APPENDIX-M

EFFECTIVE UTILISATION OF WATER RESOURCES FOR PHASE II PROJECT

APPENDIX M

EFFECTIVE UTILISATION OF WATER RESOURCES FOR PHASE II PROJECT

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APPENDIX M
EFFECTIVE UTILISATION OF WATER RESOURCES FOR PHASE II PROJECT

M1. Introduction

Under the Phase I Project, a new water treatment works with a capacity of 40,000 m3/day is planned to be constructed at Kibuye. The raw water for the works, which amounts to 42,500 m3/day including water losses at the works, is planned to be taken form the Kibos and Awach rivers by gravity.

It is envisaged that the capacity of the treatment works would have to be doubled under the Phase II Project, and that water from the Lake Victoria should be used for this expansion on the ground that the amount of raw water available from the Kibos and Awach rivers alone would be insufficient to meet a total raw water requirement of 85,000 m3/day (42,500 + 42,500) for the Kibuye WTW under the Phase II Project.

Meanwhile, the results of the JICA water resources study indicated that 85,000 m3/day of raw water can be abstracted from the Kibos and Awach rivers for a continuous period of 10 months a year with a high level of assurance and without constructing any additional water holding structures such as a dam, and that during the remaining 2 months, typically in the dry season, however, the amount of water available from the two rivers might fall below the requirement.

Water from the Lake Victoria needs a pumping head of about 80 meters to reach the Kibuye WTW while that from the Kibos and Awach rivers can gravitate to the works if pipelines with an adequate carrying capacity are provided. In addition, water from the two rivers is far superior in terms of water quality to that of the Lake Victoria.

Taking cognisance of the above, JICA Study Team developed the following alternatives, exploring the possibility of effectively utilizing the Kibos and Awach rivers as the major source of raw water for the Kibuye WTW even under the Phase II Project.

Alternative 1: to intake 42,500 m3/day from the Lake Victoria throughout the year

Alternative 2: to intake 42,500 m3/day from the Lake Victoria during 2 months and to take the same amount from the Kibos and Awach rivers during the remaining 10 months.

It should be noted that, in either of the above two alternative cases, the arrangement of raw water for the new Kibuye WTW under the Phase I Project remains the same, which is to construct new water transmission pipelines and take 42,500 m3/day of water from the Kibos and Awach rivers throughout the year.

M2. Alternative Cases for Phase II

The two alternative cases are schematically shown in Figure M-1.

In the case of Alternative 1, no pipelines from the Kibos and Awach rivers to the new Kibuye WTW will be required under the Phase II Project. Instead, electricity cost for pumping 42,500 m3/day of water from the Lake Victoria will be required throughout the year.

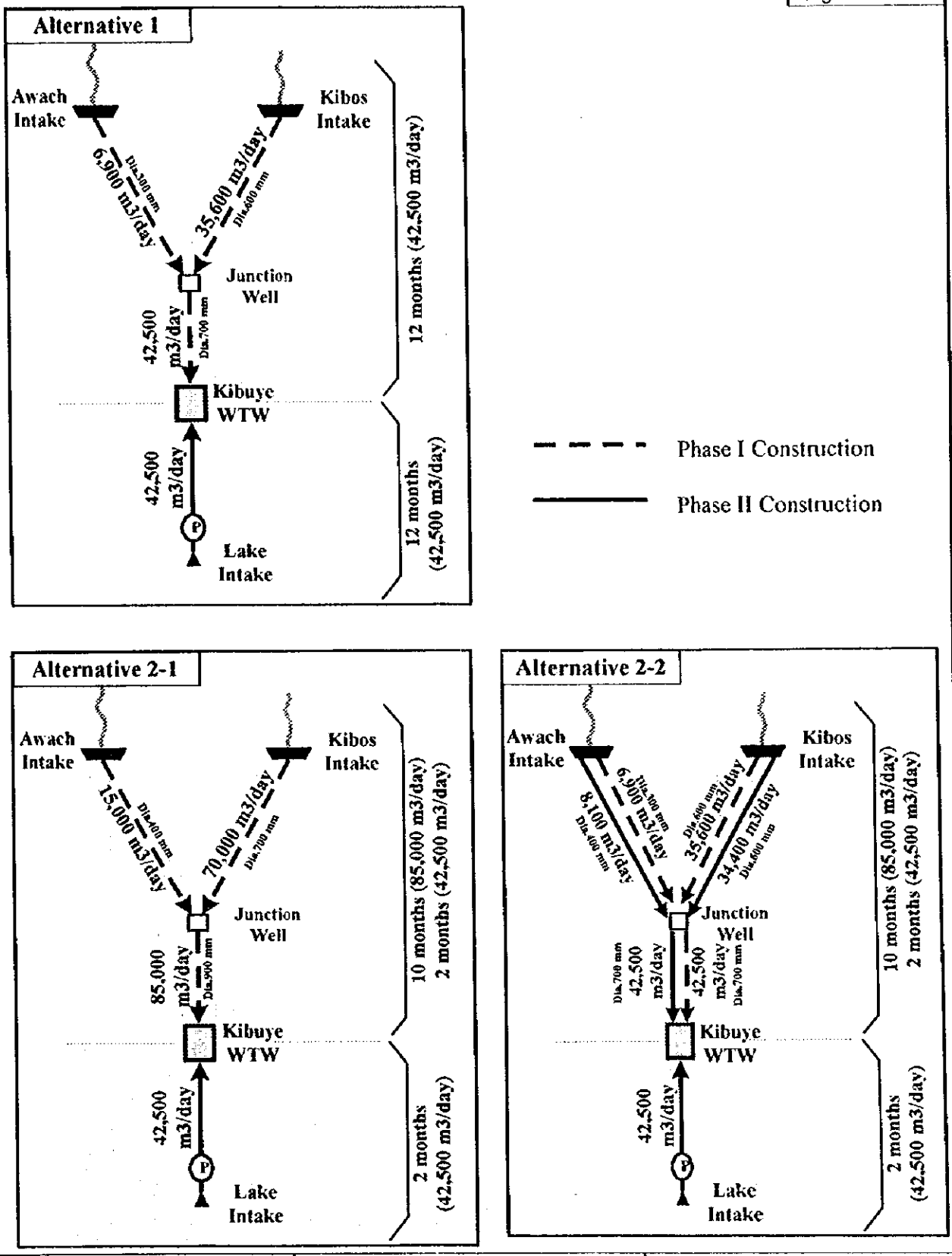
Alternative 2 will require the construction of raw water transmission pipelines through which 42,500 m3/day of water from the Kibos and Awach rivers will gravitate to the Kibuye WTW during a continuous period of 10 months a year. Only during the remaining 2 months will 42,500 m3/day of water be pumped to the treatment works from the Lake Victoria under this alternative.

With respect to the timing of construction, Alternative 2 was further developed into two sub-alternatives, i.e. Alternative 2-1 and Alternative 2-2.

Alternative 2-1 assumed that raw water transmission pipelines to be constructed under the Phase I Project would be provided from the outset with a larger capacity which can meet the Phase II requirement. It was presumed in this case that the incremental cost to be required for providing such an additional capacity would be less insignificant if done at the time of initial construction than in the case it is done at a later stage. Although the incremental cost would be marginal, however, this alternative will result in an over-investment of capital cost, which will continue for some time until the Phase II Project has been actually materialised.

Alternative 2-2 assumed that new raw water transmission pipelines will be constructed during the implementation period of the Phase II Project, duplicating those constructed under the Phase I Project. It was presumed in this case that, although a full construction cost is required, the timing for the investment of the cost can be delayed a few years than in the case of Alternative 2-1.

Figure M-1



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Schematic Flow of Alternatives for Phase II

M3. Construction Cost of Raw Water Transmission Pipelines for Phase II

For each of the three alternative cases, the incremental pipeline cost for the Phase II Project was estimated at 1997 price.

Alternative 1

There will be no incremental pipeline cost for Phase II.

From	To	Q m3/day	Length m	Diameter mm	Unit Cost US$	Cost US$
Kibos	Junction Well	35,600	6,900	600	340	2,346,000
Awach	Junction Well	6,900	6,000	300	140	840,000
Junction Well	Kibuye WTW	42,500	5,900	700	414	2,442,600
					Total	5,628,600

Phase I Cost 5,628,600
Phase II Incremental Cost 0

Alternative 2-1

Incremental cost for Phase II can be assumed to be equal to the balance between this alternative and Alternative 1.

From	To	Q m3/day	Length m	Diameter mm	Unit Cost US$	Cost US$
Kibos	Junction Well	70,000	6,900	700	414	2,856,600
Awach	Junction Well	15,000	6,000	400	203	1,218,000
Junction Well	Kibuye WTW	85,000	5,900	900	571	3,368,900
					Total	7,443,500

Phase I Cost 7,443,500
Phase II Incremental Cost 1,814,900
(7,443,500-5,628,600)

Alternative 2-2

From	To	Q m3/day		Length m	Diameter mm	Unit Cost US$	Cost US$
Kibos	Junction Well	Ph-I	35,600	6,900	600	340	2,346,000
		Ph-II	34,400	6,900	600	340	2,346,000
Awach	Junction Well	Ph-I	6,900	6,000	300	140	840,000
		Ph-II	8,100	6,000	400	203	1,218,000
Junction Well	Kibuye WTW	Ph-I	42,500	5,900	700	414	2,442,600
		Ph-II	42,500	5,900	700	414	2,442,600
						Total	11,635,200

Phase I Cost 5,628,600
Phase II Incremental Cost 6,006,600

M4. Energy Costs for Phase II

Energy costs were calculated as follows:

Energy consumption at Lake Intake Station	4,955,000 KWH/year
Monthly Consumption	412,917 KWH
Unit Energy Cost	5.55 Ksh/KWH
Monthly Energy Cost	2,291,688 Ksh
Energy Cost for 2 months	4,583,376 Ksh
Energy Cost for 12 months	27,500,256 Ksh

M5. Present Value Analysis of Alternatives

The three alternatives were evaluated in terms of capital and energy costs using the present value analysis method. In doing so, costs which are common to each alternative were neglected as they are irrelevant to this comparison. The analysis was conducted for a period of 30 years at a discount rate of 5 % per annum.

Table M-1 shows the results of the analysis. As can be seen in the table, Alternative 2-1 was found to be the least cost solution among the three. It is therefore recommended in this study that the raw water transmission pipelines from the Kibos and Awach rivers to the Kibuye WTW to be constructed under the Phase I Project be sized from the outset to be able to accommodate the Phase II raw water requirement of 85,000 m3/day, and that the Kibuye WTW after the Phase II Project be operated with raw water from the two rivers during 10 months a year, or even for a longer period of time if water is available from the two rivers. These arrangements will result in a saving of energy cost and the ease of operation and maintenance both at the Lake Intake Station and at the Kibuye WTW.

Table M-1 Comparison of Present Values - Discount Rate 5%

Discount Rate (%) 5.0%			Alternative 1				Alternative 2-1				Alternative 2-2			
			Pipe Cost	Energy	Total	P.V.	Pipe Cost	Energy	Total	P.V.	Pipe Cost	Energy	Total	P.V.
		Total	0	10,803,670	10,803,670	4,375,112	1,814,900	1,800,612	3,615,512	2,186,758	6,006,600	1,800,612	7,807,212	4,896,326
0	1997	1.00000			0	0			0	0			0	0
1	1998	0.95238			0	0			0	0			0	0
2	1999	0.90703			0	0			0	0			0	0
3	2000	0.86384			0	0			0	0			0	0
4	2001	0.82270			0	0	907,450		907,450	746,561			0	0
5	2002	0.78353			0	0	907,450		907,450	711,011			0	0
6	2003	0.74622			0	0			0	0			0	0
7	2004	0.71068			0	0			0	0	3,003,300		3,003,300	2,134,389
8	2005	0.67684			0	0			0	0	3,003,300		3,003,300	2,032,752
9	2006	0.64461		491,076	491,076	316,552		81,846	81,846	52,759		81,846	81,846	52,759
10	2007	0.61391		491,076	491,076	301,478		81,846	81,846	50,246		81,846	81,846	50,246
11	2008	0.58468		491,076	491,076	287,122		81,846	81,846	47,854		81,846	81,846	47,854
12	2009	0.55684		491,076	491,076	273,449		81,846	81,846	45,575		81,846	81,846	45,575
13	2010	0.53032		491,076	491,076	260,428		81,846	81,846	43,405		81,846	81,846	43,405
14	2011	0.50507		491,076	491,076	248,027		81,846	81,846	41,338		81,846	81,846	41,338
15	2012	0.48102		491,076	491,076	236,216		81,846	81,846	39,369		81,846	81,846	39,369
16	2013	0.45811		491,076	491,076	224,968		81,846	81,846	37,495		81,846	81,846	37,495
17	2014	0.43630		491,076	491,076	214,255		81,846	81,846	35,709		81,846	81,846	35,709
18	2015	0.41552		491,076	491,076	204,052		81,846	81,846	34,009		81,846	81,846	34,009
19	2016	0.39573		491,076	491,076	194,335		81,846	81,846	32,389		81,846	81,846	32,389
20	2017	0.37689		491,076	491,076	185,081		81,846	81,846	30,847		81,846	81,846	30,847
21	2018	0.35894		491,076	491,076	176,268		81,846	81,846	29,378		81,846	81,846	29,378
22	2019	0.34185		491,076	491,076	167,874		81,846	81,846	27,979		81,846	81,846	27,979
23	2020	0.32557		491,076	491,076	159,880		81,846	81,846	26,647		81,846	81,846	26,647
24	2021	0.31007		491,076	491,076	152,267		81,846	81,846	25,378		81,846	81,846	25,378
25	2022	0.29530		491,076	491,076	145,016		81,846	81,846	24,169		81,846	81,846	24,169
26	2023	0.28124		491,076	491,076	138,111		81,846	81,846	23,018		81,846	81,846	23,018
27	2024	0.26785		491,076	491,076	131,534		81,846	81,846	21,922		81,846	81,846	21,922
28	2025	0.25509		491,076	491,076	125,270		81,846	81,846	20,878		81,846	81,846	20,878
29	2026	0.24295		491,076	491,076	119,305		81,846	81,846	19,884		81,846	81,846	19,884
30	2027	0.23138		491,076	491,076	113,624		81,846	81,846	18,937		81,846	81,846	18,937

Pipe Cost	Alt. 1	0 US$
	Alt. 2-1	1,814,900 US$
	Alt. 2-2	6,006,600 US$

US$ 1 = 56 Ksh

Energy Cost for Q=42,500m3/day	2,291,688 Ksh/month	40,923 US$/month
	4,583,375 Ksh/2months	81,846 US$/2months
	27,500,250 Ksh/year	491,076 US$/year

APPENDIX-N

WATER AND SLUDGE QUALITY SURVEY

APPENDIX N
WATER AND SLUDGE QUALITY SURVEY

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N1. INTRODUCTION

(1) Objectives

Water and Sludge Quality Surveys were carried out as a part of the Study on Kisumu Water Supply and Sewerage System. The Surveys consists of following three parts. The objectives of each parts of the Survey are as follows;

1) Water Quality Survey for Water Supply System

- To investigate and evaluate water quality at proposed intake sites of Alternative Water Resources in Master Plan
- To investigate and evaluate functioning of existing Water Treatment Works in Kisumu Municipality
- To investigate and evaluate quality of supplied water in Kisumu Municipality

2) Water Quality Survey for Sewerage System and Lake

- To investigate and evaluate functioning of existing Sewage Treatment Works in Kisumu Municipality
- To investigate and evaluate water quality condition in Kisumu Bay

3) Sludge Quality Survey

- To investigate and prepare data of sludge condition in Sewage Treatment Works

(2) Operation of the Survey

The sampling and analysis works of the Survey were conducted by Jomo Kenyatta University of Agriculture and Technology, as sub-contract works of the Study.

The analysis works were conducted based on "STANDARD METHOD", 1989, 17th edition. Analysis procedures for each parameter are shown in Table N1-1.

(3) Study Period

The first survey was conducted in September, 1997, and the second survey was conducted in February and March, 1998.

Table N1-1 Method of Analysis

Parameter	Procedure (standard method)
1. Temperature	Celsius thermometer
2. pH	pH meter
3. Color	Colimeter cylinders and/or visual comparison
4. Odor	Threshold odor test
5. Taste	Flavour threshold test (FIT)
6. Turbidity	Turbidity meter, nephelometric method (NTU)
7. Electrical conductivity	Conductivity meter
8. Hardness	EDTA method
9. Hydrogen sulphide	Standard method
10. DO	DO meter
11. COD	Di-cromate reflux titrimetric method
12. BOD	5-day BOD test
13. SS	Filtration, oven-dried at 105±2℃
14. TN	Spectrophotometry at 220 nm
15. Ammonia nitrogen	Phenate method
16. T-P	Ascorbic acid procedure and spectrophotometry at 880 nm
17. Iron	Atomic absorption spectrophotometry (ASS)
18. Manganese	Persulphate method
19. Copper	Atomic absorption spectrophotometry (ASS)
20. Lead	Atomic absorption spectrophotometry (ASS)
21. Arsenic	Atomic absorption spectrophotometry (ASS)
22. Cadmium	Atomic absorption spectrophotometry (ASS)
23. Chromium	Atomic absorption spectrophotometry (ASS)
24. Hexavalent	Atomic absorption spectrophotometry (ASS)
25. Cyanide	Atomic absorption spectrophotometry (ASS)
26. Total mercury	Atomic absorption spectrophotometry (ASS)
27. Floride	Method to be specified
28. Chloride	Argentometric method
29. Total coliform counts	Mebrane filter technique
30. Faecal coliform count	Mebrane filter technique
31. Sludge water content	Gravimetric method
32. Chlorophyll a	Trichromatic method

N2. WATER QUALITY SURVEY FOR WATER SUPPLY SYSTEM

N2.1 Water Quality at Proposed Intake Sites

The proposed intake sites in Master Planning Stage of the Project were located as shown in Figure N2-1. The details of the proposed intake sites are described in Appendix (A). Sampling and water quality analysis at each points were conducted as follows;

	First Survey	Second Survey
1) Lake Victoria	O	O
2) Kibos River	O	O
3) Awach/Nyangori River	O	O
4) Sondu River	O	—
5) Nyando River	O	—
6) Yala River	—	O

The results of water quality survey at the proposed intake are shown in Table N2-1-1 and Table N2-1-2, respectively. For the reference, water quality records in the report of "Kisumu Water Supply and Sanitation Study" and "The Study on National Water Master Plan" are shown in Annex-1.

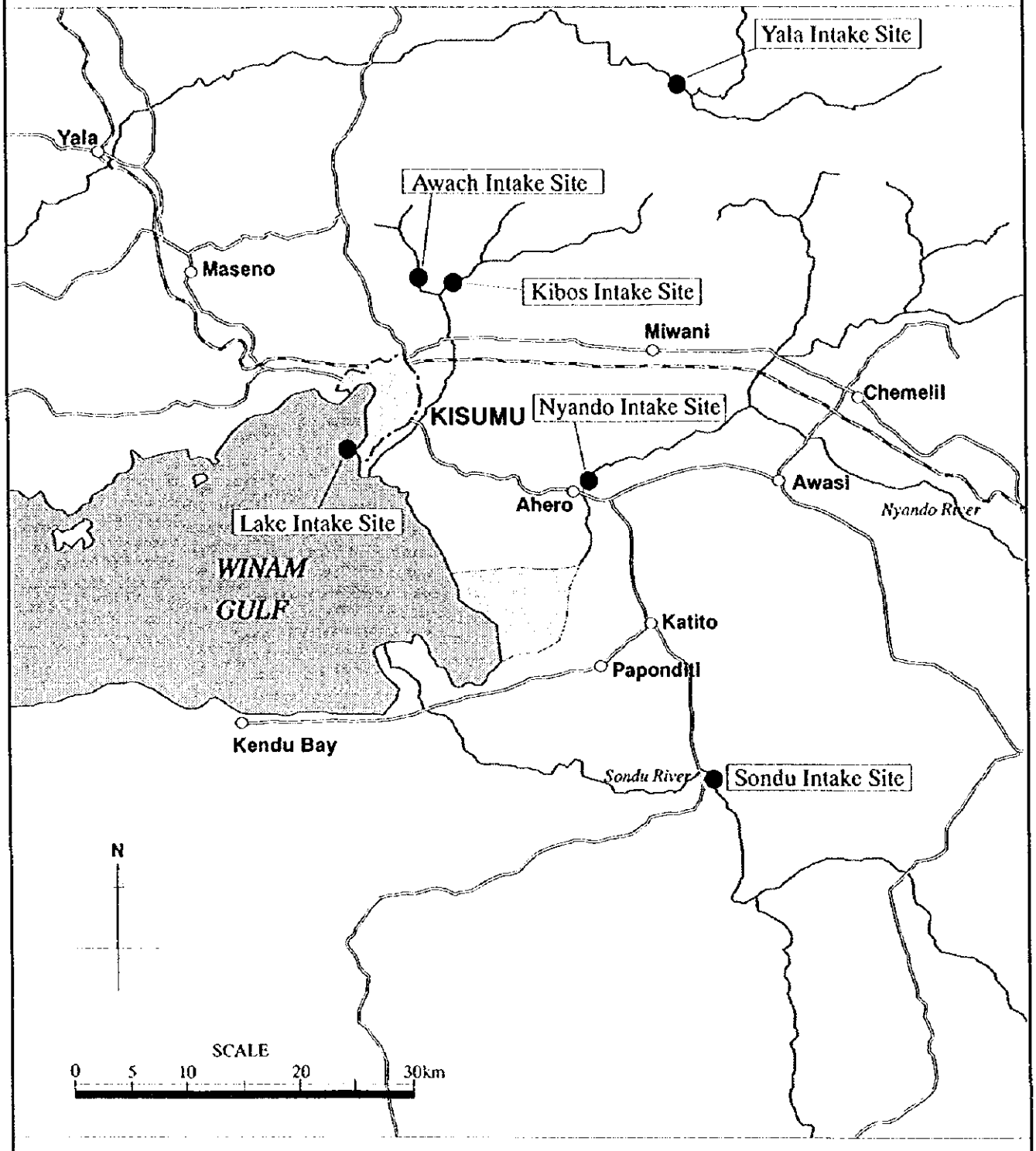
The quality level for Drinking Water Quality Standards in Kenya are indicated in "Design Manual for Water Supply in Kenya" prepared by Ministry of Water Development. The standards are attached in Table NA2-1 in Annex-2.

Based on above data, the proposed intake sites are evaluated as follows:

1) Water quality of all sites are generally acceptable for raw water abstraction, because no water quality items exceeded the level of Drinking Water Quality Standards on constituents of health significance, which is shown in Table NA2-1.

2) Even present water quality is acceptable, any water sources may be deteriorating due to development in the basins. Pollution source control in the basin of proposed intake sites are required for conservation of water quality.

Figure N2-1



THE REPUBLIC OF KENYA MINISTRY OF LOCAL AUTHORITY KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE **Sampling Points for Proposed Intake Sites**

Table N2-1-1 Water Quality at Proposed Intake Sites, at First Survey

Parameter \ River	Kibos	Awach/Nyangori	Sondu	Nyando	Lake Victoria
Ambient Temp. (℃)	27	33	28	29	29
Water Temp. (℃)	19	22	20	24	28
pH	7.9	7.5	8.0	8.0	8.8
Color	30	20	30	8	30
Taste & Odor (Thresh.No.)	1	1	1	1	30
Turbidity NTU	22	80	27	107	14
Elect. Conduc μ s	92	85	41	231	152
Hardness mg/l $caco_3$	46.7	67.6	46.7	167.1	113.5
Hydrogen sulphide mg/l	0.084	0.44	0.45	0.15	0.044
Total Nitrogen mg/l	3	3	13	68	<0.2
Total Phosphorous mg/l	0.15	0.07	0.15	1.13	0.95
Iron mg/l	0.48	1.975	0.6	1.86	0.1
Mangane mg/l	<0.01	<0.01	0.07	0.07	0.01
Asernic mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
Chrome mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Copper mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanide mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Lead mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
Total Mercury mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoride mg/l	1	<0.01	0.2	0.4	0.75
Faecal coliform count/100ml	4	Nil	Nil	22	22

Table N2-1-2 Water Quality at Proposed Intake Sites, at Second Survey

River / Parameter	Kibos		Awach/Nyangori		Yala	Lake Victoria
	upstream	downstream	upstream	downstream		
Ambient Temp. (℃)	29	29	28.5	28.5	26.3	29
Water Temp. (℃)	21	22	22	23	18.8	27
pH	7.4	7.5	7.2	7.1	7.5	6.6
Color	30	30	19	19	24	30
Taste & Odor (Thresh.No.)	1.0	1.0	1.0	1.5	1.5	1.0
Turbidity NTU	20	20	43	43	37	10
Elect. Conduc μ s	80	80	100	100	90	160
Hardness mg/l $caco_3$	10.0	20.0	15.0	25.0	20.0	28.0
Hydrogen sulphide mg/l	0.00	0.00	0.00	0.00	0.02	0.14
DO mg/l	5.0	5.0	4.7	5.1	5.5	-
BOD mg/l	1.40	1.71	2.00	1.65	2.30	3.80
SS mg/l	63.33	73.33	60.00	73.33	58.29	44.00
Total Nitrogen mg/l	6.00	6.96	9.60	6.00	7.90	6.72
Total Phosphorous mg/l	0.35	0.33	0.53	0.35	0.38	-
Iron mg/l	1.23	1.10	1.88	2.00	1.88	0.50
Mangane mg/l	0.02	0.02	0.05	0.04	<0.002	0.50
Asernic mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chrome mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Cyanide mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Mercury mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoride mg/l	0.35	0.40	0.10	0.00	0.40	0.80
Faecal coliform count/100ml	0	0	40	40	10	1

N2.2 Water Treatment Works

The water quality survey on Water Treatment Works were carried out at two water treatment works, namely Kajulu Water Treatment Works and Lake Water Treatment Works. The water sampling and analysis were conducted as follows;

	First Survey	Second Survey
Kajulu Water Treatment Works		
- Intake Site (raw water)	O	O
- Water after Sedimentation Tank	O	—
- Effluent (treated water)	O	O
Lake Water Treatment Works		
- Intake Site (raw water)	O	O
- Water after Sedimentation Tank	O	—
- Effluent (treated water)	O	O

The results of the water quality analysis are shown in Table N2-2-1 and N2-2-2. Treated water quality in the both of water treatment works are acceptable for drinking water, because all of the quality items do not exceed the level of water quality standard on constituents of health significance. The pH value of effluent from Kajulu WTW at the first survey is recorded at 6.0 against 6.5-8.0 of the standard of permissible aesthetic quality. At the second survey, it is recorded 6.5.

As described in Section N2-3, residual chlorine value of tap water supplied from Kajulu WTW is comparatively higher than supplied water from Lake WTW. Residual chlorine of effluent of Kajulu WTW is recorded 4.0 mg/L, comparing with 1.4 mg/L of Lake WTW.

Adjustment of pH is therefore required more strictly in chemical mixing process in Kajulu WTW.

Table N2-2-1 Water treatment Works, at First Survey

Parameter	Kajulu water treatment works			Lake water treatment works		
	Inlet	After Sedimetation	Outlet	Inlet	After Sedimetation	Outlet
Ambient Temp. (℃)	27	22	23	29	31	30
Water Temp. (℃)	19	19	19	28	28	27
pH	7.9	5.6	6.0	8.8	6.7	7.2
Color	1	1	1	3.5	2.5	1
Taste & Odor (Thresh.No.)	30	>30	>30	30	>30	>30
Turbidity NTU	22	3	7	14	0.0	0.0
Electrical conductivity mg/l	82	100	106	152	166	177
Hardness mg/l $caco_3$	46.7	67.6	60.1	113.5	93.5	106.8
Hydrogen sulphide mg/l	0.084	0.31	0.28	0.044	1.3	1.05
Total Nitrogen mg/l	3	1	8	<0.2	3	<0.2
Total Phosphorous mg/l	0.15	0.15	0.07	0.95	0.17	0.06
Iron mg/l	0.48	0.02	0.05	0.1	<0.01	0.03
Mangane mg/l	<0.01	0.01	0.01	0.01	<0.01	<0.01
Asernic mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chrome mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanide mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Mercury mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoride mg/l	1.00	0.50	0.40	0.75	0.75	0.55
Faecal coliform count/100ml	4	4	Nil	22	18	Nil

Table N2-2-2 Water Quality of Water treatment Works, at Second Survey

Parameter	Kajulu water treatment works		Lake water treatment works	
	Inlet	Outlet	Inlet	Outlet
Ambient Temp. (℃)	29	29	29	29
Water Temp. (℃)	19	20	27	26
pH	7.5	6.5	6.6	6.6
Color	>30	>30	>30	>30
Taste & Odor (Thresh.No.)	1	1	1	1
Turbidity NTU	21	3	10	1
Electrical conductivity mg/l	90	120	160	170
Hardness mg/l $caco_3$	16.0	28.0	28.0	20.0
Hydrogen sulphide mg/l	0.021	0.031	0.14	0.14
BOD mg/l	2.5	—	3.8	—
SS mg/l	63.0	—	44	--
Total Nitrogen mg/l	5.28	6.96	6.72	3.36
Iron mg/l	1	0.14	0.5	0.094
Mangane mg/l	1.00	0.14	0.50	0.094
Asernic mg/l	<0.01	<0.01	<0.01	<0.01
Cadmium mg/l	<0.05	<0.05	<0.05	<0.05
Chrome mg/l	<0.05	<0.05	<0.05	<0.05
Coppe mg/l	<0.02	<0.02	<0.02	<0.02
Cyanide mg/l	<0.05	<0.05	<0.05	<0.05
Lead mg/l	<0.02	<0.02	<0.02	<0.02
Total Mercury mg/l	<0.02	<0.02	<0.02	<0.02
Fluoride mg/l	0.7	0.3	0.8	0.3
Faecal coliform count/100ml	0	0	1	0
Residual Chlorine mg/l	—	4.00	--	0.14

N2.3 Quality of Supplied Water

Water supply system in Kisumu Municipality consists of municipal water supply system (by tap water) and community water supply system. Municipal water supply has two sources, one is Kibos River through Kajulu Water Treatment Works and another is Lake Victoria through Lake Water Treatment Works. Water sources of community water supply consist of spring water, Deep wells, shallow wells and Lake Victoria.

N2.3.1 Municipal Water Supply

Locations of the sampling points in municipal water distribution system are shown in Figure N2.3. The Survey was carried out two times on each ten points as below. Tap water at the sampling points A1 and A2 are supplied from Kajulu WTW, and others are supplied from Lake WTW.

	Source	Location	First Survey	Second Survey
A1	Kajulu WTW	Water Kiosk, Kanyakwar	O	O
A2	Kajulu WTW	Housing Area / Manboleo, Kanyakwar	O	O
A3	Lake WTW	Golf Course, Kibuye	O	O
A4	Lake WTW	Nyanza Club, Milimani	O	O
A5	Lake WTW	Lions High School, Milimani	O	O
A6	Lake WTW	Anderson, Kibuye	O	O
A7	Lake WTW	Kowino Market, Nyalenda	O	O
A8	Lake WTW	Pand Pieri Primary School, Nyalenda	O	O
A9	Lake WTW	Agip Petrol Station, Milimani	O	O
A10	Lake WTW	Kenol Petrol Station, Kibuye	O	O

Water qualities of the above are recorded various level, not uniformity, especially on residual chlorine and turbidity. The residual chlorine in the area served by Kajulu WTW is definitely higher than the area served by Lake WTW. The values of residual chlorine are recorded between 0.07 and 1.42 mg/L in First Survey, between 0.04 and 3.70 in Second Survey. The values of turbidity are between 3 and 17 NTU in First Survey, between 2 and 13 NTU in Second Survey. Improvement of the tap water quality is necessary throughout the service area to meet the Drinking Water Quality Standard in Kenya.

The pH value at the second survey is recorded between 6.3 and 6.7. The pH value of effluent of the both WTWs is recorded also low as described in N2.2. Proper pH adjustment is required at the both WTWs.

Figure N2-2

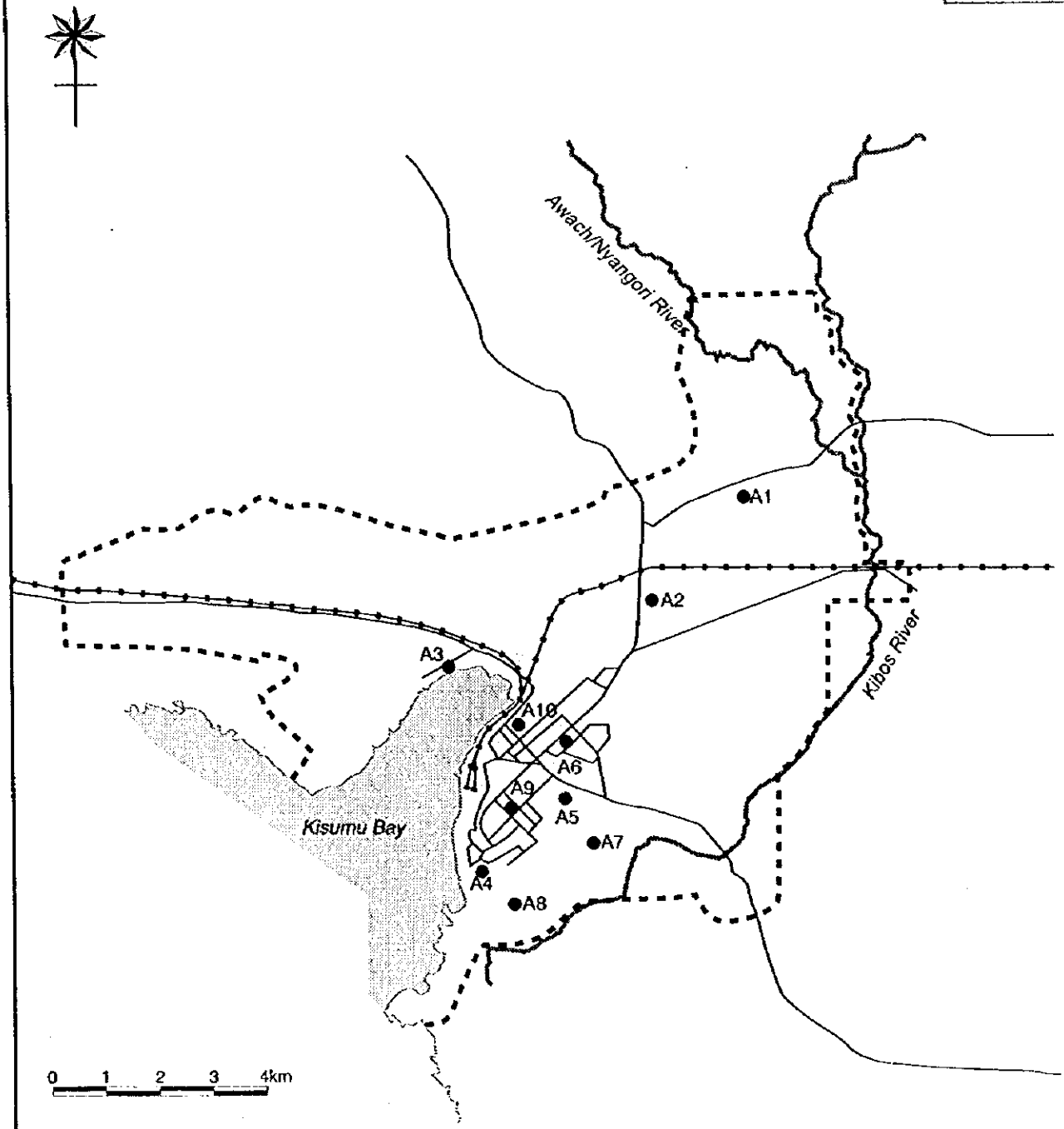


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Table N2-3-1 Quality of Municipal Water Supply, at First Survey

Parameter	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Ambient Temp. (℃)	35	30	30	28	33	32	31	27	32	32
Water Temp. (℃)	23	28	26	27	30	27	28	28	32	31
pH	6.5	6.9	7.3	7.0	7.1	7.1	7.0	7.1	7.1	7.1
Color	>30	>30	>30	>30	>30	>30	>30	>30	>30	>30
Turbidity NTU	12	3	4	8	17	5	4	10	7	4
Elect. Conduc μ s	-	-	182	172	180	168	180	177	174	177
Hardness mg/l $caco_3$	67.6	67.6	80	93.3	108.2	67.6	54	148.7	87.9	100.2
Hydrogen sulphide mg/l	1.2	0.8	0.53	0.75	0.64	0.75	0.75	0.75	0.65	0.7
Total Nitrogen mg/l	3.0	1.5	<0.2	<0.2	18	<0.2	<0.2	<0.2	3.0	3.0
Iron mg/l	0.09	0.03	0.03	0.06	0.03	0.04	0.04	0.06	0.04	0.03
Mangane mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Residue Chlorine mg/l	1.42	0.15	0.07	0.35	0.21	0.74	0.59	0.36	0.27	0.33
Faecal coliform count/100ml	(3)	Nil	(5)	Nil	Nil	Nil	(2)	(1)	(3)	(2)

Table N2-3-2 Quality of Municipal Water Supply, at Second Survey

Parameter	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Ambient Temp. (℃)	29.9	35.2	29.0	22.4	28.0	32.0	32.6	33.4	34.3	32.7
Water Temp. (℃)	23.4	23.3	27.6	25.6	26.8	26.4	27.1	27.5	29.9	29.5
pH	6.6	6.7	6.4	6.4	6.4	6.3	6.3	6.3	6.5	6.4
Color	>30	>30	>30	>30	>30	>30	>30	>30	>30	>30
Turbidity NTU	10	2	13	3	3	3	3	3	3	3
Elect. Conduc μ s	109	117	164	194	167	159	168	164	173	159
Hardness mg/l $caco_3$	30.0	28.0	32.0	30.0	36.0	32.0	28.0	26.0	28.0	28.0
Total Nitrogen mg/l	6.00	6.00	6.00	7.20	4.80	7.68	4.80	6.00	4.08	6.00
Iron mg/l	0.045	0.045	0.100	0.100	0.120	0.096	0.096	0.096	0.096	0.200
Mangane mg/l	<0.02	<0.02	0.06	0.16	0.07	0.08	0.20	0.12	0.10	0.10
Residue Chlorine mg/l	0.82	3.70	0.04	0.07	0.04	0.05	0.57	0.04	0.04	0.22
Faecal coliform count/100ml	Nil	Nil	Nil	(3)	Nil	Nil	Nil	(5)	(5)	(2)

N2.3.1 Community Water Supply

Thirteen points of water sources for community water supply are selected for the survey as below.

List of Sampling Points

	Water Source	Location	First Survey	Second Survey
B1	Spring Water	Kogweno Well, Kogony	○	○
B2	Treated River Water	Ober Kamoth, Kanyawegi	○	○
B3	Lake Victoria	Ogal Beach, Kanyawegi	○	○
B4	Deep Well	Chiga School / Kibos, Chiga	○	○
B5	Shallow Well (20m)	Nairobi Area, Migosi	○	○
C1	Shallow well (2 m)	Ober Kamoth, Kanyawegi	—	○
C2	Shallow well (2 m)	Ober Kamoth, Kanyawegi	—	○
C3	Shallow Well (2 m)	Osiri, Kanyawegi	—	○
C4	Deep Well (20 m)	Kadiju, Kadiju	—	○
C5	Deep Well (50m)	Chiga Christian Mission, Chiga	—	○
C6	Shallow Well (20 m)	Consolate Tech. Trainning Centre, Chiga	—	○
C7	Shallow Well (6 m)	Kisumu Nairobi Road, Buoye	—	○
C8	Shallow Well (3 m)	Water Kiosk, Manyatta	○	○

The locations of above points are shown in Figure N2-3. The results of the survey are shown in Table N2-4-1 and N2-4-2.

Water qualities of above thirteen points are assessed on following eight water quality items, which are listed in the Standard.

1) pH — The pH value of B1, B5, C1, C2, C7 and C8 are recorded more than 6.5 and less than 6.0 or 6.0, out of the Standard of Permissible Aesthetic Quality. However, this level is not supposed serious to human health, because Japanese Drinking Standard indicates pH values between 5.8 and 8.6.

2) Turbidity — Turbidity at B2, C1 and C2 are recorded more than 50 out of the Standard of Permissible Aesthetic Quality. Water at B2 is supplied by pipe water supply system of NWCPC. C1 and C2 are shallow wells with about 2 m depth in the same area.

3) Hardness — Hardness values at all of the sites are to meet the Standard.

4) Iron — Concentration of Iron at the points B1, B2, C1, C2, C7 are recorded out of the Standard of Permissible Aesthetic Quality, especially C1 and C2 are greatly higher than the level of the Standard. The sampling water at C1 and C2 come from wells, which are located in same area of Ober Kamouth, Kanyawegi.

5) Manganese — Manganese values at all of the sites are to meet the Standard.

6) Fluoride — Concentration of Fluoride at B4, C4, C5 are extremely higher than the level of the Standard of Constituents of Health Significance. All of the points are located in/around Chiga. It can be said that the groundwater around this area has been contaminated by Fluoride, and suitable treatment method shall be introduced for users of the groundwater around the area. High level of Fluoride is supposed to affect human health.

7) Arsenic — Arsenic values at all of the sites are to meet the Standard.

8) Fecal Coliform — Fecal Coliform has been found out at many points. Basically the water in rural water supply area shall be boiled before drinking.

Water qualities of Rivers in rural area are shown in Table N5-1.

Figure N2-3

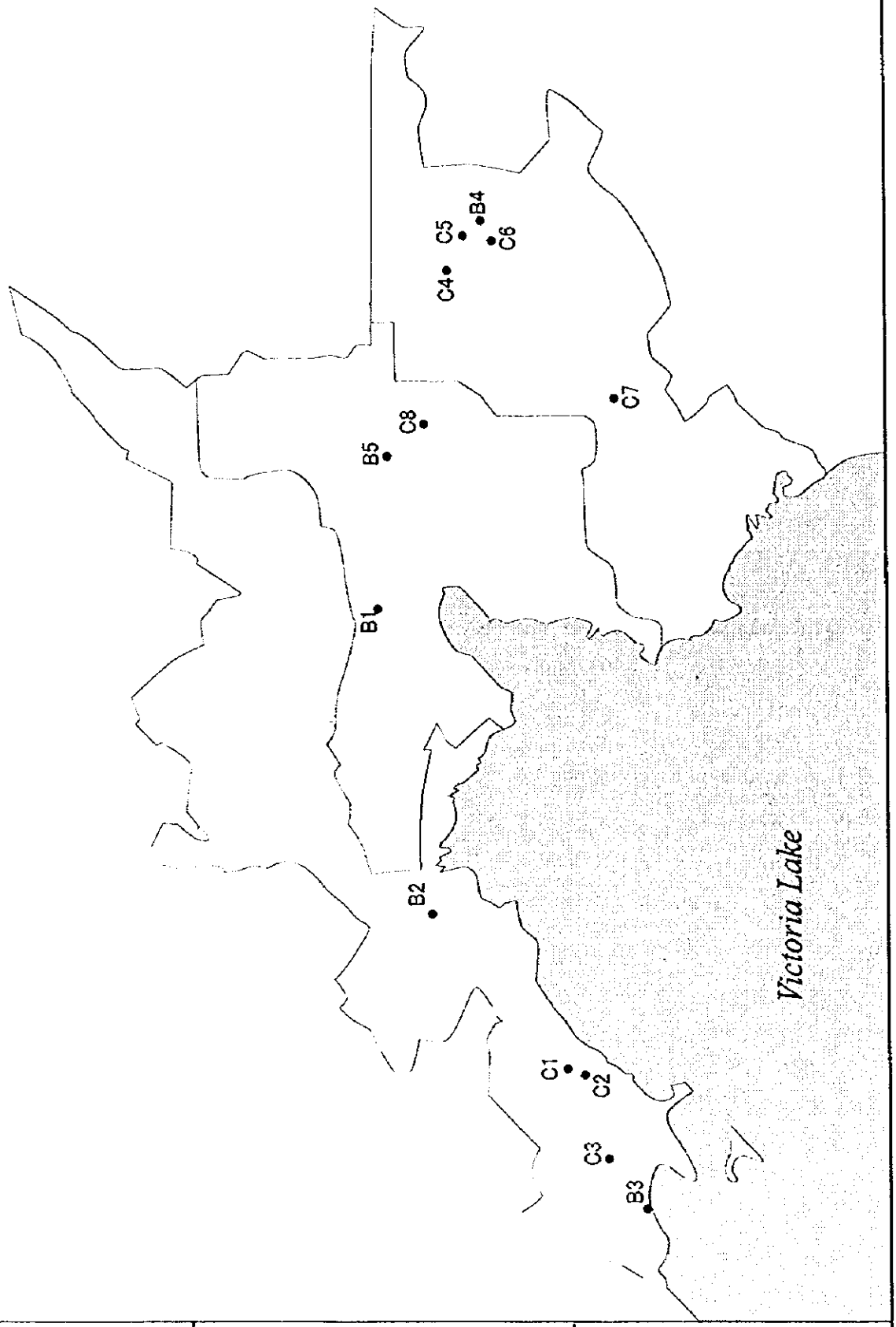

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Table N2-4-1 Quality of Rural Water Supply, at First Survey

Parameter	B1	B2	B3	B4	B5	C8
Ambient Temp. (℃)	30	34	30	25	31	31
Water Temp. (℃)	26	28	28	26	27	27
pH	6.0	6.9	8.7	7.8	6.2	6.1
Color	28	11	29	>30	>30	>30
Turbidity NTU	79	117	12	0	3.0	18.0
Elect. Conduc μ s	167	176.5	133.3	764	281	-
Hardness mg/l $caco_3$	67.6	40.1	86.8	173.6	140.2	160.3
Hydrogen sulphide mg/l	1.5	1.1	0.03	0.36	1.36	1.22
Iron mg/l	2.64	1.75	0.12	0.03	0.1	0.04
Mangane mg/l	0.03	0.05	<0.01	<0.01	<0.01	0.025
Faecal coliform count/100ml	Nil	Nil	36	Nil	Nil	6

Table N2-4-2 Quality of Rural Water Supply, at Second Survey

Parameter	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5	C6	C7	C8
Ambient Temp. (℃)	32.0	27.0	28.4	26.2	31.2	30.0	32.1	38.8	35.5	31.0	26.2	32.7	34.4
Water Temp. (℃)	25.7	26.8	27.9	27.0	26.6	26.2	26.0	26.0	28.4	27.4	25.4	25.8	26.5
pH	6.2	7.2	8.3	7.5	6.1	6.0	6.1	6.5	7.7	8.0	7.6	6.2	6.1
Color	>30	19	29	>30	>30	15	16	>30	>30	>30	>30	>30	>30
Turbidity NTU	17	43	23	2	4	57	55	7	4	2	4	6	9
Elect. Conduc μ s	247	84	127	672	322	243	162	313	906	650	842	262	354
BOD mg/l	8	20	38	20	10	20	12	10	7	7	8	13	21
SS mg/l	5	26	60	20	17	105	58	11	10	10	10	15	27
Hardness mg/l $caco_3$	40.0	10.0	20.0	30.0	46.0	40.0	22.0	70.0	130.0	38.0	34.0	24.0	60.0
Hydrogen sulphide mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Phosp mg/l	0.17	0.17	0.30	0.18	0.18	0.53	0.64	0.53	0.15	0.11	0.17	1.06	0.18
Iron mg/l	1.65	0.68	0.10	<0.02	0.55	8.18	13.50	0.45	0.05	0.05	0.05	1.16	0.20
Mangane mg/l	0.02	<0.02	0.03	<0.02	<0.02	0.07	0.27	0.81	0.02	0.02	<0.02	0.03	0.02
Fluoride mg/l	0.80	0.50	1.40	8.00	0.60	0.80	0.35	0.95	3.50	6.00	12.00	0.95	0.75
Arsenic mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Faecal coliform count/100ml	214	4	440	14	0	460	400	28	1	0	21	100	0
Taste & Oder Thresh No.	--	--	--	--	--	1.0	1.0	1.0	1.2	1.0	1.2	1.0	1.0

Table N2-5 Water Quality of Rivers at Rural Area

Parameter \ River	Awach Dar.Mbili	Kibos Town	Lielango
Ambient Temp. (℃)	31.9	31.5	31.9
Water Temp. (℃)	21.9	22.7	24.5
pH	7.1	7.0	7.4
Color	30	20	15
Taste & Odor (Thresh.No.)	1.0	1.5	1.0
Turbidity NTU	25	45	57
Elect. Conduc μ s	95	107	178
Hardness mg/l $caco_3$	16.00	15.00	20.00
Hydrogen sulphide mg/l	0.00	0.00	0.00
DO mg/l	5.0	4.2	4.5
BOD mg/l	2.40	2.49	2.52
SS mg/l	52.3	62.2	102.8
Total Nitrogen mg/l	11.52	11.50	6.00
Ammonia Nitrogen mg/l	0.252	0.994	0.800
Total Phosphorous mg/l	0.41	0.47	0.44
Iron mg/l	4.50	2.75	3.40
Mangane mg/l	0.04	0.02	0.04
Asernic mg/l	<0.01	<0.01	<0.05
Cadmium mg/l	<0.05	<0.05	<0.05
Chrome mg/l	<0.05	<0.05	<0.05
Copper mg/l	<0.02	<0.02	<0.02
Cyanide mg/l	<0.05	<0.058	<0.05
Lead mg/l	<0.02	<0.02	<0.02
Total Mercury mg/l	<0.02	<0.02	<0.02
Fluoride mg/l	0.40	0.30	0.30
Faecal coliform count/100ml	0	0	0

N3. WATER QUALITY SURVEY FOR SEWERAGE SYSTEM

N3.1 Sewage Treatment Works

Two sewage treatment works are existing in Kisumu Municipality, namely Conventional Sewage Treatment Works with trickling Filter Process and Nyalenda Sewage Treatment Works with Waste Stabilization Pond Process. Influent and Effluent quality of each sewage treatment works have been analyzed. The results are shown in Table N3-1-1 and N3-1-2. Influent and effluent water qualities are compared on BOD and SS values as below;

	Average of First Survey			Average of Second Survey		
	Influent (mg/L)	Effluent (mg/L)	Reduction Rate	Influent (mg/L)	Effluent (mg/L)	Reduction Rate
Conventiocnal STW						
BOD	869	217	75%	305	224	27%
SS	864	579	33%	490	410	16%
Nyalenda STW						
BOD	374	80	79%	153	37	76%
SS	894	197	78%	189	50	74%

Treated effluent of Conventional STW is recorded more than 200 mg/L of BOD and more than 400 mg/L of SS. It is almost same level as raw sewage generated from domestic water user.

Figure N3-1

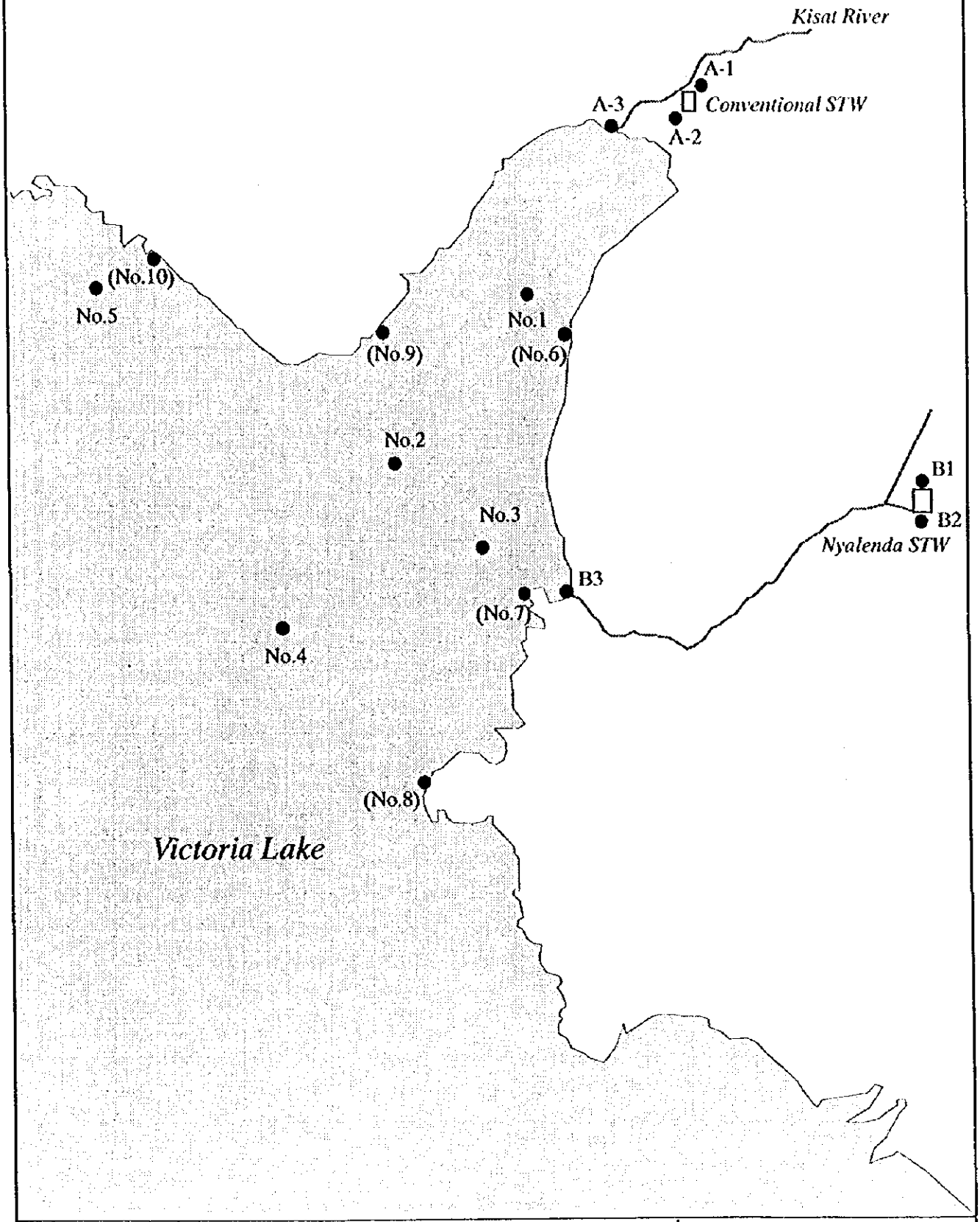

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Table N3-1-1 Water Quality of Sewage Treatment Works, at First Survey

Parameter	A. Conventional Sewage Treatment Works									B. Nyalenda Sewage Treatment works								
	A-1 Raw sewage			A-2 Treaed Discharge			A-3 River Mouth (Golf Course)			B-1 Raw water			B-2 Treated Discharge			B-3 River Mouth		
	8.00	14.00	20.00	8.00	14.00	20.00	8.00	14.00	20.00	8.00	14.00	20.00	8.00	14.00	20.00	8.00	14.00	20.00
Ambient Temp. (℃)	22	39	28	20	40	28	19	34	25	20	34	26	20	33	26	20	37	28
Water Temp. (℃)	28	30	28	25	27	27	21	31	26	25	29	23	23	29	27	20	29	28
pH	6.4	9.2	9.4	7.7	7.8	7.6	7.3	7.5	7.5	7.3	7.2	7.3	9.4	9.7	9.7	7.0	7.7	7.3
DO mg/l	0.15	0.11	0.4	0.67	0.25	0.07	0.08	0.17	0.05	1.79	0.12	0.49	4.87	7.30	9.02	4.58	7.04	4.13
BOD mg/l	822	914	870	143	253	254	218	152	237	336	472	314	78.5	74.5	86	25.5	21.3	26.1
SS mg/l	620	714.3	1257	250	570	916.7	333.3	650	1750	744.3	966.7	1000	66.67	125	400	50	166.7	450
Total Nitrogen mg/l	378.0	281	238	178	161	251	162	165	221	213	181.0	248.0	23	18	31	52	3	44
Total Phosph. mg/l	15.2	13.1	12.5	12.5	12.8	15.2	15.7	14.2	11.6	6.65	11.2	9.67	2.2	3.8	2.85	1.3	1.13	1.3
Asenic mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexzval. Chrome mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead mg/l	0.04	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride mg/l	194.9	109.97	79.98	19.99	44.99	29.99	34.99	29.99	69.98	10.00	19.99	15.00	10.00	19.99	10.00	10.00	<0.01	<0.01
Chlorophyll-a mg/l	<0.01	<0.01	1.667	<0.01	<0.01	0.144	<0.01	<0.01	<0.01	<0.01	0.135	<0.01	<0.01	0.89	0.586	<0.01	<0.01	0.77
Total Coliform ct./100ml	3.4×10^{7}	8.1×10^{7}	5.2×10^{6}	4.5×10^{6}	3.2×10^{6}	4.8×10^{5}	3.9×10^{5}	4.2×10^{5}	3.6×10^{5}	2.0×10^{6}	3.2×10^{7}	3.0×10^{6}	4.5×10^{5}	4.7×10^{5}	3.25×10^{5}	2.75×10^{4}	2.9×10^{4}	2.5×10^{4}
Electrical Conductivity μs	860	880	1030	914	1030	893	730	873	809	541	718	684	<0.02	471	1683	<0.02	<0.02	380

Table N3-1-2 Water Quality of Sewage Treatment Works, at Second Survey

Parameter	A. Conventional Sewage Treatment Works									B. Nyalenda Sewage Treatment works								
	A-1 Raw sewage			A-2 Treaed Discharge			A-3 River Mouth (Golf Course)			B-1 Raw water			B-2 Treated Discharge			B-3 River Mouth		
	8.00	14.00	20.00	8.00	14.00	20.00	8.00	14.00	20.00	8.00	14.00	20.00	8.00	14.00	20.00	8.00	14.00	20.00
Ambient Temp. (℃)	28.7	34.1	28.7	16.7	42.0	22.7	24.0	28.3	24.1	25.3	39.3	25.7	18.0	39.3	25.3	24.6	38.0	27.4
Water Temp. (℃)	17.8	28.2	24.1	25.5	28.2	27.0	20.2	29.6	27.5	18.0	28.8	27.7	25.5	29.5	30.0	18.3	28.4	24.5
pH	6.6	7.1	6.4	7.1	7.1	7.1	6.7	6.8	6.3	6.8	6.9	6.8	7.8	8.5	8.6	7.0	6.8	6.9
DO mg/l	1.2	1.8	1.2	1.6	1.6	1.6	2.9	2.75	1.6	3.6	2.5	2.35	4.2	6.5	7.2	3.0	3.0	4.5
BOD mg/l	165	438	315	178	320	175	181	163	135	103	250	107	31	53	28	24	61	16
SS mg/l	456	547	466	495	260	476	401	152	216	160	222	186	48	60	42	65	46	48
Total Nitrogen mg/l	21.1	64.8	27.8	69.2	86.4	79.2	40.8	33.6	32.6	10.6	34.1	28.3	11.0	9.1	12.0	10.6	8.2	2.9
Total Phosph. mg/l	11.4	6.2	14.3	11.4	14.0	14.1	8.3	7.1	6.7	6.2	13.2	5.2	2.6	1.5	2.3	0.5	0.3	0.2
Asernic mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hexzval. Chrome mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chloride mg/l	32.6	48.6	54.9	48.7	42.4	54.0	37.9	45.9	43.3	54.9	59.4	53.1	20.1	23.7	25.4	24.5	21.9	22.8
Chlorophyll-a mg/l	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T	N/T
Total Coliform ct./100ml	3.2×10^5	4.6×10^5	2.5×10^5	5.1×10^4	6.7×10^4	5.7×10^4	4.8×10^4	6.6×10^4	3.5×10^4	3.4×10^5	9.2×10^5	3.8×10^5	4.4×10^4	1.5×10^4	3.1×10^4	3.3×10^4	1.7×10^4	4.2×10^4
Faecal coliform count/100ml	—	—	—	—	—	—	—	—	—	110	1300	700	70	150	110	—	—	—

N3.2 Kisumu Bay (Lake Victoria)

The sampling points in Kisumu Bay are shown in Fig. N3.1. Sampling works were conducted as below;

	First Survey	Second Survey
Sampling Points	No.1, No.2, No.3, No.4, No.5	No.6, No.7, No.8, No.9, No.10

The Second Survey was planed to get samples at same points of First Survey. However, the sampling works in Kisumu Bay had been impossible during the period of Second Survey, because Kisumu Bay had been covered completely by water hyacinth, and any boat can not reach the sampling points. The sampling works in Second Survey were carried out shoreline of Kisumu Bay.

The results of survey are shown in Table N3-2-1 and N3-2-2.

Kisumu Bay has been covered completely by water hyacinth since end of 1997. If the situation continue, water quality of Kisumu Bay is supposed to change gradually.

Table N3-2-1 Water Quality Distribution Lake Victoria, at First Survey

Point / Parametre	No.1	No.2	No.3	No.4	No.5	River Mouth(1) G/C	River Mouth(2) S/P	Water Intake L/T/W
Ambient Temp. (℃)	30	28	28	27	29	25.3	28	29
Water Temp. (℃)	28	28	27	27	28	24	28	28
pH	8.8	9.0	8.9	8.8	8.3	7.4	7.3	7.9
Color	27	24	27	28	26	-	-	30
Taste & Odor (Thresh.No.)	2.5	2	2.5	2	3.5	-	-	1
Tubidity NTU	20	22	19	19	37	-	-	14
Elect. Conduc μs	144.3	143.9	143.0	140.0	149.3	809.0	380.0	152.0
Hardness mg/l $caco_3$	80	104	96	96	80	-	-	113.5
Hydrogen sulphide mg/l	0.07	0.02	0.084	0.052	0.14	-	-	-
DO mg/l	6.34	5.98	8.97	6.01	4.49	0.1	5.25	-
SS mg/l	150	200	50	200	150	1042	222	-
Total Phosphorous mg/l	0.1	0.06	0.2	1.13	3.7	13.83	1.24	0.95
Iron mg/l	0.13	0.1	0.1	0.1	0.29	-	-	-
Mangane mg/l	0.02	0.03	0.01	<0.01	0.03	-	-	-
Asernic mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chrome mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	<0.01
Cyanide mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Mercury mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoride mg/l	0.70	0.80	0.95	0.80	0.95	-	-	0.75
Faecal coliform count/100ml	45	50	6	48	50	Nil	630	22
chlorop-a mg/l	<0.01	<0.01	0.36	0.24	0.418	1.04	0.08	-

Table N3-2-2 Water Quality Distriution in Lake Victoria, at Second Survey

Point / Parametre	No.6	No.7	No.8	No.9	No.10	River Mouth(1) G/C	River Mouth(2) S/P	Water Intake L/T/W
Ambient Temp. (℃)	37.2	33.0	28.8	26.8	31.0	25.5	30.0	29.0
Water Temp. (℃)	27.2	27.3	28.7	25.0	26.9	25.8	23.7	27.0
pH	6.5	6.8	7.1	6.4	6.5	6.6	6.9	6.6
Color	>30	>30	26	27	16	–	–	>30
Taste & Odor (Thresh.No.)	2.0	2.5	2.5	2.5	3.0	–	–	1.0
Tubidity NTU	20	20	31	30	55	–	–	10
Elect. Conduc μs	142	146	134	234	187	--	–	160
Hardness mg/l $CaCO_3$	30.0	20.0	18.0	40.0	30.0	–	–	28.0
Hydrogen sulphide mg/l	0.00	0.00	0.00	0.08	0.00	–	–	0.14
DO mg/l	4.0	4.0	5.1	4.8	4.9	2.4	3.5	–
SS mg/l	185	215	152	187	275	256	53	44
Total Nitrogen mg/l	6.72	8.16	8.16	11.00	13.90	36.80	7.19	6.70
Total Phosphorous mg/l	0.99	0.17	0.17	0.18	0.58	7.40	0.30	–
Iron mg/l	1.36	0.79	0.68	2.21	1.25	–	–	–
Mangane mg/l	0.40	0.10	0.04	0.54	0.14	--	–	0.50
Asernic mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	–	–	<0.05
Chrome mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	–	–	<0.05
Copper mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	–	–	<0.02
Cyanide mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	–	–	<0.05
Lead mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total Mercury mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	–	<0.02	<0.02
Fluoride mg/l	0.50	0.75	0.55	0.00	0.70	--	–	0.80
Faecal coliform count/100ml	25	74	168	8	22	–	–	1
chlorop-a mg/l	1.61	2.17	2.03	2.44	1.67	0.179	1.27	–

N4. SLUDGE QUALITY SURVEY

The sampling of sludge are carried out at following points:

- Sludge Drying Bed of Conventional Sewage Treatment Works (Complete Dry Sludge)
- Sludge Drying Bed of Conventional Sewage Treatment Works (One day Dry Sludge)
- Around Inlet of Facultative Pond of Nyalenda Sewage Treatment Works
- Around Outlet of Facultative Pond of Nyalend Sewage Treatment Works

The results of Sludge Quality Survey are shown in Table N4-1. The Quality Standard of Dry Sludge for Agriculture use in Japan is shown in Table NA2-3 in Annex-2.

The sludge quality is generally acceptable for agriculture use, because of no harmful material in sludge. But effluent from industrial factory may discharge waste water with harmful material, and sludge may contain it. Industrial effluent shall be controlled for safety of sludge supply.

Table N4-1 Sludge

Parameters	A.Conventional Sewage Treatment Works		Nyalenda Sewage Treatment Works	
	Conventional treat. Works (dry sludge)	Conventional treat. Works (1 day dry)	Inlet	Outlet
Air Temp. (℃)	29	29	27	27
Water Temp. (℃)	27	27	26	24
pH	7.4	7.4	7.4	7.4
Water Content %	20	81	43	44
SS %	38.11	18.45	56.55	56.00
VSS %	39.00	42.21	15.17	10.00
Total Phosphorous mg/g of dry sludge	0.03750	0.12500	0.00350	0.00357
Total Nitrogen mg/g of dry sludge	0.131	1.715	0.570	0.126
Lead mg/g	<0.0005	<0.0005	<0.0002	<0.0002
Asernic mg/l	<0.01	<0.01	<0.01	<0.01
Hexavalent chrome mg/l	<0.05	<0.05	<0.05	<0.05

WATER QUALITY DATA IN OTHER PROJECT REPORT

Table NA1-1 Water Quality Record at Kibos Intake Site

Sampling No.:		1	2	3	4	5	6	7	8
Date:		4/2	4/29	6/9	7/29	9/24	10/3	1/11	2/3
Temperature	℃	19.4	19.9	18.6	18.5	18.8	18.6	19.6	20.5
Conductivity	μ S/cm	77	76	59	65	74	80	131	90
pH	-	7.2	7.0	7.7	7.6	7.4	7.8	7.8	7.8
Colour	Pt	NA	32	60	68	75	60	45	40
Turbidity	NTU	62	37	58	42	40	20	17	18
Dissolved oxygen	mg/l	8.7	8.8	8.4	9.1	8.2	7.9	8.9	7.0
D.O. % saturation	%	113	115	107	116	105	101	116	93
Carbon dioxide	mg/l	NA	6.5	10.6	NA	3.5	2.6	7.3	1.5
Alkalinity-total	mg/l	25.0	33.0	36.0	32.8	40.0	34.0	45.0	42.0
Hardness-total	mg/l	17.8	21.0	17.9	21.8	20.4	20.0	26.0	42.0
Chloride	mg/l	4.7	2.8	2.0	1.8	2.0	2.5	1.0	2.0
Fluoride	mg/l	0.10	0.20	0.20	0.69	0.30	0.21	ND	0.60
Manganese	mg/l	0.045	0.010	0.040	0.020	0.025	0.025	0.100	0.015
Iron	mg/l	0.40	0.70	0.63	0.65	0.71	0.54	0.95	0.81
Ammonia-N	mg/l	ND	0.025	0.25	0.028	0.05	0.01	0.35	0.34
T.S.S.	mg/l	51	56	104	45	37	15	41	8

		Mean	Max	Min
Temperature	℃	19.2	20.5	18.5
Conductivity	μ S/cm	81	131	59
pH	-	7.5	7.8	7.0
Colour	Pt	54	75	32
Turbidity	NTU	37	62	17
Dissolved oxygen	mg/l	8.4	9.1	7.0
D.O. % saturation	%	108	116	93
Carbon dioxide	mg/l	5.3	10.6	1.5
Alkalinity-total	mg/l	36.0	45.0	25.0
Hardness-total	mg/l	23.4	42.0	17.8
Chloride	mg/l	2.3	4.7	1.0
Fluoride	mg/l	0.33	0.69	0.00
Manganese	mg/l	0.035	0.100	0.010
Iron	mg/l	0.67	0.95	0.40
Ammonia-N	mg/l	0.15	0.35	0.01
T.S.S.	mg/l	45	104	8

ND = Not detectable
NA = Not analysed

Table NA1-2 Water Quality Record at Awach/Nytangori Intake Site

Parameter	Units	Upper Station			Lower Station		
		Mean	Max	Min	Mean	Max	Min
Temperature	℃	19.5	20.3	18.4	21.7	23.0	19.5
Conductivity	μ S/cm	72	85	59	109	160	90
pH	-	7.4	7.9	6.7	7.3	8.1	6.5
Colour	Pt	71	120	40	153	350	30
Turbidity	NTU	73	136	28	165	480	32
Dissolved oxygen	mg/l	8.0	9.0	6.7	8.0	8.9	6.5
D.O. % saturation	%	102	116	90	106	117	88
Carbon dioxide	mg/l	4	6.5	2.2	4.8	11.2	2
Alkalinity-total	mg/l	35.7	49.0	30.0	46.4	72.0	28.0
Hardness-total	mg/l	23.2	28.0	19.4	30.5	48.3	15.6
Chloride	mg/l	3.5	6.0	1.5	3.0	5.0	0.9
Fluoride	mg/l	0.30	0.57	0.20	0.41	0.70	0.20
Manganese	mg/l	0.051	0.075	0.025	0.062	0.100	0.030
Iron	mg/l	0.76	0.92	0.55	0.72	0.92	0.57
Ammonia-N	mg/l	0.179	0.5	ND	0.161	0.76	0.023
T.S.S.	mg/l	75	140	20	296	811	80

ND = Not detectable
NA = Not analysed

Table NA1-3 Water Quality Record in Sondu River

Parameter	Units	Upper zone	Middle zone
pH	-	7.0	7.1
Colour	mg Pt/l	20	10
Turbidity	NTU	8	7
Oxygen absorbed	mg/l	15	12
Conductivity	μ S/cm	58	69
Iron	mg/l	0.9	1.2
Manganese	mg/l	0.01	0.01
Calcium	mg/l	3.2	4.0
Magnesium	mg/l	1.0	1.3
Sodium	mg/l	-	-
Potassium	mg/l	-	-
Hardness-total	mg/l $CaCO_3$	12	15
Alkalinity-total	mg/l $CaCO_3$	21	32
Chloride	mg/l	6.3	7.0
Fluoride	mg/l	0.58	0.45
Sulphate	mg/l	0.8	6.0
Orthophosphate	mg/l	0.03	0.02
TDS	mg/l	35	42

Source: Ministry of Water Development, NES 1987.
Values given are mean values in 1983 to 1984.

Table NA1-4 Water Quality Record in Nyaudo River

Parameter	Units	Upper zone	Middle zone	Lower zone
pH	-	7.8	7.8	7.7
Colour	mg Pt/l	360	45	25
Turbidity	NTU	46	25	15
Oxygen absorbed	mg/l	40	27	18
Conductivity	μ S/cm	297	215	255
Iron	mg/l	0.87	2.10	2.10
Manganese	mg/l	0.02	0.10	0.02
Hardness-total	mg/l $CaCO_3$	103	178	88
Alkalinity-total	mg/l $CaCO_3$	132	93	114
Chloride	mg/l	6.4	5.3	7.9
Fluoride	mg/l	0.46	0.30	0.52
Sulphate	mg/l	3.0	2.3	0.9
Orthophosphate	mg/l	0.56	0.13	0.14
TDS	mg/l	172	129	120

Table NA1-5 Water Quality Record in Yala River

		Damsite			Kimondi			Mokong		
		Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Temperature	℃	18.7	20.1	17.2	18.8	20.0	17.5	18.4	20.1	16.5
Conductivity	μ S/cm	107	130	90	79	99	55	144	160	130
pH	-	7.8	8.8	7.0	7.4	8.3	6.8	7.4	8.5	6.7
Colour	Pt	79	110	40	40	78	10	59	112	10
Turbidity	NTU	49	88	22	17	24	12	54	90	28
Dissolved oxygen	mg/l	8.9	10.8	7.3	8.3	9.9	7.1	7.6	8.9	7.1
D.O. % saturation	%	119	140	100	113	130	96	102	115	96
Carbon dioxide	mg/l	2.8	2.9	ND	3.5	4.0	ND	6.9	9.0	4.5
Alkalinity-total	mg/l	47.3	52.0	35.0	38.1	52.0	21.0	72.3	89.0	66.0
Hardness-total	mg/l	41.4	58.0	34.0	24.2	34.0	14.3	57.5	103.6	36.0
Chloride	mg/l	3.4	7.2	*1.0	3.3	8.3	ND	3.4	7.7	1.0
Fluoride	mg/l	0.34	0.62	ND	0.27	0.53	ND	0.43	0.67	0.15
Manganese	mg/l	0.047	0.090	0.020	0.055	0.120	0.020	0.064	0.135	0.030
Iron	mg/l	1.43	2.50	0.70	1.32	2.20	0.68	1.02	2.36	0.56
Ammonia-N	mg/l	0.1	0.28	0	0.1	0.22	ND	0.11	0.23	0.02
T.S.S.	mg/l	41.0	76.0	11.0	13.3	31.2	6.1	62.8	149.0	14.2

ND = Not detectable
* = less than

Table NA1-6 Water Quality Record in Kisumu Bay

Station number:		1		2		3		4		5		6		7	
Station name:		Kisat mouth		Unga		Railway piers		Sunset point		Hippo		Offshore		Yacht club	
Conductivity	μ S/cm	226	(44)	156	(16)	144	(12)	142	(11)	143	(12)	142	(12)	157	(23)
pH	-	7.7	(0.3)	7.9	(0.3)	8.1	(0.3)	8.1	(0.2)	7.9	(0.3)	7.9	(0.2)	7.6	(0.4)
Turbidity	NTU	25.1	(8.3)	15.5	(5.3)	11.9	(3.9)	12.1	(4.2)	11.1	(4.1)	12.5	(5.7)	19.5	(15.8)
Dissolved oxygen	mg/l	5.7	(0.8)	6.3	(0.7)	7.3	(0.7)	7.5	(0.7)	6.8	(0.8)	7.2	(0.5)	5.7	(1.3)
Alkalinity-total	mg/l $CaCO_3$	91	(17)	70	(4)	68	(4)	67	(4)	66	(3)	66	(3)	69	(3)
Hardness-total	mg/l $CaCO_3$	28.1	(3.8)	23.8	(4.7)	22.4	(4.9)	22.3	(5.2)	21.2	(5.9)	21.1	(6.9)	26.2	(6.4)
Chloride	mg/l	14.0	(6.4)	7.4	(0.7)	5.9	(0.6)	5.6	(0.6)	5.9	(0.5)	5.8	(0.4)	7.8	(2.1)
Chlorophyll a	mg/m^3	25.4	(11.7)	21.6	(7.4)	15.6	6.19	15.2	(6.7)	13.6	(5.8)	14.7	(4.8)	11.1	(4.0)
Total algae	no/ml	1,284	(431)	1,412	(645)	1,381	(745)	1,537	(551)	1,135	(623)	977	(94)	1,274	(531)
Blue-green algae	no/ml	931	(318)	1,013	(374)	916	(342)	1,068	(325)	678	(204)	659	(110)	797	(176)
Green algae	no/ml	103	(52)	107	(50)	144	(183)	147	(153)	133	(177)	70	(21)	154	(169)
Diatoms	no/ml	302	(121)	355	(214)	325	(263)	327	(121)	324	(256)	248	(51)	323	(251)
Total zooplankton	no/l		714		1,979		1,419		958		255		314		105
Copepoda	no/l		335		1,567		1,245		814		218		278		84
Cladocera	no/l		108.1		71.1		14.4		13.2		4.5		2.3		1.7
Rotifera	no/l		271		341		160		131		33		34		19

WATER QUALITY STANDARD

Table NA2-1 Drinking Water Quality Standard in Kenya

		Constituents of health significance	Desirable aesthetic quality	Permissible aesthetic quality
Heavy Metal and Harmetal Material				
Arsenic	mg/l	0.05		
Cadmium	mg/l	0.005		
Chromium	mg/l	0.05		
Cyanide	mg/l	0.1		
Fluoride	mg/l	1.5		
Lead	mg/l	0.05		
Mercury	mg/l	0.001		
Nitrate	mg/l	10		
Selenium	mg/l	0.01		
Aluminium	mg/l		0.2	0.2
Copper	mg/l		1.0	1.5
Iron	mg/l		0.3	1.0
Manganeses	mg/l		0.1	0.5
Zinc	mg/l		5.0	15.0
pH			6.5 - 8.5	6.5 - 9.2
Turbidity	NTU		5	25
Colour			15	50
Hardness	mg/l		500	500
Chloride	mg/l		250	600
Sodium	mg/l		200	200
Total dissolved sodium	mg/l		1,000	1,500
Sulphate	mg/l		400	400

Source: Design Manual for Water Supply in Kenya
Arrange: JICA Study Team

Table NA2-2 Water Quality Standards Used in Japan (Receiving Water)

According to EA 1972a, the water quality standards used in Japan are intended to protect public health and the environment.

a) Standards relating to protection of public health

Item	Permissible value (mg/l)
Cyanide	not detectable
Alkyl mercury	not detectable
Organic phosphorus (parathion, methyl parathion, methyl dimeton and EPN only)	not detectable
Cadmium	< 0.01
Lead	< 0.1
Hexavalent Chromium	< 0.05
Arsenic	< 0.05
Total mercury	not detectable

b) Standards relating to preservation of the environment

b1) Rivers

Cate-gory	Use	Daily average value				
		pH	Biochemical oxygen (mg/l)	Suspended solid (mg/l)	Dissolved oxygen (mg/l)	Californ bacteria (MPN/100 ml)
M	Water supply, class 1; conservation of natural environment and uses of categories A to E	6.5 - 8.5	< 1	< 25	> 7.5	< 50
A	Water supply, class 2; fishery, class 1; bathing and uses of categories B to E	6.5 - 8.5	< 2	< 25	> 7.5	< 1,000
B	Water supply, class 3; fishery, class 2; and uses of categories C to E	6.5 - 8.5	< 3	< 25	> 5	< 5,000
C	Fisher, class 3; in dustrial water class 1, and uses of categories D to E	6.5 - 8.5	< 5	< 50	> 5	-
D	Industrial water, class 2; agricultural water*, and uses of category E	6.0 - 8.5	< 8	< 100	> 2	-
E	Industrial water, class 3; conservation of environment	6.0 - 8.5	< 10	Floating matter should not be observed	> 2	-

*: For agricultural water, pH shall be between 6.0 and 7.5 and dissolved oxygen shall not be less than 5 mg/l (The same applies to the standard for lakes).

b2) Lekes (natural, lakes, reservoirs, marshes and artificial lakes with more than 10 million m^3)

Category	Use	Daily average value				
		pH	Biochemical oxygen (mg/l)	Suspended solid (mg/l)	Dissolved oxygen (mg/l)	Caliform bacteria (MPN/100 ml)
AA	Water supply, class 1; fishery, class 1; conservation of natural environment and uses of categories A to C	6.5 - 8.5	< 1	< 1	> 7.5	< 50
A	Water supply, classes 2 and 3; fishery, class 2; bathing and uses of categories B to C	6.5 - 8.5	< 3	< 5	> 7.5	< 1,000
B	Fishery, class 3; industrial water, class 1; agricultural water, and uses of category C	6.5 - 8.5	< 5	< 15	> 5	-
C	Industrial water, class 2; conservation of environment	6.0 - 8.5	< 8	Floating matter should not be observed	> 2	-

b) Coastal Waters

Category	Use	Daily average value				
		pH	Biochemical oxygen (mg/l)	Suspended solid (mg/l)	Dissolved oxygen (mg/l)	Caliform bacteria (MPN/100 ml)
A	Fishery, class 1; bathing and uses of categories 8 to C	7.8 - 8.3	< 2	> 7.5	< 1,000**	not detectable
B	Fishery, class 2; industrial water and uses of category C	6.5 - 8.5	< 3	> 5	-	not detectable
C	Conservation of environment	7.0 - 8.3	< 8	> 2		

**: For oyster culture this must be < 70.

Source: English translation quated from "Management and Law for Water Resources", Luis V. Gunha, etc., Water Resource Publications, USA, 1977

Table NA2-3 Quality Standard of Dry Sludge for Agriculture Use in Japan

	Unit	Standard Value
Organic	/ dry sludge	Not less than 35%
Organic/Nitrogen		Not more than 10%
Total Nitrogen	/ dry sludge	Not less than 2%
P_2O_5	/ dry sludge	Not less than 2%
Alkali	/ dry sludge	Not more than 25%
Water	/ dry sludge	Not more than 30%
AS	/ 1 kg.dry sludge	Not more than 50 mg
Cd	/ 1 kg.dry sludge	Not more than 5 mg
Hg	/ 1 kg.dry sludge	Not more than 2 mg
Cu		Not more than 600 ppm
Zn		Not more than 1,800 ppm

Source: Report of Organic Fertilizer Quality Control Meeting
1994, March, Japan Agricultural Cooperative Association

RESULT OF WATER QUALITY TEST BY PORTABLE EQUIPMENT

Table NA3-1 Water Quality of Lake Vioctoria

No. 1 - 300m from The Intake
Date: 2nd Oct. 1997 11:00 Temperature 28.1℃

Parameter	Units	Depth (m) 0	3.0	Remarks
Water temperature	℃	27.6	27.0	
pH	-	8.5	8.5	
Electrical conductivity	μ S/cm	175	164	
Dissolved oxygen	mg/l	8	8	
Chemical oxygen demand	mg/l	6	6	(Mn)
Soluble iron	mg/l	ND	ND	ND: 0.2 mg/l under
Soluble manganese	mg/l	ND	ND	ND: 0.5 mg/l under
Soluble phosphorous	PO_4-P mg/l	ND	ND	ND: 0.006 mg/l under
Ammonium nitrogen	NH_4-N mg/l	ND	ND	ND: 0.4 mg/l under
Nitrite nitrogen	NO_2-N mg/l	ND	ND	ND: 0.006 mg/l under
Nitrate nitrogen	NO_3-N mg/l	ND	ND	ND: 0.23 mg/l under
Fluoride	mg/l	0.8	0.8	

No. 2 - 10,000m from The Intake
Date: 2nd Oct. 1997 12:20 Temperature 28.3℃

Parameter	Units	Depth (m) 0	2.0	4.0	Remarks
Water temperature	℃	27.7	25.8	25.8	
pH	-	8.5	8.5	8.5	
Electrical conductivity	μ S/cm	141	156	153	
Dissolved oxygen	mg/l	8	8	8	
Chemical oxygen demand	mg/l	6	7	6	(Mn)
Soluble iron	mg/l	ND	ND	ND	ND: 0.2 mg/l under
Total iron	mg/l	0.8	0.8	0.8	
Soluble manganese	mg/l	ND	ND	ND	ND: 0.5 mg/l under
Total manganese	mg/l	ND	ND	ND	ND: 0.5 mg/l under
Soluble phosphorous	PO_4-P mg/l	ND	ND	ND	ND: 0.006 mg/l under
Ammonium nitrogen	NH_4-N mg/l	ND	ND	ND	ND: 0.4 mg/l under
Nitrite nitrogen	NO_2-N mg/l	ND	ND	ND	ND: 0.006 mg/l under
Nitrate nitrogen	NO_3-N mg/l	ND	ND	ND	ND: 0.23 mg/l under
Fluoride	mg/l	0.8	0.8	0.8	

ND = Not detectable

Table NA3-2 Water Quality of Available Water Sources

Water source location		Lake Victoria intake at Lake WTW	Kibos R. Kajulu intake weir	Awach/ Nyangori R. downstream of proposed intake site	Sondu R. Sondu bridge	Sondu R. Nyakwere bridge	Nyando R. Ahero bridge	Kisyan R. former intake site
Sampling date		Aug. 26 '97	Aug. 22 '97	Aug. 22 '97	Aug. 28 '97	Aug. 28 '97	Aug. 22 '97	Aug. 23 '97
(Parameter)	(Units)							
Ambient temperature	℃	-	-	-	27.1	-	29	-
Water temperature	℃	26.5	19.9	22.2	19.6	20.4	24.1	27.1
pH	-	8.5	7.7	7.8	7	7.2	8.7	-
Turbidity	NTU	-	*100	*140	20	70	>100	-
Electrical conductivity	μ S/cm	178	77	83	40	44	210	91
Total hardness	mg/l	30	10	15	5	5	60	-
DO	mg/l	>10	10	10	>10	>10	10	-
COD	mg/l	8	7	7	7	9	40	9
NH_4	mg/l	0.2	Nil	Nil	0.3	0.3	0.2	-
PO_4	mg/l	NIL	<0.2	Nil	1	Nil	0.7	-
Fe	mg/l	Nil	0.2	0.7	Nil	0.3	0.7	Nil
Mn	mg/l	Nil	Nil	Nil	Nil	Nil	Nil	-
Fe	mg/l	1	0.7	0.7	0.2	0.8	4	0.8
NO_2	mg/l	Nil	Nil	Nil	Nil	Nil	0.01	-
NO_3	mg/l	-	-	-	-	-	0.78	-
Cr^{6+}	mg/l	-	-	-	-	-	Nil	-

Note: 1) The analysis was conducted by the Study Team by using portable water quality analizer.
2) * Relatively high turbidities is caused by the rainfall on the day before.

APPENDIX-O

ENVIRONMENTAL IMPACT ASSESSMENT

APPENDIX O
ENVIRONMENTAL IMPACT ASSESSMENT

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O1. INTRODUCTION

Environmental Impact Assessment (EIA) is conducted as a part of Study on Kisumu Water Supply and Sewerage System. The Objectives of the EIA are as follows;

- To review Environmental Impact Assessment Situation in Kenya
- To provide information of Present Environmental Conditions in Study Area of Master Plan
- To identify potential impacts of the Project formulated in Master Plan, as the result of Initial Environment Examination (IEE)
- To describe Present Environmental Condition in EIA Study Area
- To Assess Environmental Impacts of the selected Project, following UEE
- To Prepare countermeasures for mitigating the impacts

This report is therefore consists of following Chapters;

Chapter O1	Introduction
Chapter O2	Environmental Impact Assessment Situation in Kenya
Chapter O3	Present Environmental Conditions in Study Area of Master Plan
Chapter O4	Initial Environmental Examination
Chapter O5	Present Environmental Condition in EIA Study Area
Chapter O6	Environmental Impact Assessment
Chapter O7	Countermeasure for Mitigating Impacts
Chapter O8	Conclusion and Recommendation

O2. Environmental Impact Assessment Situation in Kenya

O2.1 Organisations Involved in the Environmental Issues of Project Area

The major government institutions which are relevant to this study include Kisumu Municipality; Lake Basin Development Authority; Ministry of Environmental and Natural Resources; Ministry of Land Reclamation, Regional and Water Development; Kenya Marine and Fisheries Research Institute; Lake Victoria Environmental Management Programme; Ministry of Agriculture, Livestock Development and Marketing; Ministry of Local Government and Ministry of Health.

(1) Kisumu Municipality

Kisumu Municipality operates under the Ministry of Local Government but it is independently responsible for providing water and sewerage facilities. It has several departments dealing with water quality in terms of research and treatment. It has the environmental and health components which are responsible for environmental sanitation. The Municipality in carrying out its environmental management, collaborates with relevant ministries such as Ministry of Health; Ministry of Environment and Natural Resources; Ministry of Land Reclamation, Regional and Water Development. The Municipality is responsible for the lake within its jurisdiction.

(2) Ministry of Local Government

The Ministry of Local Government deals with the establishment, development and management of urban centres in the country. Therefore, the Ministry participates in the municipality water supply and sewerage system. Its municipality activities have a bearing on the rivers and lake. By supplying adequate water and sewage treatment, it contributes to the management of water bodies.

(3) Kenya Marine and Fisheries Research Institute

Kenya Marine and Fisheries Research Institute (KMFRI) is a very important governmental organization responsible for marine and freshwater fisheries research in Kenya. It has been involved in biodiversity, aquaculture and water quality projects in Lake Victoria. Although it-s headquarters is in Mombasa, it has an important sub-headquarters in Kisumu Municipality

(4) Ministry of Land Reclamation, Regional and Water Development

The Ministry deals with water development and supply in Kenya. In doing this it is guided by the Water Act, Cap 372 which deals with conservation, control, apportionment and utilisation of water resources. It has the Water Apportionment Board which is responsible for water abstraction from various sources including rivers and lakes. Besides its responsibility for water supply, this Ministry collaborates in water pollution research and it provides water quality standards.

(5) Ministry of Health

The Ministry of Health is concerned with environmental and public health. These are conducted in accordance with Public Health Act, Cap 242. The Ministry deals with the control of waterborne diseases and monitoring of environmental sanitation.

(6) Lake Basin Development Authority

LBDA was created in 1979 by an Act of Parliament to serve the catchment of Lake Victoria. The act empowers LBDA to undertake overall planning, co-ordination and the implementation of development projects in the Lake Victoria catchment. Its activities include agriculture, hydropower, irrigation and drainage, and water resource development. It addresses issues on land use since 40% of the population of Kenya live in the catchment (51,000 km^2) within which it operates. Since its inception, it has carried out various feasibility studies that can boost socio-economic development of the area. It is the only functioning Lake Basin Development Authority among the three countries of East Africa. The LBDA falls under the Ministry of Land Reclamation, Regional and Water Development (MLRRWD), but operates as a parastatal as provided by the Act.

(7) Ministry of Agriculture, Livestock Development and Marketing

Ministry of Agriculture, Livestock Development and Marketing has its headquarters in Nairobi, but reaches farmers through Provincial and District level administration. Nyanza Province contributes significantly to the agricultural land based activities. Extension is handled through this office. Recently Kenya Agricultural Research Institute (KARI) within the Ministry has been involved in research for control of water hyacinth in the lake.

(8) Ministry of Environment and Natural Resources

This is the Ministry charged with the responsibility of environmental protection in Kenya. Environmental matters are carried out through the National Environmental Secretariat based in Nairobi. More recently the National Environment Action Plan has also been established. This is the host ministry which in 1994 signed the Tripartite Agreement of Lake Victoria and is currently implementing the Lake Victoria Environmental Management Programme (LVEMP).

(9) Lake Victoria Environmental Management Programme

The Lake Victoria Environmental Management Programme (LVEMP) is a comprehensive programme aimed at rehabilitating Lake Victoria ecosystem for the benefit of East African people who live in the catchment and in its area of influence. On August 5, 1994, the Governments of Kenya, Tanzania and Uganda signed a Tripartite Agreement jointly to prepare and implement a Lake Victoria Environment Programme. The LVEMP is provided by three national secretariats each headed by a high level officer,

selected by the respective governments and supported by a modest staff. The regional secretariat is based in Tanzania.

O2.2 National Environmental Legislative and Regulatory Measures

O2.2.1 Kenya Statutory Requirements and Limitations

Since 1972 the National Environment Secretariat (NES) within the Ministry of Environment and Natural Resources has been responsible for the co-ordination and application of environmental management policy, and the Environmental Management Policy was adopted in 1979. But Environmental impact assessment (EIA) as a regulatory process has not been established in Kenya. A comprehensive National Environment Action Plan (NEAP) and guidelines have been formulated but not yet approved by parliament.

Notwithstanding attempts since 1979 to review existing legislation on the environment, and proposed changes to provide a legal framework for the reporting process, the appropriate statutory provisions have not been developed and implemented. Environmental control of urban development within Kenya is therefore subject to the requirements of both specific legislative instruments that relate to different aspects of the environment, and to the Common Law.

O2.2.2 Co-ordination and Implementation Problems

Kenya's institutional and legal framework for environmental protection and resource management is predominately sectoral, with specific resources governed by specific Acts of Parliament. For example agricultural activities are governed by the Agricultural Act, water resources are governed by the Water Act, while pesticides are regulated by the Pesticides Control Act. Environmental legislation usually includes the establishment of an institution in-charge of implementation. The Water Act established the Water Apportionment Board.

Some of the legislative measures, relevant to the proposed water supply and sewerage project are summarized in Appendix - 1.

O2.3 National Environmental Action Plan (NEAP)

The National Environment Action Plan (NEAP) has been formulated, under the Ministry of Environment and Natural Resources, to address environmental management and conservation challenges through appropriate legislative measures. The NEAP aims at providing a broad framework for the co-ordination of environmental activities by all actors: private sector and government to guide the course of development activities. It is a step towards integrating environment and development for a better management of resources.

The document, which has yet to be approved by Parliament, provides detailed guidelines and administrative procedures for Environmental Impact Assessment (Republic of Kenya 1996)

The general policy objectives are to:

- to facilitate optimal use of the national land base and water resources in improving the quality of human environment.
- to promote sustainable use of natural resources to meet the needs of present generations while preserving their ability to meet the needs of future generations.
- to treat environmental conservation and economic development as integral aspects of the same process of sustainable development.
- to generate income and to meet national goals and international obligations by conserving biodiversity, reversing desertification, mitigating effects of disasters, and maintaining the ecological balance of the earth.

The NEAP structure comprises of a ministerial level policy steering Committee, the NEAP Co-ordinating Committee, the Secretariat headed by the co-ordinator, task forces that address the key environmental issues and the NEAP advisory committee comprising of donors, governmental representatives, private sector, NGOs and international organizations.

The environmental assessment procedures as outlined in the NEAP report guidelines (NEAP 1996) are described and presented in the seven steps as shown in Appendix - 2.

O2.4 Proposed Environmental Impact Assessment Procedure

As mentioned above, there are various organizations and Laws relevant to Environmental Issues in Kenya, however, official EIA procedure has not been established. Implementation of the National Environmental Action Plan (NEAP) will be achieved through the enactment of the National Environmental Management and Co-ordination Bill which provides for the creation of a National Environmental Management Authority (NEMA) and the imposition of Environmental Impact Assessment (EIA). "Environmental Management and Co-ordination Bill" and "Environmental Assessment (Guidelines and Administrative Procedure)", which propose official EIA procedure and guideline, have not been approved by the Government of Kenya, though two of them have been expected to be effective near future.

(1) Environmental Management and Co-ordination Bill

The bill was drafted in 1996, but has not been approved by Parliament of Government of Kenya. Once the bill is approved, it will become the Environmental Management and Co-ordination Act. The bill indicates the issues related with EIA Procedure as bellows;

- National Environmental Management Authority (NEMA) will be established. The authority will be responsible for the administration of the Act.
- Before undertaking or financing any new project specified in the bill (This Project comes under the specification), any proponent shall submit Environmental Impact Assessment Report to NEMA in order to get Environmental Impact Licence.
- NEMA may after being satisfied with the adequacy of EIA report, issue an environmental impact licence.
- Environmental Impact Assessment shall be conducted in accordance with the Environmental Impact Assessment Guidelines and Procedures provided for the bill in Fourth Schedule of the bill. The Fourth Schedule shows a form of EIA Report, which consists of "Introduction", "Title of the Project", "Project Initiator", "Statement of Need", "Project Description", "Project Options", "Description of Existing Environment", "Results of Preliminary Assessment", "Detailed Examination on Impacts", "Suggested Mitigation and Abatement Measures", "Residual Impacts", "Project Evaluation", "Summary of Conclusions".

(2) Environmental Impacts Assessment (Guidelines and Administrative Procedure)

Draft report of Environmental Impacts Assessment (Guidelines and Administrative Procedure) was prepared in 1996, under National Environmental Action Plan (NEAP) Secretariat, Ministry of Environment and Natural Resources. The report said that it was prepared by taking into considerations to the Environment Management and Co-ordination Act. The report consists of following two parts;

Part 1: It describes procedures for use in environmental planning and management in Kenya.
Part 2: It contains sector checklists, which would provide guidance to the public and private sector agencies responsible for development projects and programs.

The contents of the EIA of the Study are not away from requirement of the above guideline.

O3. Present Environmental Conditions in the Study Area in Master Plan

For the reference of Master Planning Procedure, this Chapter describes Present Environmental Conditions in the Study Area in Master Plan.

O3.1 General Environmental Conditions of Lake Victoria

Lake Victoria with a surface are of 68,800 km^2, is the worlds second largest body of fresh water. The lake is relatively shallow, reaching a maximum depth of 80m and an average depth of 40m. The lakes shore is long (about 3,500 km) and convoluted, enclosing innumerable small shallow bays and inlets, many of which include swamps. Lake Victoria holds about 2,760 km^3 of water.

The increasing human population and associated socioeconomic activities in the basin, have resulted in changes in land use, water quality, biodiversity, wetlands and fisheries. Lake Victoria Environmental Management Program (1995) gave examples as below:

- Fish stocks have been decreasing while biodiversity has declined.
- Algal blooms are frequent while turbidity, which reduces water transparency, may continue to increase due to increased eutrophication.
- Water hyacinth is gradually spreading over the lake and is interfering with light penetration, dissolved oxygen, fish breeding sires, landing beaches, recreation, lake transport and ecology among other changes.

There are many research activities on Lake Victoria, which are carried out by various government and non-government, organizations. The major organizations and activities are shown in Appendix – 3.

O3.2 Winam Gulf

Winam gulf with a surface area of 1,400 km^2, is a part of Lake Victoria with 68,800 km^2. It is relatively shallow with a mean depth of 6.8m. The Winam Gulf is fed by several rivers including the Nyando, Sondu and Kibos River. These rivers and the direct rainfall provide water inputs to the Gulf. The Gulf is important source of water supply and fish resource for a large population, and acts also as recipient of effluent from the catchment area. The Gulf is surrounded by the densely populated area and agricultural lands. The urban activities and farming around the lake have tremendous impact on the water quality and the general integrity of the lake ecosystem. Kisumu Municipality is most populated area in the catchment, and one of most serious pollution source.

O3.3 Rivers in Project Area

(1) Kibos River and Awachi/Nyangori River

The catchment of the river there is no major pollution source at present. Major pollution source of this river is considered only small scale domestic wastewater. Serious pollution source can not be found out in the catchment area. The river has been one of the safe water sources for Kisumu Municipality through Kajul Water Works. Awachi / Nyangori River is one of tributary of Kibos River. The basin of Awachi / Nyangori River is expanded in the west part of Kibos River basin. Polluiton source control measures may be necessary, if the basin developments are promoted gradually.

(2) Sondu-Miriu River

The river has three major tributaries, Yurith, Ainabkoi (Chemosit) and Kipsonoi. The catchment of these tributaries comprises Kericho, Bomet and Nyamira district areas. The rivers drain tea plantation area in Kericho and Sotik. Major pollution source of this river is considered only agricultural pollution load, and small scale industrial pollution from tea and coffee processing factories in the catchment area.

(3) Nyando River

Origin of the river is in Nandi hills, Kericho and Western Mau areas. As the river flows downstream it passes through an sugarcane growing area. The river acts as recipient of industrial effluent from East African sugar industries (Muhoroni) and Agro-chemical Food and Allied Company. Chemelil sugar company also discharges at Mbogo, a tributary which joins the main Nyando at its downstream. The semi-treated industrial load from these factories is adversely affecting the water quality of the river at its downstream. This is one of the heavily polluted rivers, especially downstream of the above industries. The river water is abstracted for domestic purpose, irrigation and livestock watering.

O3.4 Kisumu Municipality

Kisumu Municipality is largest urban area in Kenyan part of Lake Victoria catchment area, and third largest urban area in Kenya. The population in Kisumu Municipality was recorded 10,899 in 1948, 152,643 in 1979 and 192,733 in 1989(Republic of Kenya 1994). The population growth estimated between 1969 and 1979 was 3.7% per annum, while the growth rate between 1979 and 1989 was 2.33%. The current population is approximately 270,000.

(1) Water Supply System

The current public water supply in Kisumu Municipality is estimated at 18,000 m^3/day from two sources, 16,600 m^3/day from Lake Victoria through Lake Water Treatment Works and 1,400 m^3/day from Kibos River through Kajulu Water Treatment Works. The water demand is established 45,000 m^3/day against 18,000 m^3/day of the supply amount. Only limited population are served by the public system, and the rest

depends on the lake, streams, boreholes, ponds or shallow wells. Most of shallow wells are considered in pathetic conditions due to their contamination with effluents from mushrooming unplanned pit latrines.

It is said that there are high incidences of water-borne diseases due to prevalent use of untreated water. Municipal water supply system treatment effectiveness remains suspect (Mugwangía 1993).

The use of untreated water for domestic consumption means that a large proportion of the municipal population drink water which is not free from the risk of water-borne diseases, such as cholera, typhoid, amoebiasis etc.

(2) Sewerage System

There are two sewage treatment works at present in the project area, Kisumu Conventional Sewage Treatment Works with treatment capacity of 6,800 m^3/day and Nyalenda Sewage Treatment Works with treatment capacity of 11,000 m^3/day. The existing sewer network covers the areas within the old town boundary. Households who are not connected with sewer are generally equipped with septic tanks / pit latrines. Pit latrine is a dominant wastewater disposal method in Kisumu Municipality. Septage from those population are desludged by an exhauster owned by Kisumu Municipal Council then waste into sewer lines located nearby.

O4 Initial Environmental Examination

O4.1 Introduction

Initial Environmental Examination (IEE) is carried out to identify potential impacts of Phase 1 Project, which is formulated by the Master Plan of the Project.

The Project consists of Water Supply Component and Sewerage Component, which are shown as below,

a. Water Supply Component

a.1 Intake Works

- Rehabilitation and expansion of the existing Kibos River Intake (3,000 m^3/day)
- Construction of new Kibos river Intake (71,000 m^3/day)
- Construction of Awach River Intake (14,000 m^3/day)
- Rehabilitation and expansion of the existing Lake Intake Works (27,000 m^3/day)

a.2 Water Treatment Works

- Rehabilitation and expansion of the exsiting Kajulu WTW (2,800 m^3/day)
- Rehabilitation and expansion of the existing Lake WTW (25,000 m^3/day)
- Construction of Kibue WTW (40,000 m^3/day)

a.3 Pipes and Distribution Reservoirs

- Installation of raw water transmission of 1.2 km and 18.8 km in length
- Installation of treated water transmission of 3.6 km, 5.2 km, 4.2 km and 6.2 km in length
- Installation of trunk distribution main of 23.9 km and 25.5 km in length
- Installation of secondary distribution main of 330 km in total length
- Construction of three units of distribution reservoirs

b. Sewerage Component

b.1 Sewage Treatment Works

- Rehabilitation and expansion of existing Conventional STW (14,600 m^3/day)
- Rehabilitation and expansion of existing Nyalenda STW (18,000 m^3/day)

b.2 Sewer Pipes and Sewage Pumping Station

- Rehabilitation and expansion of Trunk Sewers and Branch Sewers
- Rehabilitation of three sewage pumping stations

The Initial Environmental Examination (IEE) is carried out on above two components respectively as shown in Table O4.2 and O4.3, because both of the components are expected to affect different impacts.

Impacts during construction period and impacts during operation period are considered also as different kinds of impacts. The evaluation of IEE are therefore proceeding as follows;

1) Impacts during Construction Stage
2) Impacts by Water Supply Component during Operation Period
3) Impacts by Sewerage Component during Operation Period

In order to identify the potential impacts, a checklist method was applied for IEE. The checklist includes 23 environmental items defined by JICA Environmental Guideline.

Results of IEE for Water Supply and Sewerage Components are shown in the following tables;

Table O4-1 IEE Check List: Water Supply Component

Item	Evaluation	Reason
1. Resettlement	C	Not clear
2. Economic Activities	D-2	Positive impacts are expected by increased water supply amount
3. Transport	D-1	Need attention during construction period
4. Separation of Community	D-2	This is not an issue in this component
5. Cultural Assets and Archaeology	D-2	No such sites
6. Water and Common Rights	C	This may be affected, because water discharge amount will be reduced in Rivers to be proposed as intake sites
7. Sanitation	D-2	Sanitation condition shall be improved by safe water supply
8. Waste	D-1	Need attention during construction
9. Dangers	D-1	Need attention during construction
10. Topography and Geology	D-2	Project include no big structure to give such impact
11. Soil Erosion	D-1	Need attention during construction period
12. Groundwater	D-2	Project would not be related to groundwater
13. Lake, Marsh and River	A	Kibos River shall be affected by the completion of the intakes
14. Coastline and Sea	D-2	No such area
15. Flora and Fauna	C	Changing the rivers discharge and sewage generation may affect Flora and Fauna in Lake Victoria and Kibos River
16. Weather	D-2	This Project does not include structures which might influence weather
17. View	D-2	This Project does not include structures which might influence view
18. Air Pollution	D-2	No adverse impact
19. Water Pollution	C	Sewage amount shall be increased due to the new water supply. Lake Victoria will be affected, if nothing to do any countermeasure
20. Soil Contamination	D-1	Nothing expected
21. Noise and Vibration	D-1	Need attention during construction
22. Ground Subsidence	D-2	Nothing expected
23. Noxious odors	D-2	Nothing expected

A : Serious Impact expected
B : Minor Impact expected
C : Uncertain (may become clear on investigation)
D-1 : Almost no Impact expected, if proper construction is carried out
D-2 : Almost no Impact expected, no need for EIA

Table O4-2 IEE Check List: Sewerage Component

Item	Evaluation	Reason
1. Resettlement	C	Not clear
2. Economic Activities	D-2	Any negative impacts are not expected
3. Transport	D-1	During construction period, needs attention
4. Separation of Community	D-2	Nothing expected
5. Cultural Assets and Archaeology	D-2	No such sites
6. Water and Common Rights	D-2	No impact expected
7. Sanitation	D-2	Sanitation condition shall be improved by proper sewage treatment
8. Waste	B	Sludge generated from Sewage Treatment Works should be managed properly
9. Dangers	D-1	Need attention during construction period
10. Topography and Geology	D-2	Project include no big structure to have such an impact
11. Soil Erosion	D-1	Need attention during construction period
12. Groundwater	C	Waste Stabilization Ponds may deteriorate ground water. Reduction of pit latrine user shall improve ground water deterioration
13. Lake, Marsh and River	D-2	Water quality in Lake Victoria shall be improved by strengthened sewage treatment capacity
14. Coastline and Sea	D-2	No such area
15. Flora and Fauna	C	Increase of effluent discharge from sewage treatment works may effect Flora and Fauna in Lake Victoria.
16. Weather	D-2	This Project does not include structures which might influence weather
17. View	D-2	This Project does not include structures which might influence view
18. Air Pollution	D-2	Nothing expected
19. Water Pollution	D-2	The main function of the Project is to treat sewage properly before discharge into Lake Victoria
20. Soil Contamination	C	Raw sewage may cause soil contamination during the treatment process
21. Noise and Vibration	D-1	Need attention during construction
22. Ground Subsidence	D-2	Nothing expected
23. Noxious odors	B	Any sewage generates odors.

A : Serious Impact expected
B : Minor Impact expected
C : Uncertain (may become clear on investigation)
D-1 : Almost no Impact expected, if proper construction is carried out
D-2 : Almost no Impact expected, no need for EIA

O4.2 Impacts during the Construction Stage

Any construction works may cause impacts in/around the construction sites. However, impacts during construction stage are generally temporary and are not difficult to make countermeasures to mitigate the negative impacts. In addition, the Project does not include such big structures which will affect serious impacts in/around the construction sites. Major Construction Sites are as follows;

Water Supply Components

- Kibos Intake Works and Kajulu Water Treatment Works Site
- Awach Intake Works Site
- Lake Intake Works Site
- Lake Water Treatment Works Site
- Kibue Water Treatment Works Site

Sewage components

- Conventional Sewage Treatment Works Site
- Nyalenda Sewage Treatment Works Site

As the result of IEE, it is judged that the impacts during the construction stage may be happen more or less on "Resettlement", "Transportation", "Dangers", "Soil Erosion" and "Noise and Vibration".

O4.3 Impacts by Water Supply Component during Operation Period

The purpose of the water supply component of the Project is to supply safe and stable potable water to Kisumu Municipality. The Project is therefore expected to have positive impacts on human and social environment, for example "Economic Activity" and "Sanitation".

However, the Project is also expected to have negative impacts on "Water and Common Rights", "Lake, Mash and River", "Flora and Fauna" and "Water Pollution". The major causes of the negative impacts are following phenomenon;

a) Reduction of River Water Discharge due to water abstraction by the Project

Proposed intakes on Kibos River and Awach/Nyangori River are expected to abstract 38,600 m^3/d and 6,900 m^3/d of water from each rivers respectively.

b) Increase of Wastewater Generation due to the New Water Supply

After completion of the proposed project, wastewater generated in Kisumu Municipality are expected to increase.

These phenomenons shall give impacts on Kibos and Awach/Nyangori River and Kisumu Bay.

(1) Water Right and Common Right

The intake sites are proposed in Kibos River, Awach/Nyangori River and Lake Victoria. Reduction of river flow in Kibos and Awach.nayngori River shall affect water right and/or common right.

Water Act stipulates as " the right to the use of every body of water is hereby declared to be vested in the Ministry, and except in accordance with such right, no person shall divert, abstract or use water from a body of water otherwise than under this act".

But actual situation of the water usage may include other user including common user without registration and illegal abstracts. At further stage, actual water usage condition in the rivers is to be reviewed. The usage condition includes registered water rights, and actual water usage even including illegal abstraction.

(2) Water Pollution

After completion of the proposed project, wastewater generation in Kisumu Municipality is expected to increase. The increase of wastewater generation may cause water pollution in Kisumu Bay (Lake Victoria), if any measures are not taken.

The two existing Sewage Treatment Works in Kisumu do not have enough treatment capacity even for present wastewater amount. Expansion and rehabilitation of the existing treatment works are required as countermeasure for mitigating the impacts of increase of wastewater generation.

(3) Lake, Marsh and River

The conditions of Kisumu Bay (Lake Victoria) and the Rivers may be changed by the above impacts, even if countermeasures are carried out.

(4) Flora and Fauna

Impacts on Flora and Fauna may be affected by the reduction of water flow in the rivers and/or the water pollution due to increase of the wastewater generation.

O4.4 Impacts by Sewerage Component during Operation

The purpose of the sewerage component of the Project is to collect wastewater generated in Kisumu Municipality and treat it properly. The sewerage components are therefore expected to improve sanitary conditions in the municipality, and also expected to mitigate the adverse impact of increase of wastewater generation.

Because of the function of sewage treatment works, sewage system should collect a lot of wastewater at the sites. Mismanagement of sewage treatment works therefore may cause serious impacts around the sites. However, proper design and proper O&M of the sewage works are expected to avoid the adverse impacts.

(1) Waste Disposal

A lot of sludge is generated in the wastewater treatment process. Due to increase of the treatment capacity, sludge generation will be also increased. Well-treated sludge could be useful for agriculture activities, but untreated sludge could be serious pollution source. Sludge treatment plan shall be proposed in further stage.

(2) Groundwater / Soil Contamination

Wastewater seeping through bottom of waste stabilization ponds in Nyalenda STW may cause contamination of groundwater and soil. Groundwater usage condition shall be investigated around the site.

(3) Flora and Fauna

Mismanagement of sewage and sludge may affect Flora and Fauna around the sites of Sewage Treatment Works. However, the Project is basically expected to improve ecosystem by proper wastewater treatment.

(4) Offensive Odor

Offensive odor is generated from wastewater, especially under anaerobic conditions. Any sewage treatment site generally causes this problem. The appropriate countermeasures will be proposed in further stage.

O4.5 Conclusion of IEE

As the results of IEE, following environmental items are selected as assessment items in Environmental Impacts Assessment for the Phase 1 Project

1) Impacts caused by Construction Works during Construction Period
   - Resettlement
   - Transportation
   - Dangers
   - Soil Erosion
   - Noise and Vibration

2) Impacts caused by Water Abstraction from Rivers during Operation Period
   - Water and Common Rights
   - Lake, Mash and River
   - Flora and Fauna

3) Impacts caused by Increase of Wastewater Generation due to the new water supply
   - Water Pollution
   - Lake, Mash and River
   - Flora and Fauna

4) Impacts caused by Operation of Sewage Treatment Works
   - Waste Disposal
   - Groundwater
   - Flora and Fauna
   - Soil Contamination
   - Offensive Odor

In order to assess the above environmental items, following investigation and review works shall be carried out in EIA Study Area as shown in Figure O5-1.

1) Construction Sites Survey
2) Water Usage and River condition Survey downstream from proposed intakes in Kibos River and Awach/Nyangori River
3) Pollution Load Prediction in Kisumu Municipality
4) Review Works of Environmental Impacts Procedure proposed by Government of Kenya.
5) Review Works of Ecological Survey Reports, and Study in Kisumu Bay (Lake Victoria)

O5 Present Environmental Condition In EIA Study Area

The area to be affected by the potential impacts, which is identified by IEE, are defined as EIA Study Area. EIA Study Area are as follow;

- Area in/around Proposed Construction Sites
- River Course between Proposed the Intake Sites and River Mouth on Kibos and Awach/Nyangori River
- Kisumu Bay

Figure O5-1 shows the location of the above area.

O5.1 Proposed Construction Sites

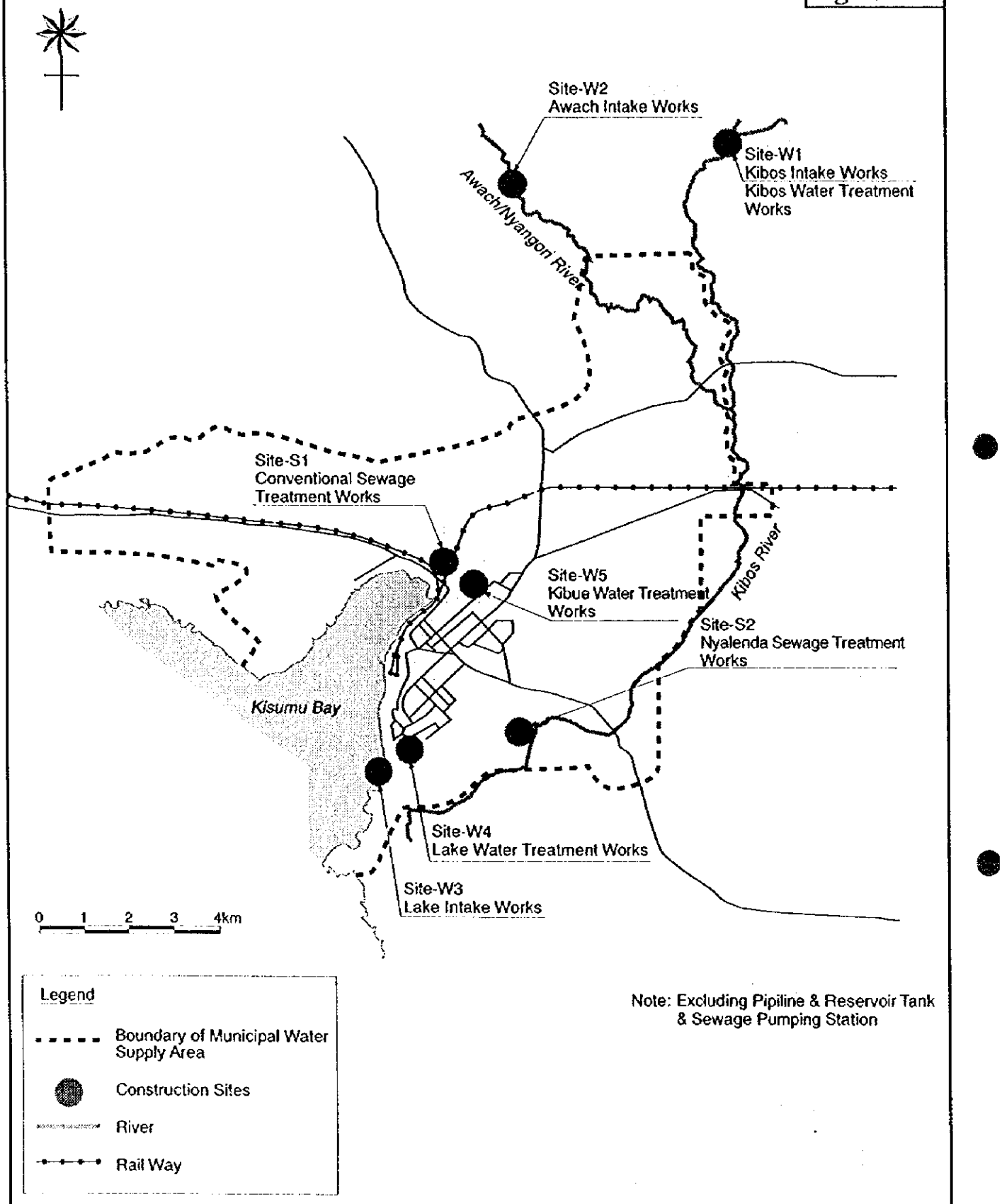
The details of Water Supply Component and Sewerage Component of Phase I Project are described in Chapter 4 and 5 in Main Report, respectively. The locations of the proposed construction are shown in Figure O5-1.

Major construction site conditions and construction work items are described in Table O5-1.

Table O5-1 Construction Site Condition and Construction Work Item

Site	Location and Condition	Construction Work Item
W1	Site is along Kibos River, and located in the vicinity of existing Kajulu Water Treatment Works, 23 km away from the river mouth. The landscape is hilly rugged and stony.	- Rehabilitation and expansion of the existing Kibos River Intake (3,000 m^3/day.) - Construction of new Kibos River Intake (71,000 m^3/day) - Rehabilitation and expansion of the existing Kajulu WTW (2,800 m^3/day)
W2	Site is in Kibos River, 8km upstream from confluence of Kibos River. The landscape is hilly rugged and stony.	- Construction of Awach River intake (14,000 m^3/day)
W3	Existing site facing Kisumu Bay, away from residential area, no need expansion of the site	- Rehabilitation and expansion of existing Lake Intake Works (27,000 m^3/day)
W4	Existing site, 1.2 km away from Lake Intake Work, near residential area, no need expansion of the site	- Rehabilitation and expansion of the existing Lake WTW (25,000 m^3/day)
W5	Existing site in center of the town, need expansion of ____m^2 land	- Construction of a Kibue WTW (40,000 m^3/day)
W6	Along the major road in the municipality and three small sites	- Installation of raw water transmission of 1.2 km and 18.8 km in length - Installation of treated water transmission of 3.6 km, 5.2 km, 4.2 km and 6.2 km in length - Installation of trunk distribution main of 23.9 km and 25.5 km in length - Installation of secondary distribution main of 330 km in total length - Construction of three units of distribution reservoirs
S1	Existing site in center of the town, no need expansion of the site	- Rehabilitation and expansion of existing Conventional STW (14,600 m^3/day)
S2	Existing site in center of the town, no need expansion of the site	- Rehabilitation and expansion of existing Nyalenda STW (18,000 m^3/day)
S3	Along the major road in the municipality and three of existing pumping station sites	- Rehabilitation and expansion of Trunk Sewers and Branch Sewers - Rehabilitation of three sewage pumping stations

Figure O5-1



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O5.2 Kibos River and Awach/Nyangori River

The EIA Study Area on Kibos river and Awach/Nyangori River is the river course between the two proposed intake sites and the river mouth (refer to Figure O5-1 and O5-2). The river course between Kibos River Intake site and the river mouth of Kibos River is 23 km in length, and the river course between Awach River Intake to the confluence of Kibos River and Awach/Nyangori Rivers is 8 km in length. About 30 villages are existing along the river course as shown in Figure O5-2.

Water Usage and River Condition Survey in the Study area on Kibos River System was carried out under the Study. As the results of the survey, it is estimated that Riparian communities with about 13,000 residents are existing along the river course. Those residents are depend on Kibos River or Awach/Nyangori River in the field of water source for domestic water, water source for irrigation, source for sand harvesting, source for fishing. The residents obtain their domestic water from River, Roof Catchment (rainwater), Pipes, Wells/boreholes, Spring. Most of the residents obtain domestic use water from river and Roof Catchment, other resources are not popular in this area.

Fishing activity is a popular along the all river course. The fish caught along the river course include Adel (*Barbus*), Fulu (*Haplochromis*), Mumi (*Claias*), Ndhira (*Xenoclarias*), Ngege (*Tilapia*), Kamongo (*Protopterus*), and Omena (*Rastrineobola argentea*). Most fish species are used for household consumption to provide protein, and some of fishes are marketed to supplement the family income.

Sand harvesting is also popular in the river course, especially downstream of the river course. The sand is used for material for building construction. Moreover, sand harvesting has become an important industry to make job opportunity for riparian communities.

Some water rights had been registered as shown in Table O5-2. However, all of water rights have already expired.

Figure O5-2

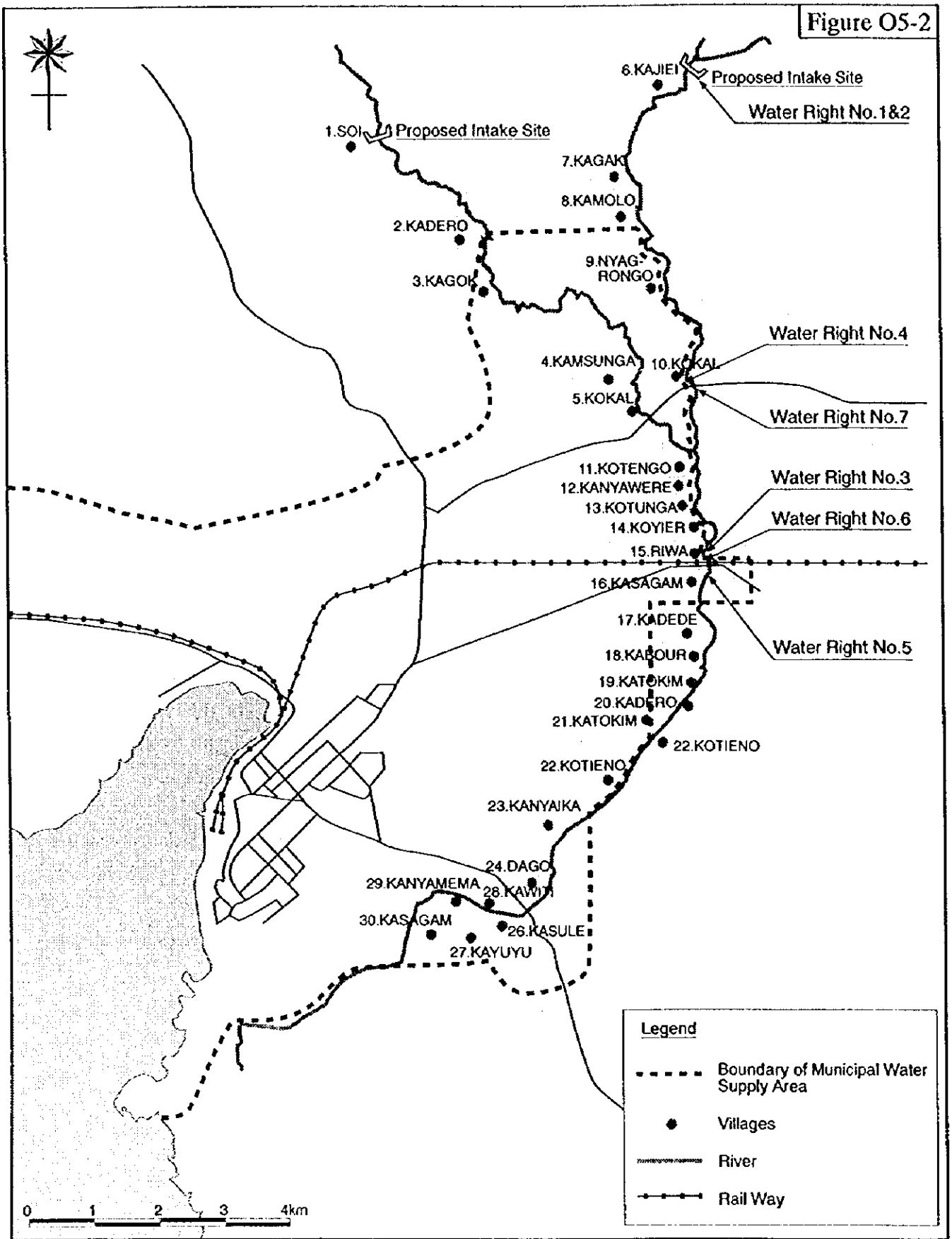

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Table O5-2 List of Water Abstraction Permissions

No.	Applicant	Allocation	Purpose	Issue Date	Expiry Date	Remarks
1.	Municipality of Kisumu	136.08 m^3/d	Public Use (Water Supply)	2-9-70	5-6-95	Under Renewal
2.	Municipality of Kisumu	1360.8 m^3/d	Public Use (Water Supply)	18-2-70	5-9-94	Under Renewal
3.	Director of Agriculture	29.8 m^3/d	Irrigation	8-2-61	31-12-85	Expired
4.	Director of Agriculture 66	7723.95 m^3/d	Irrigation	30-11-75	30-11-79	Under Renewal
5.	Kibos Industries	64.28 m^3/d	Domestic Steam Raising	19-3-75	31-12-83	Under Renewal
6.	Commissioner of Prisons (Kibos Prison)	908.7 m^3/d	Irrigation	23-6-76	23-6-78	Under Extension
7.	Rehmatk Kerdin	no-record	Domestic & Irrigation	18-9-84	13-9-86	Under propose

O5.3 Kisumu Bay (Lake Victoria)

Kisumu Bay is a part of Winam Gulf (Lake Victoria). The bay is adjacent to Kisumu Municipality, and it is important source of water supply for a large population in Kisumu Municipality. 18,000 m^3/day of raw water have been taken from the bay for the municipal water supply. The bay is acting not only as water source, but recipient of effluent from the Kisumu Municipality. The bay is therefore considered as most polluted part of Winam Gulf. The pollution load generated in the catchment area is discharged to the bay through Kisat River and drainage system in the municipality.

Currently, Kisumu Bay suffers a heavy infestation of water hyacinth (Eichhornia crassipes). During the field investigations, it was found the bay was completely covered by water hyacinth. Kisumu Port, which is an important transport facility for the region, is located in the bay. The infestation of the above weeds interferes greatly with the transportation activities. Due to the coverage by water hyacinth, there are no fishing activities in the bay.

O6 ENVIRONMENTAL IMPACT ASSESSMENT

As written in section O4.5, EIA are carried out on following Impacts,

- Impacts caused by Construction Works during Construction
- Impacts caused by Water Abstraction from Rivers
- Impacts caused by Increase of Wastewater Generation
- Impacts of Operation of Sewage Treatment Works

O.6.1 Impacts during Construction

As mentioned in section O5.1, the Study Area can be divided into 9 sub-area. Five items of potential impacts is assessed on each 9 sub-area, and the results are summarized as shown in TableO6-1.

Table O6-1 Evaluation of Impacts in/around Construction Sites

Site No.	Resettlement	Transportation	Dangers	Soil Erosion	Noise and Vibration
W1	O	O	O	O	O
W2	O	O	O	O	O
W3	O	O	O	O	O
W4	△	O	O	O	O
W5	O	O	O	O	O
W6	O	△	O	O	O
S1	O	O	O	O	O
S2	O	O	O	O	O
S3	O	△	O	O	O

O: nothing or no-possibility

△: minor

a. Resettlement — Due to the construction of Kibue WTW in the existing Kibue reservoir site, the site shall be expanded __ m^2 into residential area. Accordingly, several households shall be resettled. The land ownership belongs to the Government. The Government shall arrange reasonable resettlement plan with the residents. Other construction works will not require any resettlement for land acquisition. In case of Sites-W3, W4, S1 and S2, the construction works will be carried out within the existing sites.

b. Transportation — It is considered that there is no large scale construction works to disturb traffic condition around the construction sites. Pipe installation works for water

supply and sewerage system are to be carried out along the road in the municipal. It may effect traffic condition, but it is a temporally phenomenon.

e. Dangers — There are no construction works, which can be dangerous or cause damage or risk around the sites.

d. Soil Erosion — The Phase 1 Project does not include large scale earth works (embankment and excavation) in the construction sites. Serious soil erosion is not expected.

e. Noise and Vibration — Any construction works generate noise and vibration more or less. It is considered that there is no large-scale construction works to disturb neighbor's daily life by noise and vibration.

O6.2 Impacts caused by Water Abstraction from River

Operation of Kibos Intake Works and Awach Intake Works shall be controlled to keep the river discharge to insure water right. Water Act stipulates as " the right to the use of every body of water is hereby declared to be vested in the Ministry, and except in accordance with such right, no person shall divert, abstract or use water from a body of water otherwise than under this act". According to District Water Engineer of Kisumu District, all of registered water rights (water abstraction permits) along Kibos River downstream of the proposed intakes has expired, and any water right has not been registered, as shown in Table O5-2.

However, in actual situation, many persons use river water without any registration and permission. As described in section O5.2, riparian communities along the river course depend on the river water. These communities may be affected by the water abstraction of the Phase 1 Project. However, 20 villages among the 30 will be covered by water supply area after completion of the Phase 1 Project. Other seven villages are located within 1 km from the boundary of the water supply area, therefore it is possible for the residents to get water from public taps in the supply area. Domestic user of the river water is considered not to get serious impact.

Many kinds of fishes are found out in the river course. These fishes may be alive even if the river is dried up, because the fishes can move to Kisumu Bay (Lake Victoria) and be alive.

Even after completion of Phase I Project, the water abstract amount shall be controlled to keep maintenance flow in the rivers. As described in 4.2 in Main Repot, the river maintenance flow is assumed equivalent to the recorded minimum daily flow tentatively as below,

Kibos River (at proposed intake site): 6,100 m^3/day
Awach/Nyangori River (at proposed intake site): 2,600 m^3/day

Because there are not any water right downstream of the proposed intakes, the above maintenance flow is considered as reasonable.

O.6.3 Impacts caused by Increase of Wastewater generation

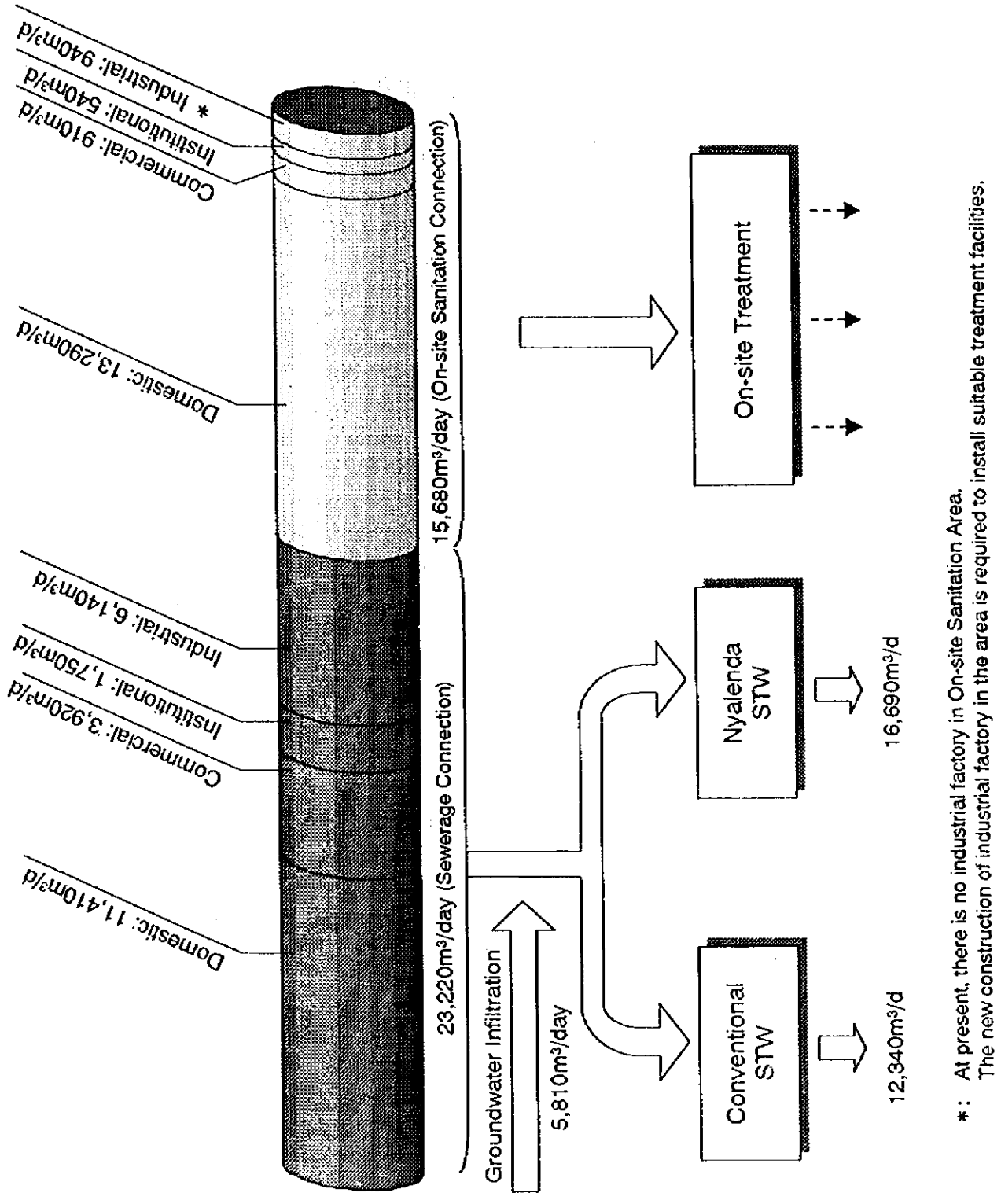
Due to the increase of water supply amount to Kisumu Municipality by the Phase 1 Project, wastewater generation in Kisumu Municipality is expected to increase. The Phase 1 Project aims not only to increase water supply amount in Kisumu Municipality, but also to increase wastewater collection and treatment capacity.

Table O6-2 and Figure O6-1 show prediction of wastewater generation in 2005 after completion of the Phase 1 Project, which are summarized from the results of the prediction in section 3.3. According to the prediction, 60 % of total wastewater in Kisumu Municipality will be collected through sewer system and treated in Sewage Treatment Works, and another 40 % of the wastewater should be treated individually by on-site treatment facilities.

Table O6-2 Wastewater Generation Prediction (2005) Unit: mg/L

	Treatment Method		Total
	Sewerage	Individual Treatment	
Domestic	11,410	13,290	24,700
Commercial	3,920	910	4,830
Institutional	1,750	540	2,290
Industrial	6,140	940	7,080
Total	23,220	15,680	38,900

Figure O6-1



THE REPUBLIC OF KENYA MINISTRY OF LOCAL AUTHORITY KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE **Prediction of Wastewater Generation in Kisumu (2005)**

(1) Wastewater in Sewerage Area

In order to assess impacts of wastewater in Sewerage Area, the Study Team calculates BOD Load of effluent from the Sewage Treatment Works in three cases as follows;

- Present Condition in 1998
- Condition in 2005, after Completion of Phase 1 Project (with Water Supply and Sewerage Components)
- Condition in 2005, after Completion of Phase 1 Project (only Water Supply Component without Sewerage Component)

The results of the calculation are shown in Table O6-3.

Table O6-3 Prediction of Effluent from Sewage Treatment Works

	1998	2005 (after completion of Phase 1)	
		with Sewerage Component	without Sewerage Component
Flow Rate (m^3/day)*1			
Conventional STW	6,800	12,340	12,340
Nyalenda STW	2,000	16,690	16,690
Total	8,800	29,030	29,030
BOD Value (mg/L)			
Conventional STW	220*2	20*3	220*2
Nyalenda STW	80*2	20*3	80*2
BOD Load (kg/day)			
Conventional STW	1,496	247	2,715
Nyalenda STW	160	334	1,335
Total	1,656	581	4,050

*1: Flow Rate includes groundwater infiltration from sewer pipes
*2: The results of Water and Sludge Survey
*3: Design Criteria for the Sewage Treatment Works

Even now, the effluent of Conventional and Nyalenda STW are considered as great pollution sources of Kisumu Bay. After completion of Phase I Project, influent of the STWs are expected to increase from 8,800 m^3/d to 29,030 m^3/d due to the increase of the water supply as shown in Figure O6-2. In case of no rehabilitation and expansion of the sewerage in the Phase 1 Project, total BOD pollution load from two STWs are expected to increase to 4,050 kg/d, which is more than double of the present value, 1,656 kg/d.

As the countermeasure for mitigating the above impacts, the Phase 1 Project includes rehabilitation and expansion program for the existing sewage treatment works as follows;

- Rehabilitation of the existing Conventional STW (trickling Filter Process) which includes an expansion of the treatment capacity on daily maximum from the existing 6,800 m^3/day to 14,600 m^3/day with design BOD effluent of 20 mg/L
- Rehabilitation of the existing Nyalenda STW (Waste Stabilization Pond Process) which includes an expansion of the treatment capacity on daily average from the existing 11,000 m^3/day to 18,000 m^3/day with design BOD effluent of 20 mg/L

Due to the above rehabilitation and expansion works, the BOD pollution load reduction is expected definitely, even comparing with the present condition, as shown in Figure O6-2.

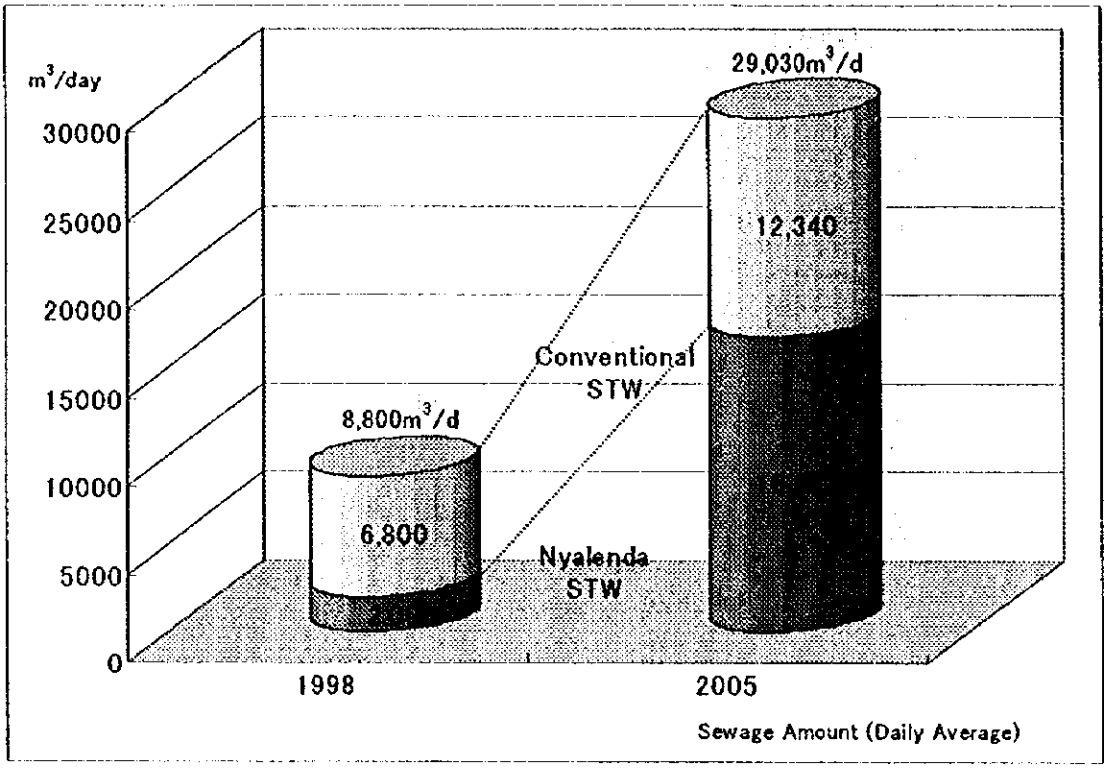
(2) Wastewater in On-site Sanitation Area

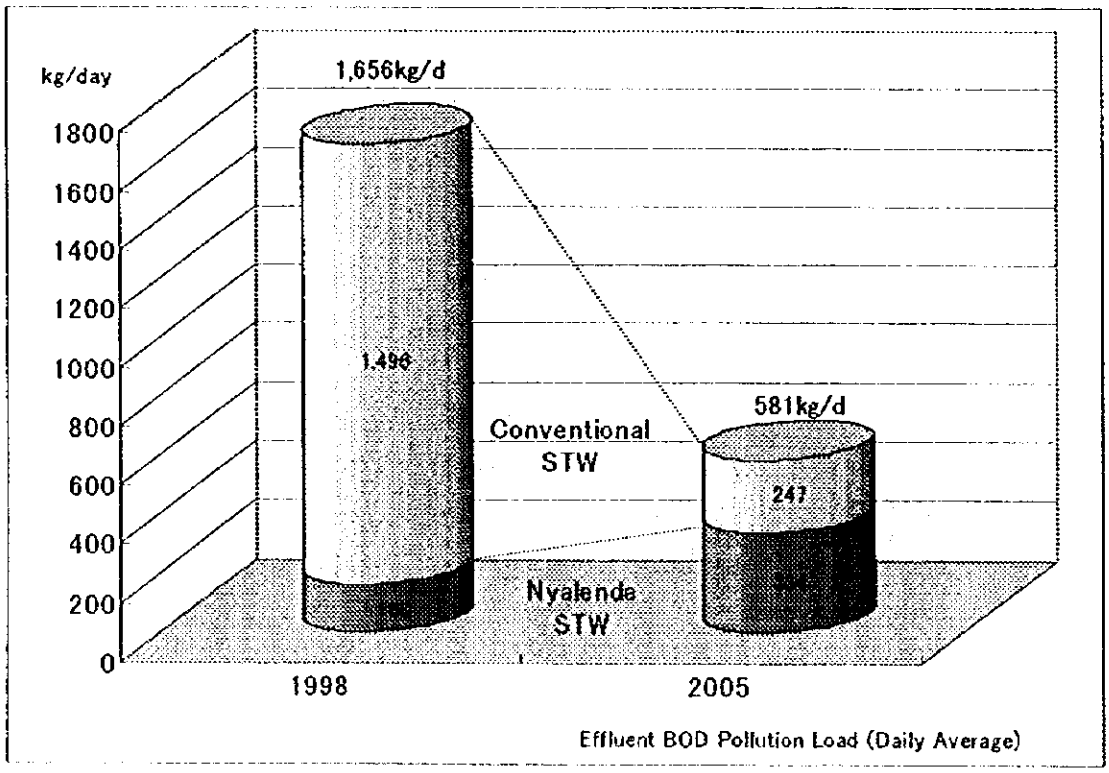
Even if sewerage system is expanded by the Phase 1 Project, sewerage system will cover about 60 % of total wastewater generated in Kisumu Municipality. Remaining 40 %, which is wastewater in on-site sanitation area, shall be treated at the source individually.

As shown in Figure 9-3, about 85 % of wastewater in on-site sanitation area, 13,290 m^3/day will be generated from domestic users. Most of the users are living in peri-urban area, and the unit water supply amount in this area is assumed low level from 15 Lpcd to 60 Lpcd. Therefore, even simple on-site treatment facilities, such as pit latrine can work well, so the 85 % of wastewater can not be expected serious pollution sources. Commercial and Institutional wastewater are also in the some condition of the domestic wastewater.

Industrial Wastewater in on-site sanitation area are predicted 940 m^3/d, only 6 % of the total wastewater in the area. However, the effluent may be high-density contamination. If on-site treatment works can not work well, the effluent become serious pollution load. At present, there is no industrial factory in the area. At the new construction of the factories in the area, the factories shall be attached with wastewater treatment facilities to meet the effluent standard as same as the Sewage Treatment Works adopted.

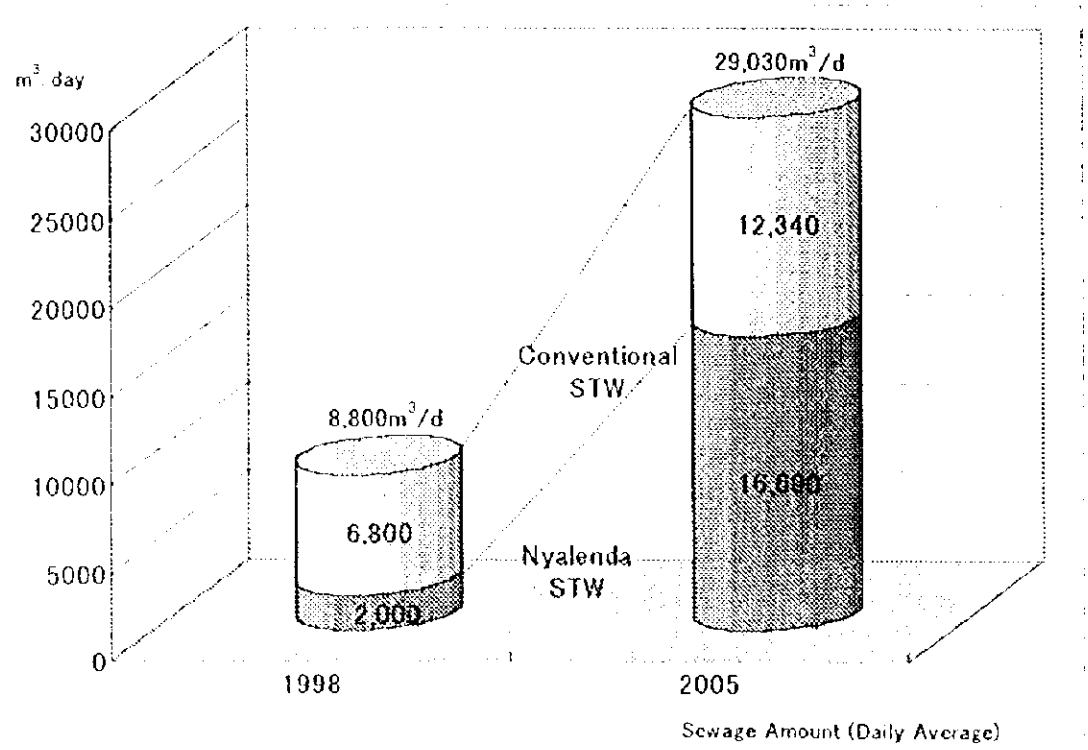
Figure O6-2



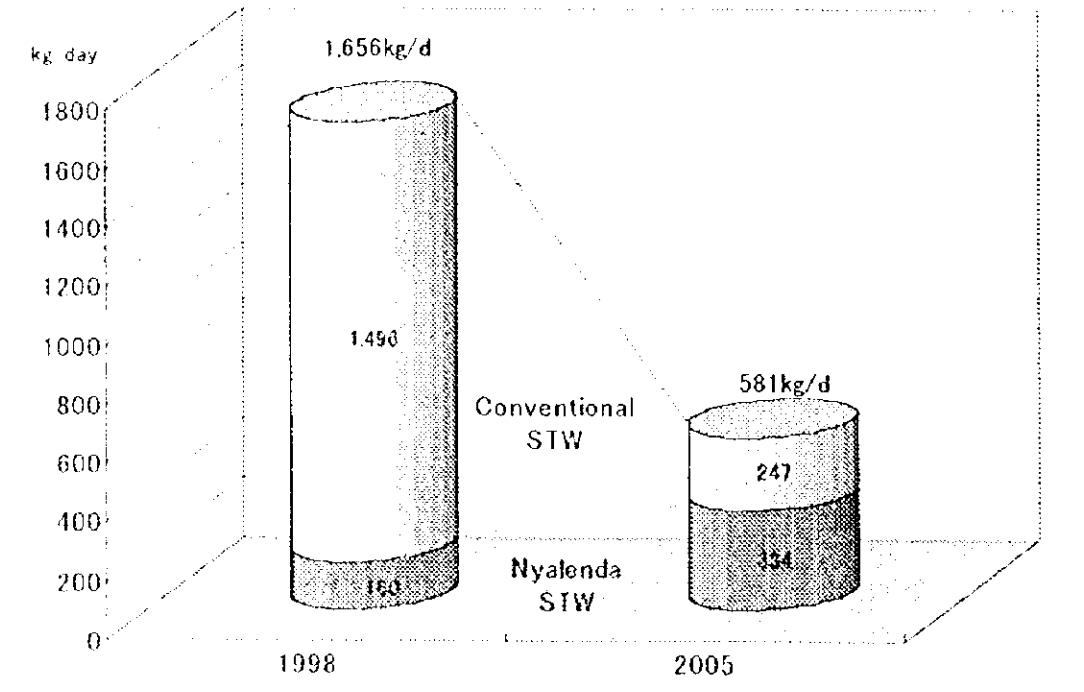


THE REPUBLIC OF KENYA MINISTRY OF LOCAL AUTHORITY KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Prediction of Sewage Amount and Effluent BOD Pollution Load of Sewage Treatment Works

Figure O6-2



Sewage Amount (Daily Average)



Effluent BOD Pollution Load (Daily Average)

THE REPUBLIC OF KENYA MINISTRY OF LOCAL AUTHORITY KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Prediction of Sewage Amount and Effluent BOD Pollution Load of Sewage Treatment Works

O6.4 Impacts of Operation of Sewage Treatment Works

Operation of Conventional and Nyalenda Sewage Treatment Works are expected to affect positive impacts rather than negative impacts, as described in section O6.3. This section describes about impacts caused by operation themselves of the two sewage treatment works, but does not describe about impacts by effluent of the STWs because they were already assessed in O6.3.

(1) Outline of Sewage Treatment Works

The treatment capacity of Conventional STW will be doubled from 6,800 m^3/d to 14,600 m^3/d on daily maximum by the rehabilitation and expansion works. Though the increase of the treatment capacity, Conventional Sewage Treatment Works will adopt same treatment method, and the difference is only adopting Super Rate Plastic Media for Biofilter. The treatment capacity of Nyalenda STW will be increased from 11,000 m^3/d to 18,000 m^3/d on daily average by installation of three anaerobic ponds. Table O6-4 shows the comparison of major components of sewage treatment works between present and after Phase 1 completion.

Table O6-4 Major Component of Sewage Treatment works, at Present and after Completion of Phase 1 Project

	Present	After Completion of Phase 1
1. Conventional STW		
Primary Sedimentation	6 units	7 units
Biofilter	6units (using stone media)	8 units (using SR plastic media)
Secondary Sedimentation	6 units	6 units
Design Capacity (Daily Maximum)	6,800 m^3/day	14,600 m^3/day
Management Capacity (Daily Average)	6,800 m^3/day	—
2. Nyalenda STW		
Anaerobic Pond	0	3 units
Facultative Pond	3 units	3 units
Maturation Pond	6 units	6 units
Design Capacity (Daily Average)	11,000 m^3/day	18,000 m^3/day
Management Capacity (Daily Average)	2,000 m^3/day	—

(2) Assessment

The potential impacts, which were identified in IEE are assessed on the two STWs and the results are summarized as bellows;

Table O6-5 Evaluation of Impacts by Operation of Sewage Treatment Works

	Waste Disposal	Groundwater	Flora and Fauna	Soil Contamination	Offensive Odor
Conventional STW	△	○	○	○	○
Nyalenda STW	△	△	○	○	△

○: nothing or no-possibility

△: not serious or minor

a. Waste Disposal — Certain amount of sludge is continuously generated in the process of waste water treatment. Dry sludge, which is treated through the sludge treatment process in existing Conventional STW, is utilized for agriculture activities by farmers. As long as sludge is managed properly, the dry sludge is in great demand for agriculture use.

b. Groundwater — The ponds of Nyalenda STW are constructed by earth works. The wastewater in Nyalenda STW, therefore may infiltrate to groundwater through the bottom of ponds during treatment process. It may be dangerous for health if ground water is used for drinking. Fortunately, near the site, any well for drinking water can not be found out. The infiltration of the wastewater is not expected serious impacts.

c. Flora and Fauna — Any impacts on Flora and Fauna can hardly be expected as long as sewage treatment works are operating properly.

d. Soil Contamination — Heavy metal and toxic material shall contaminate surface soil around the site. However, as long as industrial factories do not discharge such materials, soil contamination is not expected.

e. Offensive Odor — Anaerobic ponds in Nyalenda STW may generate offensive odour. However, the site of Nyalenda STW is far from residential area, and located in open area. Odour problem is not expected so seriously.

Because of function of sewage treatment works, large amount of raw wastewater should be collected to the site of sewage treatment works and treated. In case of mismanagement and/or broken down of sewage treatment Works, collected raw wastewater may cause great impacts around the site. Suitable operation and maintenance of sewage treatment works are minimum requirement for environmental conservation.

O7 Countermeasure for Mitigating Impacts

The countermeasures to the each potential impact are recommended to mitigate magnitude of the impacts as below.

(1) Impacts caused by Construction Works during Construction Period

Impact Item	Countermeasure
a. Resettlement	The resettlement plan for expansion of Kibue WTW site shall be prepared as soon as possible. The plan shall be established in cooperation with the residents to be resettled.
b. Transportation	During installation of pipes along the road, the Contractor shall submit installation plan to the Municipality. The Contractor shall take necessary action such as traffic control to mitigate impacts on traffic condition in cooperation with the Municipality.
d. Dangers	The site condition and progress of construction works shall be checked periodically. The Contractor shall prepare safety-working condition.
e. Soil Erosion	After completion of earth works (embankment and excavation works) in the sites, soil condition shall be checked by the Consultant.
f. Noise and Vibration	Basically, any construction in midnight will not be allowed

(2) Impacts caused by Water Abstraction from Rivers during Operation Period

Impact Item	Countermeasure
a. Water and Common Rights	Intake Works shall be designed and operated to keep maintenance flow in the rivers. The maintenance flow is assumed equivalent to the recorded minimum daily flow in the rivers.
b. Lake, Mash and River	
c. Flora and Fauna	

(3) Impacts caused by Increase of Wastewater Generation

Impact Item	Countermeasure
a. Water Pollution	Rehabilitation and expansion of the sewerage system, which is one of components of the Project, are expected to act as the countermeasure. On-site treatment facilities will cover about 40 % of total wastewater generated in the Project Area. The Municipality is recommended to promote installation of proper on-site treatment facilities in the area.
b. Lake, Mash and River	
c. Flora and Fauna	

(4) Impacts of Operation of Sewage Treatment Works

	Countermeasure
a. Waste Disposal	After expansion of treatment capacity of the STWs, sludge management system will be strengthened to meet new generation of the sludge. Sludge management shall be considered from the view point of demand and supply condition
b. Groundwater	It will be forbidden to drink raw groundwater near Nyalenda STW.
c. Flora and Fauna	Safety and proper operation of STWs shall be kept under the suitable O & M system.
d. Soil Contamination	It is not allowed to discharge with any toxic material by law. It is recommendable Effluent monitoring system will be organized especially for industrial effluent.
e. Offensive Odor	At detail design stage for anaerobic ponds in Nyalenda STW, tree planting shall be considered to protect the neighborhood from offensive odor. At present there is no residential area around site.

O8 Conclusion and Recommendation

(1) Conclusion

a. Impacts by Construction Works

- Any serious impacts can not be expected during construction period, if the countermeasures are carried out as shown in Section 9.5.

b. Impacts by Water Abstraction from River during Operation

- There is no water right on the river course downstream from the proposed Kibos and Awach intake sites. However, many residents of riparian communities use river water for domestic use, irrigation or water for live stocks without any permission from the government. Many kinds of fishes are found out in the river course, and fishing is very popular in the riparian communities. Therefore, the maintenance flow, which is assumed equivalent to the recorded minimum daily flow, shall be kept in the rivers, in order to avoid great impacts on the river condition and riparian community life. After completion of Phase 1 Project, it will become possible that most of riparian communities get water through the public taps.

c. Impacts by Increase of Wastewater during Operation

- Due to increase of water supply amount under Phase 1 Project, total influent amount of Conventional and Nyalenda STWs is supposed to increase to 23,400 m^3/day from 8,500 m^3/day. However, total BOD pollution load from the both STWs is expected to decrease to 464 kg/day from 1,590 kg/day, due to rehabilitation and expansion of the STWs under Phase 1 Project. Phase 1 Project is therefore expected to work for environmental conservation in Kisumu Bay (Lake Victoria).
- Wastewater generated in On-site Sanitation Area shall be treated individually. Most of the wastewater in the area is generated from domestic water users, whose unit water consumption rate is low. This kind of wastewater is not expected serious pollution source, even if only simple on-site treatment facilities are installed.
- According to the prediction, 940 m2/d of industrial wastewater will be generated in On-site Sanitation Area. It may become serious pollution sources, because Industrial effluent may discharge highly polluted material directly without proper treatment. At present, there is no

industrial factory in the area. The government shall take attention to new construction of industrial factory in the area.

d. Impacts of Operation of Sewage Treatment Works

- If the sewage treatment works can not operate properly, large amount of collected wastewater at the sites will change to a serious pollution source. Proper operation and maintenance of the treatment works are required.

(2) Recommendation

a. Maintenance Flow

The operation of Kibos Intake Works and Awach Intake Works shall be controlled to keep the maintenance flow in Kibos and Awach/Nyangori Rivers. At further detail design of the intake works of Phase 1 Project, structural and institutional measures shall be considered in order to keep the maintenance flow.

The river maintenance flow is assumed equivalent to the recorded minimum daily flow tentatively. It is considered quite reasonable. However, the amount of maintenance flow has not been justified and approved officially. At the detail design stage, it shall be reconsidered by the relevant organizations in Kenya.

b. On-site Treatment Facilities

Even after completion of Sewerage Component of Phase 1 Project, about 40 % of wastewater generated in the Study Area shall be treated individually. Individual treatment facilities has not been overseen and controlled systematically in Kisumu Municipality. Installation of proper on-site treatment facilities shall be promoted for environmental conservation. It is recommended that Municipal Council of Kisumu establish the control and promotion program for on-site treatment facility.

c. Strengthen of O & M system of STW

Lack of proper operation and maintenance of STW may cause serious pollution problem. If the sewage treatment works can not work properly, large amount of collected wastewater will become serious pollution load immediately. Strengthen of O & M system for STWs is required for environmental conservation.

Attachment -1

The Water Act, Cap 372

Co-ordination and implementation problems within Kenyaís legal and institutional framework can be illustrated by looking at the management of water in the urban environment. Water resources are regulated and managed by a number of ministries and departments. In addition to the Water Act, other laws that have a bearing on water include the Agriculture Act, the Local Government Act, the Factories Act and the Public Health Act provide the legal framework. This situation calls for a high level of co-ordination if water resources are to be well managed.

Water in Kenya belongs to the nation, this with rare exceptions, water use requires a permission from the Kenya government. The legislation regarding such a matter is provided by the Water Act which deals with conservation, control, apportionment, and use of water resources in the country. A permission for water abstraction from any source of water issued by the Water Apportionment Board of Water Law Section of the Ministry of Land Reclamation, Regional and Water Development (MLRRWD). The Water Act defines an order of priority for water abstraction, which is supposed to reflect the government policy. It is in the order of domestic water, agriculture, industrial, and power generation.

Based on the Water Act, MLRRWD holds a primary responsibility of supplying water to rural and urban areas, except those under the jurisdiction of local governments.

The Water Act prohibits water pollution and gives control devices by giving such conditions in the water use permit as will ensure that pollutant substances are not left in any water supply. The Water Act states that any person who by any act of neglect, causes any source of supply, the water from which is used or is likely to be used for human consumption or domestic purposes, or for manufacturing of food or drink for human consumption, to be polluted, shall be guilty of an offence.

The Act prohibits among others the unlawful interference with water in a water-course or body of water and prohibits the release of water without a permit, and specify penalties for polluting water used for human consumption. Any person who unlawfully throws or conveys or causes or permits to be thrown or conveyed any rubbish, dust, refuse, effluent, trade wastes or other offensive or unwholesome matter or thing into or near anybody of water in such a manner as to cause or likely to cause pollution thereof, shall be guilty of any offence, punishable by a fine.

The Act further provides thereof for standard to be set. The effluent from any works in which water is used in any process or for any purpose shall be returned to the body of water from which it is directed or abstracted or to such other body of water as may be authorized by ... in such a degree as will satisfy the Board, and the effluent shall contain no matter poisonous or otherwise likely to be injurious directly or indirectly to public health, livestock or crops or orchards or gardens irrigated with such water or to any

product such water is used in any process whatever and it shall not contain a burden of silt by the body of water from which it is directed or abstracted.

For smooth enforcement of the anti-pollution legislation a Water Quality and Pollution Control Section in the Department of Water Development was set up to undertake scientific and technical laboratory work on standardization of water quality. The knowledge on water quality is very useful on the event of prosecutions under the Act where sampled waters are shown not to be of the required standard.

The Public Health Act, Cap 242

This Act contains directives regarding regulation of activities that affect human health. There exists provision within the Act to deal, in a general way, with water, air and noise quality as they pertain to human health. An environmental nuisance is defined and includes the emissions from premises of waste waters, gases, smoke which could be regarded as injurious to health. The owner and/or occupier of premises responsible for such nuisances are liable to prosecution under the Act.

As regards waste treatment, an industry may take any of the following options:

- Treat the waste (if liquid) to a standard that is high enough to allow disposal to a stream. This has to be done especially if the area is not served by the municipal sewer.
- Pre-treat to a standard that can be accepted into a municipal sewer.
- If solid, obtain a permit to dump in a municipal garbage site or let the municipal council collect for a fee and dispose of the waste. In case of harzadous waste, permit may be obtained for incineration in a municipal sewage works where facilities exist.

Chief's Authority Act, Cap. 128

This Act empowers Chiefs to:

- prevent the pollution of water in any stream, watercourse or water-hole, and prevent the obstruction of any stream or watercourse;
- regulate the cutting of timber and the wasteful destruction of any stream or watercourse;
- prohibit any act that might cause damage to any work constructed or maintained for the benefit of the community;
- control grass fires; and
- regulate the use of artificial water supplies constructed from public funds.

The Chief's Authority Act also provides for the Minister to authorize any Chief to issue orders for work or services for the conservation of natural resources. This Act is currently being reviewed with a possibility of being abandoned if found ineffective.

The Local Government Act, Cap. 265

The Local Government Act is concerned with a wide range of matters that affect the day-to-day activities of individuals and organizations. To this extent the Act has provisions that will affect management of wastes.

- The Act empowers a local authority with the consent of the Minister to make grants for the establishment and maintenance of game parks and other related facilities.
- The Act provides for the control of the cutting of timber and the destruction of trees and shrubs.
- The Act empowers municipal councils, town councils and urban councils to control or prohibit all businesses, factories and workshops which by reason of smoke, fumes, chemicals, gases, dust, smell, noise or vibration or other causes may be a source of danger discomfort or annoyance to the neighbourhood and to prescribe the conditions subject to which business, factories and workshops shall be carried on.
- The Act authorizes municipal councils, such as Kisumu Municipality to undertake the supply of water.

The Antiques **and Monuments Act, Cap. 251**

The Act provides for historical sites and structures, whereby such sites and structures are known, or are unearthed by exploration, are protected.

The Lake and Rivers Act, Cap. 409

The Act provides for dredging in a lake or river to be licensed and sets out the regulations governing the licensing procedures.

The Land Planning Act, Cap. 303

This Act provides for the preparation, submission and approval of areas plans and town plans and for subsequent control of development. It also covers change of land use and stipulates the powers of the Land Control Board and the means of enforcement of planning control.

The Wildlife (Conservation and Management) Act, Cap. 376

The Act deals with areas declared as National Parks under the Act. The Act controls activities within the parks which may lead to the disturbance of animals. The Minister is able to make regulations as necessary for the well being of the parks and their wildlife.

The Forest Act, Cap 385

The Act refers to areas defined as "Forest Areas" or "Central Forests". Gazetted forests are located in Lake Victoria catchment area.

The Forest Act specifically forbids certain activities within the conservation areas. These include cutting and burning, access at certain times, building of certain types of structures and roads, cultivation, grazing, taking of animals and the collection of honey, without appropriate authority. The Act also prohibits activities, such as cutting and burning on alienated public lands not specified as "Forest Areas" or "Central Forests". The Minister can make regulations to control development activities within all such areas.

The Agricultural Act, Cap 318

Legislative control over soil conservation and land development are mainly controlled within this act and many of the provisions can be generally applied beyond those lands suitable for agriculture.

After concurrence with the Central Agricultural Board and consultation with the District Agricultural Committee, the Minister administering the act can impose land conservation orders on lands to control cultivation, grazing and clearing. These controls may be necessary to protect the land against soil erosion, to protect fertility and to maintain catchments. Local authorities are generally empowered to administer these sections of the Act. The District Agricultural Committee is entitled to make regulations relating to these controls. Acquiring (Basic Land Usage) rules are prescribed under the Act whereby vegetation clearing in steep slope areas or adjacent to watercourses without authorization is controlled.

The land Acquisition Act, Cap. 295

It is possible under the provisions of this Act for land to be acquired or granted access to for purpose of a project. Acquisitions or access must be shown to be for the public benefit and compensation must be provided to the land owners whose land is acquired or damaged.

The Factories Act, Cap. 514

Environmental health and safety requirements within a functioning factory facility are regulated by this Act. A factory must be registered with the Chief Inspector of Factories. The Act requires that work areas be of an appropriate standard, well ventilated, with suitable lighting. Sanitary areas and drinking and washing areas should be provided and safety provisions are described in the Act.

The Public Roads and Roads of Access Act

The use of public roads and the rights and obligations associated with construction and maintenance of roads are outlined in this Act. Public roads shall be absolutely dedicated to the public. Roads of access, however, can be provided across private land but there exists the opportunity for objection to the proposed road by the landowner. Once established, the road of access must be maintained by the applicant.

The Radiation Protection Act, Cap. 243

The purpose of this Act was to establish a Board to regulate the importation, exportation, use and disposal of materials capable of producing ionizing radiation.

One of the powers given to the Board by the Act is to ensure safe disposal of toxic waste arising from the use of radioactive material. The licensee is required to take proper care of disposing such waste.

The radiation Act has several weaknesses which are succinctly summarized below:

- The Act does not make it an offence to fail to dispose toxic waste arising from use of radioactive materials properly. In fact no offence is provided by this Act for wrongful dumping of radioactive waste.
- The Act does not make provision for "polluter pays" principle, hence a licensee can dump radioactive waste anywhere and walk scot-free irrespective of the danger of such wastes to the environment.
- Regulations required to have been developed in 1984 (13 years ago) for "disposal of radioactive" waste have never been developed.
- Although the Statute was intended to control and prevent environmental degradation from radioactive wastes, it has been rendered ineffective by absence of standards or regulations.

The Penal Code Act Cap. 63

The Penal Code ranks among the oldest colonial statutes on air quality management. Enacted in 1930 it contains a chapter entitled, "Offences against Health and Convenience". The code strictly prohibits

releasing of foul air which affects the health of other persons. Any person who voluntarily violates the atmosphere at any place, to make it noxious to health of persons in general dwelling or carrying on business in the neighbourhood or passing along public way is guilty of a misdemeanour, i.e., imprisonment not exceeding two years with no option of a fine.

The code prohibits fouling of air by industrialists and manufacturers etc. Under this code any person who for the purpose of a trade or otherwise makes loud noise or offensive or awful smells in such places and circumstances as to annoy any considerable number of persons in the exercise of their rights, commits an offence and is liable to be punished for a common nuisance, i.e., imprisonment not exceeding one year with no option of a fine.

The Traffic Act, Cap. 403

The Traffic Act empowers police officers to stop and remove from the road vehicles producing noxious emissions or to charge their owners in a court of law. Under the Traffic Rule, every motor vehicle shall be constructed, maintained and used that no avoidable smoke or visible vapour is emitted therefrom.

The other Act apart from the penal code deals with usage of substances that are potentially toxic and therefore can pollute water, air and soil or causes harm to animals and people. The users are prohibited from handling the substances in a manner that they can cause pollution. The ministries and departments enacting this Act are therefore empowered to prevent pollution.

In 1993, the Government amended the Traffic Act, however, the amendment did not introduce any substantive changes in the Law, but was mainly concerned with controlling loud music of *"matatus"*, their flash lights and colours.

One major pollution of the atmosphere occurs on the highway either by use of adulterated petroleum products or unroadworthy vehicles, aircrafts, rail-locomotives and ships. The Traffic Act requires that the vehicle shall only use the fuel specified in the vehicles license.

The control of vehicular pollution is an example of grossly inadequate standards and enforcement. The Traffic Act prohibits the operation of motor vehicles that emit black fumes which pollute the air and cause visibility problems. The problem with this requirement is that there is no standard measure or definition of what constitutes black fumes or visibility problem. The Act does not address specific pollutants that are particularly harmful, such as lead and carbon monoxide. Most important, Kenya does not have any programmes to reduce or even monitor vehicular pollution.

Attachment -2

The major institutions conducting research in the project area are the Kenya Marine and Fisheries Research Institute; Lake Basin Development Authority; OSIENALA; BKH Consulting Engineers; National Universities (comprising University of Nairobi, Moi University, Jomo Kenyatta University of Agriculture and Technology, Maseno University College); IUCN; ICIPE; Ministry of Land Reclamation, Regional and Water Development (MLRRWD).

(a) Kenya Marine and Fisheries Institute (Kisumu)

This is perhaps the most active institution with regard to research work on Lake Victoria and the inflowing rivers. The institute through its two research centres namely Kisumu and Sangoro conducts research on fisheries, limnology and aquaculture. The institution has enormous collection of published and unpublished material, raw data and other forms of research products.

(b) Lake Basin Development Authority

Since its inception, Lake Basin Development Authority has carried out various feasibility studies with the aim of boosting development of the area. The Authority has departments of Fisheries and Environmental Protection. The Fisheries Department is charged with the development and promotion of aquaculture while the Environmental Protection Department is responsible for water quality and pollution control in the Lake Victoria basin. This department has a water quality monitoring laboratory.

(c) National Universities

The national universities include University of Nairobi, Kenyatta University, Moi University, Maseno University and Jomo Kenyatta University of Agriculture and Technology. These universities carry out research in ecology, Limnology, fisheries and land use. Their activities contribute directly to the management of the Lake.

(d) Ministry of Land Reclamation, Regional and Water Development

Through its division of pollution and water quality control, the above ministry is involved in water analysis and the monitoring of pollution and water quality.

(e) Lake Victoria Environmental Management Programme

The Lake Victoria Environmental Management Project (LVEMP) is a comprehensive program aimed at rehabilitating the lake ecosystem for the benefit of the people who live in the catchment, the national economies of which they are a part, and the global community. LVEMP will support specific national and regional activities including:

Fisheries

- Management of fisheries including the establishment and operations of the Lake Victoria fisheries organisation.
- Improvement of fisheries research and information base for fisheries.
- Strengthening of extension, monitoring and enforcement capabilities of national fisheries administration.
- Studying and implementing a fish levy trust.
  Management and control of water hyacinth infestation

Lake Pollution and Water Quality

- Management of lake pollution and water quality including strengthening and harmonizing national regulatory and incentive frameworks and enforcement capabilities.
- Establishing a lake-wide water quality monitoring system.
- Improvement of research and information base for pollution control and water quality.
- Pilot investments in industrial and municipal waste water management.
- Priority waste management investments.

Land Use

- Management of land use in the catchment including improvement of research and information base for pollution loading.
- Assessment of agro-chemicals and pilot investments in soil conservation and afforestation.

Wetlands

- Wetland management including improving the information base.
- Pilot investment in sustainable management of wetland products.

Support for institutions for lake-wide research and management and pollution disaster contingency planning.

(f) *OSIENALA*

OSIENALA (Friends of the Lake Victoria) is the major NGO directly involved in the management of Lake Victoria. OSIENALA is a community-based NGO whose main objective is to enhance environmental conservation and protection of Lake Victoria and its catchment area. The organization is based in Kisumu and is actively involved in community mobilization programme to abate the worsening situation of the degradation of the lake and the surroundings. OSIENALA has developed project proposals for funding in areas such as fisheries, renewable energy, socio-economics, land use, education and public awareness, wetlands, water hyacinth and women participation.

The above NGO is the main collaborating institution in a regional IUCN project on socio-economics of the Nile Perch fishery on Lake Victoria. The purpose of the project is to come up with solutions on how the fisheries resources of the lake can be sustainably utilized and managed to satisfy the needs of the local fishing communities.

OSIENALA with support from a United States Government grant are involved in boat building and fishnet making project. This project will train groups and individuals to develop or enlarge their income generating capacity. The organization is a partner in River Nyando and Sondu-Miriu Wetlands Rehabilitation Conservation Project. This project was initiated to intervene and contain ecological degradation processes of the above river system. The project, implemented with collaboration from Linkoping University of Sweden is funded by Swedish International Development Agency (SIDA).

(g) BKH Consulting Engineers

This firm is affiliated to the Netherlands Association of Consulting Engineers (ONRI) and the International Federation of Consulting Engineers (FIDIC). BKH deals with rural domestic water supply and sanitation. Although it collaborates with Lake Basin Development Authority (LBDA), Provincial Steering Committee and District Development Committees (DDCs), it is not directly involved in the management of urban environments and the lake. But it concentrates on rural water quality monitoring and evaluation, which may contribute to environmental deterioration in the project area. Also it is important to note that the projects initiated through this firm have been approved by the DDCs.

(h) Lake Victoria Wetlands Team

Lake Victoria Wetlands Team (LVWT) is a voluntary group of scientists and conservationists working to promote the sustainable utilization of wetlands in the Lake Victoria basin as set out in the Ramsar Convention. The LVWT is a non-profit making non-governmental organization (NGO). Since its inception in 1993, LVWT has been involved in conservation activities in critical wetland habitats.