C.6 Demographic Characteristics of Southern Sudan and Other Cities and Countries

City/Country	Year	Life Expectancy At Birth	Infant Mortality Rates	Under Five Mortality Rates	Crude Death Rate Per 1000	Crude Birth Rate Per 1000	Total Fertility Rates
Nairobi, Kenya	1989-1999 *1 2003	57	49.7	93			2.7*1
Kenya	2005		77	115			4.9
Uganda	*2 2005 2008	52.3	70 *2	136 *2	12.3	48.2	6.8
Southern Sudan 1)	2001	42	150	250	22	50.5	**6.7**
CES 2)	2006		107	141			

Source:
*1): Towards a Baseline: Best Estimates of Social Indicators for Southern Sudan, New Sudan Centre for Statistics and Evaluation in Association with Unicef, May 2004
*2): Sudan Household Health Survey (Southern Sudan report), 2006, Government of Southern Sudan

The current trend of high population increase will not continue because the recent drastic increase is attributed mainly to the migration. The growth rate will eventually drop to the level of natural increase as well as in the cities of the neighboring countries. Considering the factors analyzed above, JICA Study Team assumes three scenarios of the future population growth rate for Juba as shown in Table C.7.

Table C.7 Scenario of Future Population Growth Rate for Juba Population Forecast

	2010	2011	2015	2020	2025
High Estimate	13%	13%	7%	6%	5%
Medium Estimate	13%	13%	6%	5%	4%
Low Estimate	13%	13%	5%	4%	3%

Based on these growth rates, the future population was estimated in Table C.8 and Figure C.3. The population in Juba in 2025 will be 1.16 million, 1.01 million and 0.89 million for high, medium and low estimates, respectively. JICA Study Team and South Sudan side agreed to adopt the high estimate as the future population for Juba. The adopted populations of Juba in 2015 and 2025 are 680,000 and 1,161,000, respectively.

Table C.8 Future Population Forecast with Different Growth Trends

(Thousand persons)

	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

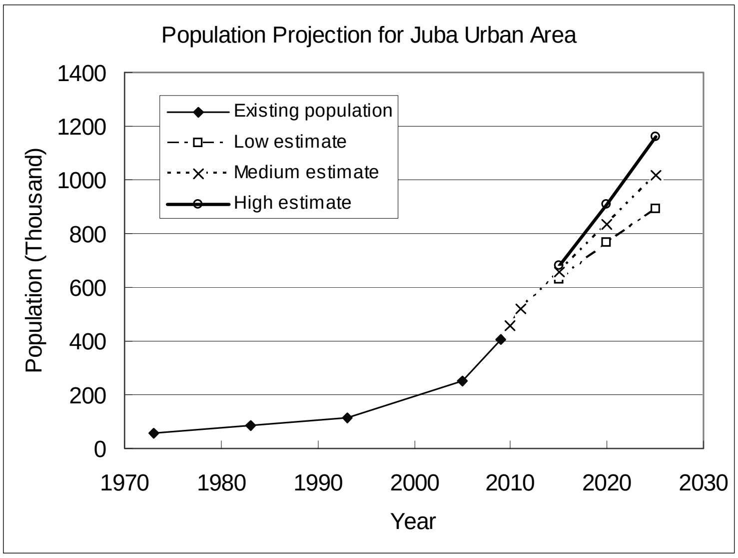


Figure C.3 Future Population Forecast for Juba Urban Area

Without a suitable economic growth, a rapid population increase will result in emergence of large number of unemployment, large tract of informal or slum areas, and requirement of large public investment and social welfare. It is required that Southern Sudan government implements social and infrastructural development to accommodate this population increase in a well planned way.

As for water supply, water distribution network can be developed in organized area and service connection can be connected to legal houses. Therefore, to increase public water supply connection, land rearrangement and legalization of informal houses will be required.

C.2.3 Future Population Distribution

The total population estimated above is distributed to sub-district by the following model.

- The saturated population densities for each sub-district are set up considering the population density obtained from the pilot head counting survey and the quick land use survey.
- The total population is distributed to sub-districts in proportion to the land area of potential residential area, where the future population can be accommodated.
- The population increase of the sub-district ceases once the population density of the sub-district concerned reaches the saturated population density.

In this model, the growth rate in the center of city becomes relatively low as the center of city is already developed and there is little space for new residents. Contrarily, the growth rate in suburb area becomes high as new residential area is located in suburb area and there is much space for new residents. After several years, the population increase in the center of the city will cease and afterwards, the increased population will shift mainly to the suburbs.

Based on this model, future total population was distributed and the result of the estimated population distribution to sub-district up to 2025 is shown in as shown in Table C.9 and the summary by Payam is shown in Figure C.4 The population increase in Juba Town and Kator Payams is relatively low because most of those areas have been already developed. On the contrary, the population growth in Rejaf and Gudele Payams is high because those areas have open space to be developed as residential areas. This increase trend is coincident with the direction of recent expansion of urbanized area and new residential areas on future land use.

Table C.9 Estimated Future Population Distribution

(Persons)

Area	Payam No.	Area (Ha)	2005	2009	2010	2015	2020	2025
Juba	J-1	30.14	2,438	2,339	2,384	2,572	2,729	2,827
	J-2	33.71	959	2,093	2,172	2,501	2,813	3,091
	J-3	71.49	3,942	7,884	8,101	9,014	9,996	11,128
	J-4	205.90	9,312	16,705	17,649	21,615	25,736	30,218
	J-5	144.90	4,986	9,100	10,010	13,831	17,598	21,306
	J-6	80.64	2,099	6,959	7,335	8,913	10,513	12,176
	J-7	63.19	4,587	5,927	6,079	6,718	7,504	8,592
	J-8	32.46	6,504	3,968	4,054	4,417	4,790	5,188
	J-9	64.08	11,433	7,815	7,965	8,593	9,118	9,446
	J-10	40.62	4,516	4,616	4,709	5,100	5,581	6,247
	J-11	42.97	7,835	6,975	7,116	7,708	8,435	9,441
	J-12	43.21	4,414	4,796	4,950	5,594	6,209	6,776
	J-13	42.28	6,254	3,750	3,835	4,192	4,493	4,690
	J-14	78.86	4,954	6,700	6,961	8,059	9,240	10,602
	J-15	58.61	3,102	3,460	3,569	4,027	4,547	5,199
	J-16	47.30	6,375	5,610	5,774	6,461	7,227	8,158
	J-17	42.95	5,816	5,629	5,749	6,251	6,844	7,626
	J-18	709.62	7,636	7,868	9,682	17,300	24,312	30,215
	J-19	36.23	1,690	1,311	1,340	1,463	1,588	1,720
	J-20	64.15	1,895	1,422	1,530	1,979	2,376	2,671
	J-21	101.51	2,190	2,251	2,420	3,132	3,759	4,226
	S-Total	2,034.82	102,937	117,178	123,384	149,440	175,408	201,543
Kator	K-1	17.42	4,563	2,418	2,470	2,688	2,927	3,210
	K-2	46.04	10,736	7,189	7,344	7,992	8,702	9,543
	K-3	33.93	4,301	4,957	5,057	5,477	5,994	6,709
	K-4	29.86	4,963	4,847	4,945	5,356	5,861	6,560
	K-5	38.91	6,209	6,316	6,444	6,979	7,638	8,549
	K-6	65.66	6,555	9,860	10,110	11,159	12,297	13,625
	K-7	60.26	8,702	7,826	7,984	8,647	9,463	10,591
	K-8	51.36	4,275	6,068	6,298	7,263	8,261	9,338
	K-9	50.81	6,165	7,211	7,489	8,660	9,725	10,597
	K-10	165.06	7,972	13,176	14,114	18,052	21,767	25,092
	K-11	829.20	4,850	9,012	12,284	26,026	39,330	51,943
	S-Total	1,388.51	69,291	78,880	84,539	108,299	131,965	155,757
Munuki	M-1	51.77	5,208	5,831	5,968	6,545	7,203	8,031
	M-2	94.10	5,595	8,514	9,075	11,433	13,954	16,830
	M-3	228.70	9,368	19,710	20,826	25,514	30,306	35,367
	M-4	168.60	6,107	10,995	11,915	15,779	19,664	23,640
	M-5	44.99	4,464	7,183	7,355	8,076	8,710	9,181
	M-6	61.64	6,234	8,748	9,047	10,306	11,454	12,398
	M-7	40.95	3,313	5,085	5,301	6,210	7,062	7,813
	M-8	58.69	1,769	3,875	4,132	5,213	6,432	7,944
	M-9	97.93	9,489	10,641	11,101	13,034	14,846	16,440
	M-10	66.47	9,681	9,433	9,736	11,006	12,166	13,123
	M-11	45.54	4,263	2,289	2,467	3,213	3,992	4,844
	M-12	65.59	8,776	6,981	7,355	8,927	10,435	11,835
	M-13	85.05	3,504	7,921	8,405	10,439	12,373	14,138
	M-14	170.00	0	4,524	5,537	9,791	13,775	17,275
	M-15	150.00	0	5,411	6,271	9,883	13,539	17,330
	S-Total	1,430.02	77,771	117,141	124,491	155,369	185,911	216,189
Rejaf	R-1	514.40	0	6,461	9,986	24,792	40,136	56,749
	R-2	773.00		0	5,259	27,349	52,557	84,268
	R-3	335.00		2,971	5,661	16,956	28,674	41,385
	R-4	1,617.00		21,514	31,245	72,117	114,163	159,091
	R-5	499.00		0	1,368	7,115	11,044	11,431
	R-6	562.00		0	1,904	9,900	18,751	29,412
	S-Total	4,300.40	0	30,946	55,423	158,229	265,325	382,336
Gudele	G-1	188.81	0	10,217	11,253	15,604	20,295	25,722
	G-2	1,027.37		38,914	45,042	70,780	99,739	135,457
	G-3	485.22		13,128	14,894	22,312	31,436	44,053
	S-Total	1,701.40	0	62,259	71,189	108,696	151,470	205,232
Total		10,855.15	249,999	406,404	459,026	680,033	910,079	1,161,057

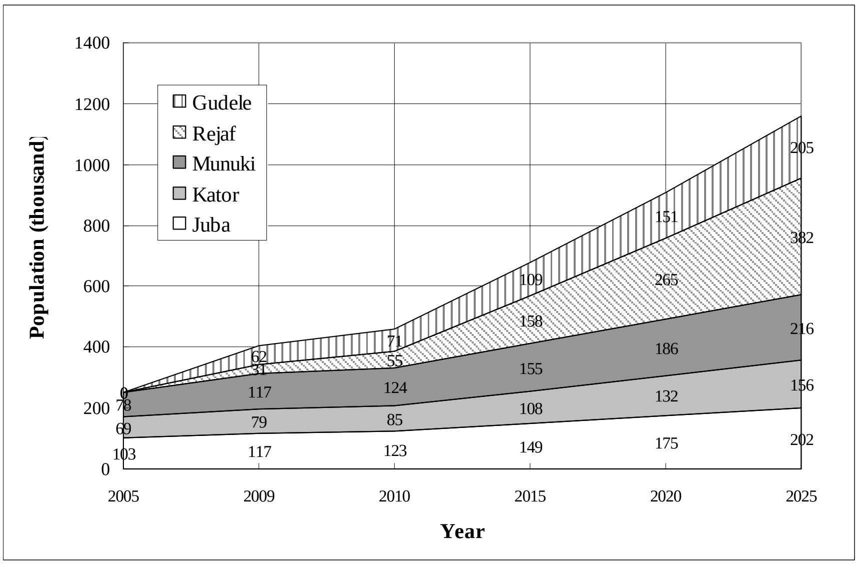


Figure C.4 Estimated Population Distribution by Payams up to 2025

The population density by Payams against entire area and habitable area of the Payam concerned up to 2025 is shown in Figure C.5. The habitable area includes only potential residential areas and excludes other types of occupants such as institution, commercial and industry, and unsuitable land for residence such as marsh land and gully.

The average population density against habitable area in 2025 is 176 persons/ha for entire Juba Urban Area. Comparing with the population density obtained from the pilot survey; 180 persons/ha for organized residential area and 222 persons/ha unorganized residential area, Juba urban area can accommodate more people after 2025 in terms of land availability.

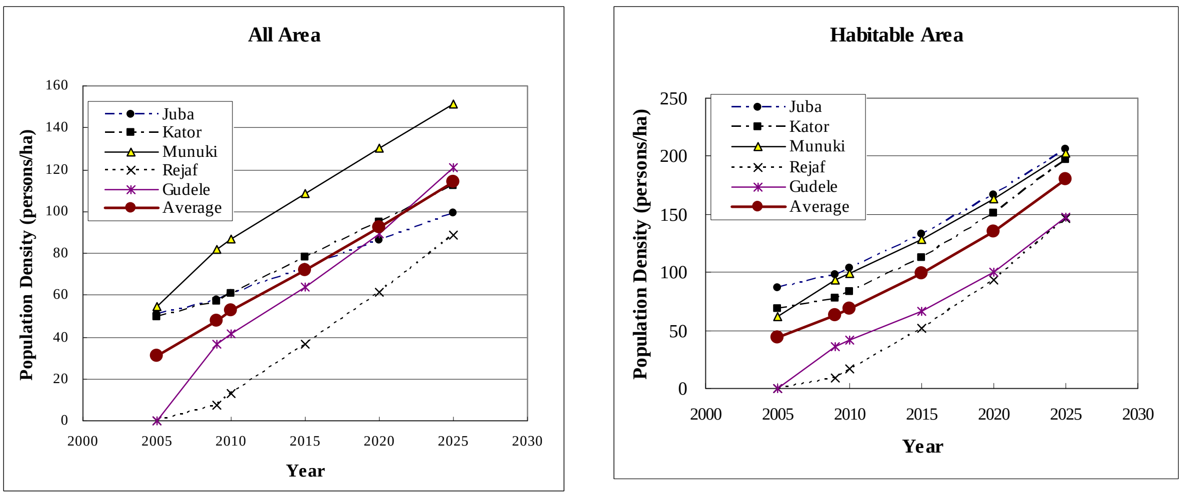


Figure C.5 Population Density by Payam up to 2025

C.3 Water Demand Projections

C.3.1 Analysis of Water Consumption per Capita

The current per capita water consumption of house connection, public tap and water tank truck supply was calculated based on result of the socio-economic survey by JICA Study Team. The current average water consumption per capita of domestic users (house connection, public tap and tanker supply) is estimated as 33 L/c/d.

The design or target water consumption per capita for domestic users was set up as shown in the table below, considering those of other areas in Sudan and other countries (see Section C.4). The target water consumption per capita for 2025 is set up at 120 L/c/day, with 105 L/c/d for 2020 and 90 L/c/d for 2015.

Table C.10 Design Domestic Water Consumption per Capita for Juba

Users/main water sources	Current water use		Target in 2015		Target in 2020		Target in 2025	
	L/c/d *1	% *2	L/c/d	%	L/c/d	%	L/c/d	%
- House connection	26	58	90		105		120	
- Public tap	32.5	5	40		40		40	
- Tank truck	35.5	-	40		40		40	
Total of domestic users	33	63	-	62	-	66	-	70

Note:
*1 The current water consumption per capita was estimated from results of socio-economic survey by JICA Study Team.
*2 The ratio of the current water use was estimated based on the water bill amount data of Juba UWC.

The following table summarizes the number of connections and water bill of Juba UWC for 2007. In terms of water bill, the domestic bill occupies 58 % of total bill. The institutional water bill is as high as 28 %.

Table C.11 Analysis of UWC Water Bill for 2007

Category	Nos. of connections	Water bill	
		(SDG)	(%)
Domestic	2,153	341,316	0.58
Stand Pipe	38	27,360	0.05
Institutional	179	162,000	0.28
Commercial	97	55,200	0.09
Sub-total	2,467	585,876	1.00
New connection	298	75,990	
Total	2,765	661,866	

The ratio of water consumption of current water supply by user category of UWC was assumed based on the water billing data of Juba UWC. The ratio of current UWC water consumption of domestic users (household connection and public tap) amounts for 58 % and 5 % of total water consumption, respectively, and non-domestic users account for 37 %.

The ratio of water consumption of domestic users for 2025 are set up at 70 % and 30 %, respectively, assuming the institutional water consumption will be reduced from the current 28 % as the public sector in Juba will relatively decrease in future and considering the typical ratio of total water consumption in a large city, i.e. 20 – 30 %.

The total percentage of the non-domestic water consumption was distributed to each non-domestic user group as shown in the table below. As explained above, the share of institution/government is assumed to be reduced in future. The share of commercial & business and industry is set up 10 % and 3 %, respectively and will stay same in future. The low industrial water consumption rate was assumed as industry will use own water supply source or other public water supply exclusively for industry. The future water demand is estimated based on these ratios of the domestic consumption.

Table C.12 Design Ratio of Non-Domestic Water Consumption for Juba

(%)

Class/main water sources	Current water use	Target		
		in 2015	in 2020	in 2025
1. Domestic	**63**	**62**	**66**	**70**
2. Non-domestic	**37**	**38**	**34**	**30**
- Commercial & business	9	10	10	10
- Industry	0	3	3	3
- Institution/government	28	25	21	17

C.3.2 Conditions of Water Demand Projections

(1) Target Level of Water Supply Service

The current main water supply methods in the Study Area are as follows:

- UWC piped water supply by house connection and public taps
- Wells equipped with public tap
- Vender water /Water supply by tank truck

Considering the existing conditions of UWC's water supply facilities and the current small number of UWC customers (2,765 connections), which is corresponding to about 10 % of the total population, it is not possible to supply clean and safe water by house connection to all the rapidly increasing population in Juba urban area in the near future. Therefore, it is assumed that water supply by public taps of piped water, wells and water tank truck will be continued for certain future.

JICA Study Team and Southern Sudan side discussed about coverage target of treated water and reached the consensus that it is difficult to achieve 100% in 2015 considering many factors such as budget, technical ability and rapid expansion of city. Finally, it was agreed that the water supplied to the Juba urbanized area should be clean and safe until 2025 as a basic policy of this plan. The target coverage of treated water during transitional period was set as shown in following table.

Table C.13 Target Coverage of Treated Water

	2015	2020	2025
Treated Water Supply	80 %	90 %	100 % (Target)
Non-treated Water Supply	20 %	10 %	0 %

Therefore, the source of water for all supply methods should be clean and safe water appropriately treated in water treatment plant or disinfected good quality of ground water, although these 3 types of water supply methods are assumed to be continued. In addition, the supplementary use of disinfected well water by public taps will be continued but this water shall not be used for drinking and cooking purposes and used for non-drinkable purpose.

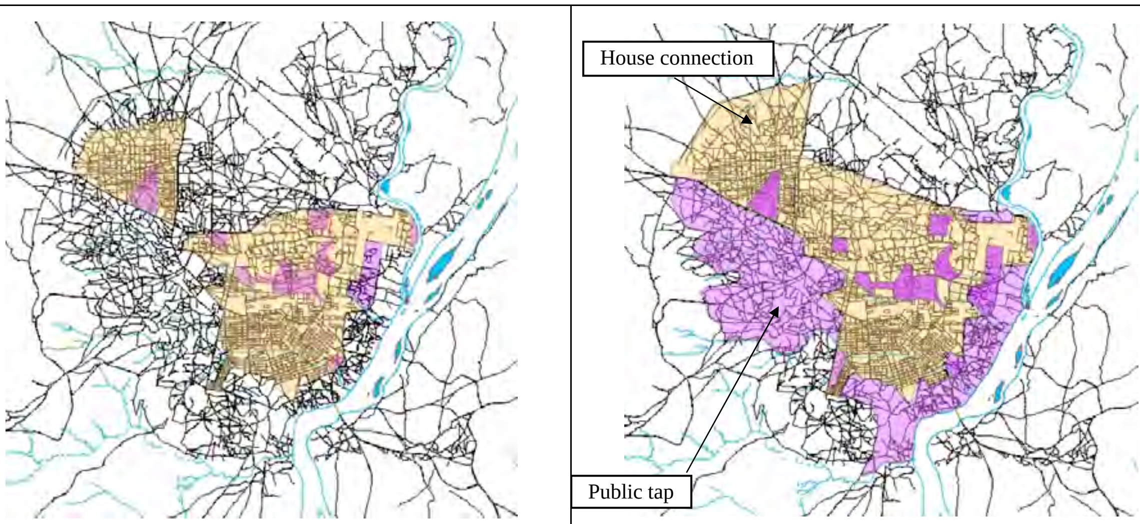
JICA Study Team worked out the improvement scenarios of water supply level for 2015 and 2025 as follows.

1) Target Level of Main Water Supply Service in 2015

The following two cases were prepared and the border of covered area of water distribution network is shown in
Figure C.6.

Case 1: (Low estimate)	• The border of covered area of water distribution network is delineated along the existing organized urban area. • In the covered area, only existing organized urban area is supplied by house connection and unorganized urban area is supplied by public taps, the water of which is supplied by pipe. • The area outside of the covered area is supplied by tank truck, the water of which is supplied from UWC treated water.

Case 2: (High estimate)	• The border of covered area of water distribution network is delineated along the existing organized urban area and its surrounding areas. • In the covered area, existing and possible organized urban area is covered by house connection and unorganized urban area is supplied by public taps, the water of which is supplied by pipe. • The area outside of the covered area is supplied by tank truck, the water of which is supplied from UWC treated water.



Case 1 (Low coverage estimate)   Case 2 (High coverage estimate)

Figure C.6 Planned Covered Area of Water Distribution Network in 2015

The target level of water supply service in 2015 estimated based on these cases is shown in Table C.14.

Table C.14 Target Level of Main Water Supply Service in 2015

Payam	Existing House Connect (UWC)	Case 1 (Low coverage)				Case 2 (High coverage)			
		House Connect (UWC)	Public Tap (UWC)	Tank Truck	Non-treated	House Connect (UWC)	Public Tap (UWC)	Tank Truck	Non-treated
Juba Town		34 %	18 %	36 %	12 %	57 %	24 %	11 %	8 %
Kator		42 %	3 %	41 %	14 %	42 %	34 %	14 %	10 %
Munuki		23 %	1 %	56 %	20 %	37 %	50 %	8 %	5 %
Rejaf		0 %	0 %	74 %	26 %	0 %	0 %	60 %	40 %
Gudele		0 %	0 %	74 %	26 %	0 %	0 %	60 %	40 %
Total	Approx 5 %	19 %	5 %	56 %	20 %	28 %	22 %	30 %	20 %
No of connection	2,153	16,900	-	-		24,200	-	-	
Population covered by type	34,000	131,700	31,700	382,300	134,300	188,000	151,000	204,000	136,000

Note: The number of house connections are calculated assuming 7.8 persons per household in 2015.

2) Target Level of Main Water Supply Service in 2025

The following two simple cases were prepared for 2025 and the target level of water supply service in 2025 estimated based on these cases is shown in Table C.15.

Case 1:	• The coverage of house connection in the existing main city areas (Juba Town, Kator and Munuki) will be 60 % and that of the rest of the area (Rejaf and Gudele) will be 40 %
Case 2:	• The coverage of house connection in the existing main city areas (Juba Town, Kator and Munuki) will be 80 % and that of the rest of the area (Rejaf and Gudele) will be 60 %.

Table C.15 Target Level of Main Water Supply Service in 2025

Payam	Case 1 (Low coverage)				Case 2 (High coverage)			
	House Connect (UWC)	Public Tap (UWC)	Tank Truck	Non-treated	House Connect (UWC)	Public Tap (UWC)	Tank Truck	Non-treated
Juba Town	60 %	20 %	20 %	0 %	80 %	10 %	10 %	0 %
Kator	60 %	20 %	20 %	0 %	80 %	10 %	10 %	0 %
Munuki	60 %	20 %	20 %	0 %	80 %	10 %	10 %	0 %
Rejaf	40 %	20 %	20 %	0 %	60 %	10 %	10 %	0 %
Gudele	40 %	20 %	20 %	0 %	60 %	10 %	10 %	0 %
Total	50 %	25 %	25 %	0 %	70 %	15 %	15 %	0 %
No of connection	74,200	-	-		115,900	-	-	
Population covered by type	579,100	291,000	291,000	0	811,300	174,900	174,900	0

Note: The number of house connections are calculated assuming 7.0 persons per household in 2025.

Following table summarizes the estimated coverage for house connection by low and high coverage scenarios.

Table C.16 Summary of House Connection Coverage Forecast

Items	Case	2007	2015	2025
1. House connection coverage (%)	Case 1 Low estimate	5	19	50
	Case 2 High estimate	5	28	70
2. Number of house connections (nos.)	Case 1 Low estimate	2,153	16,900	74,200
	Case 2 High estimate	2,153	24,100	115,900
3. House connection covered population (persons)	Case 1 Low estimate	34,000	131,700	579,100
	Case 2 High estimate	34,000	188,000	811,300

JICA Study Team and South Sudan side agreed to target the high estimate scenario of water service supply level for both 2015 and 2025. In the adopted targeted level, percentage of house connection coverage in 2015 and 2025 are 28 percent and 70 percent, respectively.

(2) Estimation Conditions of Water Demand

In estimating the water demand, the following factors are considered:

1) Ratio of continuous use of existing wells equipped with public tap

Even after 2015, existing wells equipped with public tap will be continuously used and the following percentage of use is assumed. In the assumption, the users of household connection and non-domestic category do not use existing wells but the following percentage of the users of public tap and tanker will still continuously use existing wells.

Table C.17 Ratio of Continuous use of Existing Wells equipped with Public Tap

Category	Target		
	2015	2020	2025
House connection	0 %	0 %	0 %
Public tap and tanker truck	30 %	20 %	10 %
Non-domestic users	0 %	0 %	0 %

2) Leakage ratio

At the early stage of improvement project of water supply facilities in the water supply master plan, the first priority is given to the rehabilitation of existing distribution network and all existing network will be upgraded by replacement. This intervention is assumed to complete before 2015. Considering this conditions, the leakage ratio in 2015 is set up at 20 %, and after 2015, the leakage ratio is kept 20 % by appropriate leakage management measures.

3) Seasonal peak /daily maximum factor

JICA Study Team regards the design water consumption per capita set up in the previous section as annual average water consumption. Therefore, to estimate maximum daily water demand, daily maximum coefficient or seasonal peak factor is required.

The result of the socio-economic survey by JICA Study Team indicated that the water consumptions per capita in dry and rainy seasons are 30 L/c/d and 36 L/c/d, with average of 33 L/c/d. Therefore, seasonal variation of water consumption is 20 % between dry season and rainy season. In other words, it can be said that the rainy season's consumption is 1.1 times of the annual average consumption. In this case, therefore, the daily maximum coefficient is 1.1. The current water consumption is suppressed due to scarcity of water, especially in dray season, when the water is scarcer. Therefore, if the water consumption is not suppressed, the peak factor becomes high.

Usually, peak factor tends to be high in the area where it has very hot dry season. This is applied to Juba. On the other hand, peak factor of the larger city tends to be low because water consumption tends to be flattened due to different consumption patterns of different human activities including office, commercial and industry. The maximum daily water demand coefficient of the larger city falls between 1.1 and 1.2 in Japan. Considering very hot dry season in Juba, the maximum daily water demand coefficient is set at 1.2.

C.3.3 Water Demand Estimation

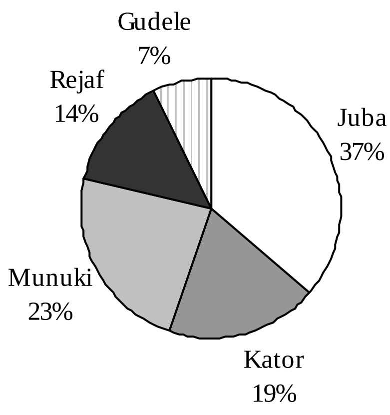
(1) Water Demand Estimation and Distribution

With the conditions set up in the previous sections, the water demands are estimated and distributed to each payam for both 2015 and 2025 in Table C.18 and Figure C.7, respectively. Domestic demand is distributed according to estimated future population distribution and targeted level of water supply service. Non-domestic demand is distributed according current land use and future land use plan.

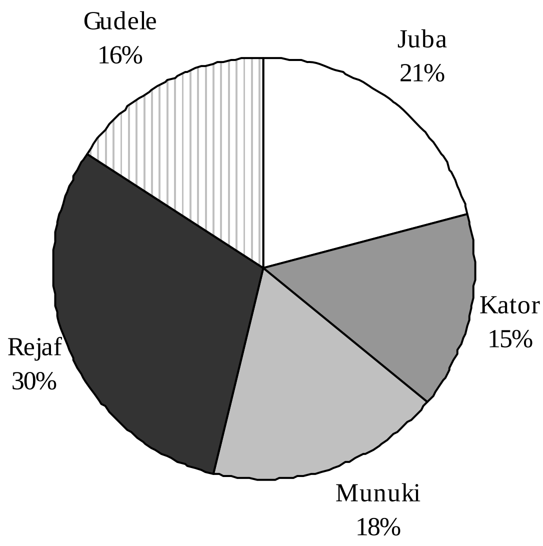
The average daily water demand in 2015 and 2025 is estimated as 58,000 m^3/day and 197,000 m^3/day, respectively and the maximum daily water demand in 2025 and 2025 is estimated as 69,000 and 237,000 m^3/day.

Table C.18 Average and Maximum Daily Water Demand Estimation and Distribution

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**



Average demand: 58,000m^3/day in 2015



Average demand: 197,000m^3/day in 2025

Figure C.7 Average Daily Water Demand Distribution

(2) Summary of Water Demand Estimation

With the conditions set up in the previous sections, the water demands are estimated in Table C.19. The maximum daily water demand in 2015 and 2025 is estimated as 69,000 m^3/day and 237,000 m^3/day, respectively.

Table C.19 Summary of Water Demand Estimation

Demand	2015	2025	Remark
Average daily water demand	58,000	197,000	Including leakage and considering usage of well
Max daily water demand	69,000	237,000	Seasonal peak / daily maximum factor is considered

C.4 Literature Review on Water Consumption

To establish design unit water consumption for domestic and non-domestic uses in case of Juba, a literature review study was carried out.

(1) Sudan

The Government of Sudan has set the goals of providing access to safe drinking water and sanitary means of human waste disposal to all its citizens. To achieve these goals, the Comprehensive National

Strategy (CNS) (1992-2002) gives priority to the following strategies: protection of water from pollution; increased community involvement; low-cost appropriate technology; and the availability of 18 liters per capita per day (L/c/d) for rural areas and 90 L/c/d for urban centers.

Source:
The damage of declining public investment on services
Dr. Hassan Abdel Ati; Dr. Galal El Din El Tayeb, National Civic Forum
http://www.socialwatch.org/en/informesNacionales/202.html

(2) Southern Sudan Guidelines

The domestic use includes water requirements for drinking, cooking, bathing, washing of clothes, utensils and house and flushing of water closets. The amount for domestic uses, however, differs from place to place and from country to country as shown in the following Table.

Domestic Use in different areas in Sudan (L/c/d)

Area	Average domestic water demand
Sudan (Khartoum)	90 - 120
Sudan (Gedarif, Kassala, Nyala)	60
Sudan (Wad Medani)	125

Source : Khartoum State Water Corporation
PWC: Feasibility study and preliminary design for Wad Medani Water Supply

The amount of domestic use rates even within the same city differs according to the standard of living, types of building and facilities, etc. In case of Sudan, the cities are classified under three categories and the design domestic demand for these categories are presented as follows:

Design Domestic Water Demand (L/c/d)

Residential Class	Khartoum	Gedarif, Kassala and Nyala towns	Wad Medani
First Class	150-200	110	200
Second Class	120-150	75	150
Third Class	80 -100	40	100
Industry	About 15 %		

For institutional uses, different countries again have different rates of demand. For comparative purposes, Table 3 shows average water requirement of some selected institutions for Germany and India. No data was available for Sudan specifically.

Water Requirement for Some Selected Institutions

Institution	Water requirement (L/c/d)	
	Germany	India
Hospitals	250-600	340-450
Schools	10-50	45-135
Offices	40-60	45
Hotels	200-600	135-180
Restaurants	100-1000	70

Water system losses from a water distribution system consists of leakage from main and service pipe connections, leakage and overflow from reservoirs, leakage and losses on un-metered household supplies, leakages from public taps, etc. This rate varies in the range of 20-50%. The lowest losses is for well maintained and fully metered distribution systems, while the highest losses is observed for cases of partly metered domestic connections and partly un-metered municipal taps. For Khartoum, it has been observed that unaccounted for water is in the range of 35-50% for the old network system and 10% for the new water supply network.

(3) Water connection and bills of UWC Juba

The following table summarizes number of connections, water bill and water bill per connection of UWC for 2007. In terms of water bill, the domestic bill occupies 58 % of total bill. The institutional water bill is as high as 28 %.

Category	Nos. of connections	Water bill		Water bill amount per connection
		(SDG)	(%)	(SDG/connection)
Domestic	2,153	341,316	0.58	159
Stand Pipe	38	27,360	0.05	720
Institutional	179	162,000	0.28	905
Commercial	97	55,200	0.09	569
Sub-total	2,467	585,876	1.00	237
New connection	298	75,990		255
Total	2,765	661,866		239

(4) Previous JICA Emergency Study in Juba, Southern Sudan

a) Targeted daily per capita consumption

In due consideration of the targeted daily per capita consumption in 2015 suggested by Gibb Africa Company in Juba Town planning (120 lpcd for a house connection, 60 lpcd for an yard connection, and 40 lpcd for a communal standpipe), the following values are adopted.

Target Water Consumption Level in Juba (JICA Emergency Study)

Class	Population ratio by class in 2006 (%)	Target population ratio by class in 2015 (%)	Type of connection	Target Consumption (l/c/d)
High	2	15	House	120
Middle	8	40	Yard	60
Low	90	45	Communal Standpipe	40

Note: Based on the goal of achieving decrease in the ratio of the poor in South Sudan from 90% at present to 45% according to the MDG.

Daily Average Consumption per Capita

Class	Type of connection	2006	2011	2015
High	House Connection	100	111	120
Middle	Yard Connection	50	56	60
Low	Communal Standpipe	20	31	40
Average		26	46	60

Daily Average Consumption per Capita for Other Purposes

Purpose of Water Use	2006	2011	2015	Remarks
School	15	21	25	
Hospital	90	123	150	per Bed
Government office	30	36	40	
Others	30	26	40	

b) Maximum daily per capita consumption

The maximum daily per capita consumption will be applied to the targeted average per capita consumption in due consideration of load factor for seasonal changes in water consumption (water supply).

Load factor, which is the ratio of average daily per capita consumption against maximum daily per capita consumption, is set to be 0.75 considering that significant seasonal changes in water consumption is anticipated due to local conditions in Southern Sudan; the dry season is extremely hot and the rainy season is relatively cool. Accordingly, the daily average per capita consumption and daily maximum per capita consumption are shown below.

Daily Average and maximum Consumption Per Capita

Household Class	Supply Type	Daily Average Consumption per Capita			Daily Maximum Consumption per Capita		
	Year	2006	2011	2015	2006	2011	2015
High	House connection	100	111	120	133	148	160
Middle	Yard connection	50	56	60	67	75	80
Low	Public tap	20	31	40	27	41	53
Average	-	26	46	60	38	61	80

(5) Uganda

The design criteria and actual estimated levels of per capita consumption of water for different service levels in selected towns are shown in Table below:

Design Criteria and Actual Estimated Levels of Per Capita Consumption of Water

Service Level	Estimate (L/c/d)	Actual average (L/c/d)
Household connection	50- 200	70
Yard taps	40	19
Stand tap/kiosk	20	8
Rural water supply	20	13
Commercial	50-200	1,988 l/day
Hotels	50-100	
Industrial (L/ha/day)	10,000	

Source: National Water Development Report: Uganda, prepared for the 2nd UN World Water development report, 2006

The per capita consumption by user category and their ratio in Uganda were calculated in the Table below based on the National Water and Sewerage Corporation in Uganda, Annual Report, 2006-2007.

Per Capita Consumption by User Category and Ratio in Uganda

Category	No. of connection	Volume of Water billed		Per capita consumption	Percentage
		m^3/y	m^3/d	L/c/d	(%)
Public taps	5,317	2,076,173	5,688		5
Domestic	149,478	19,672,409	53,897	60	48
Institutional/Government	5,504	9,837,446	26,952	30	24
Industrial/Commercial	20,397	9,262,629	25,377	28	23
	180,696	40,848,657	111,914	118	100

Note: The per capita consumption was calculated based on the estimated service population (896,868: 6 persons/no of domestic connection).
Source: National Water and Sewerage Corporation, Annual Report, 2006-2007 National Water and Sewerage Corporation (NWSC).

(6) Kenya

The following Table explains recommended consumption rates in urban area in Kenya.

Recommended Consumption Rates in Urban Area in Kenya (L/c/d)

Consumer	High class housing	Medium class housing	Low class housing
House connections	250	150	75
People without connections	NA	NA	20
Boarding school		50	
Day schools With WC Without WC		 25 5	
Clinic		5000	
Administrative offices		25	

Source: MW&I Draft Water Practice Manual, 2005

(7) South Africa

The design standards of domestic water demand equipped with standpipes, yard connections and house connections in South Africa is shown in the Table below.

Design Standards for Domestic Water Demand in South Africa

Type of Water Supply	Type of Consumption (L/c/d)	Range (L/c/d)
Standpipe (200 m walking)	25	10-50
Yard Connection With dry sanitation With LOFLOs With full-flush sanitation	55	50-100 30-60 45-75 60-100
House connection (developed areas) Development level: Moderate Moderate to high High Very high	 80 130 250 450	60-475 48-98 80-145 130-280 260-480

Source: South African Water Demand Guidelines "Red Book"

(8) Egypt

Egypt National Standards for Water Consumption

Consumption Case	Average annual consumption L/c/d	Water loss in the network L/c/d	The total average consumption L/c/d	Industrial use
City	150	(15-30)	(165-180)	2 L/ha/sec
Villages up to 50,000	125	(10-25)	(135-150)	2 L/ha/sec

(9) Reference on Minimum Water Requirements

The normal water requirement of human body for an adult in a temperate climate is about 2.2 L/day, though some of this will be obtained from food. In a hot humid climate, the requirement can exceed 9 L/day. Apart from this, water is required for personal ablutions, cooking and washing dishes, laundering, house cleaning, and toilet flushing (if any).

Following Table shows estimated actual consumption obtained during two studies in areas where water is scarce, either through lack of availability or inadequate facilities. They may be considered to give an indication of the minimum supplies likely to be acceptable to consumers.

Estimated Minimum Water Requirements (l/c/d)

Source	Male, Maldives		Kathmandu, Nepal
	Private wells	Piped	Standpipes
Drinking, cooking, dishwashing, house cleaning	7 -15	15	10.5
Laundering	8-10	5	5
Ablutions	20-40	44.5	17.5
Toilet flushing			
Cistern flush	15	45	
Hand flush	8	17.5	2.5
Other uses	-	8	4
Total	43-73	90-117.5	39.5

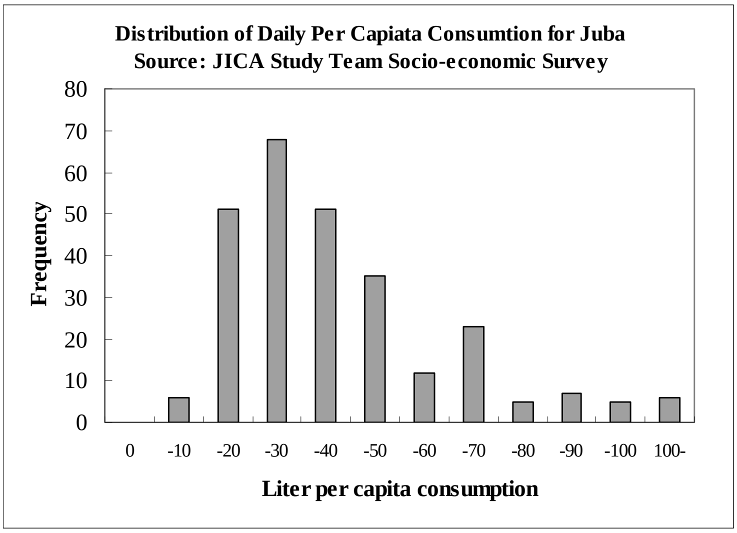
Source: Water Practice Manuals, Water Supply and Sanitation in Developing Countries, The Institute of Water Engineers and Scientists, 1983.

(10) Socio-economic survey in Juba (JICA Study Team)

JICA study team carried out socio-economic survey on water use in December 2008. Table below shows the result of water consumption per household and capita by season. The water supply methods of the surveyed households include piped water, public taps and tanker truck. The average per capita water consumption is 33 L/c/d. Figure below shows distribution of the daily per capita consumption. Out of 270 samples, about 70 households use 20- 30 L/c/d, which falls in the highest frequency range.

Estimated Water Consumption Per Capita

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



Distribution of Daily Per Capita Consumption

APPENDIX – D

TRANSMISSION AND DISTRIBUTION FACILITY PLAN

APPENDIX - D TRANSMISSION AND DISTRIBUTION FACILITY PLAN

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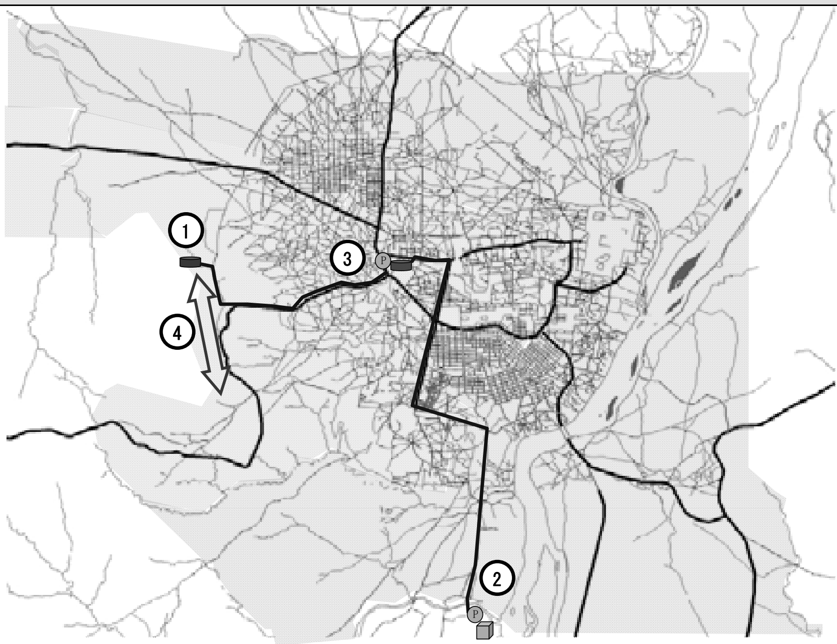
D.1 Alternatives of High Distribution Zone

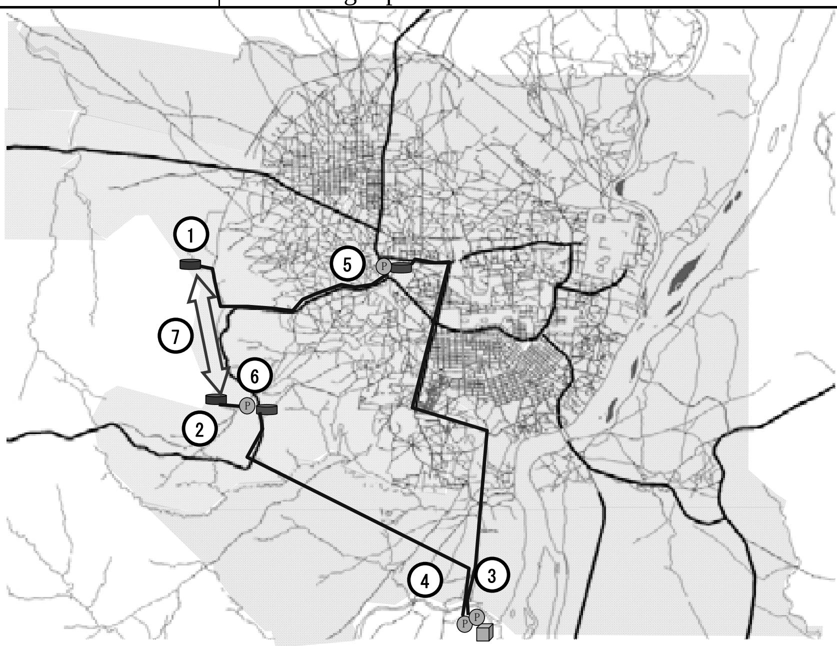
Alternative-1

2015



1	North High SR	Capacity = 10,000m^3
2	Transmission facilities	Flow = 51,000m^3/day, Pipe = Dia.1000mm/8.5km, Pump Head = 90m
3	Transmission facilities	Flow = 30,000m^3/day, Pipe = Dia.700mm/4.2km, Pump Head = 45m
4	Distribution main	Connecting Pipeline between reservoirs

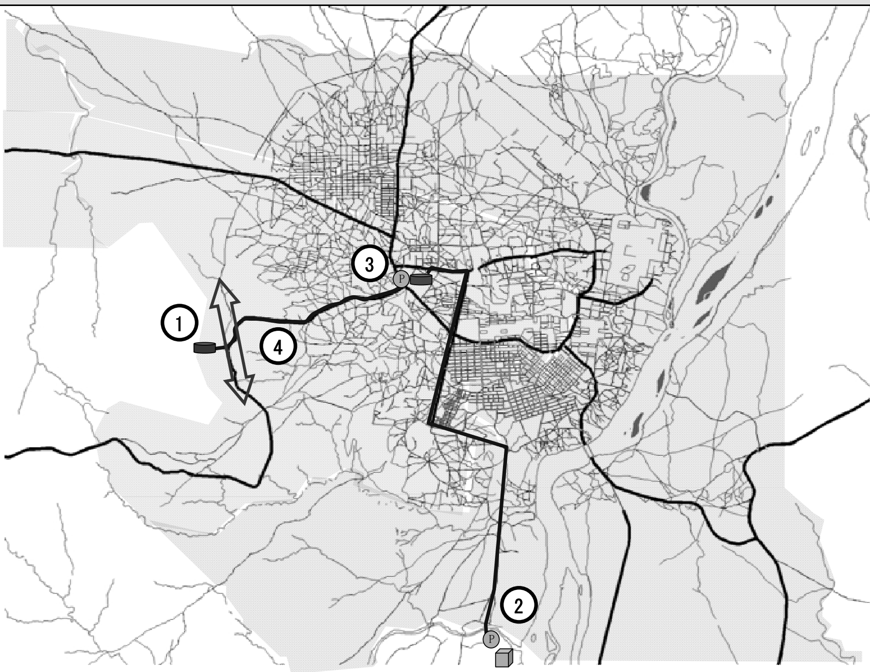
2025



1	North High SR	Capacity = 16,000m^3
2	South High SR	Capacity = 16,000m^3
3	Transmission facilities	Flow = 107,000m^3/day, Pipe = Dia.1000mm/8.5km, Pump Head = 90m
4	Transmission facilities	Flow = 79,000m^3/day, Pipe = Dia.900mm/5.9km, Pump Head = 85m
5	Transmission facilities	Flow = 48,000m^3/day, Pipe = Dia.700mm/4.2km, Pump Head = 45m
6	Transmission facilities	Flow = 48,000m^3/day, Pipe = Dia.700mm/1.5km, Pump Head = 40m
7	Distribution main	Connecting Pipeline between reservoirs

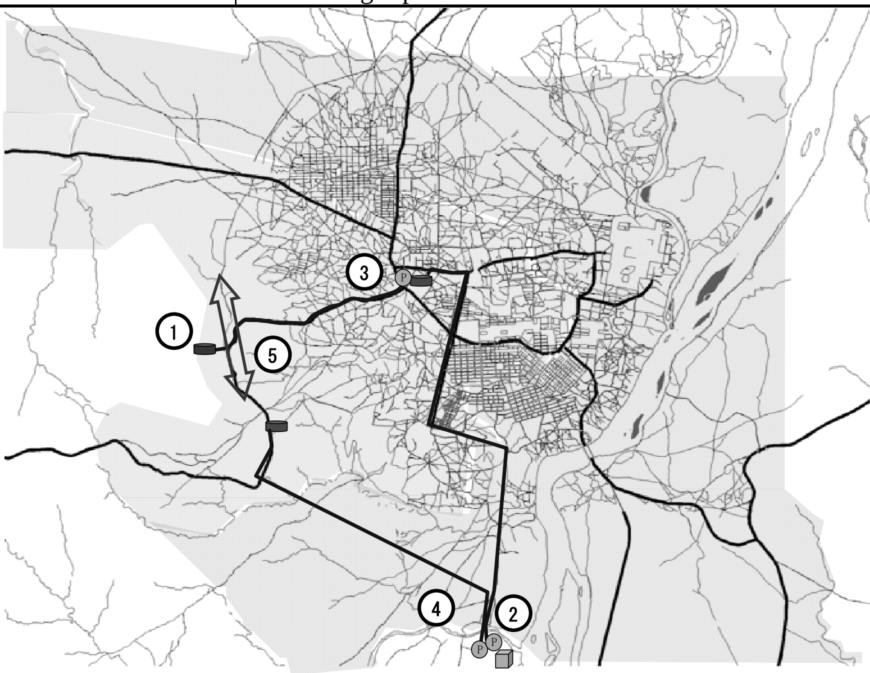
Alternative-2

2015



1	High SR	Capacity = 10,000m^3
2	Transmission facilities	Flow = 51,000m^3/day, Pipe = Dia.1100mm/8.5km, Pump Head = 95m
3	Transmission facilities	Flow = 31,000m^3/day, Pipe = Dia.900mm/4.2km, Pump Head = 45m
4	Distribution main	Connecting Pipeline between reservoirs

2025



1	High SR	Capacity = 32,000m^3
2	Transmission facilities	Flow = 155,000m^3/day, Pipe = Dia.1100mm/8.5km, Pump Head = 95m
3	Transmission facilities	Flow = 96,000m^3/day, Pipe = Dia.900mm/4.2km, Pump Head = 45m
4	Transmission facilities	Flow = 31,000m^3/day, Pipe = Dia.600mm/5.9km, Pump Head = 85m
5	Distribution main	Connecting Pipeline between reservoirs