B2.3 Results of Water Quality Analyses

Tables B-2 up to B-8 show the results for sampling on 23 ~ 24 June 1993 and Tables B-9 up to B-15 show the results for sampling on 21 ~ 22 July 1993.

Table B-16 shows the results of oil and anionic surfactant concentrations in the influent and final effluent on 1~2 September 1993. Table B-17 shows the effluent quality of Third Maturation Ponds in Njoro STW on 31 August 1993.

Tables B-18 up to B-21 show the diurnal variation of Influent and Effluent quality (pH, DO, ORP and conductivity) of Facultative Ponds and Third Maturation Ponds on 1~2 September 1993.

Tables B-22 and B-23 show the influent flowrate variation at Town STW on 30 June ~ 1 July and 28 ~ 29 July 1993. Table B-24 shows the final effluent flowrate variation for both sampling. Tables B-25 up to B-29 show results of water quality analyses for sampling on 30 June ~ 1 July 1993 and Tables B-30 up to B-34 show the results of water quality analyses for sampling on 28 ~ 29 July 1993.

Table B-2 Influent Flow Rate Variation at Njoro STW on 23 ~ 24 June 1993

Time h	Gauge Reading cm	Flowrate m3/h	Remarks
9:00	25.0	316	
10:00	-	-	
11:00	-	-	
12:00	18.5	201	
13:30	18.0	193	
14:30	19.0	209	
15:00	22.0	261	
16:00	17.0	177	
17:00	18.5	201	
18:00	18.5	201	
19:00	18.0	193	
20:00	17.5	185	
21:00	16.5	169	
22:00	15.5	154	
23:00	13.5	125	
24:00	12.5	112	
1:00	10.5	86	
2:00	10.0	80	
3:00	11.5	99	
4:00	-	-	
5:00	-	-	
6:00	11.0	92	

Note :

Total Flow	4,173 m3/d
Average Flowrate	174 m3/h
Peak Flowrate	316 m3/h
Peak Factor	1.80

Table B-3 Influent Quality at Njoro STW on 23 - 24 June 1993

XI/W

Item		Time							
		9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Flow rate, m3/h		316	201	261	201	170	112	99	92
Temperature, °C		19.4	22.4	22.9	23.4	22.7	24.0	24.0	24.0
pH		7.98	7.02	7.13	7.26	7.31	7.12	7.33	7.28
Conductivity, mS/cm		3.170	1.300	1.150	0.980	0.912	1.047	0.715	0.642
ORP, mV		-	-	-	-	-	-	-	-
BOD5, mg/L		1,550	500	680	600	520	670	180	620
COD, mg/L		1,840	680	800	760	640	820	240	720
SS, mg/L		494	1,040	980	761	480	580	120	80
TDS, mg/L		1,860	860	660	690	640	870	450	460
T-N (Total Nitrogen) mg/L		207.2	728.0	207.2	240.8	240.8	364.0	162.4	128.8
NH4-N, mg/L		160.4	45.6	53.2	51.2	53.2	64.4	24.1	4.5
NO3-N, mg/L		0.3	0.8	1.7	2.5	1.1	1.7	2.2	1.4
SO4 2-, mg/L		0.03	0.03	0.12	0.06	0.04	0.13	0.13	0.18
Chloride (Cl-), mg/L		71	74	80	59	62	72	54	59
Total suphide, mg/L		116.8	36.0	24.8	16.8	12.0	10.4	10.4	9.6
Phenol, mg/L		3.205	2.178	0.645	1.864	1.268	6.216	-	-
Anionic surfactant as MBAS, mg/L		-	-	-	-	-	-	-	-
Total coliform count, colonies/100 mL		101,000	90,000	85,000	60,000	55,000	50,000	48,000	40,000
Oil (n-Hexane extract), mg/L		-	-	-	-	-	-	-	-
T-P (total phosphorous), mg/L		24.0	25.5	23.2	49.0	29.5	31.0	18.0	10.5
Ortho-P (PO4 3-), mg/L		16.0	25.5	12.5	4.0	10.5	18.5	1.0	1.0
Organochlorine Pesticides	Aldrin, mg/L	ND	17.6	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F-), mg/L		3.98	1.78	2.00	1.78	1.58	2.00	1.58	-
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		65.0	50.0	45.0	40.0	35.0	40.0	25.0	20.0
Cyanide (CN-), mg/L		0.09	0.07	0.06	0.06	0.04	0.07	0.02	0.01
Lead (Pb), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn), mg/L		0.17	0.18	0.35	0.31	0.17	0.19	0.10	0.07
Total Chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent Chromium (Cr 6+), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Total Mercury (Hg), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Total Manganese (Mn), mg/L		0.24	0.27	0.20	0.24	0.15	0.18	0.07	0.07
Copper (Cu), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Iron (Fe), mg/L		1.60	2.27	3.05	2.30	1.49	1.74	0.92	0.89
Nickel (Ni), mg/L		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table B-4 Anaerobic Pond Effluent Quality at Njoro STW on 23 - 24 June 1993

XA/W

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	23.3	22.7	23.1	22.5	21.6	23.5	23.5	23.5
pH	6.78	6.99	6.74	6.73	6.72	6.74	6.70	6.74
Conductivity, mS/cm	1.870	1.760	1.910	1.870	1.802	1.709	1.801	1.866
ORP, mV	-	-	-	-	-	-	-	-
BOD5, mg/L	1,050	1,370	740	730	700	760	810	1,040
Soluble BOD, mg/L	820	1,040	500	510	450	540	570	800
COD, mg/L	1,280	1,560	920	920	840	960	1,080	1,200
Soluble COD, mg/L	1,000	1,270	640	650	560	640	820	940
SS, mg/L	384	560	440	500	560	520	520	540
TDS, mg/L	1,050	820	1,030	840	940	900	932	1,000
Cl -, mg/L	150	128	137	132	130	118	133	141
T-N (Total Nitrogen), mg/L	789.6	464.8	448.0	364.0	358.0	380.8	408.8	436.8
NH4-N, mg/L	47.6	66.4	68.9	70.6	63.3	62.7	68.0	70.8
NO3-N, mg/L	2.24	2.24	2.52	2.52	2.52	0.28	2.2	0.28
Total coliform count, colonies/100 mL	36,500	36,000	29,000	30,000	30,000	30,000	25,000	24,000
T-P (Total Phosphorous), mg/L	113	89	111	192	134	222	38	84
Ortho-P (PO4 3-), mg/L	20.5	23.0	23.5	19.0	17.5	21.5	25.0	18.5
Sulphide, mg/L	40.8	39.8	36.4	28.8	35.6	33.6	36.4	29.6

Table B-5 Facultative Pond Effluent Quality at Njoro STW on 23 - 24 June 1993

XF/W

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	20.8	25.5	28.5	24.4	20.9	20.2	18.0	18.9
pH	7.29	7.28	7.39	7.17	7.21	7.21	7.23	7.23
Conductivity, mS/cm	1.660	1.740	1.730	1.810	1.719	1.741	1.780	1.781
ORP, mV	-	-	-	-	-	-	-	-
BOD5, mg/L	160	310	180	210	150	310	170	380
Soluble BOD, mg/L	90	230	110	160	80	230	100	320
COD, mg/L	200	400	240	280	200	400	240	520
Soluble COD, mg/L	110	300	160	180	100	290	170	420
SS, mg/L	100	80	80	60	70	70	100	80
TDS, mg/L	840	860	840	730	840	833	940	853
Cl -, mg/L	110	109	121	114	111	112	110	112
T-N (Total Nitrogen), mg/L	414.4	397.6	375.2	386.4	380.8	347.2	364.0	364.0
NH4-N, mg/L	73.1	83.2	65.0	74.5	72.8	68.0	74.2	75.6
NO3-N, mg/L	2.52	4.48	4.76	3.92	5.04	1.12	0.84	1.1
Total coliform count, colonies/100 mL	16,800	17,000	15,500	14,000	14,000	15,000	10,500	8,000
T-P (Total Phosphorous), mg/L	62	50	72	28	46	68	32	68
Ortho-P (PO4 3-), mg/L	20.5	23.0	23.5	19.0	17.5	21.5	25.0	18.5
Sulphide, mg/L	20.4	11.5	20.1	22.0	18.4	22.1	16.8	23.0

Table B-6 First Maturation Pond Effluent Quality at Njoro STW on 23 - 24 June 1993

XM/W

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	20.6	23.8	27.6	20.8	20.3	21.0	18.2	17.4
pH	7.82	7.70	8.34	7.69	7.66	7.77	7.73	7.72
Conductivity, mS/cm	1.720	1.800	1.660	1.800	1.728	1.656	1.734	1.741
ORP, mV	-	-	-	-	-	-	-	-
BOD5, mg/L	100	80	790	130	150	130	260	490
Soluble BOD, mg/L	70	50	700	90	110	100	220	410
COD, mg/L	160	120	1,040	160	200	160	320	600
Soluble COD, mg/L	130	90	740	100	160	110	220	440
SS, mg/L	110	90	80	90	120	110	100	40
TDS, mg/L	920	1,142	1,224	950	890	875	833	1,182
Cl -, mg/L	126	129	127	126	126	129	129	128
T-N (Total Nitrogen), mg/L	336.0	358.4	336.0	386.4	308.0	364.0	285.6	285.6
NH4-N, mg/L	61.3	65.0	65.3	63.3	66.4	62.7	68.3	64.1
NO3-N, mg/L	2.52	0.56	3.92	4.48	2.80	0.28	3.10	2.52
Total coliform count, colonies/100 mL	37,000	36,500	55,000	35,500	36,600	32,000	35,000	31,000
T-P (Total Phosphorous), mg/L	22.5	21.0	18.0	22.5	21.0	35.3	41.4	24.8
Ortho-P (PO4 3-), mg/L	16.0	20.0	15.3	19.0	19.0	26.0	21.5	18.5
Sulphide, mg/L	6.4	5.6	5.0	5.4	5.6	5.6	6.3	3.6

Table B-7 Second Maturation Pond Effluent Quality at Njoro STW on 23 - 24 June 1993

XS/W

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	20.0	21.6	22.8	22.2	20.4	20.0	18.0	17.4
pH	7.91	7.91	7.92	7.90	8.01	8.02	7.95	7.86
Conductivity, mS/cm	1.760	1.790	1.800	1.740	1.659	1.716	1.723	1.730
ORP, mV	-	-	-	-	-	-	-	-
BOD5, mg/L	60	20	280	270	760	770	320	260
Soluble BOD, mg/L	40	20	260	250	700	710	280	210
COD, mg/L	80	40	320	320	920	960	440	320
Soluble COD, mg/L	70	30	300	300	890	910	410	290
SS, mg/L	90	110	120	110	80	90	70	70
TDS, mg/L	1,182	875	970	890	970	913	950	767
Cl -, mg/L	135	140	138	137	143	139	145	144
T-N (Total Nitrogen), mg/L	302.4	224.0	336.0	268.8	313.6	330.4	296.8	296.8
NH4-N, mg/L	63.8	59.9	58.0	61.3	59.6	43.6	58.8	57.1
NO3-N, mg/L	2.50	0.56	2.80	3.36	2.52	3.64	2.52	7.84
Total coliform count, colonies/100 mL	29,000	30,000	28,000	27,000	30,000	21,600	20,400	18,000
T-P (Total Phosphorous), mg/L	22.0	28.0	16.5	26.0	20.0	15.0	23.5	22.5
Ortho-P (PO4 3-), mg/L	14.5	8.0	11.5	17.5	10.5	11.0	20.5	10.5
Sulphide, mg/L	18.3	17.6	11.0	8.0	8.0	5.6	5.4	6.4

Table B-8 Final Effluent Quality at Njoro STW on 23 - 24 June 1993

XE/W

Item		Time							
		9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, ˚C		19.8	20.9	21.3	20.7	20.5	19.6	18.2	18.2
pH		8.14	8.17	8.21	8.14	8.25	8.43	8.24	8.20
Conductivity, mS/cm		1.710	1.770	1.770	1.760	1.679	1.710	1.706	1.680
ORP, mV		-	-	-	-	-	-	-	-
BOD5, mg/L		130	330	130	300	290	100	310	300
COD, mg/L		160	440	160	360	360	120	360	360
SS, mg/L		100	100	110	100	110	100	80	50
TDS, mg/L		1,010	1,060	1,040	970	1,070	1,020	1,020	1,010
T-N (Total Nitrogen) mg/L		218.4	218.4	184.8	257.6	235.2	218.4	246.4	201.6
NH4-N, mg/L		51.0	58.5	53.5	42.3	40.3	35.3	39.2	39.5
NO3-N, mg/L		1.1	0.6	2.2	1.7	2.2	2.5	2.0	2.8
SO4 2-, mg/L		0.07	0.24	0.13	0.13	0.17	0.15	0.25	0.20
Chloride (Cl-), mg/L		150	144	147	136	146	133	146	136
Total suphide, mg/L		8.8	12.0	8.8	8.8	7.2	8.0	7.2	8.0
Phenol, mg/L		0.592	0.477	0.470	0.418	0.453	-	-	-
Anionic surfactant as MBAS, mg/L		-	-	-	-	-	-	-	-
Total coliform count, colonies/100 mL		39,000	39,500	38,900	37,900	38,100	29,600	28,400	25,400
Oil (n-Hexane extract), mg/L		-	-	-	-	-	-	-	-
T-P (total phosphorous), mg/L		36.0	32.0	50.0	72.0	32.0	62.0	56.0	28.0
Ortho-P (PO4 3-), mg/L		23.5	23.5	15.0	25.0	21.0	23.5	16.0	23.0
Organochlorine Pesticides	Aldrin, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F-), mg/L		2.82	2.51	2.24	2.51	2.51	2.82	2.82	2.51
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		55.0	55.0	55.0	50.0	55.0	55.0	55.0	55.0
Cyanide (CN-), mg/L		0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.03
Lead (Pb), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn), mg/L		0.02	0.02	0.02	0.12	0.02	0.02	0.02	0.01
Total Chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent Chromium (Cr 6+), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Total Mercury (Hg), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Total Manganese (Mn), mg/L		0.24	0.24	0.24	0.26	0.26	0.24	0.25	0.24
Copper (Cu), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Iron (Fe), mg/L		0.17	0.17	0.18	0.25	0.21	0.20	0.20	0.20
Nickel (Ni), mg/L		0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02

Table B-9 Influent Flow Rate Variation at Njoro STW on 21 ~ 22 July 1993

Time h	Gauge Reading cm	Flowrate m3/h	Remarks
9:00	21.7	256	
10:00	17.5	185	
11:00	18.0	193	
12:00	13.0	119	oily, grease, light brown
13:30	15.0	147	
14:30	12.5	112	
15:00	18.8	206	Black/brown
16:00	17.5	185	
17:00	12.5	112	
18:00	24.5	307	
19:00	15.0	147	
20:00	-	-	
21:00	12.0	105	
22:00	10.5	86	
23:00	9.5	74	
24:00	9.0	68	
1:00	7.0	47	
2:00	6.0	37	
3:00	7.0	47	
4:00	6.0	37	
5:00	6.0	37	
6:00	7.0	47	Greenish, fats/floating matter
7:00	11.0	92	
8:00		174	Assuming linear increase between 7:00 h to 9:00 h to 255.6 m3/h

Note :

Total Flow	2,945 m3/d
Average Flowrate	123 m3/h
Peak Flowrate	306 m3/h
Peak Factor	2.50

Table B-10 Influent Quality at Njoro STW on 21 - 22 July 1993

XI/D

Item		Time							
		9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Flow rate, m3/h		256	118	206	207	105	68	47	47
Temperature, °C		23.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
pH		7.65	7.35	7.12	7.94	7.31	7.40	8.53	7.40
Conductivity, mS/cm		1.033	1.071	1.008	2.920	1.057	0.998	7.870	0.900
ORP, mV		-112	-204	-196	-315	-223	-216	-385	-175
BOD5, mg/L		730	1,890	1,070	2,060	690	540	2,500	410
COD, mg/L		936	2,500	1,448	2,720	896	712	3,200	528
SS, mg/L		519	814	1,100	2,066	420	266	861	110
TDS, mg/L		564	980	760	1,920	825	708	5,068	660
T-N (Total Nitrogen) mg/L		165.2	112.0	126.0	235.2	78.4	103.6	442.4	47.6
NH4-N, mg/L		58.8	39.2	46.5	76.7	42.3	40.6	252.2	19.9
NO3-N, mg/L		2.2	0.8	ND	2	ND	0.6	1.4	ND
SO4 2-, mg/L		0.13	0.06	0.12	0.07	0.07	0.08	0.08	0.08
Chloride (Cl-), mg/L		132	203	306	700	226	297	305	389
Total suphide, mg/L		8.4	10.4	9.2	34.8	6.8	5.6	152	4.4
Phenol, mg/L		1.411	3.937	2.439	3.902	1.516	1.31	14.96	1.289
Anionic surfactant as MBAS, mg/L		-	-	-	-	-	-	-	-
Total coliform count, colonies/100 mL		80,100	75,000	80,000	70,000	65,000	70,000	40,000	30,000
Oil (n-Hexane extract), mg/L		-	-	-	-	-	-	-	-
T-P (total phosphorous), mg/L		25.9	14.0	11.0	22.5	16.1	10.7	16.6	15.7
Ortho-P (PO4 3-), mg/L		2.6	2.8	2.3	2.7	4.0	4.0	3.7	8.5
Organochlorine Pesticides*	Aldrin, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	0.03	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F-), mg/L		1.41	1.41	1.58	2.82	2.51	3.16	7.94	3.55
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		40.0	35.0	40.0	60.0	50.0	40.0	160.0	40.0
Cyanide (CN-), mg/L		0.038	0.012	0.088	0.021	0.021	0.026	0.028	0.013
Lead (Pb), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn), mg/L		0.06	0.09	0.05	0.05	0.08	0.05	0.10	0.04
Total Chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	0.68	ND
Hexavalent Chromium (Cr 6+), mg/L		ND	ND	ND	ND	ND	ND	0.31	ND
Arsenic (As), mg/L		ND	ND	0.0001	0.0005	0.0005	0.0008	0.0031	0.0009
Total Mercury (Hg), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Total Manganese (Mn), mg/L		0.02	0.02	0.02	0.12	0.01	0.01	0.22	0.02
Copper (Cu), mg/L		0.01	0.01	0.01	0.01	0.01	0.01	0.01	ND
Iron (Fe), mg/L		0.23	0.85	0.35	0.60	0.36	0.33	1.00	0.56
Nickel (Ni), mg/L		ND	ND	ND	ND	ND	ND	ND	ND

* Oxychlordane *0.01 *0.08

Table B-11 Anaerobic Pond Effluent Quality at Njoro STW on 21 - 22 July 1993

XA/D

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
pH	6.89	6.83	6.70	6.76	6.62	6.77	6.75	6.62
Conductivity, mS/cm	1.766	1.999	1.929	2.100	2.170	2.150	2.070	2.090
ORP, mV	-270	-304	-265	-270	-296	-309	-282	-268
BOD5, mg/L	390	570	590	570	610	560	570	490
Soluble BOD, mg/L	290	500	490	480	520	500	500	410
COD, mg/L	508	748	780	756	804	728	760	652
Soluble COD, mg/L	484	699	704	700	780	649	710	612
SS, mg/L	394	476	517	449	581	484	508	516
TDS, mg/L	902	1,018	980	1,060	1,179	1,180	1,040	1,040
Cl -, mg/L	351	263	336	272	295	292	279	282
T-N (Total Nitrogen), mg/L	154.0	156.8	156.8	187.6	224.0	193.2	229.6	229.6
NH4-N, mg/L	77.0	79.8	77.6	79.8	78.7	79.8	74.2	80.4
NO3-N, mg/L	1.7	ND	ND	2.2	ND	1.1	0.3	0.6
Total coliform count, colonies/100 mL	1,400	1,300	1,300	1,000	1,000	1,200	800	700
T-P (Total Phosphorous), mg/L	44.9	42.4	31.4	46.6	60.2	47.5	11.0	53.4
Ortho-P (PO4 3-), mg/L	7.86	6.43	3.56	6.11	5.79	7.23	6.43	6.27

Table B-12 Facultative Pond Effluent Quality at Njoro STW on 21 - 22 July 1993

XF/D

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	20.0	23.0	21.0	24.0	22.0	22.0	20.0	18.0
pH	7.89	7.73	7.62	7.57	7.40	7.51	7.50	7.37
Conductivity, mS/cm	1.718	1.892	1.736	1.699	1.697	1.693	1.682	1.652
ORP, mV	161	115	89	81	52	15	28	18
BOD5, mg/L	320	330	270	310	260	310	270	290
Soluble BOD, mg/L	280	280	220	270	210	280	240	250
COD, mg/L	412	416	348	408	332	400	348	380
Soluble COD, mg/L	374	373	300	380	304	370	304	362
SS, mg/L	160	170	160	170	160	180	130	180
TDS, mg/L	1,052	1,131	1,043	1,096	1,066	1,079	1,063	1,100
Cl -, mg/L	322	309	207	327	262	205	201	228
T-N (Total Nitrogen), mg/L	162.4	187.6	182.0	170.8	173.6	170.8	156.8	173.6
NH4-N, mg/L	65.8	66.6	68.9	64.7	67.8	63.3	65.0	63.0
NO3-N, mg/L	1.1	ND	2.5	0.3	ND	ND	ND	2.5
Total coliform count, colonies/100 mL	7,100	5,500	6,900	4,000	3,300	2,000	2,200	1,800
T-P (Total Phosphorous), mg/L	31.0	22.5	27.6	31.4	21.2	30.5	25.9	30.1
Ortho-P (PO4 3-), mg/L	6.67	7.07	5.63	6.11	5.55	5.71	5.95	5.71

Table B-13 First Maturation Pond Effluent Quality at Njoro STW on 21 -22 July 1993

XM/D

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	21.0	22.0	21.0	22.0	22.0	21.0	20.5	20.0
pH	8.34	8.22	8.01	8.01	7.97	7.99	7.92	7.75
Conductivity, mS/cm	1.572	1.733	1.605	1.546	1.556	1.551	1.526	1.510
ORP, mV	227	123	114	105	84	88	80	75
BOD5, mg/L	240	220	230	210	240	250	240	220
Soluble BOD, mg/L	200	200	190	180	180	200	190	190
COD, mg/L	300	292	312	272	320	308	316	280
Soluble COD, mg/L	260	259	284	250	265	262	264	266
SS, mg/L	90	89	120	123	58	120	103	90
TDS, mg/L	932	968	1,000	991	963	943	946	1,100
Cl -, mg/L	202	183	436	206	185	142	166	185
T-N (Total Nitrogen), mg/L	98.0	131.6	131.6	145.6	145.6	145.6	159.6	151.2
NH4-N, mg/L	56.0	59.4	65.5	61.6	64.4	72.8	65.8	75.5
NO3-N, mg/L	ND	ND	3.4	5.6	5.3	2.8	ND	ND
Total coliform count, colonies/100 mL	200	200	600	1,400	600	1,200	1,300	900
T-P (Total Phosphorous), mg/L	14.4	32.2	18.6	18.6	34.7	22.9	28.0	33.0
Ortho-P (PO4 3-), mg/L	7.9	3.8	7.1	8.1	4.4	4.9	7.4	6.2

Table B-14 Second Maturation Pond Effluent Quality at Njoro STW on 21 - 22 July 1993

XS/D

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	21.0	21.0	22.0	21.5	22.0	21.0	21.0	20.0
pH	8.44	8.22	8.05	8.09	8.14	8.15	8.11	7.85
Conductivity, mS/cm	1.480	1.641	1.494	1.463	1.462	1.458	1.441	1.447
ORP, mV	230	122	114	107	82	88	80	75
BOD5, mg/L	280	170	190	180	200	190	200	200
Soluble BOD, mg/L	220	130	160	140	160	170	170	160
COD, mg/L	316	216	232	224	252	236	248	268
Soluble COD, mg/L	274	186	180	176	194	181	193	170
SS, mg/L	142	90	87	98	90	100	110	100
TDS, mg/L	902	930	909	960	982	963	946	930
Cl -, mg/L	362	196	402	133	205	219	178	200
T-N (Total Nitrogen), mg/L	120.4	134.4	56.0	98.0	137.2	140.0	117.0	131.6
NH4-N, mg/L	46.2	49.8	45.1	49.3	47.6	49.6	47.9	50.4
NO3-N, mg/L	ND	1.4	ND	1.1	0.6	0.8	ND	ND
Total coliform count, colonies/100 mL	1,300	100	0	0	0	400	100	200
T-P (Total Phosphorous), mg/L	16.9	17.8	31.4	36.4	31.4	32.2	16.1	16.1
Ortho-P (PO4 3-), mg/L	7.8	7.1	7.7	7.0	7.0	6.0	9.4	8.1

Table B-15 Final Effluent Quality at Njoro STW on 21 - 22 July 1993

XE/D

Item		Time							
		9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C		21.0	21.0	22.0	22.0	22.0	21.0	21.0	20.0
pH		8.09	8.15	7.99	8.30	8.00	8.14	7.95	7.67
Conductivity, mS/cm		1.608	1.578	1.585	1.587	1.582	1.582	1.557	1.547
ORP, mV		255	135	127	108	91	95	89	88
BOD5, mg/L		240	190	230	210	230	240	240	250
COD, mg/L		308	260	296	268	292	296	304	308
SS, mg/L		110	132	118	150	125	113	116	125
TDS, mg/L		980	1,013	1,013	1,000	1,032	1,032	1,021	982
T-N (Total Nitrogen) mg/L		137.2	126.0	131.6	142.8	154.0	140.0	142.8	140.0
NH4-N, mg/L		59.1	57.1	54.9	60.8	58.8	55.2	59.1	59.6
NO3-N, mg/L		1.1	0.3	1.1	ND	1.7	ND	3.4	1.1
SO4 2-, mg/L		0.20	0.18	0.02	0.15	0.25	0.11	0.10	0.02
Chloride (Cl-), mg/L		-	-	-	-	-	-	-	-
Total suphide, mg/L		7.2	6.8	7.6	8.0	1.6	2.4	4.0	3.2
Phenol, mg/L		1.359	1.324	0.993	1.132	0.923	0.801	0.888	0.976
Anionic surfactant as MBAS, mg/L		-	-	-	-	-	-	-	-
Total coliform count, colonies/100 mL		300	300	200	700	600	600	200	300
Oil (n-Hexane extract), mg/L		-	-	-	-	-	-	-	-
T-P (total phosphorous), mg/L		53.4	46.6	48.3	44.9	48.6	33.0	44.9	36.4
Ortho-P (PO4 3-), mg/L		4.1	3.8	6.3	3.3	2.3	5.5	2.3	7.1
Organochlorine Pesticides	Aldrin, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F-), mg/L		2.82	2.82	2.51	2.51	2.82	2.51	2.51	2.24
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		50.0	50.0	50.0	49.0	50.0	50.0	50.0	50.0
Cyanide (CN-), mg/L		0.018	0.014	0.02	0.016	0.016	0.024	ND	0.017
Lead (Pb), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn), mg/L		0.01	0.01	0.01	0.01	0.01	0.01	0.02	ND
Total Chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent Chromium (Cr 6+), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As), mg/L		0.0010	0.0011	0.0009	0.0014	0.0012	0.0012	0.0011	0.0011
Total Mercury (Hg), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Total Manganese (Mn), mg/L		0.08	0.07	0.07	0.09	0.08	0.06	0.04	0.05
Copper (Cu), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Iron (Fe), mg/L		0.10	0.11	0.10	0.10	0.10	0.09	0.08	0.08
Nickel (Ni), mg/L		ND	ND	ND	ND	ND	ND	ND	ND

Table B-16 Variation of Oil and Surfactant Concentration in the Influent and Final Effluent at Njoro STW on 1-2 September 1993

	Item	Time							
		9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Influent	Flowrate, m3/h	92	86	63	68	57	47	42	37
	Oil (n-hexane extract), mg/L	457.8	410.1	45.8	1841.7	110.6	88.5	110.0	25.2
	Anionic Surfactant, mg/L	2.65	3.30	4.00	4.45	0.80	0.85	3.15	0.21
Effluent	Oil (n-hexane extract), mg/L	9.5	33.1	71.7	4.3	21.7	30.2	47.6	31.1
	Anionic Surfactant, mg/L	1.89	3.15	2.85	3.25	3.15	3.15	3.05	3.05

Note : Total flowrate was 1,476 m3/d due to water shortage on that day in Nakuru Town

Table B-17 Third Maturation Ponds Influent and Effluent Quality at Njoro STW on 31 August 1993 (11:30 AM - 12:00 PM)

Item	Pond Number					
	M 3.1		M 3.2		M 3.3	
	Influent	Effluent	Influent	Effluent	Influent	Effluent
Temperature, °C	20.3	20.3	21.2	22.4	20.2	21.6
pH	8.06	8.33	8.39	8.74	8.38	8.82
DO, mg/L	2	6.3	8.6	20.2	1	10.3
ORP, mV	-118	-23	-21	14	-158	6
Total Coliform Count, colonies/100 mL	6,000,000	8,000,000	1,000,000	2,000,000	4,000,000	3,000,000

Table B-18 Diurnal Variation of Temperature, pH, DO, ORP and Conductivity of Influent to Facultative Ponds in Njoro STW on 1-2 September 1993

Item	Time			
	10 ~ 11	14 ~ 15	18 ~ 19	6 ~ 7
Temperature, °C	23.8	23.8	23.7	23.2
pH	6.72	6.61	6.73	6.65
DO, mg/L	0.6	0.6	0.6	0.7
ORP, mV	-250	-256	-280	-251
Conductivity, mS/cm	2.09	2.15	2.33	2.39

Table B-19 Diurnal Variation of Temperature, pH, DO, ORP and Conductivity of Facultative Pond Effluents in Njoro STW on 1-2 September 1993

Item		Time			
Pond Number	Parameter	10 ~ 11	14 ~ 15	18 ~ 19	6 ~ 7
F1	Temperature, °C	20.4	20.5	25.5	17.9
	pH	8.28	8.18	8.27	7.71
	DO, mg/L	12.1	6.5	26.9	1.3
	ORP, mV	60	88	143	-10
	Conductivty, mS/cm	1.564	1.572	1.700	1.549
F2	Temperature, °C	21.9	22.9	25.6	18.3
	pH	7.55	7.46	7.73	7.35
	DO, mg/L	7.8	2.6	11.0	0.8
	ORP, mV	38	-5	151	-69
	Conductivty, mS/cm	1.690	1.737	1.839	1.615
F3	Temperature, °C	22.6	24.4	25.5	18.5
	pH	8.06	8.14	8.28	7.47
	DO, mg/L	21.7	29.4	28.2	1.2
	ORP, mV	66	75	133	-38
	Conductivty, mS/cm	1.650	1.688	1.729	1.541

Table B-20 Diurnal Variation of Temperature, pH, DO, ORP and Conductivity of Third Maturation Pond Influents at Njoro STW on 1-2 September 1993

Item		Time			
Pond Number	Parameter	10 ~ 11	14 ~ 15	18 ~ 19	6 ~ 7
M3.1	Temperature, °C	21.3	21.3	25.7	19.7
	pH	8.23	8.10	8.72	8.03
	DO, mg/L	6.1	1.4	25.8	0.8
	ORP, mV	-131	-100	98	-112
	Conductivity, mS/cm	1.616	1.612	1.688	1.557
M3.2	Temperature, °C	22.5	22.0	25.9	20.0
	pH	8.56	8.35	8.85	8.10
	DO, mg/L	11.9	5.6	31.3	0.9
	ORP, mV	-60	-98	102	-88
	Conductivity, mS/cm	1.620	1.632	1.666	1.560
M3.3	Temperature, °C	20.4	20.5	25.8	19.7
	pH	8.17	8.02	8.75	8.19
	DO, mg/L	0.8	0.9	9.0	0.9
	ORP, mV	-208	-221	102	-157
	Conductivity, mS/cm	1.508	1.532	1.649	1.482

Table B-21 Diurnal Variation of Temperature, pH, DO, ORP and Conductivity of Third Maturation Pond Effluents at Njoro STW on 1-2 September 1993

Item		Time			
Pond Number	Parameter	10 ~ 11	14 ~ 15	18 ~ 19	6 ~ 7
M3.1	Temperature, °C	24.4	21.9	23.2	19.4
	pH	8.58	8.43	8.56	8.06
	DO, mg/L	12.6	19.4	12.0	2.2
	ORP, mV	17	-37	49	-10
	Conductivity, mS/cm	1.536	1.568	1.589	1.477
M3.2	Temperature, °C	21.9	23.4	24.4	19.9
	pH	8.70	8.68	8.78	8.27
	DO, mg/L	14.7	14.2	18.1	3.4
	ORP, mV	-12	-53	50	-34
	Conductivity, mS/cm	1.571	1.628	1.619	1.517
M3.3	Temperature, °C	20.8	20.3	21.6	19.4
	pH	8.74	8.63	8.65	8.46
	DO, mg/L	5.2	2.0	2.8	1.7
	ORP, mV	-57	-103	86	-72
	Conductivity, mS/cm	1.452	1.478	1.503	1.437

Table B-22 Influent flow Variation at Town STW on 30 June ~ 1 July 1993

Time h	Gauge Reading cm	Flowrate m3/h	Remarks
9:00	16.0	214	
10:00	19.0	214	
11:00	18.0	256	
12:00	14.5	185	
13:30	13.5	166	
14:30	16.0	214	
15:00	18.5	266	
16:00	19.0	277	
17:00	17.5	245	
18:00	16.5	225	
19:00	17.0	235	
20:00	16.5	225	
21:00	13.0	157	
22:00	11.0	122	
23:00	10.0	106	
24:00	10.0	106	
1:00	9.0	90	
2:00	9.0	90	
3:00	8.0	76	
4:00	8.0	76	
5:00	8.0	76	
6:00	8.0	76	
7:30	14.5	185	
8:00	16.0	214	

Note :

Total Flow	4,097 m3/d
Average Flowrate	171 m3/h
Peak Flowrate	266 m3/h
Peak Factor	1.55

Table B-23 Influent Flow Variation at Town STW on 28 ~ 29 July 1993

Time h	Gauge Reading cm	Flowrate m3/h	Remarks
9:00	16.0	214	
10:00	19.0	277	
11:00	18.0	256	
12:00	17.5	245	
13:30	16.5	224	
14:30	19.0	277	
15:00	16.5	224	Rain started
16:00	40.0	846	(Heavy rain between
17:00	32.0	606	15:15 ~ 17:00 h)
18:00	30.5	564	Rain stopped
19:00	18.0	226	
20:00	14.0	176	
21:00	12.5	148	
22:00	13.0	157	
23:00	13.5	166	
24:00	10.5	114	
1:00	10.0	106	
2:00	9.5	98	
3:00	10.0	106	
4:00	10.0	106	
5:00	10.0	106	
6:00	10.0	106	
7:00	14.0	176	
8:00	15.0	195	
9:00	15.5	204	

Note :

Total Flow		5,747 m3/d	
Average Flowrate		185 m3/h	(excluding stormwater)
Peak Flowrate	-	277 m3/h	
	-	846 m3/h	(due to storm)
Peak Factor		1.50	

Assuming sewage flowrate is 235 m3/h (Gauge reading 17cm) between 16:00 h to 18:00 h, stormwater inflow into the sewage works is about 1,310 m3

Table B-24 Final Effluent Flow Rate Variation at Town STW on 30 June ~ 1 July '93 and 28 ~ 29 July '93

Date	Time	Q, m3/h	Total Q, m3/h
30 June ~ 1 July	9:00	131	3,592
	12:00	168	
	15:00	154	
	18:00	145	
	21:00	161	
	24:00	148	
	3:00	146	
	6:00	144	
28 July ~ 29 July	9:00	131	5,157
	12:00	115	
	15:00	174	
	18:00	359	
	21:00	321	
	24:00	261	
	3:00	190	
	6:00	168	

Table B-25 Influent Quality at Town STW on 30 June ~ 1 July 1993

YI/W

Item		Time							
		9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Flow rate, m3/h		214	185	266	225	157	116	76	76
Temperature, °C		22.0	24.0	23.0	23.0	24.0	24.0	23.0	22.0
pH		6.85	7.12	7.24	7.07	7.09	7.48	7.11	7.06
Conductivity, mS/cm		0.737	0.713	0.725	0.714	0.661	0.656	0.422	0.391
ORP, mV		-338	-265	-155	-139	-54	-74	-75	54
BOD5, mg/L		1,010	1,950	1,740	1,200	310	390	290	110
COD, mg/L		1,400	2,240	1,920	1,480	480	500	348	192
SS, mg/L		711	827	180	392	90	240	20	60
TDS, mg/L		475	480	650	471	400	457	300	250
T-N (Total Nitrogen), mg/L		369.6	296.8	263.2	207.2	184.8	263.2	364.0	240.8
NH4-N, mg/L		68.9	52.1	44.8	45.9	35.6	38.6	31.4	31.9
NO3-N, mg/L		1.96	4.48	0.56	1.4	0.56	2.5	0.56	1.68
SO4 2-, mg/L		0.24	0.27	0.28	0.14	0.16	0.15	0.17	0.14
Chloride (Cl-), mg/L		51	48	53	51	50	46	31	28
Total suphide, mg/L		9.6	6.0	2.4	10.8	8.0	4.0	5.6	5.2
Phenol, mg/L		2.212	2.160	0.854	1.150	0.488	0.488	0.348	0.348
Anionic surfactant as MBAS, mg/L		-	-	-	-	-	-	-	-
Total coliform count, colonies/100 mL		4,200	4,000	3,900	3,200	3,700	3,550	3,030	2,830
Oil (n-Hexane extract), mg/L		-	-	-	-	-	-	-	-
T-P (total phosphorous), mg/L		26.6	28.0	20.5	24.3	32.5	20.0	16.5	22.4
Ortho-P (PO4 3-), mg/L		14.0	27.5	19.5	20.5	24.5	17.0	15.0	20.5
Organochlorine Pesticides	Aldrin, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F-), mg/L		0.89	1.26	1.26	1.26	1.26	1.26	1.00	1.00
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		37.5	32.5	35.0	35.0	35.0	27.5	20.0	15.0
Cyanide (CN-), mg/L		0.06	0.05	0.05	0.06	0.07	0.07	0.07	0.09
Lead (Pb), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn), mg/L		0.07	0.05	0.06	0.05	0.05	0.05	0.08	0.02
Total chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent Chromium (Cr 6+), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As), mg/L		0.005	0.004	0.005	0.006	0.005	0.004	0.004	0.004
Total Mercury (Hg), mg/L		ND	0.001	0.001	0.001	0.001	ND	ND	ND
Total Manganese (Mn), mg/L		0.07	0.05	0.04	0.03	0.03	0.01	0.02	0.02
Copper (Cu), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Iron (Fe), mg/L		1.24	0.62	0.88	0.64	0.63	0.55	0.67	0.63
Nickel (Ni), mg/L		ND	ND	ND	ND	ND	ND	ND	ND

Table B-26 Primary Clarifier Effluent Quality at Town STW on 30 June ~ 1 July 1993

YP/W

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	22.0	23.0	25.0	23.0	23.0	23.0	23.0	22.0
pH	7.25	7.26	7.18	6.85	6.83	7.19	7.06	6.83
Conductivity, mS/cm	0.611	0.734	0.730	0.676	0.689	0.703	0.601	0.546
ORP, mV	-148	-190	-184	-165	-166	-132	-85	-80
BOD5, mg/L	290	310	480	470	460	280	300	290
Soluble BOD, mg/L	200	220	410	400	410	190	190	210
COD, mg/L	384	440	592	560	592	360	408	368
Soluble COD, mg/L	286	360	410	400	420	270	310	280
SS, mg/L	120	200	170	80	160	130	70	60
TDS, mg/L	500	621	571	580	586	537	457	427
Cl -, mg/L	46	52	53	58	55	51	48	39
T-N (Total Nitrogen), mg/L	156.8	212.8	179.2	134.4	190.4	173.6	140.0	218.4
NH4-N, mg/L	33.6	51.2	44.0	38.9	39.8	42.0	32.5	29.4
NO3-N, mg/L	2.0	5.9	29.7	4.5	3.4	1.7	3.1	4.2
Total coliform count, colonies/100 mL	9,000	8,800	9,500	8,400	7,400	8,000	1,290	1,400
T-P (Total Phosphorous), mg/L	28.0	17.4	17.6	19.4	8.4	15.0	11.0	6.5
Ortho-P (PO4 3-), mg/L	10.0	11.5	13.5	12.0	7.5	15.0	8.5	6.2

Table B-27 Trickling Filter Effluent Quality at Town STW on 30 June ~ 1 July 1993

YT/W

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Flow rate, m3/h	204	192	192	127	144	104	116	104
Temperature, °C	21.2	24.0	23.0	23.0	23.0	23.0	23.0	22.0
pH	7.73	7.69	7.66	7.24	7.06	7.45	7.31	7.10
Conductivity, mS/cm	0.580	0.679	0.683	0.713	0.717	0.678	0.609	0.561
ORP, mV	63	-4	49	-44	-142	-33	-16	-63
BOD5, mg/L	30	100	110	270	280	110	50	270
Soluble BOD, mg/L	30	80	80	220	200	80	40	200
COD, mg/L	56	168	184	312	376	168	92	320
Soluble COD, mg/L	40	108	132	270	308	110	64	230
SS, mg/L	50	123	130	200	150	110	80	120
TDS, mg/L	340*	500	514	586	614	543	500	414
Cl -, mg/L	44	50	51	52	49	46	50	37
T-N (Total Nitrogen), mg/L	212.8	179.2	207.2	229.6	212.8	263.2	151.2	156.8
NH4-N, mg/L	30.5	43.7	35.8	39.2	44.5	38.1	30.8	26.9
NO3-N, mg/L	0.6	1.1	0.6	27.4	0.6	0.8	ND	1.1
Total coliform count, colonies/100 mL	920	870	810	810	790	750	640	660
T-P (Total Phosphorous), mg/L	21.5	22.5	15.5	25.0	17.5	14.5	7.0	19.0
Ortho-P (PO4 3-), mg/L	16.5	19.0	9.5	13.5	17.0	14.0	7.0	13.5

Table B-28 Final Clarifier Effluent Quality at Town STW on 30 June ~ 1 July 1993

YS/W

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	22.0	24.0	24.0	23.0	23.0	22.0	23.5	22.0
pH	7.51	7.65	7.65	7.36	7.15	7.45	7.36	7.12
Conductivity, mS/cm	0.593	0.675	0.710	0.679	0.671	0.702	0.684	0.651
ORP, mV	-1	-5	21	-52	-98	-103	-98	-92
BOD5, mg/L	210	230	240	250	460	270	290	280
Soluble BOD, mg/L	170	210	200	200	430	230	250	240
COD, mg/L	236	384	308	308	572	372	392	352
Soluble COD, mg/L	200	250	260	270	410	300	310	280
SS, mg/L	70	70	80	70	90	90	90	60
TDS, mg/L	371	386	371	386	529	400	429	440
Cl -, mg/L	48	52	49	50	52	50	48	45
T-N (Total Nitrogen), mg/L	229.6	347.2	173.6	246.4	196.0	173.6	173.6	224.0
NH4-N, mg/L	32.2	31.6	36.4	36.7	32.8	37.2	34.7	31.9
NO3-N, mg/L	6.7	5.0	5.6	6.2	6.7	5.0	8.7	7.8
Total coliform count, colonies/100 mL	2,030	1,880	1,780	1,510	1,500	1,430	1,230	1,020
T-P (Total Phosphorous), mg/L	11.0	6.2	6.4	12.5	11.5	9.0	13.8	12.5
Ortho-P (PO4 3-), mg/L	10.0	3.1	5.5	5.0	9.5	8.0	5.0	9.5

Table B-29 Final Effluent Quality at Town STW on 30 June ~ 1 July 1993

YE/W

Item		Time							
		9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Flow rate, m3/h		131	168	154	145	161	148	146	144
Temperature, °C		21.0	25.0	26.0	25.0	23.0	22.0	22.0	22.0
pH		7.71	7.90	7.92	7.63	7.34	7.70	7.62	7.30
Conductivity, mS/cm		0.666	0.713	0.736	0.674	0.620	0.635	0.655	0.632
ORP, mV		-186	36	86	-82	-135	-145	-125	-155
BOD5, mg/L		60	70	130	100	90	90	140	150
COD, mg/L		104	108	200	180	164	160	216	240
SS, mg/L		50	60	50	70	70	40	50	60
TDS, mg/L		420	457	457	443	480	440	440	420
T-N (Total Nitrogen), mg/L		218.4	240.8	252.0	280.0	184.8	280.0	218.4	336.0
NH4-N, mg/L		38.4	35.8	34.7	42.0	32.5	31.6	31.4	31.9
NO3-N, mg/L		0.28	0.28	0.56	0.84	1.96	1.12	8.4	2.24
SO4 2-, mg/L		0.05	0.04	0.04	0.10	0.07	0.03	0.06	0.05
Chloride (Cl-), mg/L		50	40	50	50	51	52	50	47
Total suphide, mg/L		2.6	6.4	6.4	5.2	8.0	8.0	7.6	5.6
Phenol, mg/L		0.453	0.436	0.418	0.383	0.383	0.418	0.488	0.401
Anionic surfactant as MBAS, mg/L		-	-	-	-	-	-	-	-
Total coliform count, colonies/100 mL		1,180	1,160	1,070	940	860	900	650	890
Oil (n-Hexane extract), mg/L		-	-	-	-	-	-	-	-
T-P (total phosphorous), mg/L		19.0	13.0	12.1	14.0	12.0	13.1	15.7	12.0
Ortho-P (PO4 3-), mg/L		13.0	12.0	12.0	13.0	7.0	12.0	13.0	8.0
Organochlorine Pesticides	Aldrin, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F-), mg/L		1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.12
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		32.5	35.0	35.0	35.0	32.5	35.0	32.5	32.5
Cyanide (CN-), mg/L		0.10	0.12	0.11	0.07	0.07	0.11	0.09	0.13
Lead (Pb), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn), mg/L		0.05	0.06	0.06	0.05	0.04	0.05	0.05	0.05
Total chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent Chromium (Cr 6+), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As), mg/L		0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006
Total Mercury (Hg), mg/L		0.0002	ND	ND	ND	0.0002	0.0001	0.0002	0.0002
Total Manganese (Mn), mg/L		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Copper (Cu), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Iron (Fe), mg/L		0.43	0.38	0.41	0.43	0.43	0.47	0.49	0.48
Nickel (Ni), mg/L		ND	ND	ND	ND	ND	ND	ND	ND

Table B-30 Influent Quality at Town STW on 28 ~ 29 July 1993

YI/D

Item		Time							
		9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Flow rate, m3/h		214	245	224	564	148	114	106	106
Temperature, °C		23.0	23.0	24.0	22.0	23.0	22.0	22.0	21.0
pH		7.52	7.53	7.53	7.09	7.30	7.59	7.19	7.09
Conductivity, mS/cm		0.982	0.771	0.803	0.420	0.709	0.593	0.389	0.378
ORP, mV		74	55	50	130	68	88	106	124
BOD5, mg/L		1,060	660	720	390	490	180	100	80
COD, mg/L		1,420	868	956	524	652	240	136	104
SS, mg/L		621	603	865	388	266	125	33	84
TDS, mg/L		716	552	600	254	572	344	246	273
T-N (Total Nitrogen), mg/L		218.4	128.8	106.4	39.2	131.6	64.4	36.4	19.6
NH4-N, mg/L		60.8	33.3	36.4	19.9	30.0	25.5	14.0	15.1
NO3-N, mg/L		1.1	ND	ND	ND	1.1	0.3	0.8	ND
SO4 2-, mg/L		0.06	0.06	0.08	0.11	0.16	0.15	0.10	0.11
Chloride (Cl-), mg/L		-	-	-	-	-	-	-	-
Total suphide, mg/L		1.6	4.0	3.2	0.8	1.6	9.6	2.0	0.8
Phenol, mg/L		0.766	0.627	0.714	0.470	1.063	0.383	0.401	0.366
Anionic surfactant as MBAS, mg/L		1.42	1.30	3.40	2.17	4.00	1.66	0.70	0.61
Total coliform count, colonies/100 mL		380,000	330,000	400,000	380,000	300,000	350,000	420,000	290,000
Oil (n-Hexane extract), mg/L		33.1	11.5	19.7	6.2	1.0	17.4	26.0	64.7
T-P (total phosphorous), mg/L		26.7	55.1	9.8	11.4	9.3	11.5	18.2	33.0
Ortho-P (PO4 3-), mg/L		8.3	9.0	2.6	6.8	7.4	6.1	7.2	1.8
Organochlorine Pesticides	Aldrin, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F-), mg/L		1.78	1.26	1.26	0.63	0.89	0.89	1.00	0.79
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		35.0	30.0	30.0	16.0	40.0	25.0	30.0	15.0
Cyanide (CN-), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn), mg/L		0.02	0.02	0.04	0.04	0.03	0.01	0.03	0.04
Total chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent Chromium (Cr 6+), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Total Mercury (Hg), mg/L		ND	ND	ND	ND	0.0004	ND	ND	ND
Total Manganese (Mn), mg/L		0.14	0.12	0.09	0.19	0.14	0.07	0.05	0.01
Copper (Cu), mg/L		ND	ND	0.01	ND	0.01	ND	ND	ND
Iron (Fe), mg/L		0.37	0.53	0.39	0.72	0.47	0.13	0.07	0.02
Nickel (Ni), mg/L		ND	ND	ND	ND	ND	ND	ND	ND

Table B-31 Primary Clarifier Effluent Quality at Town STW on 28 ~ 29 July 1993

YP/D

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	23.0	23.0	23.0	22.0	23.0	22.0	22.0	20.0
pH	7.16	7.06	7.06	6.84	7.05	7.41	7.15	6.87
Conductivity, mS/cm	0.798	0.857	0.814	0.587	0.572	0.595	0.536	0.500
ORP, mV	7	-81	-47	31	41	48	62	62
BOD5, mg/L	310	550	440	330	290	260	190	160
Soluble BOD, mg/L	270	510	400	290	230	200	160	140
COD, mg/L	408	724	592	436	384	344	260	208
Soluble COD, mg/L	352	609	504	372	310	306	251	200
SS, mg/L	142	160	230	239	140	107	45	49
TDS, mg/L	418	600	485	418	303	412	303	230
Cl -, mg/L	259	299	341	227	316	331	284	262
T-N (Total Nitrogen), mg/L	92.4	182.0	128.8	98.0	98.0	64.4	42.0	30.8
NH4-N, mg/L	39.2	44.0	426.0	28.6	24.6	29.7	22.4	18.2
NO3-N, mg/L	ND	5.0	ND	ND	ND	ND	1.7	0.3
Total coliform count, colonies/100 mL	80,000	70,000	100,000	90,000	85,000	105,000	110,000	75,000
T-P (Total Phosphorous), mg/L	14.0	10.7	10.3	12.3	10.6	12.7	3.0	3.3
Ortho-P (PO4 3-), mg/L	2.1	3.1	4.2	3.4	1.9	1.8	1.3	0.2
Total sulphide, mg/L	3.2	4.0	4.8	2.0	3.2	2.8	ND	1.2

Table B-32 *Trickling Filter Effluent Quality at Town STW on 28 ~ 29 July 1993*

YT/D

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	22.0	23.0	23.0	22.0	22.0	22.0	21.5	19.5
pH	7.70	7.66	7.66	7.29	7.35	7.64	7.51	7.15
Conductivity, mS/cm	0.724	0.833	0.787	0.592	0.551	0.601	0.546	0.512
ORP, mV	46	2	4	58	41	56	61	64
BOD5, mg/L	280	420	330	280	200	270	160	130
Soluble BOD, mg/L	250	370	290	260	190	240	120	90
COD, mg/L	360	556	456	372	256	356	208	180
Soluble COD, mg/L	301	407	392	306	212	306	171	172
SS, mg/L	150	160	230	239	140	107	45	49
TDS, mg/L	415	539	484	388	303	352	300	273
Cl -, mg/L	101	101	331	364	229	121	97	70
T-N (Total Nitrogen), mg/L	100.8	89.6	72.8	81.2	64.4	56.0	84.0	33.6
NH4-N, mg/L	37.2	37.8	35.6	25.8	25.2	25.2	20.4	16.0
NO3-N, mg/L	ND	1.4	ND	0.6	0.6	ND	ND	ND
Total coliform count, colonies/100 mL	120,000	95,000	90,000	110,000	95,000	90,000	86,000	71,000
T-P (Total Phosphorous), mg/L	7.2	30.5	25.0	9.8	13.2	5.3	15.7	2.1
Ortho-P (PO4 3-), mg/L	2.0	2.0	3.7	5.1	2.1	0.7	2.8	0.7
Total sulphide, mg/L	1.6	2.4	3.2	2.8	2.8	32.0	ND	ND

Table B-33 Final Clarifier Effluent Quality at Town STW on 28 ~ 29 June 1993

YS/D

Item	Time							
	9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Temperature, °C	22.0	23.0	23.0	22.0	22.0	22.0	21.0	19.5
pH	7.51	7.61	7.61	7.22	7.46	7.53	7.49	7.08
Conductivity, mS/cm	0.746	0.822	0.774	0.729	0.634	0.587	0.583	0.593
ORP, mV	42	4	6	51	17	50	43	50
BOD5, mg/L	220	280	330	270	230	210	190	190
Soluble BOD, mg/L	180	200	290	210	200	190	170	160
COD, mg/L	292	376	420	352	316	276	264	248
Soluble COD, mg/L	284	308	392	307	275	255	250	251
SS, mg/L	80	70	90	65	66	68	51	47
TDS, mg/L	383	467	492	427	364	338	338	319
Cl -, mg/L	91	291	94	278	300	287	303	61
T-N (Total Nitrogen), mg/L	114.8	103.6	70.0	106.4	165.2	126.0	56.0	42.0
NH4-N, mg/L	28.6	36.7	34.7	34.4	22.7	25.5	25.5	24.1
NO3-N, mg/L	1.4	0.6	0.6	ND	ND	0.3	ND	2.8
Total coliform count, colonies/100 mL	82,000	75,000	70,000	80,000	74,000	50,000	65,000	60,000
T-P (Total Phosphorous), mg/L	4.6	38.1	49.3	6.3	15.3	3.1	4.9	6.9
Ortho-P (PO4 3-), mg/L	3.4	4.4	0.2	5.2	1.7	1.9	1.6	1.4
Total sulphide, mg/L	1.2	3.6	2.4	4.4	ND	0.8	2.8	ND

Table B-34 Final Effluent Quality at Town STW on 28 ~ 29 July 1993

YE/D

Item		Time							
		9:00	12:00	15:00	18:00	21:00	24:00	3:00	6:00
Flow rate, m3/h		131	115	241	359	321	261	190	168
Temperature, °C		20.0	24.0	25.0	22.0	22.0	21.0	19.0	19.0
pH		7.70	7.90	7.90	7.35	7.58	7.53	7.44	7.14
Conductivity, mS/cm		0.768	0.758	0.756	0.713	0.764	0.731	0.744	0.770
ORP, mV		-40	-41	-9	-23	-71	-95	-120	-110
BOD5, mg/L		250	170	350	200	350	190	190	170
COD, mg/L		320	224	472	268	336	252	260	232
SS, mg/L		30	30	230	20	42	33	40	30
TDS, mg/L		440	418	403	439	441	456	424	403
T-N (Total Nitrogen), mg/L		98.0	61.6	70.0	67.2	72.8	84.0	70.0	33.6
NH4-N, mg/L		32.5	28.3	31.9	30.5	31.4	31.4	30.5	28.3
NO3-N, mg/L		ND	ND	ND	1.4	0.6	0.8	ND	0.3
SO4 2-, mg/L		0.02	0.07	0.05	0.08	0.08	0.15	0.08	0.10
Chloride (Cl-), mg/L		-	-	-	-	-	-	-	-
Total suphide, mg/L		6.0	7.2	3.6	2.4	4.0	2.8	32.0	4.0
Phenol, mg/L		0.453	0.488	0.540	0.488	0.488	0.488	0.418	0.470
Anionic surfactant as MBAS, mg/L		0.56	0.63	1.00	1.00	12.55	0.74	0.71	0.81
Total coliform count, colonies/100 mL		28,000	29,000	27,000	25,000	26,000	20,000	21,000	11,000
Oil (n-Hexane extract), mg/L		9.2	37.3	56.9	74.17	2.7	6.7	23.1	61.05
T-P (total phosphorous), mg/L		156.0	106.8	127.2	181.4	29.3	5.9	26.3	5.3
Ortho-P (PO4 3-), mg/L		5.3	5.0	6.0	12.9	3.2	3.3	2.1	2.6
Organochlorine Pesticides	Aldrin, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F-), mg/L		1.12	1.00	1.00	1.12	1.00	0.89	0.89	0.89
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		30	30	25	25	30	30	15	25
Cyanide (CN-), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Lead (Pb), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn), mg/L		0.06	0.05	0.06	0.13	0.06	0.05	0.02	0.05
Total chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent Chromium (Cr 6+), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Total Mercury (Hg), mg/L		ND	ND	ND	ND	ND	ND	ND	ND
Total Manganese (Mn), mg/L		0.10	0.10	0.12	0.11	0.11	0.11	0.05	0.12
Copper (Cu), mg/L		0.01	ND	ND	0.01	ND	ND	ND	ND
Iron (Fe), mg/L		0.38	0.32	0.38	0.41	0.40	0.38	0.20	0.52
Nickel (Ni), mg/L		ND	ND	ND	ND	ND	ND	ND	ND

B2.4 Discussion

B2.4.1 Njoro Sewage Treatment Works

(1) Influent flowrate variation

Influent flowrates at Njoro STW on 23 ~ 24 June 1993 and on 21 ~ 22 July 1993 over a 24 hour period were 4,173 and 2,945 m^3/d respectively. Fig. B-3 shows the influent flowrate variation. Generally, the flow shows peaks at 9:00 h and at 15:00 h. However, due to slug industrial discharges peaks also occurs between 9:00 h to 18:00 h, as can be seen at 18:00 h on 21 July '93 which was higher than the morning peak at 9:00 h on that day.

Peak factor was 1.8 on 23 ~ 24 June 1993 and 2.5 on 21 ~ 22 July '93. However, if peak factor is calculated based on the morning peak of 255.6 m^3/h on 21 July '93 peak factor is 2.0 which is closer to the value, on 23 ~ 24 June '93.

Low flowrates were observed during early morning hours between 2:00 h ~ 5:00 h except for occasional industrial discharges. Lowest flowrates were observed 80 m^3/h and 37 m^3/h on first and second sampling respectively.

(2) Flow distribution and condition of ponds

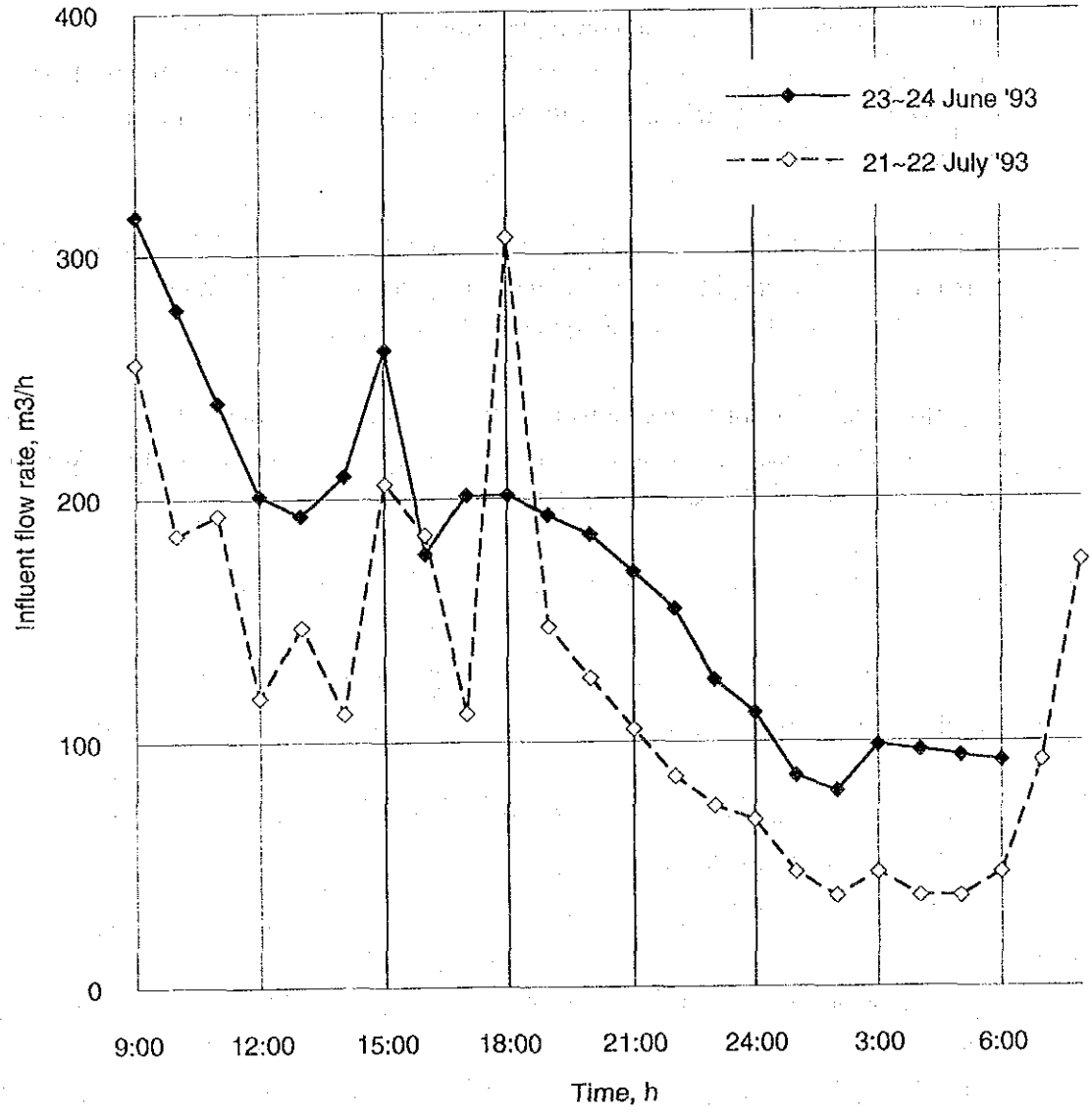
Flow distribution to anaerobic ponds and to facultative and maturation ponds were unsatisfactory. The causes are

(a) accumulation of scum at flow distribution chamber
(b) deteriorated weirs
(c) partial blockage of pipes

On the first sampling, total flowrate was 4,173 m^3/d which was 572 m^3/d above the design flowrate of these ponds. Ratio of flow through Line 1, 2 and 3 were 0.45 : 0.50 : 0.05. Even though the design flowrate through each of these lines is 1,200 m^3/d, actual flowrate through Line 1 was 1,878 m^3/d, which is 56 % more than its design capacity.

The ponds in Line 1 and 2 were of dark gray colour while that of Line 3 is green due to algal growth.

Fig. B-3



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(3) Characteristics of Influent and Final Effluent

Variation of BOD, COD and SS were drastic in the Njoro STW influent. For example in the first sampling, average BOD was 776 mg/L in the with the maximum and minimum BOD of 1,550 mg/L and 180 mg/L respectively. Similarly on the second sampling, average, maximum and minimum BOD concentrations were 1,307, 2,500 and 410 mg/L respectively. These variations are caused by slug industrial discharges. As shown in Table B-10, influent BOD was measured at 2,500 mg/L with a conductivity of 7.87 mS/cm at 3:00 h. In this sample chromium was also detected which was being discharged by the Tannery. Similar sample was also observed on 9:00 h (Table B-3) on 23~24 June 1993. Its conductivity was 3.17 mS/cm and the total sulphide concentration was 116.8 mg/L, however chromium was not detected. High sulphide levels are not only due to the tannery but could have been discharged by textile industries. Industries in the Njoro Sewerage District are responsible for the high levels of sulphide in the Njoro STW influent (4.4 ~ 152 mg/L) compared to the sulphide concentration in the Town STW Influent (0.8 ~ 10.8 mg/L, Table B-25 and Table B-30). Yellowish white deposits (sulphur) were observed in the interconnection between ponds. Deposits of purple pigments could also be observed prominently at the Third Maturatio Pond effluent chambers (Line 1 and Line 2) which is due to the purple sulphur bacteria.

Influent oil (n-hexane extract) concentrations (Table B-16) were extremely high, fluctuating widely with a maximum at 1,841.7 mg/L and minimum 25.2 mg/L. In the Town STW, influent oil concentrations were lower (1~64.7 mg/L, Table B-30) compared to that of Njoro. In the Njoro Sewerage District, vegetable oil extraction industries, creamery and tannery discharges oil containing wastewaters. Inspection of oil traps in these industries showed that they are not functioning as intended due to inadequate maintenance and operation.

Most of the oil and grease accumulate in the anaerobic ponds since the effluent withdrawal pipe is submerged. In the Facultative and Maturation ponds, presence of oil was not visible.

Anionic surfactant levels in the Njoro STW influent was in the range of 0.21~4.45 mg/L as MBAS (Methylene Blue Active Substances) while that in the Final Effluent was 1.89~3.25 mg/L. Foaming at the effluent chambers could be observed especially during the early morning before sun-rise.

Chloride levels in the Njoro STW influent was 54 ~ 80 mg/L while that in the final effluent was 133~150 mg/L, which is more than a factor of two. However, not much difference was observed in the fluoride concentrations. For example influent levels were 1.58~3.98 mg/L (Table B-3) while effluent levels were 2.24~2.82 mg/L. Conductivity of the influent and effluent also did not show much difference. Investigation into the increase in chloride levels is necessary in the future investigations.

One of the organochlorine pesticides namely oxychlordane was detected in the influent to the Njoro STW at midnight and at 3:00 AM (Table B-10) on the second sampling. Pesticides to the sewage treatment works could be either from the grain milling industries or due to a minor spill.

Results of the total coliform count was erratic, especially along each of the treatment units. Sampling and analysis of the Third Maturation Pond effluents was conducted and Table B-17 shows the results. Total coliforms in the effluent is in the order of 10^6 colonies/100 mL which is not satisfactory. Due to high organic concentrations in the maturation ponds, their function to reduce the coliforms is affected.

Effluent quality was poor, exceeding the effluent discharge standards in terms of BOD and SS. Overloading and poor operation of the ponds are responsible for the unacceptable effluent quality.

(4) Performance of Treatment Units

ORP levels in the influent was negative (-112 mV ~ -385 mV) indicating reducing conditions. Anaerobic Pond effluents were also negative showing reducing conditions. However, ORP levels during the day increased from the Facultative Pond Effluents through the Maturation Pond effluents and Final effluent. During the night time, ORP levels were lower than the daytime indicating the effect of sunlight and algal activity.

In the first sampling, average influent BOD concentration was 776 mg/L (flow weighted average) while that of the Anaerobic Pond effluent (average) was 710 mg/L indicating only marginal removal. However, during the second sampling average influent BOD concentration was 1,307 mg/L (flow weighted average) and the Anaerobic Pond effluent BOD (average) was 544 mg/L showing more than 50% removal. Judging from the effluent pH on both samplings, which was just below neutral pH of 7 (6.62~6.99), it could be said that the process is not functioning well.

Anaerobic process is susceptible to shock loading and could be inhibited by high sulphide concentration, heavy metals etc.

As discussed in the flow distribution, facultative ponds and maturation ponds in Line 1 and 2 were overloaded hydraulically as well as organically (i. e. high influent concentrations). Even though the final effluent quality is not satisfactory, total pollutant load reduction in terms of BOD was about 70% and 81% on the first and second sampling. Higher removal rates could be expected by improving the operation and maintenance and reducing the overloading.

B2.4.2 Town Sewage Treatment Works

(1) Influent and Effluent Flowrate Variation

Fig. B-4 shows the influent flowrate variation at Town STW on 30 June - 1 July 1993. Peak flow occurred around 9:00 h on 30 June 1993. However, on 28 July, the peak occurred around 10:00 h. Influent flowrates were 4,097 m^3/d and 5,747 m^3/d respectively, which were higher than the design capacity of 3,400 m^3/d by 697 and 2,347 m^3/d respectively.

On 28 July inflow rate increased because of a storm between 15:00 h to 18:00 h. Assuming a constant sewage flow of 235 m^3/h during 16:00 h to 18:00 h sewage flowrate would be 4,437 m^3/d while stormwater inflow was 1,310 m^3. Average sewage flowrates were 171 m^3/h and 185 m3/h on both sampling dates. Excluding the peak due to stormwater and stormwater inflow, peak factor on both days were 1.5. Compared to Njoro STW, peak factor is lower, since there are only one major industry in the Town Sewerage District.

Fig. B-5 shows both influent and effluent flowrate variation. Effluent flowrate did not vary much except that on the second sampling which was due to stormwater inflow. During this stormwater inflow a time lag of about 2 hours was observed between influent and effluent flowrates.

Fig. B-4

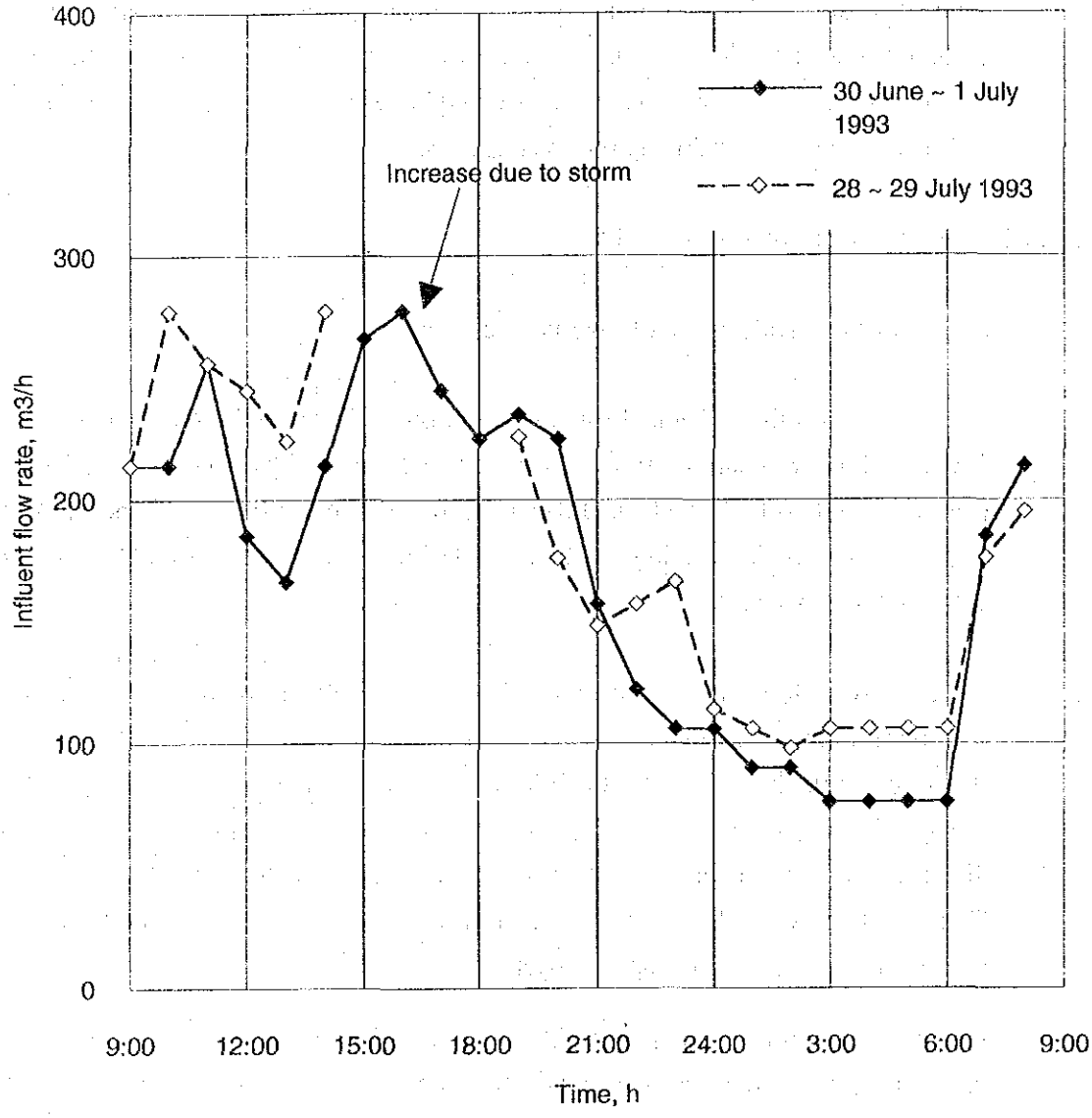

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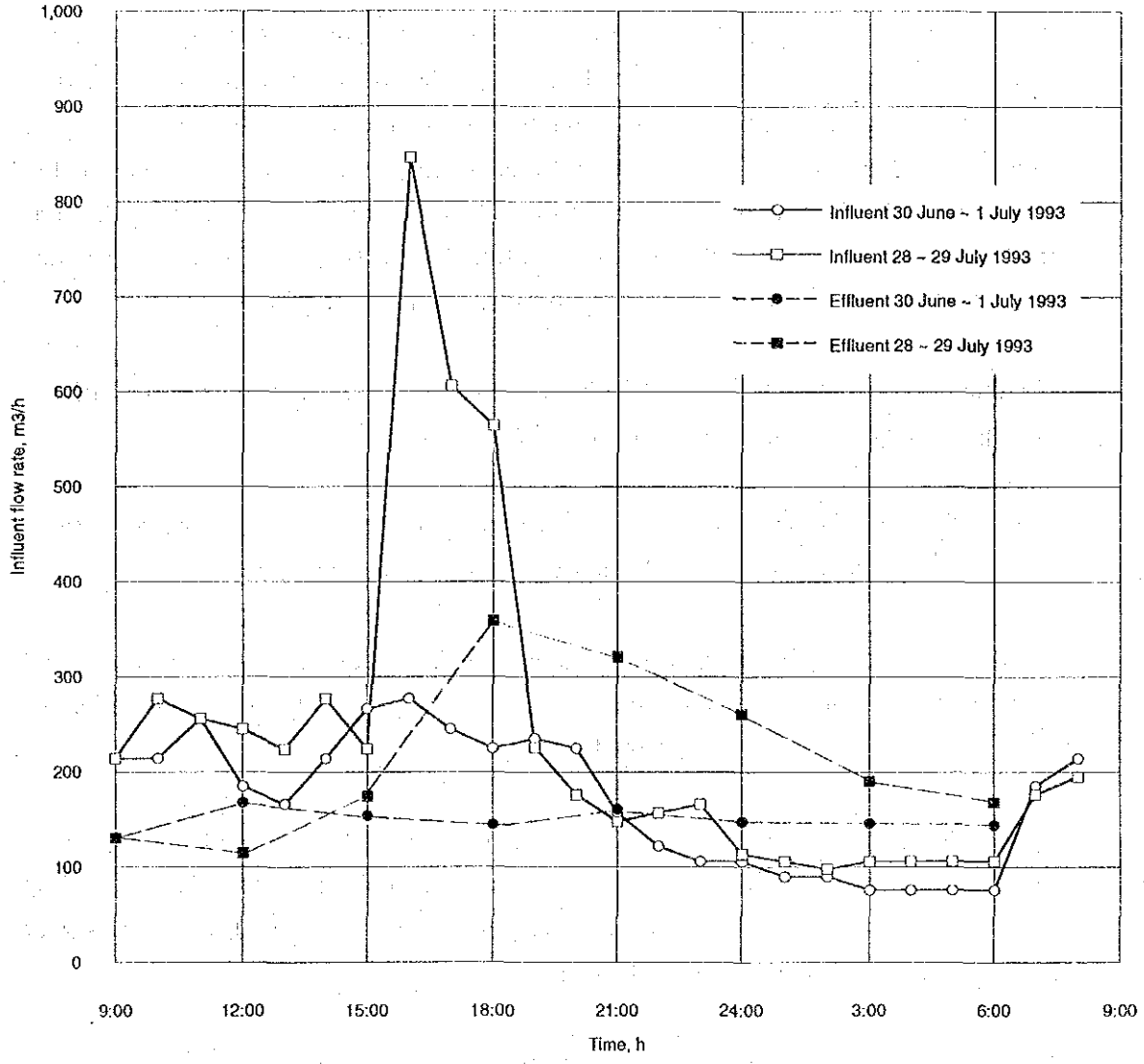
Fig. B-5



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(2) Characteristics of Influent and Final Effluent

Unlike Njoro STW, BOD concentration of Town STW was high during the day time (1,010~1,950 mg/L) and decreased very much during the night time (110~390 mg/L) as shown in Table B-25. Town STW serves mainly residential, commercial and institutional area and this characteristic could be seen in the influent. Influent BOD concentrations during day time are extremely high, most probably due to the discharge of seepage and night soil collected from the unsewered area into the sewers. Influent T-N concentrations were high not only during the daytime but also during the night time. However, T-N concentrations during night time are questionable comparing with the low BOD concentrations (110~390 mg/L) on that day as well as the T-N concentrations on the second sampling (Table B-30, BOD concentrations between 490~80 mg/L while T-N concentrations are 131.6~19.6 mg/L).

Conductivity, chloride and TDS (total dissolved solids) concentrations in the influent are slightly lower than that of the Njoro STW.

Mercury and arsenic were detected at micrograms per liter level (less than 10 μg/L). However, these levels are below that allowed in the drinking water.

Similar to Njoro STW, zinc was detected in the influent at 0.01~0.08 mg/L levels and most probable sources are water supply pipes and fittings as well as human beings (zinc is an essential element for growth).

Total coliform counts were erratic similar to Njoro STW , i. e. in first sampling in the order of thousands (Table B-25) and in the second sampling in the order of hundred thousands. Analysis of the final effluent showed, the final effluent levels were simlar to that of Njoro STW in the order of millions.

ORP levels in the final effluent were negative indicating reducing conditions. Since, the capacity of maturation ponds are too small and are filled with accumulated sludge, final effluent has become septic.

Quality of the final effluent was poor exceeding the discharge standards. In the first sampling average effluent BOD concentration was 104 mg/L while that on the second sampling was 250 mg/L. Increased inflow during storm must have resulted in poor effluent quality during the second sampling.

(3) Performance of Treatment Units

On the first sampling high BOD removal (about 70%) was observed in the primary clarifier while that in the second sampling was only 38%. SS removal rates (including that at the grit chamber) were 66% and 83%. High SS removal rate in the second sampling might have been due to not only the primary clarifier but also by the grit chamber (high grit content could be expected in the stormwater inflow and would be settled in the grit chamber).

Effluent quality of the trickling filter was poor especially during the night time (18:00 h ~6:00 h) compared to that during daytime as shown in Table B-27. Recirculation of final clarifier effluent was conducted only during the day time (6:00 h~18:00 h). Trickling filter rotor is self-propulsion type and stops rotating when there is no recirculation i. e. low flow. Stopping of rotor is not suitable for attached microorganisms growing on the surface of the filter when the air is dry. Wetting of the filter surface is a precondition for proper functioning of the filters and recirculation would be required throughout the day.

B3. INDUSTRIAL EFFLUENTS SURVEY

B3.1 Methodology

An Industrial Effluents Survey was conducted to investigate the characteristics of major industrial effluents discharged to the sewerage system. Selection of industries was made by conducting a questionnaire survey. Results of the questionnaire survey are summarized in Data book on questionnaire surveys.

For the Industrial Effluent Survey, industrial effluents are classified into three major categories namely 1) high organic containing wastes 2) heavy metal containing wastes and 3) acidic / alkaline wastes. Table B-35 shows the classification of these industries discharging more than 50 m^3/d.

Table B-35 Classification of Major Industries According to their Wastewater Characteristics

Industry	Number of Industries	Wastewater Discharge Rate m^3/d	Effluent Characteristics
Textile (Spinning, weaving and dyeing	3	258	Acidic/Alkaline
Edible Oil Extraction	3	113	High organic
Tannery (hyde processing and chrome tanning	1	100	heavy metal (chromium) and high organic
Milk processing and ghee making	1	100	High organic
Soft drink bottling	1	180	Acidic/Alkaline and high organic

The industries are textile, edible oil extraction, tannery, milk processing and ghee making, and soft drink bottling. Five industries were selected out of these nine industries together with one paint manufacturing industry under the category of heavy metal containing wastes. (It should be noted that for heavy metal containing wastes, dry cell manufacturing industry was not selected because its process stream is not connected to public sewer and was out of production during most part of the field survey.)

High Organic	-	Edible oil extraction (1) and milk processing and ghee making (1)
Heavy metal	-	Tannery (1) and paint manufacturing industry (1)
Acidic/alkaline	-	Textile industry (2)

Sampling of these industries (except paint manufacturing industry) were conducted on 13 July 1993, for every three hours during twelve hours. Temperature, pH and conductivity conductivity were measured for each samples. Composite samples were made of the collected samples and their pH and conductivity were also measured. Sludge from pretreatment unit of Tannery was also sampled. Flowrate of Tannery was measured at site. Flowrates of textile industries, edible oil extraction and milk processing and ghee making were estimated from water consumption. Sampling of the paint manufacturing industry was conducted on 26 August 1993.

B3.2 *Effluent and Sludge Quality*

Tables B-36 and B-37 show the results of water and sludge quality analysis.

(1) High Organic

Effluent from Industry 1 (ZND4) was oily and viscous. The colour was yellow and looked like thick soup. Effluent temperature was as high as 48 °C.

BOD of effluent is very high at 58,000 mg/L. BOD load from this industry is significant. The ratio of BOD : T-N : T - P is 557 : 1.1 : 1 and may have significant effect on biological treatment process. Even though the calculated load from this industry is 4,350 kg/d, the survey at the Njoro sewage treatment works did not show high BOD loading.

Effluent from Industry 2 (ZND5) was from milk processing and ghee making. However, during sampling effluent from ghee making process was not observed. Effluent was from wash-off from milk containers etc.

Effluent BOD concentration is moderately high. Ratio of BOD : T-N : T-P is 121 : 7.3 : 1. pH of the effluent was 9.24 indicating slightly alkaline nature due to milk wastes.

Table B-36 Quality of Industrial Effluents (Composite Samples)

Item		High Organic		Heavy Metal				Acidic / Alkaline	
		1	2	3		4		5	6
		Effluent	Effluent	Before Pretreatment	After Pretreatment	Before* Pretreatment	After Pretreatment	Effluent	Effluent
		ZND4	ZND5	ZND/I	ZND1/E	ZND1/E	ZND6/E	ZND2	ZND3
Flowrate, m3/d		75	100	85		1.5		100	58
Temperature, °C	Average	42.8	29.8	22	21.8	-	20	36.5	27
	Maximum	48	33	24	23	-	-	40	29
	Minimum	40	26	21	20	-	-	32	26
pH	Composite	7.88	9.24	9.31	9.62	-	7.41	9.75	8.51
	Maximum	8.66	9.3	10.26	11.3	-	-	10.12	8.64
	Minimum	6.4	7.98	7.2	8.3	-	-	9.27	8.33
Conductivity, mS/cm	Composite	2.16	0.494	10.68	12.2	-	0.358	3.02	1.517
	Maximum	3.98	0.585	68.6	15.4	-	-	4.27	1.778
	Minimum	0.76	0.367	6.64	8.44	-	-	1.65	1362
Alkalinity, mg CaCO3/L		-	-	-	-	-	-	559	818
Acidity, mg CaCO3/L		-	-	-	-	-	-	28	27
BOD5, mg/L		58,000	1,290	3,900	13,700	-	130	370	380
COD, mg/L		78,400	1,560	4,080	16,400	-	1,600	456	468
SS, mg/L		-	-	-	-	-	-	120	30
T-N, mg/L		114.8	78.4	-	-	-	124.3	-	-
T-P, mg/L		104	10.7	-	-	-	2.6	44.8	92.4
Total Sulphide, mg/L		-	-	151.2	455.2	-	-	-	-
Hexavalent Chromium (Cr6+), mg/L		-	-	0.5	3.0	-	-	-	-
Total Chromium (Cr), mg/L		-	-	4.9	25.4	-	-	-	-
Lead (Pb), mg/L		-	-	-	-	-	ND	-	-
Zinc (Zn), mg/L		-	-	-	-	-	0.63	-	-
Cobalt (Co), mg/L		-	-	-	-	-	ND	-	-
Total Dissolved solids (TDS), mg/L		-	-	-	-	-	-	2,080	1,460

* For paint industry floor and container washwater is collected in an underground tank and the effluent port was not accessible. Sample was collected from the collection tank.

Table B-37 Quality of Sludge Produced from Pretreatment of Industrial Effluents (Heavy Metal)*

Item	Heavy metal	
	3	4
	ZND1/SLD	ZND6/SLD
Temperature, °C	23	20
pH	7.69	7.06
Conductivity, mS/cm	1.438	0.576
Moisture content, %	91.6	48.8
Apparent density, kg/m3	1,034	1,317
Total Solids, g/kg wet weight	84.5	512
Volatile solids, g/kg	573	153
Hexavalent chromium ($Cr6^+$), mg/kg	1.5	
Total chromium (Cr), mg/kg	3.2	
Lead (Pb), mg/kg	-	34
Zinc (Zn), mg/kg	-	377
Cobalt (Co), mg/kg	-	3.8
Total sulphide, mg/kg	84	-

Note : * For each industry only selected heavy metals were analyzed. For tannery total and hexavalent chromium and for paint industry lead, zinc and cobalt were analyzed.

(2) Heavy metal

Process effluents form Tannery (Industry 1, (ZND1)) are discharged into settlement tanks and the effluent flowrate an equalization tank. When equalization tank is filled up tank contents are pumped up to another settlement tank. At the time of sampling, desludging of the settlement tanks were not conducted for more than two weeks and the tanks were full of sludge. Overflow, short circuiting and carry-over of sludge were observed in the settlement tanks. Rate of discharge of final effluent was that of the pumps and is 57.5 or 115 m^3/h depending on the number of pumps used. Duration of discharge was about 10 ~ 25 minutes. Therefore effluent was sampled during pumping. Total volume of tanks can provide a retention time of about 9.0 h if all tanks are empty.

Effluents from tannery showed higher BOD concentration than the influent. Carry-over of accumulated sludge and partially degraded matter must have caused the high effluent BOD concentration. Organic matter is due to process effluents from soaking of skins and fleshing. Chromium (trivalent and hexavalent) were found in the

influent and effluent together with high sulphide concentration. These originate from chromium sulphate and sodium sulphide used in the processing. In summary tannery is one of the most polluting industry which discharges heavy metal and sulphides at very high concentrations. Pretreatment facility shall be improved to reduce the heavy metal and sulphide loads discharged to the sewage treatment works.

Sludge from the tannery showed low concentration of chromiums because the chromium was not settled and contained in the effluent to Njoro STW. Sludge from the tannery is generally disposed at the Municipal Council Dumping Site. Even though the measured concentrations were not high (1.5 mg/kg). However, when the process effluents are properly treated chromium content in the sludge will increase.

Effluent from paint manufacturing industry (ZND6) was mainly due to washing of containers used for mixing paints and floor. An equalization/settling pond receives the waste and large amount of inert material was observed to accumulate within that tank.

Moisture content of the sludge was 48.8%. Sludge was of grayish-white colour containing mainly inorganic matter. Settling tank did not have sufficient opening for desludging. Lead and zinc in the sludge originate from the lead dryers and zinc compounds used in the paint making. Proper housekeeping would reduce the residual materials during the paint making.

(3) Acidic / Alkaline

Effluent from Industry 5, was coloured (dark red) due to dyeing process. Effluent temperatures were high even though equalization tanks were provided. The maximum observed at the effluent manhole was 40 °C. Conductivity was also high at 4.27 mS/cm (maximum) and composite being 3.02 mS/cm. Highest pH was 10.12.

Effluent from Industry 6 (ZND 3) was slightly dark. During sampling effluents from fabric washing (after weaving) passed through equalization tank. Maximum temperature was 27 °C while the maximum pH was only 8.64. Effluents from the textile industries are one of the major source of detergents, as can be observed by the foaming at the Njoro STW.

B4. POLLUTANT LOAD SURVEY OF RIVERS AND SPRINGS DRAINING INTO LAKE NAKURU

B4.1 Introduction

Lake Nakuru has no outlets and serves as a sink for rivers and springs draining into it. Rivers reaching the lake shore are Njoro River, Makalia River and Nderit River, Some Rivers, namely Lamuriak River and Ngosorr River disappear before reaching the Lake. Several springs appear near lake shore i.e. Baharin Spring. Effluents from Njoro STW and Town STW are also discharged into the lake through Njoro River and Town Stormwater Drainage Channel, respectively.

Sampling of rivers are springs draining to Lake Nakuru was conducted twice during the study period to estimate the pollutant loads and their characteristics. Sampling locations are as shown in Fig. B-6. They are :

(a)	Njoro River, upstream of Njoro Town	UI
(b)	Njoro River, upstream of Nakuru City	UII
(c)	Njoro River, upstream of Njoro STW discharge	UIII
(d)	Njoro River mouth	UIV
(e)	Town Stormwater Drainage Channel	T
(f)	Baharin Spring	PR
(g)	Spring near special camp site	NE
(h)	Spring near Lion Hill	E
(i)	Nderit River	N
(j)	Makalia River	M
(k)	Lake Nakuru	LN

For Njoro River, four sampling locations were selected at upstream of Njoro Town, upstream of Nakuru city, upstream of Njoro STW discharge and at Njoro River Mouth for the following reasons.

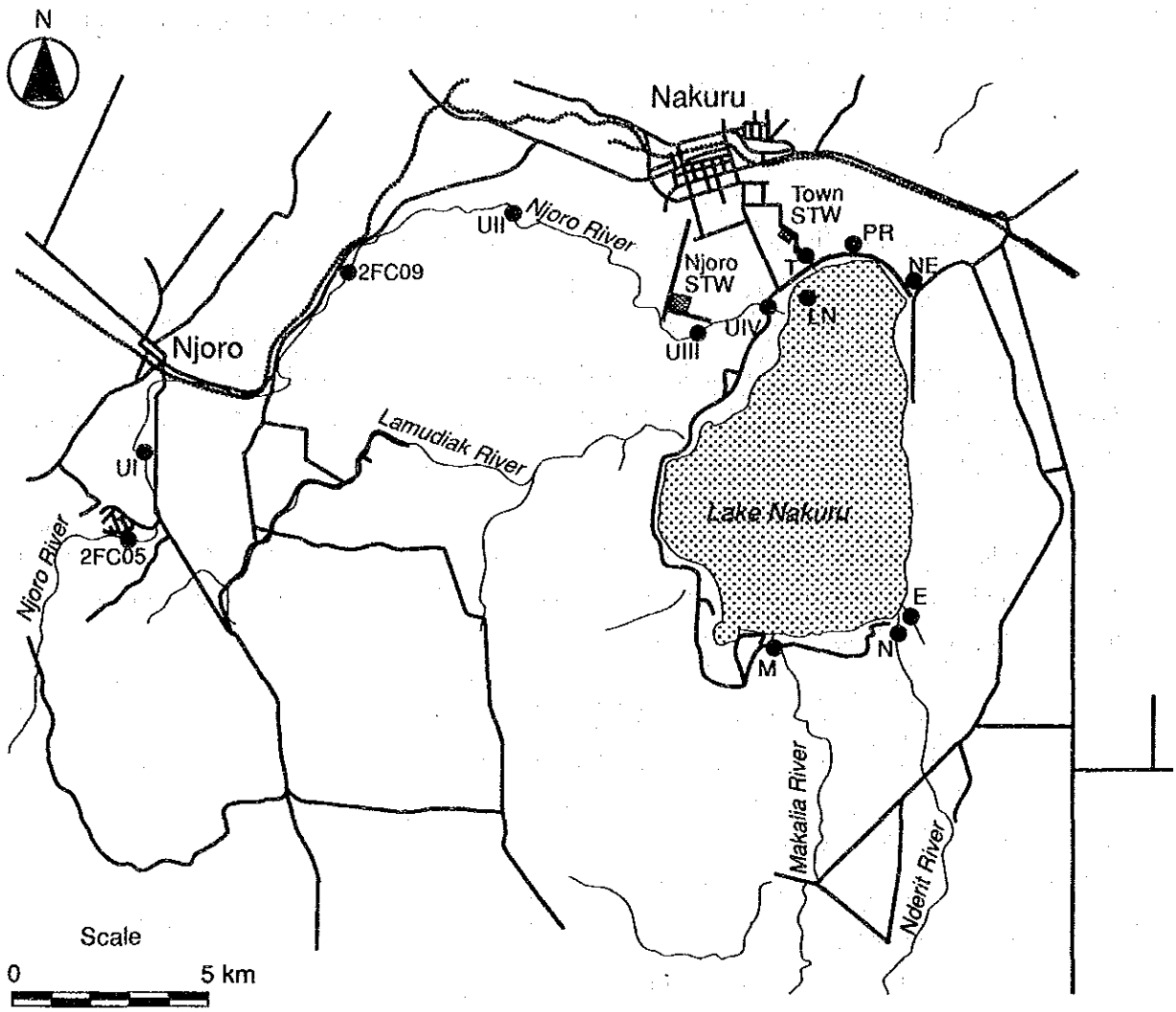
(1) upstream of Njoro Town has substantial development with a university

(2) in between Njoro Town and Nakuru City, river is being used all for drinking (human and cattle), bathing, agriculture etc.

(3) Njoro STW effluent is discharged into the river before, it reaches the lake.

Flowrates were also measured at the time of sampling. Sampling were on 7th and 27th July 1993.

Fig. B-6



LEGEND

UI	: Njoro River, Upstream of Njoro Town
UII	: Njoro River, Upstream of Nakuru City
UIII	: Njoro River, Upstream of Njoro STW Discharge
UIV	: Njoro River Mouth
PR	: Baharin Spring
T	: Town Stormwater Drainage Channel
NE	: Spring near Special Camp Site
E	: Spring near Linon Hill
N	: Nderit River
M	: Makalia River
LN	: Laku Nakuru, near Njoro River Mouth
2FC05	: River Flow Gauging Station
2FC09	: River Flow Gauging Station

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B4.2 Results

Tables B-38 and B-39 show part of the analytical results.

(1) Flowrate

On 7th July 1993, flowrate of Njoro River at sampling location UII was 7,843 m^3/d (0.091 m^3/s) while that on 27th July 1993 was 45,892 m^3/d (0.531 m^3/s). Fig. B-7 shows the flowrate -duration curves of Njoro River (measured at gauging station 2FC05) in the year 1968 and 1990. These years were selected because flowrate data was incomplete during the other years. Mean flowrate is 0.45 m^3/s (38,880 m^3/d) in 1968 and 0.165 m^3/s (14,256 m^3/d) in 1990. Frequency of flowrate on 27th July 1993 being exceeded is less than 50 %. Sampling on that date can be considered to be representative of wet weather. Flowrate on 7th July 1993, is being exceeded 91 % of the time and can be considered to represent dry weather.

Flowrate of Makalia River was higher on 27th July (8,350 m^3/d) than on 7th July 1993 (5,621 m^3/d). Even though the difference is not as good as flowrates of Njoro River to show wet and dry weather, similar to Njoro River sampling of 7th July 1993 is considered to represent dry weather while that of 27th July represents wet weather. Past flowrate data are incomplete and the analysis of flow-duration curve is not possible.

Nderit River bed was dry and a very low flow (about 300 m^3/d) appeared near the lake shore. Both sampling can be considered as for dry weather. Flowrates of the springs did not show much variation on both sampling dates and judging from their cross-section their flowrates could be assumed to be constant throughout the year.

Flowrate along Njoro River showed reduction during low flow condition. There was a reduction of 6,842 m^3/d between sampling location UI and UII on 7th July 1993. Flowrate between sampling locations UII and UIII reduced by 5,569 m^3/d and 4,668 m^3/d on 7th and 27th July 1993 respectively. Ground infiltration and other usage along the river may have reduced the flowrate.

(2) Temperature

Temperature of the rivers were below 20°C except that of Nderit River which was due to heating of ground during day time (Note : maximum flow depth was only 2 cm). Temperatures of springs were also high either due to ground heating (shallow depth) or due to geological features of the area.

Table B-38 Water Quality of River and Springs Draining to Lake Nakuru, 7th July '93

Items		Njoro River				Town Storm Water Drainage Channel	Baharin Spring	Spring near Special Camp Site	Spring near Lion Hill	Nderit River*	Makalia River	Lake Nakuru near Njoro River mouth
		Upstream of Njoro Town	Upstream of Nakuru City	Upstream of Njoro STW Discharge	River Mouth							
		UI/W	UII/W	UIII/W	UIV/W	T/W	PR/W	NE/W	E/W	N/W	M/W	LN/W
Flowrate, m3/d		14,685	7,843	2,274	7,896	2,254	1,348	726	224	259	5,621	-
Temperature, °C		15	18	21	21	28	30	33	29	30	19	28
pH		7.75	8.10	7.53	7.85	7.45	8.86	8.00	8.76	8.95	7.62	10.12
Conductivity, mS/cm		0.024	0.020	0.188	0.775	0.768	0.570	0.464	6.62	4.31	0.117	52.3
BOD5, mg/L		20	60	80	100	130	3	3	640	280	30	560
COD, mg/L		27	80	110	140	175	5	5	840	370	40	730
SS, mg/L		20	15	45	60	30	4	17	35	60	190	426
TDS, mg/L		222	200	230	542	356	430	320	4,090	2,530	862	18,233
T-N, mg/L		5.3	8.7	4.8	27.7	40.4	7.0	3.0	5.6	4.5	8.4	33.6
NH4-N, mg/L		2.8	5.6	4.8	26.6	31.1	3.1	0.8	2.8	2.5	2.8	9.5
NO3-N, mg/L		2.5	3.1	ND	1.1	2.0	3.9	2.2	0.6	2.0	0.5	6.2
SO4-2, mg/L		0.07	0.01	0.04	ND	0.14	0.05	0.013	0.07	0.08	0.02	0.20
Total sulphide, mg/L		ND	ND	ND	3.5	0.8	ND	5.4	ND	4.8	2.1	8.0
Total coliform count, colonies/100mL		40	30	180	40	20,000	60	490	230	30	0	40
T-P (Total Phosphorous), mg/L		6.4	ND	ND	19.1	10.7	ND	11.8	ND	5.9	ND	13.7
Ortho-P, mg/L		2.1	ND	ND	2.7	2.2	ND	1.3	ND	ND	ND	1.2
Organochlorine pesticides	Aldrin, mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F), mg/L		2.00	0.89	0.56	1.58	1.26	5.62	2.24	56.23	35.48	1.00	316.23
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		12.5	7.5	17.5	29.0	31.0	7.5	15.0	80.0	55.0	12.5	455.0
Cyanide (CN-), mg/L		0.005	ND	0.003	0.016	0.001	ND	0.001	0.049	0.02	0.018	0.001
Lead (Pb), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc (Zn), mg/L		0.01	0.01	0.02	0.01	0.04	ND	ND	0.01	0.03	0.04	0.04
Total chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent chromium (Cr6+), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As), mg/L		0.0010	0.0003	0.0013	0.0011	0.0006	0.0050	0.0020	0.0050	0.0140	0.0015	0.0400
Total mercury (Hg), mg/L		0.0004	0.0002	0.0002	0.0002	0.0003	0.0005	0.0005	0.0010	0.0007	0.0003	0.0010
Copper (Cu), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron (Fe), mg/L		2.29	2.60	3.36	1.20	0.50	0.79	0.19	1.85	4.29	6.62	0.39
Total manganese (Mn), mg/L		0.01	0.01	0.07	0.05	0.03	ND	ND	0.10	0.03	0.01	0.02
Nickel (Ni), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenols, mg/L		0.662	0.592	1.045	0.863	0.644	-	0.401	-	2.456	1.428	0.976
Anionic surfactant as MBAS, mg/L		-	-	-	-	-	-	-	-	-	-	-
Oil (n-Hexane extract), mg/L		-	-	-	-	-	-	-	-	-	-	-

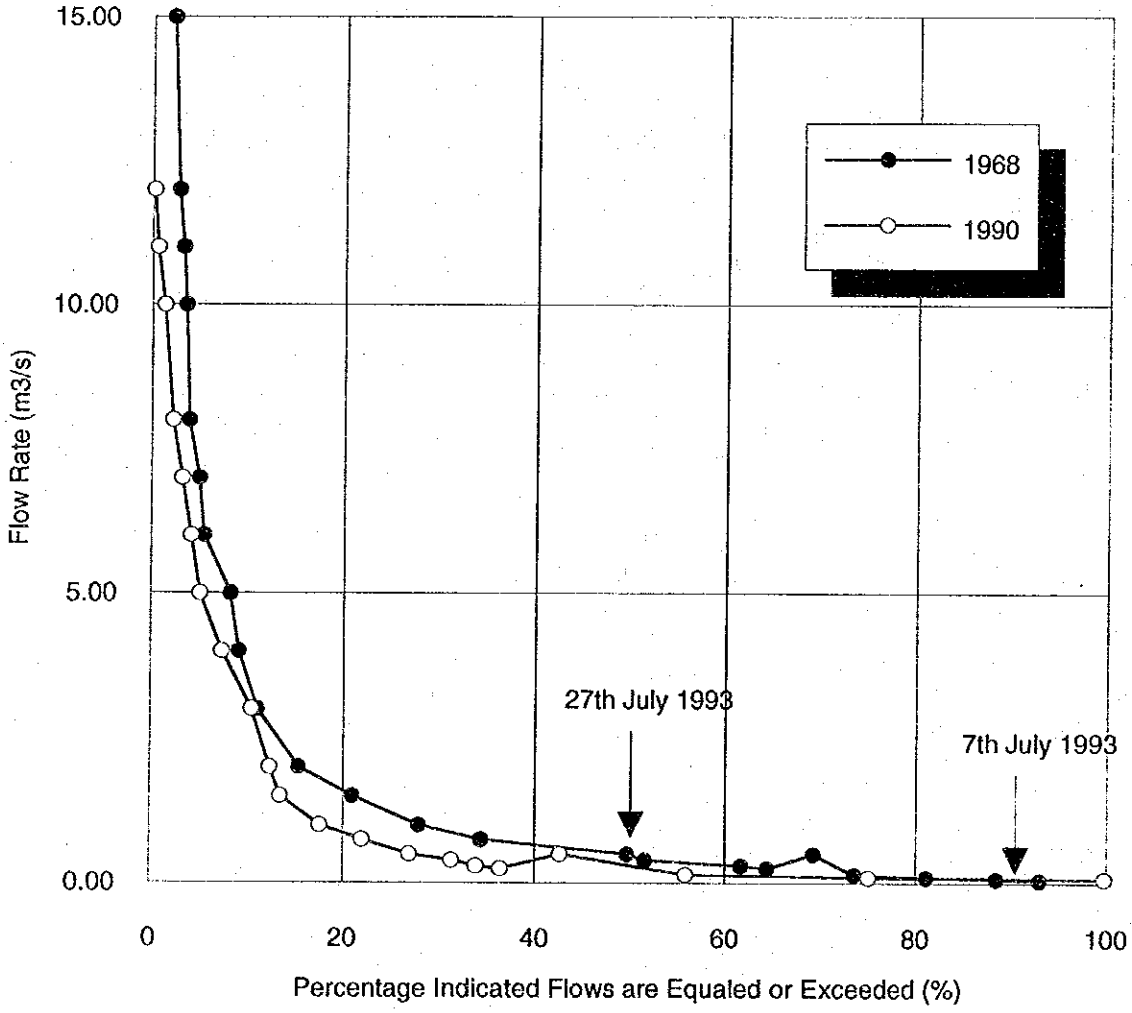
Note : * Nderit River bed was dry and a small flow appeared near the lake and affected by adjacent marshlands near the lake

Table B-39 Water Quality of River and Springs Draining to Lake Nakuru, 27th July '93

Items		Njoro River				Town Storm Water Drainage Channel	Baharin Spring	Spring near Special Camp Site	Spring near Lion Hill	Nderit River*	Makalia River	Lake Nakuru near Njoro River mouth
		Upstream of Njoro Town	Upstream of Nakuru City	Upstream of Njoro STW Discharge	River Mouth							
		UI/D	UII/D	UIII/D	UIV/D	T/D	PR/D	NE/D	E/D	N/D	M/D	LN/D
Flowrate, m3/d		47,467	45,892	41,224	41,497	4,763	1,465	659	324	181	8,350	-
Temperature, °C		14	15	19	16	23	28	30	26	29	16	29
pH		7.73	7.83	7.43	7.88	7.73	8.77	7.83	8.65	8.85	7.48	10.21
Conductivity, mS/cm		0.072	0.074	0.072	0.410	0.704	0.548	0.446	5.84	3.83	0.077	52.6
BOD5, mg/L		40	35	55	45	335	3	0	550	70	80	430
COD, mg/L		60	48	72	56	460	4	0	740	100	100	568
SS, mg/L		15	30	75	85	73	80	24	75	271	135	879
TDS, mg/L		150	150	150	180	425	406	360	4,130	2,220	220	31,940
T-N, mg/L		4.5	7.3	1.1	1.1	67.2	7.6	3.3	2.8	14.0	ND	42.0
NH4-N, mg/L		4.5	5.9	ND	1.1	32.2	5.9	1.7	2.0	ND	ND	7.3
NO3-N, mg/L		ND	1.4	1.1	ND	ND	1.7	1.4	0.6	3.6	ND	ND
SO4-2, mg/L		0.06	0.02	0.04	0.09	0.04	0.02	0.09	0.06	0.19	ND	0.44
Total sulphide, mg/L		4.0	0.8	2.4	4.0	ND	3.6	8.0	ND	3.2	2.8	16.0
Total coliform count, colonies/100mL		300	200	300	400	7,800	100	200	500	600	300	100
T-P (Total Phosphorous), mg/L		ND	5.7	2.4	5.7	9.7	ND	8.3	ND	ND	ND	9.1
Ortho-P, mg/L		ND	0.8	1.7	1.7	3.6	ND	ND	ND	ND	ND	1.6
Organochlorine pesticides	Aldrin, mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	BHC, mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	MCPA, mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Metolachlor, mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Flouride ion (F), mg/L		0.50	0.25	0.22	0.32	0.79	3.16	2.82	50.12	28.18	0.40	316.23
Cadmium (Cd), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Potassium (K), mg/L		3.8	4.2	4.2	6.8	25.0	7.8	25.0	80.0	50.0	6.0	410.0
Cyanide (CN-), mg/L		0.104	0.152	0.212	0.210	0.142	0.103	0.180	0.180	0.143	0.213	0.197
Lead (Pb), mg/L		ND	0.04	0.04	0.04	ND	0.06	0.04	0.06	ND	0.03	ND
Zinc (Zn), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total chromium (Cr), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexavalent chromium (Cr6+), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic (As), mg/L		ND	ND	ND	ND	ND	ND	ND	0.0002	ND	ND	0.015
Total mercury (Hg), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper (Cu), mg/L		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.04
Iron (Fe), mg/L		2.29	2.58	2.6	2.26	0.27	0.31	ND	0.86	5.9	1.29	0.09
Total manganese (Mn), mg/L		0.13	0.02	0.01	0.01	0.16	0.01	ND	0.03	0.13	0.03	0.02
Nickel (Ni), mg/L		0.02	0.01	0.01	0.02	0.01	0.01	0.03	0.04	0.02	0.05	0.12
Phenols, mg/L		0.557	0.575	0.557	0.505	0.436	0.314	ND	ND	1.481	1.254	ND
Anionic surfactant as MBAS, mg/L		0.17	0.04	0.13		0.88	0.01	0.01	0.02	0.10	0.12	0.11
Oil (n-Hexane extract), mg/L		-	-	-	191.4	192.5	-	-	-	-	-	-

Note : * Nderit River bed was dry and a small flow appeared near the lake and affected by adjacent marshlands near the lake

Fig. B-7



THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITATION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE FLOW DURATION CURVE OF NJORO RIVER (2FC05)

(3) pH

pH of Njoro River, Makalia River and Town Stormwater Drainage Channel were in the range of 7.43 ~ 7.85 except for that at UII on 7th July 1993. However, pH of springs and Nderit River was above 8.00 showing alkaline inflow into the lake. pH of Lake Nakuru was 10.12 and 10.21 showing high alkalinity.

(4) Conductivity

Along Njoro River, during low flowrate (i.e. 7th July 1993) there was a marked increase in conductivity between UII (0.020 mS/cm) and UIII (0.188 mS/cm) and in between UIII and UIV (0.775 mS/cm). Use of water along the Njoro River by nearby population and cattle has resulted in the increase of conductivity. Increase between UIII and UIV is due to effluent discharge from Njoro STW.

Nderit River and Spring near Lion Hill were also of very high conductivity, due to high dissolved solids. Colour of both water were dark brown which may be due to marshy nature of the adjacent area.

(5) Others

Arsenic and total mercury were detected in the natural waters in fractions of micrograms per liter levels. Trace amount of arsenic and mercury are generally found in the Rift Valley Area due to their geological characteristics. Except for these other heavy metals were not detected.

Oil concentrations in the Town Stormwater Drainage Channel and Njoro River Mouth were high. Anionic surfactant concentration at 0.88 mg/L as MBAS was also measured in the Town Stormwater Drainage Channel.

Pesticides were not detected in any of the samples. Even though drainage areas of Njoro River are mainly farmlands, pesticides could only be expected during heavy rainfall.

B4.3 Pollutant Load to Lake Nakuru through Rivers and Springs

Table B-40 shows the pollutant loads entering Lake Nakuru through rivers and springs as measured on 7th and 27th July 1993. Pollutant load is higher during high flowrate (i.e. 27th July 1993) than during low flowrates. Njoro River and Town Stormwater Drainage Channel are the major source of pollutant loads.

In terms of BOD, both of them account for 73 % (7th July 1993) and 80 % (27th July 1993). BOD load entering through Town Stormwater Drainage Channel showed much variation. On 27th July both flowrate as well as BOD concentration were high. BOD load through Makalia River accounted for about 10 ~ 15 % of the BOD load.

Total nitrogen and total phosphorous enter mostly through Njoro River and Town Stormwater Drainage Channel.

Table B-40 Pollutant Load Entering Lake Nakuru through River and Springs

Name of River/Spring	Pollutant Load, kg/d							
	BOD		COD		T-N		T-P	
	7/8/93	27/8/93	7/8/93	27/8/93	7/8/93	27/8/93	7/8/93	27/8/93
Njoro River (Mouth)	790	1,867	1,105	2,324	219	46	94	236
Town Stormwater Drainage Channel	293	1,596	394	2,191	91	320	24	46
Baharin Spring	4	4	6	6	9	11	0	0
Spring near Special Campsite	2	0	4	0	2	2	9	5
Spring near Lion Hill	143	178	188	240	1	1	0	0
Nderit River	73	13	96	18	1	3	15	0
Makalia River	169	668	225	835	47	0	0	0
Total	1,474	4,326	2,018	5,614	370	383	142	287

Table B-41 Variation of Pollutant Load along Njoro River

Name of River/Spring	Pollutant Load, kg/d							
	BOD		COD		T-N		T-P	
	7/8/93	27/8/93	7/8/93	27/8/93	7/8/93	27/8/93	7/8/93	27/8/93
Upstream of Njoro Town	294	1,899	396	2,848	78	214	94	-
Upstream of Nakuru City	470	1,606	627	2,203	68	335	-	262
Upstream of Njoro STW discharge	182	2,267	250	2,968	11	45	-	99
River Mouth	790	1,867	1,105	2,324	219	46	94	236

B5. POLLUTANT LOAD SURVEY OF RIVERS DRAINING INTO LAKE NAKURU DURING STORM DRAINAGE

B5.1 Introduction

During storms debris, garbage, oil and other matter accumulated on the surface of urban and natural landscape is flushed to the stormwater drains. Accumulation of these matter depends on landuse (urban, agricultural etc.) and their maintenance such as garbage collection and drain cleaning. Amount of pollutants flushed during a storm depends on the storm intensity and the number of consecutive days without rain. During storm, flushing of pollutants occurs within a short period. Generally, at the beginning of the flushing, amount of pollutants will be higher and will decrease with time.

To estimate the pollutant load entering Lake Nakuru during storm drainage, sampling during storm was planned to be conducted at the following locations. They are :

(1) Town Stormwater Drainage Channel
(2) Njoro River Mouth
(3) Njoro River upstream of Njoro STW Discharge
(4) Makalia River
(5) Nderit River

However, due to the dry spell storm drainage in the rivers could not be sampled. Due to the porous nature of the drainage area of rivers, peak flows could be observed only during successive rainfall events of high intensity.

B5.2 Town Stormwater Drainage Channel

Sampling of Town Stormwater Drainage Channel was conducted on 28th July 1993. Sampling location was about 200 m upstream of Town STW Gate. Storm started around 15:00 h and stopped around 18:15 h. Storm intensity was heavy between 15:15 h and 17:00 h. Amount of rainfall recorded at Nakuru Showground Meteorological Station was 11.8 mm, while that recorded near Lanet Gate of Lake Nakuru National Park was 8 mm, showing spatial variation. Previous rainfall event was on 20th July 1993 and was 10.5 mm.

Before storm there was almost no flow along the upstream of Town Stromwater Drainage Channel because the water was being used for irrigation. Stormwater flow appeared at 15:45 h and the samples were taken at 15:45, 15:50, 16:05, 16:10, 16:25, 16:45, 17:00, 17:15 and at 18:15 hrs. Peak flow occurred between 16:45 ~ 17:00 h. Samples collected at 16:25 h and 18:15 h were taken for analysis, representing increasing flow and decreasing flow during storm drainage. Bottom sediments was collected from the drainage channel near the lake.

Table B-42 shows the results of the water quality analysis and Table B-43 shows that of sediment, BOD, COD and suspended solids were higher during increasing flow compared to decreasing flow. High BOD/COD ratio (about 0.75) shows high organic matter and is not typical of stormwater drainage from other cities. Suspended solids concentrations were also high.

Organochlorine pesticide (BHC) was detected at 0.01 mg/L which must have originated from spills on the surface during carcless handling within the Town Drainage Area.

Heavy metals, namely zinc and cadmium were detected. Oil concentration was 553.3 mg/L in the increasing flow and 40.5 mg/L in the decreasing flow. Oils mostly come from the indiscriminate disposal in the ground by 'juakali garages'.

In the sludge collected from the Town Stormwater Drainage Channel (Table B-43) zinc, lead, copper and cadmium were detected while trace levels of arsenic and mercury were found. However, the concentrations in the sediment of Lake Nakuru are lower except for that of copper although the levels are not high. Accumulation of copper could have occurred due to leaching from copper fittings etc.

Table B-42 Water Quality of Town Stormwater Drainage Channel During Storm

Items		Concentration	
		increasing flow T/S/B	decreasing flow T/S/E
Temperature, °C		18	16
pH		7.18	7.61
Conductivity, mS/cm		0.279	0.229
BOD5, mg/L		2,180	600
COD, mg/L		2,900	800
SS, mg/L		5,512	860
T-N, mg/L		13.4	ND
NH4-N,mg/L		ND	1.7
NO3-N, mg/L		13.4	ND
T-P (Total Phosphorous), mg/L		11.7	8.3
Ortho-P, mg/L		0.7	0.1
Organochlorine pesticides	Aldrin, mg/L	ND	ND
	BHC, mg/L	0.01	ND
	MCPA, mg/L	ND	ND
	Metalochlor, mg/L	ND	ND
Cadmium (Cd), mg/L		ND	0.01
Potassium (K), mg/L		10	10
Cyanide (CN-), mg/L		0.091	0.12
Lead (Pb), mg/L		ND	ND
Zinc (Zn), mg/L		0.02	0.11
Total chromium (Cr), mg/L		ND	ND
Hexavalent chromium (Cr6+), mg/L		ND	ND
Arsenic (As), mg/L		ND	ND
Total mercury (Hg), mg/L		ND	ND
Copper (Cu), mg/L		ND	ND
Iron (Fe), mg/L		1.74	2.75
Total manganese (Mn), mg/L		0.65	1.05
Nickel (Ni), mg/L		ND	0.01
Phenols, mg/L		2.474	0.488
Oil (n-Hexane extract), mg/L		553.3	40.5

Table B-43 Quality of Sludge Accumulated in the Town Stormwater Drainage Channel During Storm

Item	Town Stormwater Drainage Channel T/S/SLD	Lake Nakuru LN/SLD
pH	7.82	-
Conductivity, mS/cm	1487	-
Moisture content, %	66.2	56.8
Volatile solids, g/kg	138.5	28.4
BOD5, mg/L	28,360	1080
COD, mg/L	37,800	1400
NH4-N, mg/kg	-	0.8
Cadmium (Cd), mg/kg	0.023	0.597
Potassium (K), mg/kg	123.29	86.83
Cyanide (CN-), mg/kg	-	-
Lead (Pb), mg/kg	2.301	1.609
Zinc (Zn), mg/kg	7.42	1.394
Total Chromium, mg/kg	ND	ND
Hexavalent Chromium (Cr6+), mg/kg	ND	ND
Arsenic (As), mg/kg	0.002	0.021
Total Mercury (Hg), mg/kg	0.001	0.013
Copper (Cu), mg/kg	0.913	11.554
Iron (Fe), mg/kg	410.96	0.116
Total Manganese (Mn), mg/kg	1.256	0.509
Nickel (Ni), mg/kg	ND	0.093

B6. QUALITY OF SLUDGE GENERATED IN THE SEWAGE WORKS

B6.1 General

Sewage sludge from drying beds of Town STW is being sold to farmers as fertilizer or soil conditioner. At Njoro STW, sludge accumulated as bottom sediment in the waste stabilization ponds. Desuldging is required to maintain the effective volume for treatment. Disposal of this bottom sediment requires its characteristics be known since industrial wastes are discharged to Njoro STW. Sampling of sewage sludge was carried out at Njoro STW and Town STW. Sampling locations are as follows :

Njoro STW - Bottom sediments of anaerobic pond (A2) and facultative pond (F1)
Town STW - Digested sludge and dried sludge

Table B-44 shows the results of the sludge quality analyses.

B6.2 Njoro STW

Physical properties of sludge from both anaerobic pond and facultative pond such as pH, conductivity, moisture content, volatile solids and apparent density are similar. Moisture content is high at around 84.7 ~ 87.7 %. Reuse of sludge requires drying. In case of chromium, both total and hexavalent chromium were higher in the facultative pond sludge compared to anaerobic pond sludge. Presence of chromium can be traced to the tanneries which is in operation since 1960. Mercury levels are 2.2 mg/kg and 0.6 mg/kg. Other metals which are of concern are copper and zinc. Possible sources are water supply pipes and fittings and chemicals used for controlling algal/biological film in the cooling systems. Disposal and reuse of this sludge would require further analysis.

B6.3 Town STW

Digested sludge is of neutral pH and moisture content is 97.0 %. Moisture content of dried sludge is 59.7 showing efficient drying in the drying beds. Similar to Njoro STW sludge, relatively high levels of copper and zinc were observed. Total mercury in the digested sludge was 19.8 mg/kg which is high, however, the concentration was only 1.6 mg/kg in the dried sludge. Possible sources could be thermometers and medical equipments using mercury at the hospitals.

In summary, disposal and reuse of the sludge especially that of Njoro STW would require further analysis to ensure that they are properly disposed.

Table B-44 Quality of Sludge Generated in the Sewage Treatment Works

Item	NJORO STW		TOWN STW	
	Anaerobic Pond SLD/X/A	Facultative Pond SLD/X/F	Digested Sludge SLD/Y/W	Dried Sludge SLD/Y/D
pH	6.10	6.67	6.98	5.36
Conductivity, mS/cm	1.49	1.383	4.62	2.01
Moisture content, %	84.7	87.7	97.0	59.7
Volatile solids, g/kg	413	418	29.6	403
Total solids, g/kg (wet)	153	123	562	373
Apparent density, kg/m3	1,164	1,103	954	623
BOD5, mg/L	4,260	4,000	21,600	10.7*
COD, mg/L	5,680	5,300	26,200	14.2*
T-N (Total Nitrogen), mg/kg	90.2	111	250	215
NH4-N, mg/kg	3.1	3.7	12.3	0.3
T-P, mg/kg	7.1	4.0	33.2	62.5
Cadmium (Cd), mg/kg	ND	ND	ND	2
Potassium (K), mg/kg	255	482.8	3,994	20
Cyanide (CN-), mg/kg	0.2	0.02	6.2	0.5
Lead (Pb), mg/kg	118	ND	ND	79
Zinc (Zn), mg/kg	1,327	212	1,013	1,484
Total Chromium, mg/kg	33.5	198.8	ND	ND
Hexavalent Chromium (Cr6+), mg/kg	0.2	0.3	ND	ND
Arsenic (As), mg/kg	1.7	ND	ND	1.1
Total Mercury (Hg), mg/kg	2.2	0.6	19.8	1.7
Copper (Cu), mg/kg	90	19	91	112
Iron (Fe), mg/kg	30,020	4,097	27,732	29,010
Total Manganese (Mn), mg/kg	323	96	380	743
Nickel (Ni), mg/kg	12	ND	ND	8

* units in mg/kg of wet sample

ANNEXES

Annex-1 Analytical Methods Used

Parameter	Method Used
BOD	Incubation Method /DO measurement by Azide modification
COD	Open Reflux Method with Potassium Dichromate
Total Nitrogen	Digestion Method (Kjeldahl)
NH_4-N	Distillation/titration
NO_3-N	Devarda's Alloy Method
T-P (Total Phosphorous)	Digestion Method
PO_4-P (Ortho Phosphorous)	Ascorbic Acid Method
Chloride	Argentometric Method
Total Sulphide	Iodometric Method
Sulphate	Gravimetric Method
Acidity	Titration
Alkalinity	Titration
SS	Gravimetric Method
TDS	Gravimetric Method
Volatile Solids	Gravimetric Method (550°C)
Total Solids	Gravimetric Method
Cyanide	Colorimetric Method
Flouride	Electrode Method
Phenol	Direct Photometric Method
Anionic Surfactant	MBAS (Methylene Blue Active Substances)
Organo Chlorine Pesticides	ECD Gas Chromatograph Method
Oil and Grease	n-Hexane Extract Method

Annex-2 Analytical Methods Used for Heavy Metals

Parameter	Method	Detection Limit mg/L
Potassium	Flame Photometric	0.005
Cadmium	AAM (Atomic Absorption Method)	0.002
Lead	AAM	0.05
Zinc	AAM	0.005
Total Chromium	Colorimtric Method	0.01
Hexavalent Chromium	Colorimetric Method	0.01
Arsenic	AAM	0.002
Total Mercury	AAM (with Vapour Generation assembly)	0.001
Total Manganese	AAM	0.01
Copper	AAM	0.01
Iron	AAM	0.02
Nickel	AAM	0.02

C : EXISTING SANITARY SERVICES

C: EXISTING SANITARY SERVICES

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C1. INTRODUCTION

The existing sanitary services were surveyed with a view to the wastewater treatment, stormwater drainage, urban refuse disposal and public health. The survey covered the following items:

(1) Water supply system
(2) Sewerage system
(3) On-site wastewater treatment
(4) Industrial wastewater pre-treatment facilities
(5) Stormwater drainage system
(6) Urban refuse collection and disposal
(7) Public health services

The results of the survey have been reflected and employed in planning and designing of the rehabilitation/expansion of sewage treatment works stormwater retention pond and water pollution control plan.

The survey was carried out during the period from June to July 1993 in a joint effort of the Kenyan Counterpart and JICA Study Teams.

C2. PUBLIC SANITARY SERVICES

C2.1 Sanitary Services Area

In view of the existing public sanitary services, the Nakuru Municipality is divided into two : one is the Town area excluding Lanet area (hereinafter defined as the Town area) and the other is Lanet area (hereinafter referred to as the Lanet area).

(1) Town area

The sanitary services in Town area such as sewerage, water supply, and dustbin services are systematically managed by means of an integrated database, which allows NMC to issue only one bill to each registrant for monthly payment. Basically the Town area is sub-divided into a number of sections and the database systematically numbers each registrant in the section concerned and further indicates what types of the services the registrant receives. Fig. C-1 presents the demarcation of the section areas.

(2) Lanet area

The Lanet area is mainly used for the military services and therefore is provided with specific water supply facilities which are operated and maintained by MOLRRWD. According to the MOLRRWD, sewerage system is provided only to the 3rd Kenya Rifles, which is one of the five military services in the area, and the system is connected to the Town STW of WSD.

C2.2 Public Service Registrants

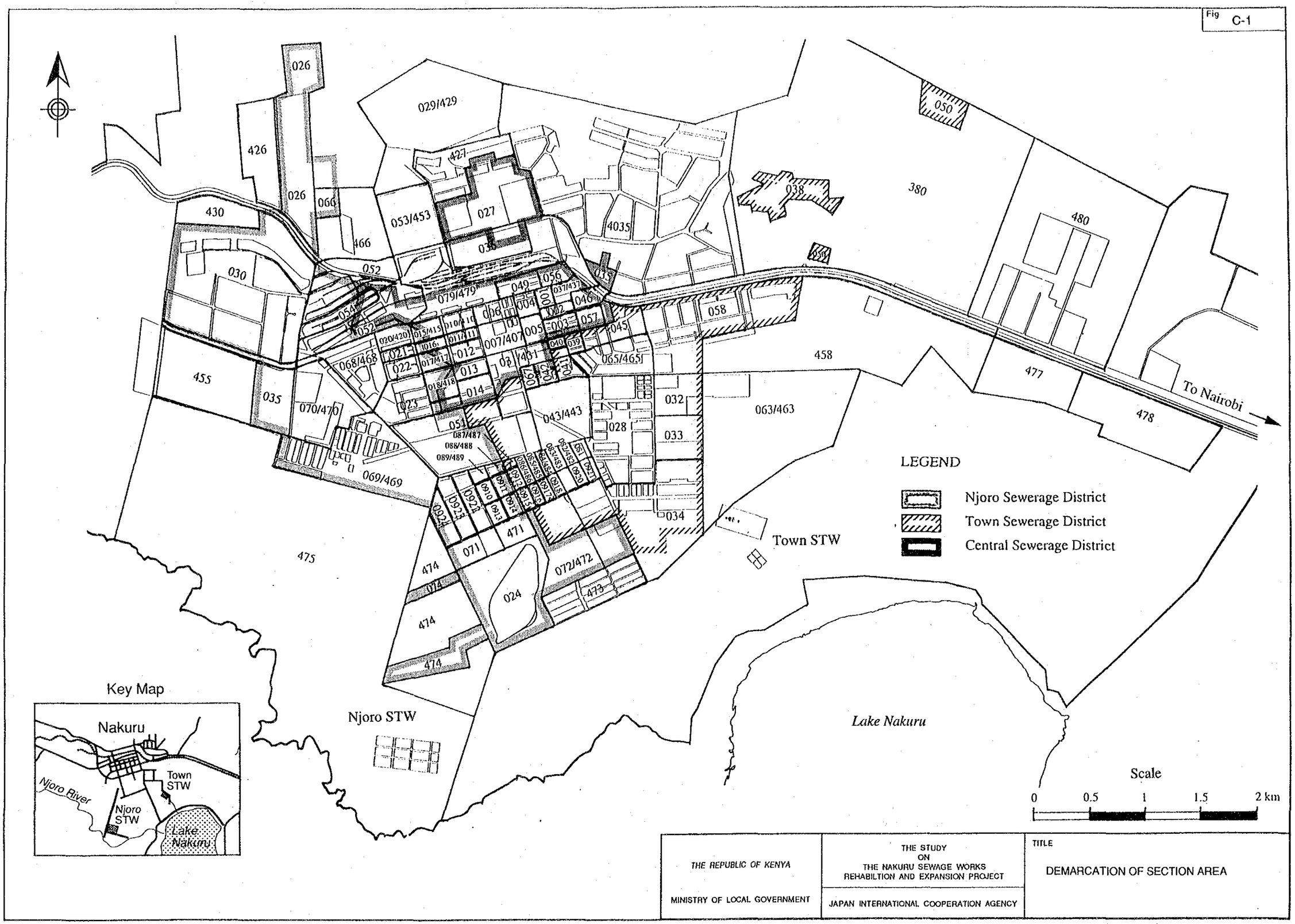
Table C-1 gives the number of registrants and types of services being extended as of April 1993. It should be noted that the Sections 425, 510, 511, 520 and 540 are outside the gazzeted administrative area of the Nakuru Municipality.

It should also be noted that registrant does not necessarily mean a household. There are a number of registrants representing communal areas, especially in mass housing areas. Also judging from the result of questionnaire survey and inventory of existing water supply facilities, it is not exaggerated to say that a whole population in the area depends on the public water supply for their drinking water.

The number of water served registrants is 14,904 in the Town area, out of the total registrants of 15,465. Out of the 14,904 water registrants, 9,538 and 11,674 registrants are also served with sewerage and dustbins respectively. The Lanet are serves 60 registrants including five military services.

At present, water supply and sewerage services are administered and managed by WSD and dustbin service by PHD. PHD also extends such services as septage exhausting of on-site wastewater treatment facilities and health care.

Fig C-1



THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILTION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE DEMARCATION OF SECTION AREA

Table C-1 Number of Water Meters and Water and Sewer Served Registrants

Section No.	Number of Registrants			Section No.	Number of Registrants		
	Water Supply	Sewer	Dustbin		Water Supply	Sewer	Dustbin
(1) Within Municipal Area							
01	72	71	71	052	3	3	3
02	71	71	71	053/453	11	5	7
03/403	594	123	557	054	125	123	124
04	36	36	36	055	193	180	180
05	0	0	0	056	47	47	46
06	82	82	82	058	611	600	599
07/407	84	80	81	063/463	4	2	3
010/410	19	13	18	065/465	124	117	121
011/411	12	10	12	066	2	2	1
012	23	22	22	067	6	6	6
013	70	68	69	068/468	86	81	86
014	82	81	80	069/469	1519	1321	1399
015/415	29	24	28	070/470	362	278	324
016	23	23	21	071	327	309	310
017/417	17	12	16	072/472	848	837	826
018/418	16	14	16	074	121	109	77
020/420	20	19	20	079/479	28	19	3
021	26	26	26	081	56	55	55
022	28	28	28	082/482	85	79	81
023	140	139	137	083/483	44	36	39
024	821	792	798	084/484	61	58	58
026/260	224	196	214	085/485	62	61	61
027	33	31	33	086/486	85	84	83
028/428	122	114	42	087/487	17	15	14
029/429	6	1	5	088/488	23	18	22
030	128	119	123	089/489	11	2	10
031/431	18	14	16	091/491	533	464	518
032	81	78	80	092/492	429	371	395
033	39	39	39	380	354	0	52
034/434	889	880	849	426	296	0	204
035	31	30	28	427	41	0	35
036	199	199	199	430	228	0	211
037/437	58	54	57	4035	0	0	0
038	130	101	98	455	151	0	74
039	56	56	56	458	239	0	191
040	34	34	32	466	4	0	3
041	118	117	118	471	485	0	424
042	49	49	49	473	227	0	198
043/443	153	144	148	474	598	0	20
045	37	35	37	475	853	0	20
046	4	4	4	477	166	0	60
049	87	86	87	478	357	0	12
050	1	0	0	480	175	0	152
051/451	9	7	8	INS	136	134	56
				Sub-Total	14904	9538	11674
(2) Outside Municipality							
425	42	0	3	520	153	0	4
510	339	1	9	540	26	0	1
511	1	0	0				
				Sub-Total	561	1	17
				TOTAL	15465	9539	11691

(Data source : NMC)

C3. POTABLE WATER SUPPLY

C3.1 Public Water Supply Services

C3.1.1 Water Supply Area

The water supply is basically classified into two systems : WSD is responsible for the public water supply for the Town area, while MOLRRWD specifically serves the Lanet area.

The total area of the sections served with public water supply is 33.58 km^2, which corresponds to 48 % of the entire municipal area.

C3.1.2 Water Supply Facilities

WSD operates two water treatment works (Gilgil and Nakuru) and three borehole fields (Kabatini, Playing Field and Baharini). The Gilgil and Nakuru treatment works depend on the unregulated surface runoffs from the Murindati and Meroroni Rivers respectively and have nominal production capacities of 1,000 and 5,740 m^3/day respectively. Both treatment works are of conventional rapid sand filtration type. Of the present source supply of about 21,000 m^3/day, more than 75% is derived from the three borehole fields. The quantity of source supply has been subjected to a large fluctuation from time to time due to unstable runoffs in the rivers and breakdown of the borehole pumps.

The Lanet area is fed by both deep well and Lanet treatment works with a nominal production capacity of 1,050 m^3/day , which makes a full treatment of the surface runoff from the Meroroni River. Distribution network is under the jurisdiction of the military station. According to the production records during the period from April to November 1991, the production rate varied from 1,290 to 1,320 m^3/day, averaging 1,300 m^3/day, of which 260 m^3/day is supplied to the 3rd Kenya Rifles.

In 1991, the Greater Nakuru Water Supply Project, Eastern Division, Stage 1 was completed by NWCPC. This project is capable of supplying potable water amounting to 13,300 m^3/day to the municipality by a full treatment of the surface runoff from the Malewa River, but its actual operation has been suspended as a precaution until adequate measures are accomplished by GOK to prevent probable adverse effect on ecology of Lake Nakuru owing to increasing sewage resulting from the augmented water supply.

C3.1.3 Quantity of Supply

The amount of water supply is recorded at both water supply sources and at individual meters. The recorded source supply and metered water quantity are as shown in Table C-2 for a five-year period from 1988 to 1992. The records of the metered water quantity implicate twofold : the first is that there is a great amount of un-accounted for water, more than 50 %, and the other is that its accuracy appears questionable, especially in 1988 and 1989.

The quantity of the source water supply is 22,079 m^3/day on the average and on the basis of this figure, a daily water consumption per capita is estimated at 61 litters only, presuming that the entire present population of about 361,000 is wholly dependent on the public supply.

According to the statistic made available from WSD, proportions of domestic, industrial, commercial and institutional water consumptions are 57.0 %, 16.1%, 10.4 %, and 16.5 % respectively.

Table C-2 Public Water Supply (1/2)

(Unit : cu.m/day)

Year	Month	Source Supply	Metered Water Supply			Unaccounted for Water	
			Sewered Area	Unsewered Area	Total	Volume	Ratio
1988	Jan.	19,453	26,430	14,922	41,352	-21,899	-1.13
	Feb	19,947	29,148	15,951	45,099	-25,152	-1.26
	Mar.	21,235	27,449	14,924	42,373	-21,138	-1.00
	Apr.	21,905	32,906	15,444	48,350	-26,445	-1.21
	May	21,805	29,450	14,946	44,396	-22,591	-1.04
	June	22,898	28,212	15,423	43,635	-20,737	-0.91
	July	21,390	15,136	5,124	20,260	1,130	0.05
	Aug.	21,601	14,850	4,507	19,357	2,244	0.10
	Sep.	19,447	15,076	4,355	19,431	16	0.00
	Oct.	22,437	14,896	4,406	19,302	3,135	0.14
	Nov.	22,336	14,476	3,493	17,969	4,367	0.20
	Dec.	23,925	13,117	2,648	15,765	8,160	0.34
	Average	**21,532**	**21,762**	**9,679**	**31,441**	**-9,909**	**-0.46**
1989	Jan.	24,227	13,379	2,510	15,889	8,338	0.34
	Feb	23,571	15,216	3,575	18,791	4,780	0.20
	Mar.	23,471	13,792	3,128	16,920	6,551	0.28
	Apr.	26,372	16,040	5,153	21,193	5,179	0.20
	May	26,024	14,057	3,422	17,479	8,545	0.33
	June	26,276	15,118	4,397	19,515	6,761	0.26
	July	26,979	5,598	3,264	8,862	18,117	0.67
	Aug.	25,795	6,127	3,324	9,451	16,344	0.63
	Sep.	22,875	6,193	2,570	8,763	14,112	0.62
	Oct.	20,806	6,283	3,166	9,449	11,357	0.55
	Nov.	21,094	6,438	2,789	9,227	11,867	0.56
	Dec.	17,553	5,971	2,723	8,694	8,859	0.50
	Average	**23,754**	**10,351**	**3,335**	**13,686**	**10,068**	**0.42**
1990	Jan.	21,996	6,024	2,659	8,683	13,313	0.61
	Feb	24,708	6,483	2,877	9,360	15,348	0.62
	Mar.	22,994	6,127	2,756	8,883	14,111	0.61
	Apr.	22,884	6,612	3,306	9,918	12,966	0.57
	May	24,669	6,373	2,788	9,161	15,508	0.63
	June	20,982	6,763	3,239	10,002	10,980	0.52
	July	24,328	6,150	2,549	8,699	15,629	0.64
	Aug.	24,452	5,578	3,865	9,443	15,009	0.61
	Sep.	24,911	5,713	2,806	8,519	16,392	0.66
	Oct.	22,003	5,534	2,670	8,204	13,799	0.63
	Nov.	25,312	5,770	2,719	8,489	16,823	0.66
	Dec.	24,237	4,962	3,066	8,028	16,209	0.67
	Average	**23,623**	**6,007**	**2,942**	**8,949**	**14,674**	**0.62**

Table C-2 Public Water Supply (2/2)

(Unit : cu.m/day)

Year	Month	Source Supply	Metered Water Supply			Unaccounted for Water	
			Sewered Area	Unsewered Area	Total	Volume	Ratio
1991	Jan.	22,645	5,879	2,752	8,631	14,014	0.62
	Feb	23,550	6,575	3,551	10,126	13,424	0.57
	Mar.	27,170	6,662	2,825	9,487	17,683	0.65
	Apr.	26,952	7,406	3,469	10,875	16,077	0.60
	May	25,256	6,114	3,015	9,129	16,127	0.64
	June	25,498	6,862	2,823	9,685	15,813	0.62
	July	25,215	5,497	2,424	7,921	17,294	0.69
	Aug.	24,513	5,223	2,907	8,130	16,383	0.67
	Sep.	23,424	5,012	1,878	6,890	16,534	0.71
	Oct.	23,766	5,903	2,242	8,145	15,621	0.66
	Nov.	24,625	6,100	2,316	8,416	16,209	0.66
	Dec.	22,628	5,903	2,242	8,145	14,483	0.64
	Average	**24,604**	**6,095**	**2,704**	**8,798**	**15,805**	**0.64**
1992	Jan.	19,553	6,871	2,568	9,439	10,114	0.52
	Feb	23,727	7,345	3,232	10,577	13,150	0.55
	Mar.	22,618	6,118	3,201	9,319	13,299	0.59
	Apr.	23,824	5,976	3,423	9,399	14,425	0.61
	May	23,120	5,783	3,313	9,096	14,024	0.61
	June	20,909	6,025	3,010	9,035	11,874	0.57
	July	18,077	8,889	5,373	14,262	3,815	0.21
	Aug.	18,019	9,914	7,472	17,386	633	0.04
	Sep.	19,363	11,024	7,362	18,386	977	0.05
	Oct.	16,497	8,533	-	8,533	7,964	0.48
	Nov.	17,791	-	-	-	-	-
	Dec.	20,823	8,905	6,499	15,404	5,419	0.26
	Average	**20,360**	**7,762**	**4,132**	**11,894**	**8,699**	**0.43**
1993	Jan.	19,726	10,982	6,268	17,250	2,476	0.13
	Feb.	20,953	8,400	5,929	14,329	6,624	0.32
	Overall Average	**22,079**	**10,194**	**4,998**	**15,192**	**6,920**	**0.31**

(Data Source : WSD)

C3.2 Private Water Supply Facilities

According to NMC there are 8 deep wells in the Town area. These wells are mainly used for making up of and/or emergency source in case of failure of the public water supply. The quantity of water supply is reported as follows :

Table C-3 Private Deep Wells and Their Production

Owner of Well	Daily Production (m^3/day)
1. Bedi Investment	66
2. Eveready Battery Kenya *	Nil
3. Spin Knit	240
4. Flamingo Bottlers	180
5. Gohil Soap Factory	20
6. Menengai Soap	24
7. Nakuru Tanner	100
8. Valley Bakery	10
Total	630

* Capacity of 100 m^3/day for emergency supply

(Data source : NMC and JICA Study Team)

C4. WASTEWATER TREATMENT

C4.1 Public Sewerage Services

C4.1.1 Sewered Area and Sewer Connection Ratio

There are two sewage treatment works, Njoro and Town STWs at present in the project area. The existing sewer network covers mainly a central part of the Town area as shown in Fig. C-2 and is divided into Njoro, Town and Central Sewerage Districts. Njoro STW receives sewage from the entire area of Njoro SD and portion of Central SD, while Town STW receives sewage from the entire area of Town SD and remaining area of Central SD.

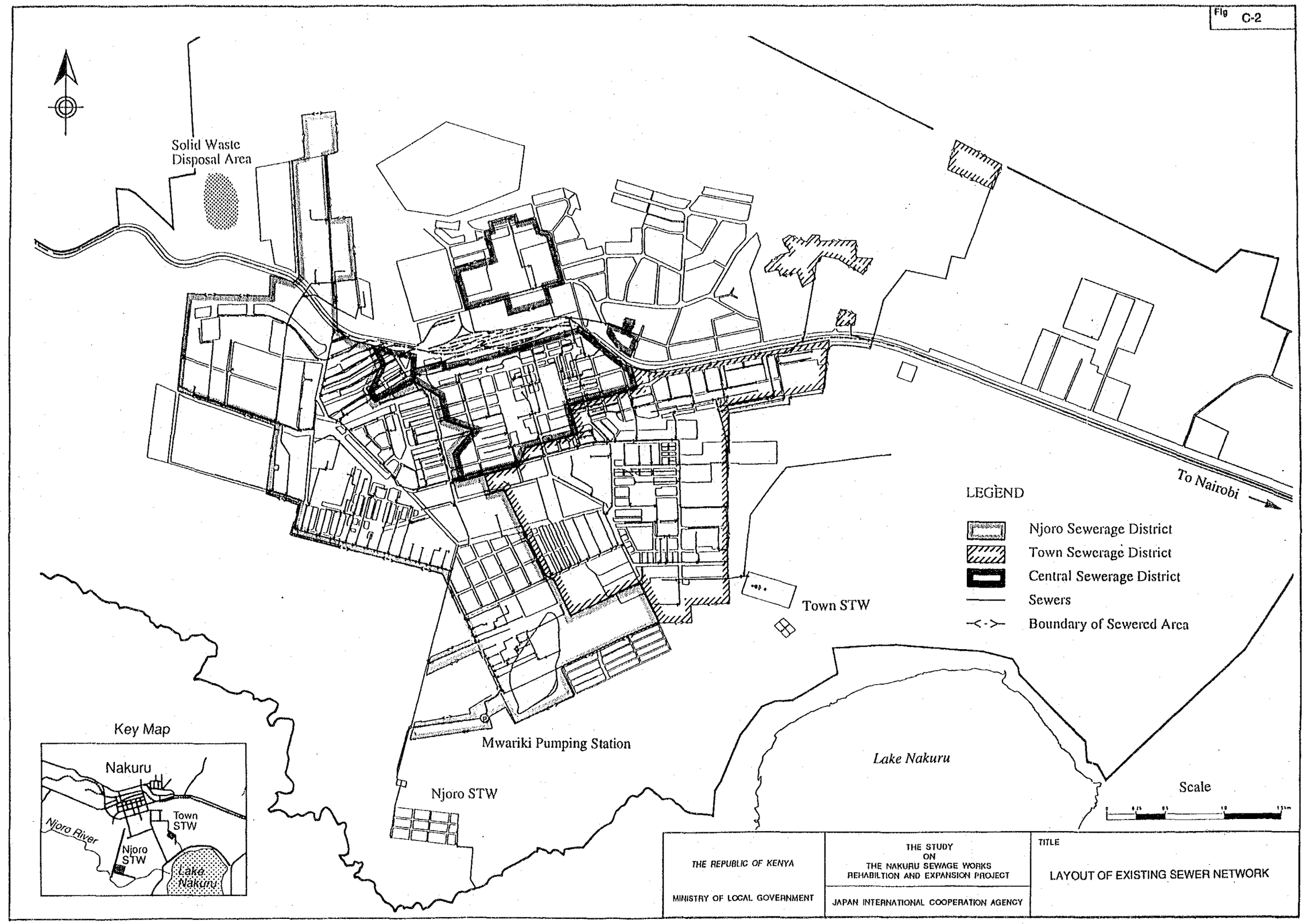
The existing sewered area and sewerage connection ratio are assessed for the Town and Lanet areas separately.

(1) Town area

The existing sewer network covers an area of 12.92 km^2 in total, including Section 471 with area of 0.07 km^2, which is left unconnected to the sewers although the existing sewers run nearby. Therefore a net sewered area is 12.85 km^2, composing of 6.33 km^2 of Njoro SD, 4.19 km^2 of Town SD and 2.33 km^2 of Central SD.

Table C-4 shows the numbers of the water and sewerage served registrants in the areas of Njoro, Town and Central SDs respectively. On the basis of the numbers of the registrants for the water supply and sewerage services, sewer connection ratio for the entire sewered area is computed as given in Table C-5.

Fig C-2



THE REPUBLIC OF KENYA MINISTRY OF LOCAL GOVERNMENT	THE STUDY ON THE NAKURU SEWAGE WORKS REHABILITION AND EXPANSION PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE LAYOUT OF EXISTING SEWER NETWORK

Table C-4 Numbers of Water Supply and Sewerage Registrants (1/2)

Section No.	Njoro Sewerage District				Town Sewerage District				Central Sewerage District				Total			
	Area (ha)	Water Served Regis-trants (nos.)	Sewer Served Regis-trants (nos.)	Non-sewer Served Regis-trants (nos.)	Area (ha)	Water Served Regis-trants (nos.)	Sewer Served Regis-trants (nos.)	Non-sewer Served Regis-trants (nos.)	Area (ha)	Water Served Regis-trants (nos.)	Sewer Served Regis-trants (nos.)	Non-sewer Served Regis-trants (nos.)	Area (ha)	Water Served Regis-trants (nos.)	Sewer Served Regis-trants (nos.)	Non-sewer Served Regis-trants (nos.)
1. Sewer Served Area																
01	0.0	0	0	0	0.0	0	0	0	2.4	72	71	1	2.4	72	71	1
02	0.0	0	0	0	0.0	0	0	0	2.8	71	71	0	2.8	71	71	0
03/403	0.0	0	0	0	0.0	0	0	0	5.4	594	123	471	5.4	594	123	471
04	0.0	0	0	0	0.0	0	0	0	3.6	36	36	0	3.6	36	36	0
5	0.0	0	0	0	0.0	0	0	0	3.7	0	0	0	3.7	0	0	0
06	0.0	0	0	0	0.0	0	0	0	6.4	82	82	0	6.4	82	82	0
07/407	0.0	0	0	0	0.0	0	0	0	9.6	84	80	4	9.6	84	80	4
010/410	0.0	0	0	0	0.0	0	0	0	4.2	19	13	6	4.2	19	13	6
011/410	0.0	0	0	0	0.0	0	0	0	2.2	12	10	2	2.2	12	10	2
012	0.0	0	0	0	0.0	0	0	0	4.2	23	22	1	4.2	23	22	1
013	0.0	0	0	0	0.0	0	0	0	3.9	70	68	2	3.9	70	68	2
014	0.0	0	0	0	0.0	0	0	0	8.5	82	81	1	8.5	82	81	1
015/415	0.8	3	2	1	0.0	0	0	0	3.0	26	22	4	3.8	29	24	5
016	0.8	7	7	0	0.0	0	0	0	1.2	16	16	0	2.0	23	23	0
017/417	2.3	8	6	2	0.0	0	0	0	1.5	9	6	3	3.8	17	12	5
018/418	3.9	8	7	1	0.0	0	0	0	2.6	8	7	1	6.5	16	14	2
020/420	3.6	20	19	1	0.0	0	0	0	0.0	0	0	0	3.6	20	19	1
021	1.6	26	26	0	0.0	0	0	0	0.0	0	0	0	1.6	26	26	0
022	4.9	28	28	0	0.0	0	0	0	0.0	0	0	0	4.9	28	28	0
023	14.9	140	139	1	0.0	0	0	0	0.0	0	0	0	14.9	140	139	1
024	53.3	821	792	29	0.0	0	0	0	0.0	0	0	0	53.3	821	792	29
026/260	47.8	224	196	28	0.0	0	0	0	0.0	0	0	0	47.8	224	196	28
027	0.0	0	0	0	0.0	0	0	0	45.8	33	31	2	45.8	33	31	2
028/428	0.0	0	0	0	63.9	122	114	8	0.0	0	0	0	63.9	122	114	8
030	133.9	128	119	9	0.0	0	0	0	0.0	0	0	0	133.9	128	119	9
031/431	0.0	0	0	0	0.0	6	5	1	22.0	12	9	3	22.0	18	14	4
032	0.0	0	0	0	18.5	81	78	3	0.0	0	0	0	18.5	81	78	3
033	0.0	0	0	0	19.4	39	39	0	0.0	0	0	0	19.4	39	39	0
034/434	23.6	249	247	2	70.3	640	633	7	0.0	0	0	0	93.9	889	880	9
035	0.0	0	0	0	0.0	0	0	0	5.4	31	30	1	5.4	31	30	1
036	0.0	0	0	0	0.0	0	0	0	14.1	199	199	0	14.1	199	199	0
037/437	0.0	0	0	0	0.0	0	0	0	3.8	58	54	4	3.8	58	54	4
038	0.0	0	0	0	20.4	130	101	29	0.0	0	0	0	20.4	130	101	29
039	0.0	0	0	0	3.2	56	56	0	0.0	0	0	0	3.2	56	56	0
040	0.0	0	0	0	1.6	34	34	0	0.0	0	0	0	1.6	34	34	0
041	0.0	0	0	0	4.7	118	117	1	0.0	0	0	0	4.7	118	117	1
042	0.0	0	0	0	2.5	34	34	0	1.0	15	15	0	3.5	49	49	0
043/443	0.0	0	0	0	33.7	153	144	9	0.0	0	0	0	33.7	153	144	9
045	0.0	0	0	0	18.2	37	35	2	0.0	0	0	0	18.2	37	35	2
046	0.0	0	0	0	0.0	0	0	0	2.9	4	4	0	2.9	4	4	0
049	0.0	0	0	0	0.0	0	0	0	4.2	87	86	1	4.2	87	86	1
050	0.0	0	0	0	14.0	1	0	1	0.0	0	0	0	14.0	1	0	1
051/451	41.0	6	5	1	19.2	3	2	1	0.0	0	0	0	60.2	9	7	2
052	63.8	3	3	0	0.0	0	0	0	0.0	0	0	0	63.8	3	3	0
054	7.8	125	123	2	0.0	0	0	0	0.0	0	0	0	7.8	125	123	2
055	18.8	193	180	13	0.0	0	0	0	0.0	0	0	0	18.8	193	180	13
056	0.0	0	0	0	0.0	0	0	0	2.8	47	47	0	2.8	47	47	0
058	0.0	0	0	0	65.9	611	600	11	0.0	0	0	0	65.9	611	600	11
065/465	0.0	0	0	0	20.8	124	117	7	0.0	0	0	0	20.8	124	117	7
066	4.7	2	2	0	0.0	0	0	0	0.0	0	0	0	4.7	2	2	0
067	0.0	0	0	0	2.0	5	5	0	0.5	1	1	0	2.5	6	6	0
068/468	19.1	86	81	5	0.0	0	0	0	0.0	0	0	0	19.1	86	81	5
069/458	63.6	1,519	1,321	198	0.0	0	0	0	0.0	0	0	0	63.6	1,519	1,321	198
070/470	34.3	362	278	84	0.0	0	0	0	0.0	0	0	0	34.3	362	278	84

Table C-4 Numbers of Water Supply and Sewerage Registrants (2/2)

Section No.	Njoro Sewerage District				Town Sewerage District				Central Sewerage District				Total			
	Area (ha)	Water Served Registrants (nos.)	Sewer Served Registrants (nos.)	Non-sewer Served Registrants (nos.)	Area (ha)	Water Served Registrants (nos.)	Sewer Served Registrants (nos.)	Non-sewer Served Registrants (nos.)	Area (ha)	Water Served Registrants (nos.)	Sewer Served Registrants (nos.)	Non-sewer Served Registrants (nos.)	Area (ha)	Water Served Registrants (nos.)	Sewer Served Registrants (nos.)	Non-sewer Served Registrants (nos.)
071	9.9	327	309	18	0.0	0	0	0	0.0	0	0	0	9.9	327	309	18
072/472	19.8	509	502	7	13.2	339	335	4	0.0	0	0	0	33.0	848	837	11
074	21.6	121	109	12	0.0	0	0	0	0.0	0	0	0	21.6	121	109	12
079/479	0.0	0	0	0	0.0	0	0	0	65.6	28	19	9	65.6	28	19	9
081	0.0	0	0	0	1.7	56	55	1	0.0	0	0	0	1.7	56	55	1
082/482	0.0	0	0	0	1.8	85	79	6	0.0	0	0	0	1.8	85	79	6
083/483	0.0	0	0	0	1.3	44	36	8	0.0	0	0	0	1.3	44	36	8
084/484	0.0	0	0	0	1.4	61	58	3	0.0	0	0	0	1.4	61	58	3
085/485	0.0	0	0	0	1.6	62	61	1	0.0	0	0	0	1.6	62	61	1
086/486	0.0	0	0	0	1.7	85	84	1	0.0	0	0	0	1.7	85	84	1
087/487	0.0	0	0	0	0.8	17	15	2	0.0	0	0	0	0.8	17	15	2
088/488	1.0	23	18	5	0.0	0	0	0	0.0	0	0	0	1.0	23	18	5
089/489	1.2	11	2	9	0.0	0	0	0	0.0	0	0	0	1.2	11	2	9
091/491	11.5	275	240	35	12.6	258	224	34	0.0	0	0	0	24.1	533	464	69
092/492	22.9	365	316	49	4.6	64	55	9	0.0	0	0	0	27.5	429	371	58
471	7.3	485	0	485	0.0	0	0	0	0.0	0	0	0	7.3	485	0	485
INS	0.0	39	38	1	0.0	49	48	1	0.0	48	48	0	0.0	136	134	2
Sub-Total	639.7	6,113	5,115	998	419.0	3,314	3,164	150	233.3	1,767	1,251	516	1292.0	11,194	9,530	1,664
2. Un-sewered Area																
380	-	-	-	-	-	-	-	-	-	-	-	-	403.0	354	0	354
426	-	-	-	-	-	-	-	-	-	-	-	-	27.0	296	0	296
427	-	-	-	-	-	-	-	-	-	-	-	-	24.3	41	0	41
029/429	-	-	-	-	-	-	-	-	-	-	-	-	75.0	6	1	5
430	-	-	-	-	-	-	-	-	-	-	-	-	20.5	228	0	228
4035	-	-	-	-	-	-	-	-	-	-	-	-	240.9	0	0	0
053/453	-	-	-	-	-	-	-	-	-	-	-	-	25.6	11	5	6
455	-	-	-	-	-	-	-	-	-	-	-	-	50.3	151	0	151
458	-	-	-	-	-	-	-	-	-	-	-	-	21.7	239	0	239
063/463	-	-	-	-	-	-	-	-	-	-	-	-	121.4	4	2	2
466	-	-	-	-	-	-	-	-	-	-	-	-	34.5	4	0	4
473	-	-	-	-	-	-	-	-	-	-	-	-	23.8	227	0	227
474	-	-	-	-	-	-	-	-	-	-	-	-	75.6	598	0	598
45	-	-	-	-	-	-	-	-	-	-	-	-	598.0	853	0	853
477	-	-	-	-	-	-	-	-	-	-	-	-	36.0	166	0	166
478	-	-	-	-	-	-	-	-	-	-	-	-	67.5	357	0	357
480	-	-	-	-	-	-	-	-	-	-	-	-	221.0	175	0	175
Sub-Total	-	-	-	-	-	-	-	-	-	-	-	-	2066.1	3,710	8	3,702
TOTAL	639.7	6,113	5,115	998	419.0	3,314	3,164	150	233.3	1,767	1,251	516	3358.1	14,904	9,538	5,366

Note: (1) Sec. 425, 510, 511, 520 and 540 are all outside the municipal area.
(2) Accordingly total number of registrants for water supply and sewerage services are 14,904 and 9,538 respectively.
(3) INS: Institutions

(Data source NMC)