4.1.2 Rehabilitation Works Component

The improvement works proposed for the Phase I Project are classified into two components, i.e. rehabilitation and expansion, given the nature of the works involved.

Works included in the rehabilitation component are summarized as follows:

(1) Works Related to Rehabilitation of Kajulu WTW

- Rehabilitation of the existing Kibos river intake for the Kajulu WTW which includes an expansion of the intake capacity from the existing 1,500 m3/day to 3,000 m3/day.
- Rehabilitation of the existing Kajulu WTW which includes an expansion of the treatment capacity from the existing 1,400 m3/day to 2,800 m3/day.
- Construction of a treated water transmission main (steel) 200 mm in diameter and 3.6 km in length from the Kajulu WTW to the Kajulu Distribution Reservoir.
- Construction of a 700 m3 distribution reservoir at Kajulu.

(2) Works Related to Rehabilitation of Lake WTW

- Rehabilitation of the existing Lake Intake Station for the Lake WTW which includes an expansion of the intake capacity from the existing 19,000 m3/day to 27,000 m3/day.
- Construction of a new raw water transmission main (steel) 450 mm in diameter and 1.2 km in length from the Lake Intake Station to the Lake WTW.
- Rehabilitation of the existing Lake WTW which includes an expansion of the treatment capacity from the existing 16,600 m3/day to 25,000 m3/day.
- Construction of a treated water transmission main (steel) 550 mm in diameter and 5.2 km in length from the Lake WTW to the Kibuye Distribution Reservoir.

4.1.3 Expansion Works Component

Works included in the expansion component are listed below.

- Construction of a new water intake with an ultimate intake capacity of 14,000 m3/day on the Awach river.

- Construction of a new water intake with an ultimate intake capacity of 71,000 m3/day on the Kibos river.

- Construction of new raw water transmission mains (steel) 400 to 900 mm in diameter and 18.8 km in total length from the new Awach and Kibos water intakes to the Kibuye WTW, including construction of a junction well.

- Construction of a new water treatment works with a treatment capacity of 40,000 m3/day at Kibuye (Kibuye WTW).

- Construction of a new 27,000 m3 distribution reservoir at Kibuye (Kibuye Distribution Reservoir) which will increase the total reservoir capacity at the location from the existing 6,300 m3 to 33,300 m3.

- Construction of a new treated water transmission main (steel) 350 mm in diameter and 4.2 km in length from the Kibuye Distribution Reservoir to the Kanyakwar Distribution Reservoir.

- Construction of a new 5,000 m3 distribution reservoir at Kanyakwar (Kanyakwar Distribution Reservoir).

- Construction of a new treated water transmission main (steel) 400 mm in diameter and 6.2 km in length from the Kibuye Distribution Reservoir to the Kogony Distribution Reservoir.

- Construction of a new 3,500 m3 distribution reservoir at Kogony (Kogony Distribution Reservoir).
- Construction of wastewater disposal facilities in Nyalenda which consist of 4 lagoons (each 1,000 m2 in surface area and 2 m in depth) and a sludge drying area of 5,000 m2, including construction of a new wastewater disposal main (PVC) 200 mm in diameter and 4.0 km in length from the Kibuye WTW to the lagoons.

- Construction of trunk distribution mains, comprising (a) PVC mains 160 to 315 mm in diameter and 23.9 km in total length and (b) SP mains 350 to 800 mm in diameter and 25.5 km in total length.

- Construction of secondary distribution mains (PVC) 63 to 100 mm in diameter and 330 km in total length.

4.1.4 Preliminary Designs of Major Infrastructure

Preliminary designs of major water supply infrastructure such as reservoir, pump station and pipework have been prepared by the Study Team and they are presented in Appendix G. These preliminary designs have been prepared on the basis of information made available to the Study Team through surveys and investigations in Kisumu and are only intended to indicate general features of the infrastructure included in the proposed water supply plan. Designs meeting more site-specific requirements will be prepared during the detailed design stage.

4.2 WATER SOURCES

4.2.1 Availability of Raw Water from Kibos and Awach Rivers

In the Master Plan, various available water sources were evaluated by the Study Team through the review of previous studies. As a result, the Study Team selected Kibos River, Awach/Nyangori Rivers (hereinafter referred to as the "Awach River") and Lake Victoria as the most preferable water sources for the priority project. Hydrological analyses based on raw hydrological data are conducted in this section to further confirm the availability of raw water from the Kibos and Awach rivers.

(1) General River Condition

a. Catchment

The Kibos river has a catchment area of 117 km2 at the gauging station 1HA04 where the existing Kajulu Intake Weir is located. The river runs from northeast to southwest from EL 1,940 m at the Kobujoi market to EL 1,273 m at Kajulu through a vacant area where houses exist only along the roads that pass through the watershed. At present, the Kibos catchment is almost entirely covered by forests, grasslands or pasturelands, and cultivated land can be seen only in the upstream of Kajulu. The Kibos river runs down the Nyando Escarpment towards the south until it meets the Awach river. After joining the Awach river, it goes into swampy alluvial plain near Lake Victoria, cutting a deep and altering channel.

The Awach river is the biggest tributary of the Kibos. It has a catchment area of 108 km2 at the gauging station 1HA14 and runs from EL 1,700 m (Kapsotik) in the north to EL 1,180 m at the confluence of the Kibos river. Kisumu Water Supply and Sanitation Study (1988, MOLA) (hereinafter referred to as the "1988 Study") stated that the Awach River runs through a densely populated area and there are dangers of pollution. However, site reconnaissance surveys of the watershed conducted by the Study Team in February 1998 confirmed that the river actually runs through almost a vacant land where only a very small number of houses are located mainly along the roads that pass through the watershed, and that the catchment area is therefore well qualified as being a good water source in terms of water quality.

Kibos and Awach catchments are shown in Figure 4-5.

b. Intake Site

On the Kibos River, it is proposed that the existing Kajulu intake located at an elevation of 1,273 m be used as the intake for the Phase I Project, as the elevation allows the river water to gravitate to the Kibuye WTW over a long distance of around 11 km.

On the Awach River, the 1988 Study previously identified a possible intake site at an elevation of about 1,300 m. The Study Team carried out site reconnaissance surveys along the Awach River in February 1998. These surveys indicated that the intake site proposed by the 1988 Study is difficult to approach and to construct raw water transmission mains, as there are no existing roads leading to the site. Given the situation, the Study Team selected a new location at an elevation of 1,255 m. The proposed site is located at about 100 m downstream of the abandoned weir constructed by MOWR; around 11 km away from the Kibuye WTW; and has a catchment area of approximately 82 km2.

Geomorphologically, the proposed intake sites for both rivers are located at the top of an alluvial fan.

Figure 4-5

THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL **AUTHORITIES** KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Catchment of Kibos and Awach Rivers

(2) Reliability of Discharge Rating Curve

The objective gauging stations under operation on both rivers are listed in Table 4-3.

Table 4-3 Objective Water Level Gauging Stations

MOWR Station Code	River	Latitude	Longitude	Elevation (EL m)	Catchment Area (km2)	Observation Type	Observation Period	
							Open	Close
1HA04	Kibos	00:00:10S	34:48:15	1,273	117	S (feet), W	1929	-
1HA14	Awach	00:02:50S	34:48:15	1,180	108	S (metric)	1961	-

Notes: S = Staff Gauge, W = Weir

The hydrological data such as 1)daily water levels, 2) discharge measurement records and 3) discharge rating equations at both stations were collected from the database system in the headquarters of MOWR in Nairobi and the Provincial Water Engineer's Office, MOWR in Kisumu. The water level data after 1994 are excluded from the analysis, since the reliability of available data appears to be low and the water level data at the station 1HA04 after 1995 is not available.

In order to examine the existing conditions of these stations, the Study Team carried out field reconnaissance surveys during the period from 9 to 13 February 1998, which normally is the midst of dry season. As part of these surveys, measurement of discharges at both stations was conducted by the Study Team in collaboration with the Provincial Water Engineer's Office, MOWR to examine the reliability of rating equations under a very low flow condition. However, due to the abnormal weather conditions that persisted for a long time with frequent heavy rains, measurement was unsuccessful. The observed water level at 1HA04 was 0.48 m (4.36 m3/s), while that at 1HA14 was 0.37 m (1.15 m3/s) on 12 February.

The discharge measurement data collected for both stations are plotted together with discharge rating curves as shown in Figure 4-6. The gauging station 1HA04 is located at the existing Kajulu intake weir and the rigid weir section provides an ideal condition for the measurement. The width of the weir is 9.90 m. The regular discharge measurements for 1HA04 have been done at a river section downstream the weir, although the water level has been read at the weir. Four (4) different equations have been prepared for this station, despite the relatively rigid river section around the station. The last staff gauge at the station was washed away before 1971. It is assessed by the Study Team that the rating equations established by MOWR for both stations are most reliable given the range of discharges in question and the range supplemented by weir formulae.

(3) General Flow Conditions

The daily mean flows of the Kibos and Awach Rivers during the period 1974-1993 are shown in Figure 4-7. The average daily flows of both rivers during the same period are shown in Figure 4-8. As can be seen in Figure 4-8, drought generally appears on both rivers at the end of December and lasts until mid February with the minimum flow at the end of January.

Since both Kibos and Awach catchments are relatively small in their extents and are in close proximity to each other, the hydrographs of both catchment areas show a similar flow pattern as demonstrated in Figure 4-8. In fact, the annual runoff volumes of both rivers indicate a linear relationship as shown in Figure 4-9. The total runoff volume of the Awach River is about 60 % of the Kibos River.

(4) River Maintenance Flow

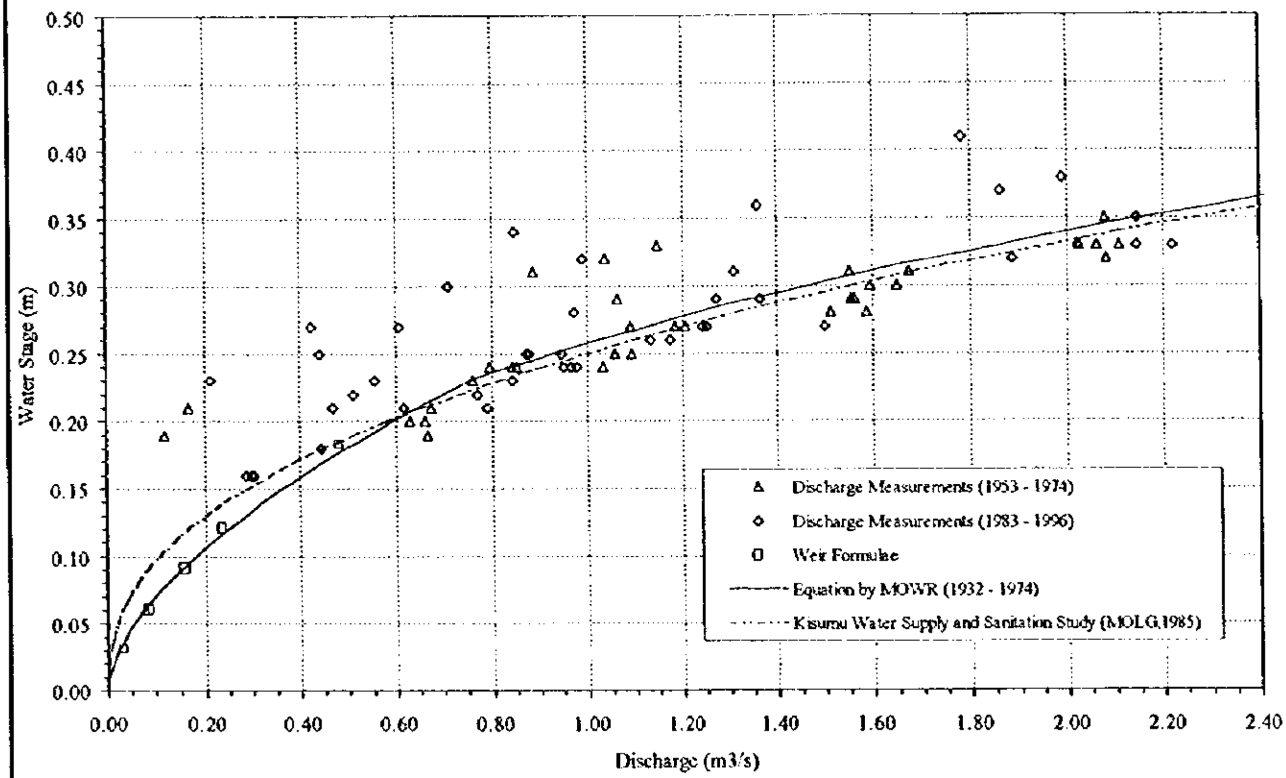
The minimum required flow in perennial rivers is not mentioned in "Design Manual for Water Supply in Kenya" (MOWR, 1986) (hereinafter referred to as the "Manual"). However, it is necessary to maintain a certain amount of water for conservation of the natural riverine environments as recommended by "The Study on the National Water Master Plan" (MOWR, 1992) (hereinafter referred to as "NWMP"). In this Study, the river maintenance flow is assumed to be equal to the Recorded Minimum Daily Flow which is recommended by NWMP.

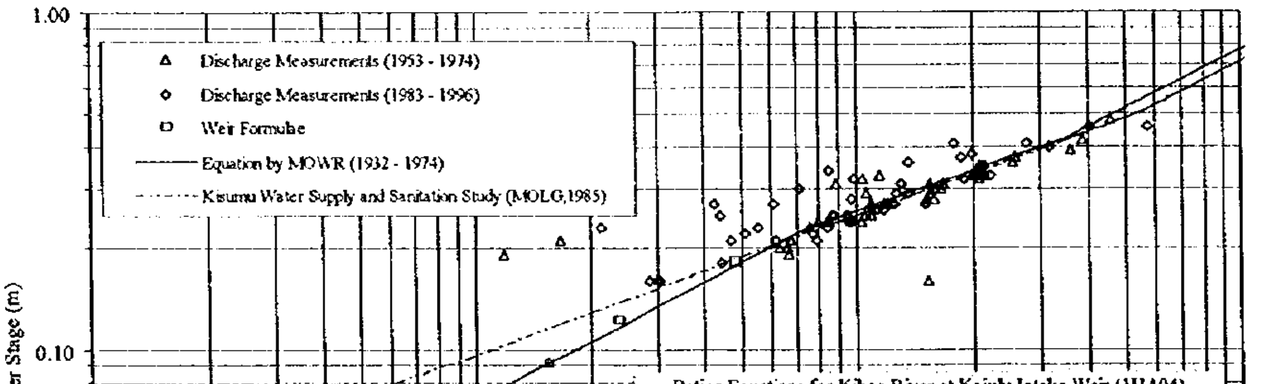
Table 4-4 shows the minimum daily flows recorded at the two gauging stations. The minimum daily flow of 0.07 m3/d recorded at the gauging station 1HA04 is adopted by the Study Team as the maintenance flow for the Kibos River. Although theoretically the minimum daily flow for the Awach River falls somewhat lower at the proposed intake site than it is at the gauging station 1HA14, the Study Team adopted the minimum daily flow of 0.04 m3/d recorded at the station as the maintenance flow for the Awach River.

Table 4-4 River Maintenance Flows

River	Objective Gauging Station			Proposed Intake Site		
	(m3/s)	(m3/d)	Area(km2)	(m3/s)	(m3/d)	Area (km2)
Kibos	0.07	6,100	117 (1HA04)	0.07	6,100	117
Awach	0.04	3,500	108 (1HA14)	0.03	2,600	82

Figure 4-6 (1/2)





Rating Equations for Kibos River at Kajulu Intake Weir (1HA04)

Period		Boundary		Coefficients			Agency
from	to	Lower	Upper	A	B	C	
		(m)		Q=C*(H+A)**B m³/s			
1-Dec-32	31-Dec-74	0.00	0.23	0.0000	1.7202	9.4632	MOWR
		0.23	0.43	0.0000	2.5151	30.2639	
		0.43	-	0.0000	1.7361	15.5885	
		0.10	0.50	0.0000	2.4362	29.169	***
		0.50	-	0.0000	1.73	17.880	

***: This Equation has been adopted in "Kisumu Water Supply and Sanitation Study" (MOLG, 1985).

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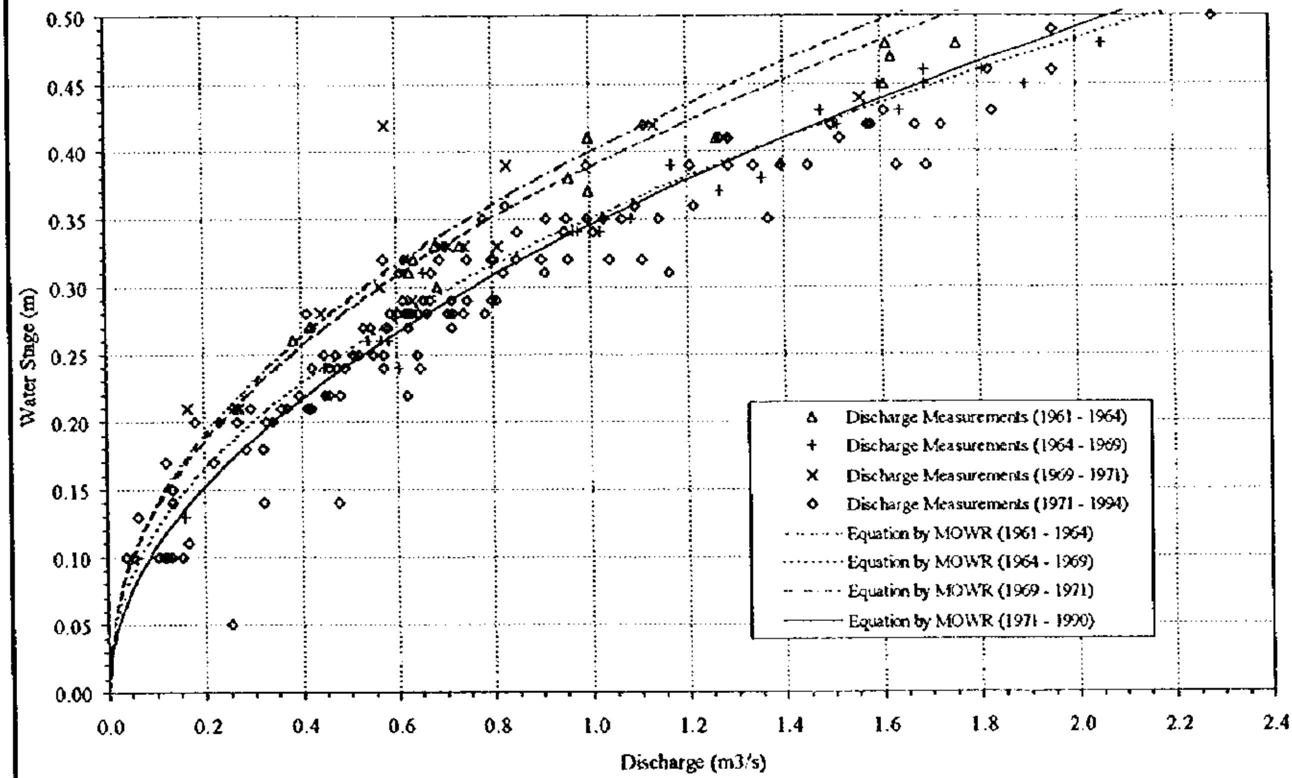
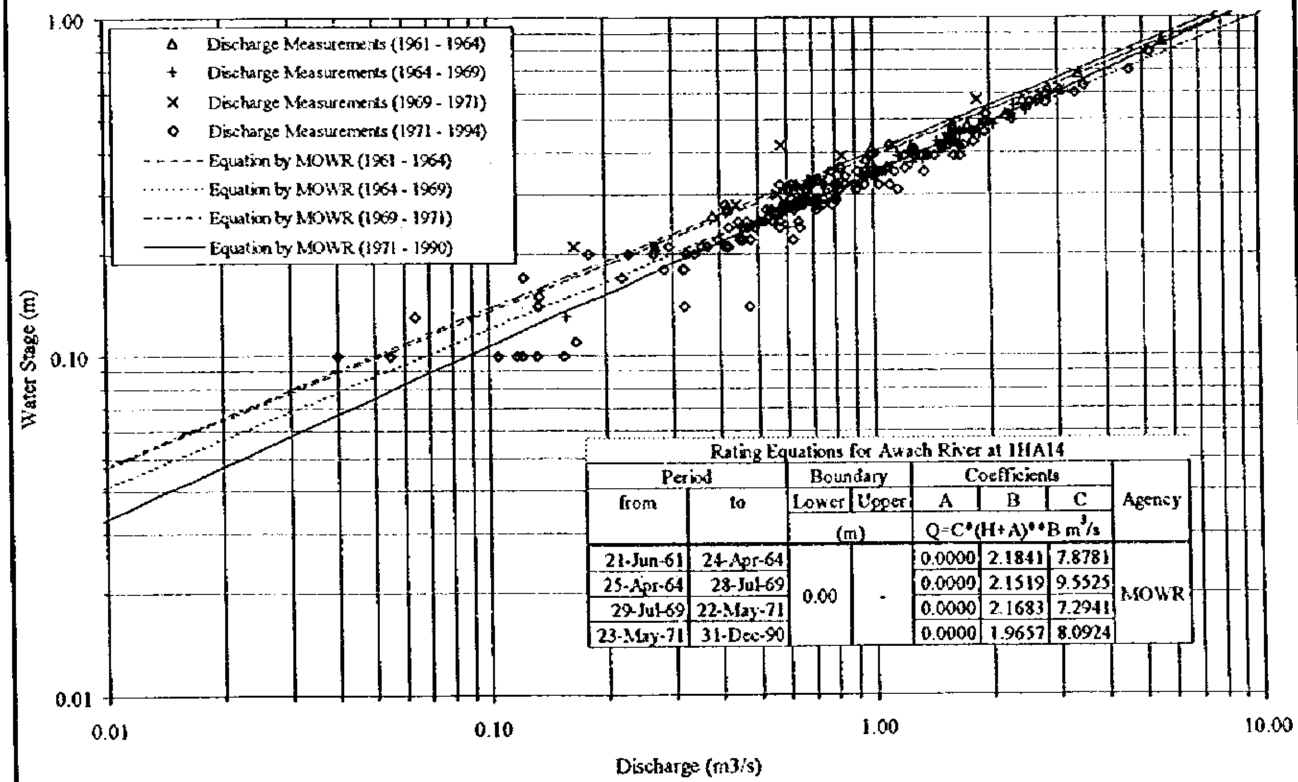
Figure 4-6 (2/2)





Rating Equations for Awach River at 1HA14

Period from	Period to	Boundary Lower (m)	Boundary Upper (m)	Coefficients A	Coefficients B	Coefficients C	Agency
				$Q=C*(H+A)**B$ m^3/s			
21-Jun-61	24-Apr-64	0.00	-	0.0000	2.1841	7.8781	MOWR
25-Apr-64	28-Jul-69			0.0000	2.1519	9.5525	
29-Jul-69	22-May-71			0.0000	2.1683	7.2941	
23-May-71	31-Dec-90			0.0000	1.9657	8.0924	

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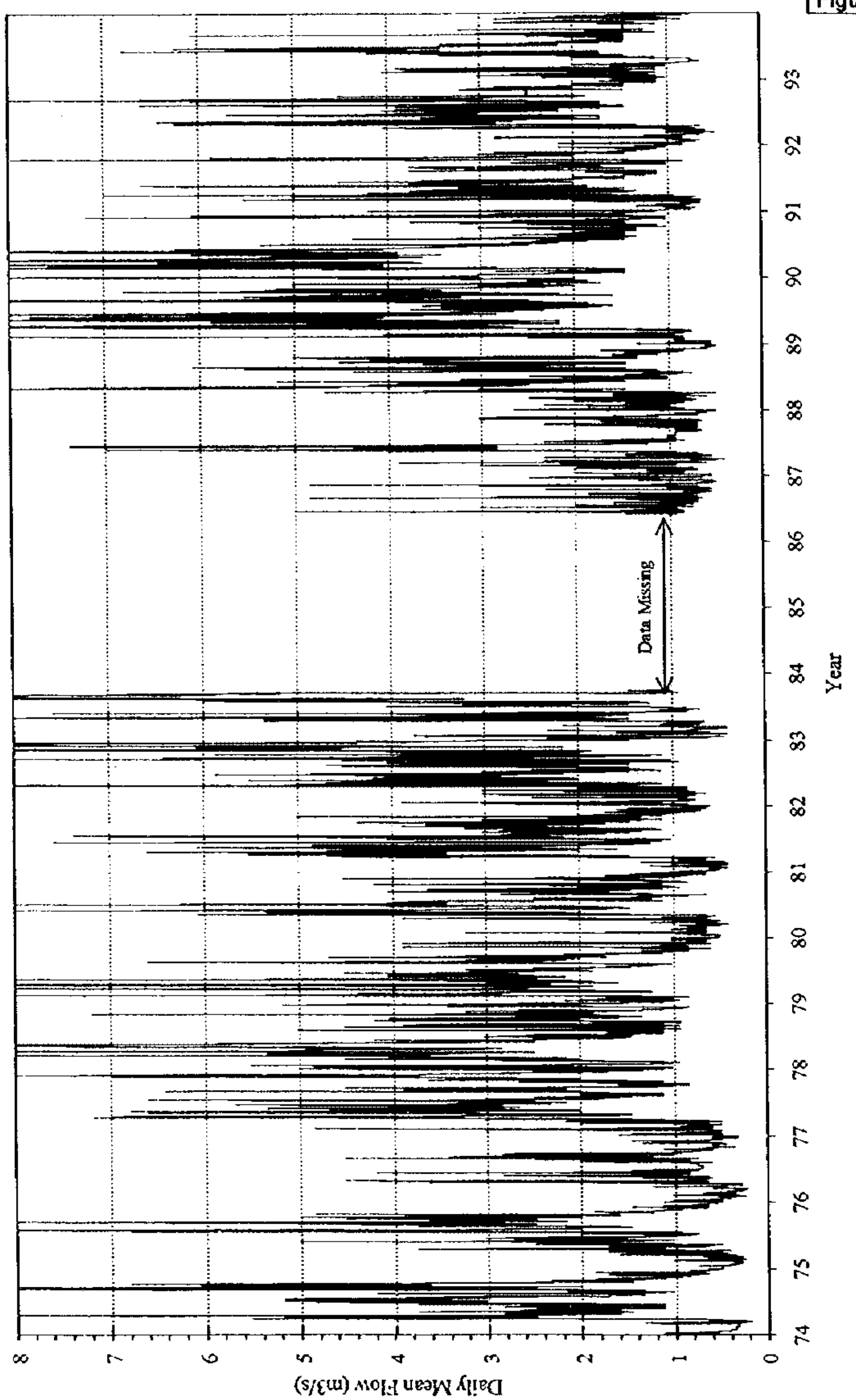
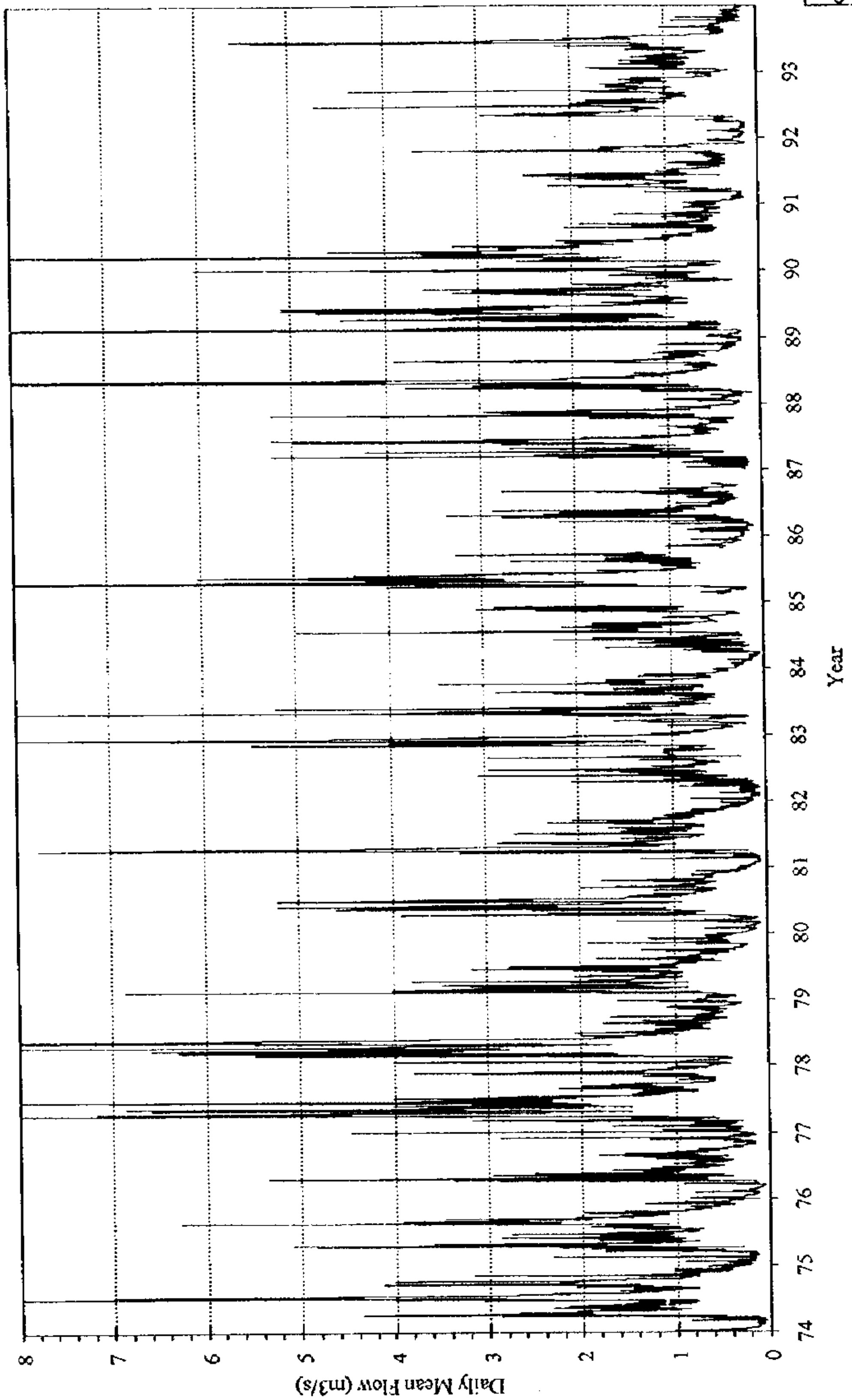
Figure 4-7 (1/2)



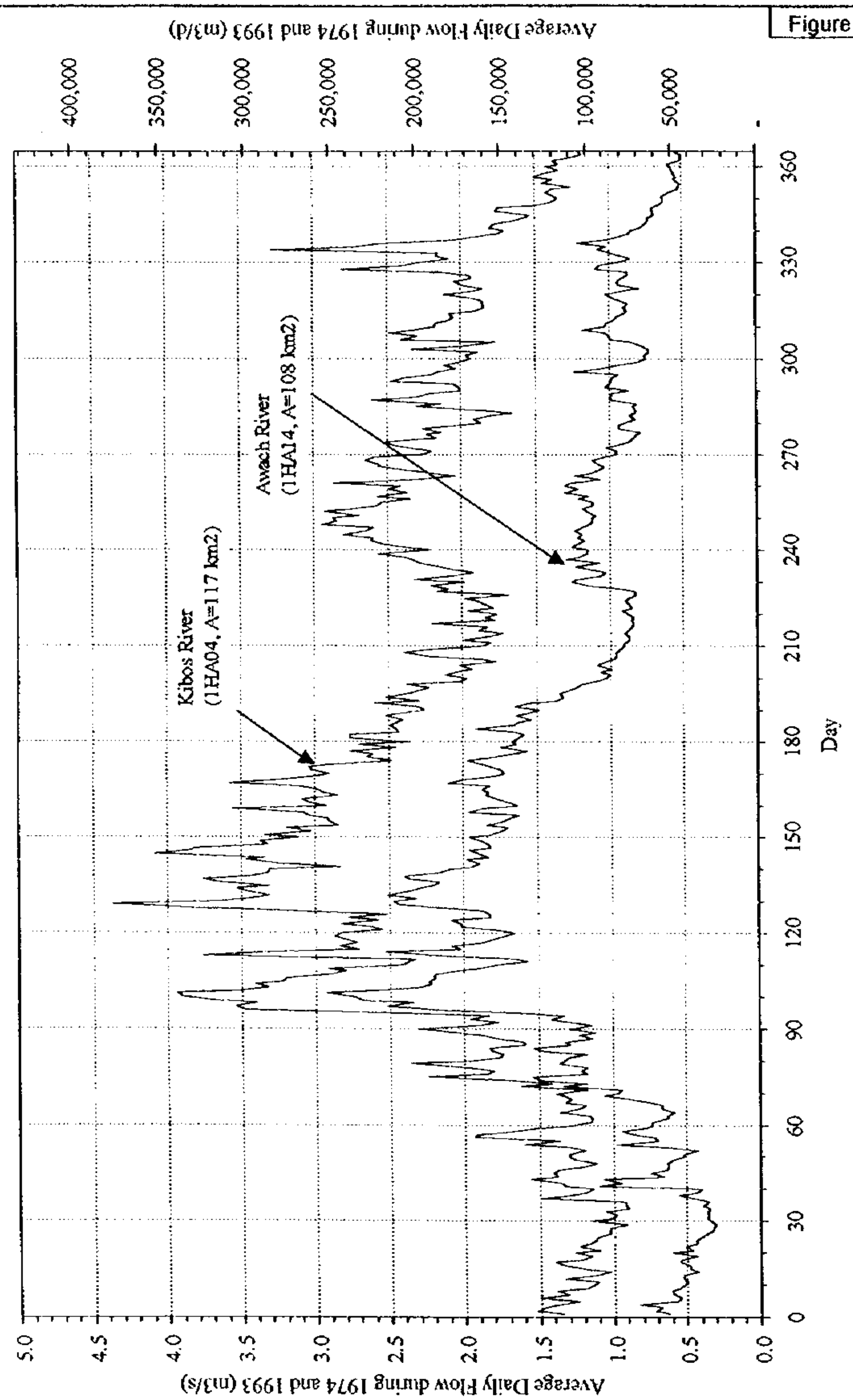
THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Daily Mean Flow (Kibos River at 1HA04)

Figure 4-7 (2/2)



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Daily Mean Flow (Awach River at 1HA14)

Figure 4-8



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Average Daily Flows of Kibos and Awach Rivers (1974 - 1993)

Figure 4-9

Annual Runoff Volume of Kibos and Awach Rivers

River	Kibos River			Awach River		
Gauging Station	1HA04 (A=117 km²)			1HA14 (A=108 km²)		
Year	Annual Mean (m^3/s)	Runoff Volume Annual (mil m^3)	Runoff Volume Accumulative (mil m^3)	Annual Mean (m^3/s)	Runoff Volume Annual (mil m^3)	Runoff Volume Accumulative (mil m^3)
1974	2.08	65.6	65.6	1.35	42.6	42.6
1975	1.66	52.3	117.9	1.22	38.5	81.1
1976	0.88	27.8	145.7	0.59	18.6	99.7
1977	2.44	76.9	222.6	1.82	57.4	157.1
1978	2.92	92.1	314.7	1.79	56.4	213.5
1979	2.35	74.1	388.8	1.08	34.1	247.6
1980	1.78	56.1	444.9	1.05	33.1	280.7
1981	1.99	62.8	507.7	1.02	32.2	312.9
1982	2.87	90.5	598.2	1.14	36.0	348.9
1987	1.34	42.3	640.5	1.03	32.5	381.4
1988	1.91	60.2	700.7	1.10	34.7	416.1
1989	3.12	98.4	799.1	1.48	46.7	462.8
1990	3.19	100.6	899.7	1.42	44.8	507.6
1991	2.01	63.4	963.1	0.80	25.2	532.8
1992	2.24	70.6	1,033.7	0.99	31.2	564.0
1993	1.84	58.0	1,091.7	0.88	27.8	591.8
Average	2.16	68.2		1.17	37.0	

note: Data from 1983 to 1986 are excluded because of the data missing and imcompleteness of 1HA04.

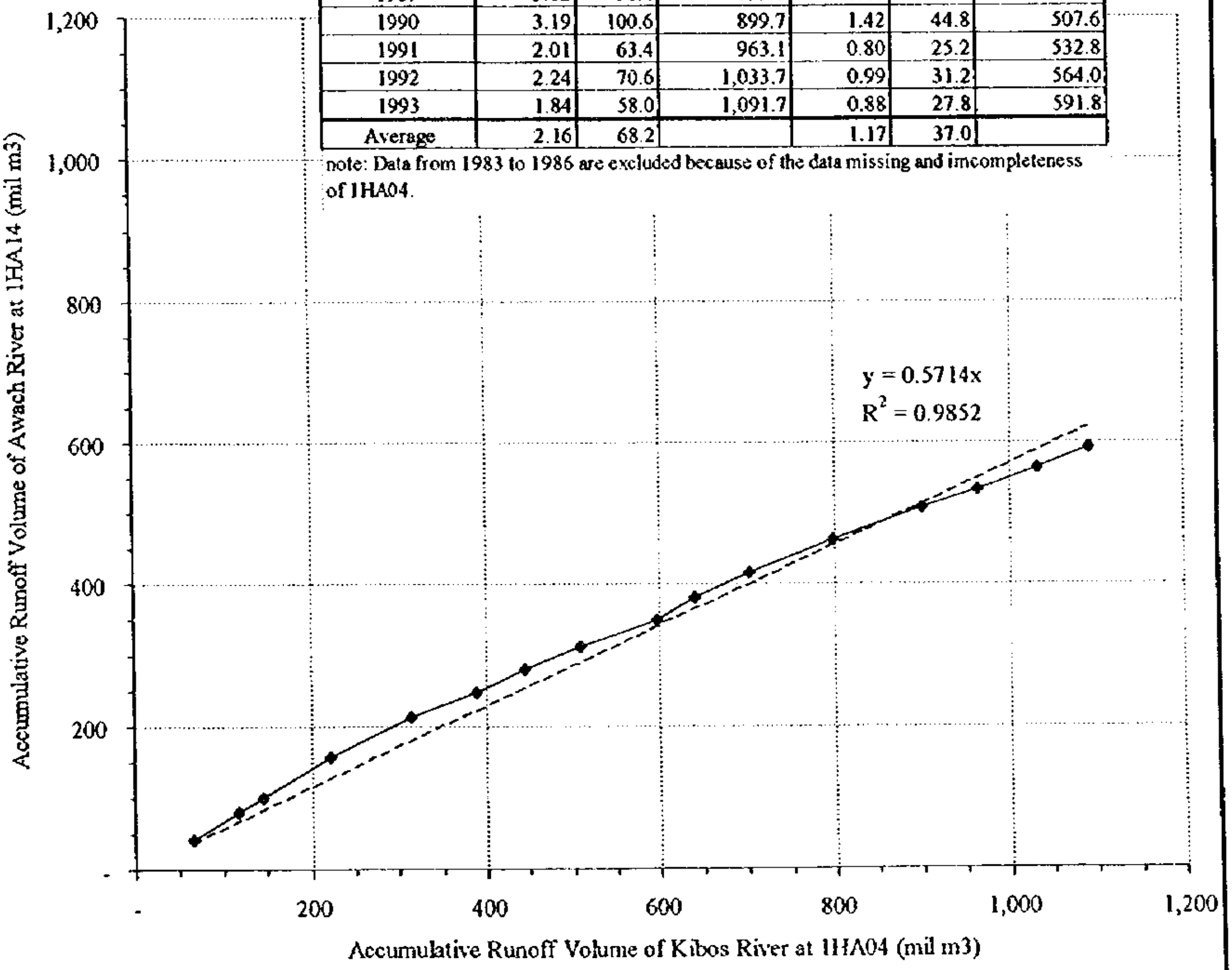


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Table 4-5 shows the existing water abstraction permits from the Kibos river in its section after the confluence of the Awach river. The total permitted abstraction volume of 0.027 m3/s is fairly small compared to the total river maintenance flow of 0.11 m3/s (0.07 m3/s for Kibos plus 0.04 m3/s for Awach) estimated by the Study Team.

Table 4-5 Water Abstraction Permits along Kibos/Awach Rivers (As of 1997)

Permit No.	Permit Holder	Use	Nogroabs (m3/d)	Flodgros (m3/d)	Isuedate	Expdate
12585	Director of Agriculture	Gen. Irr.	0.00	768.22	04/03/75	11/30/79
12870	Municipal Council of Kisumu	Public	1370.08	0.00	02/18/70	09/05/94
12871	Municipal Council of Kisumu	Public	137.01	0.00	09/20/70	06/05/95
2190	Director of Agriculture	Minor Irr.	9.00	0.00	-	-
P16969	Commissioner of Prisons	Gen. Irr.	0.00	0.91	06/23/76	-
P22812	Channah Agricultural Constructors	Dom/Minor Irr.	454.35	18.18	05/06/85	-
-	Kibos Industries	Industrial	315.00	0.00	-	-
-	Joseph M. Ochieng	Dom/Minor Irr.	7.65	0.00	-	-
Total		(m3/d)	2293.09	787.31		
		(m3/s)	0.027	0.009		

Source: MOWR and Data Center, LBDA.

Note: Norgroabs; Amount abstracted when the river is flowing normally,
Flodgros; Amount abstracted when the river is under floods,
Isuedate; Date when the permit was issued, Expdate; Date when the permit will expire.

(5) Frequency and Flow Duration Analyses

The frequency and flow duration analyses which will form the basis for evaluation of the raw water availability of the Kibos and Awach Rivers are conducted by the Study Team.

a. Frequency Analysis for Average Minimum Flow

The frequency of average minimum flows is analyzed for the duration of one, seven and thirty days. The average minimum flows for each of these duration are shown in Figure 4-10. The data length for the analysis is 39 years for the station 1HA04 on the Kibos River and it is 31 years for the station 1HA14 on the Awach River. The data before 1954 at the station 1HA04 are excluded from the analysis because of their low reliablity. The frequency analysis is conducted in accordance with the "minimum distribution method", and the results are summarised in Figure 4-11. The values shown for the Awach intake site are estimated pro rata to the river's catchment areas, 108 km2 at the gauging station 1HA14 and 82 km2 at the proposed intake site.

b. Flow Duration Analysis

The flow duration of daily mean flows is analyzed for the recent 20 years (1974-1993). Two types of flow duration curves: 1) average flow duration curve and 2) sequential flow duration curve are prepared. The average flow duration curve is prepared by taking the average of each annual duration curve in order to perceive the average flow condition. The results are shown in Figure 4-12. On the other hand, the sequential flow duration curve which is more widely used, is prepared by applying the series method throughout the available data period in order to grasp the absolute low flow condition throughout the objective period. The results are shown in Figure 4-13. Data at 1HA04 from 1983 to 1986 and that at 1HA14 from 1984 to 1986 are excluded from this analysis as they are either missing or incomplete.

Figure 4-10 (1/2)

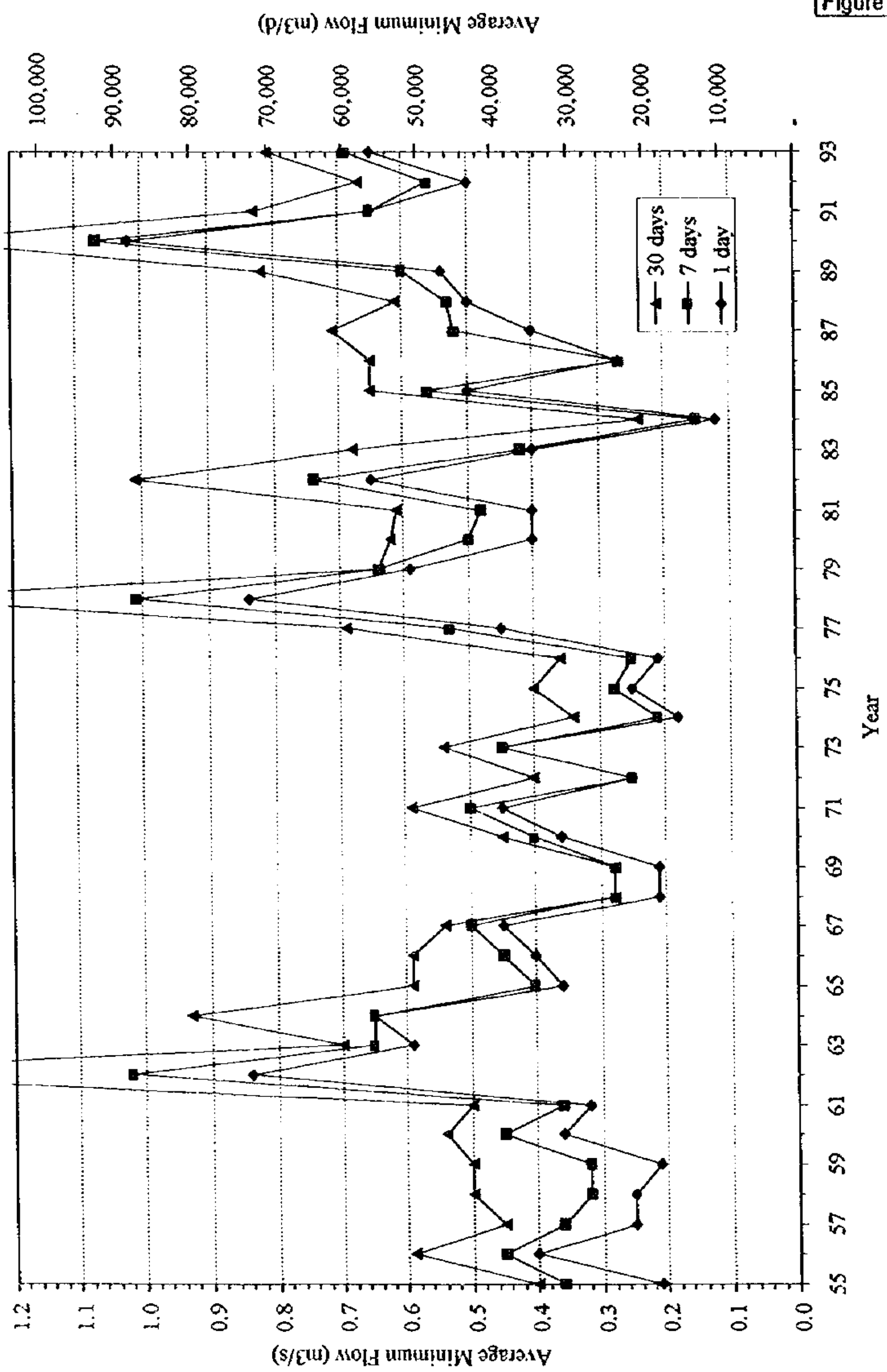

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Figure 4-10 (2/2)

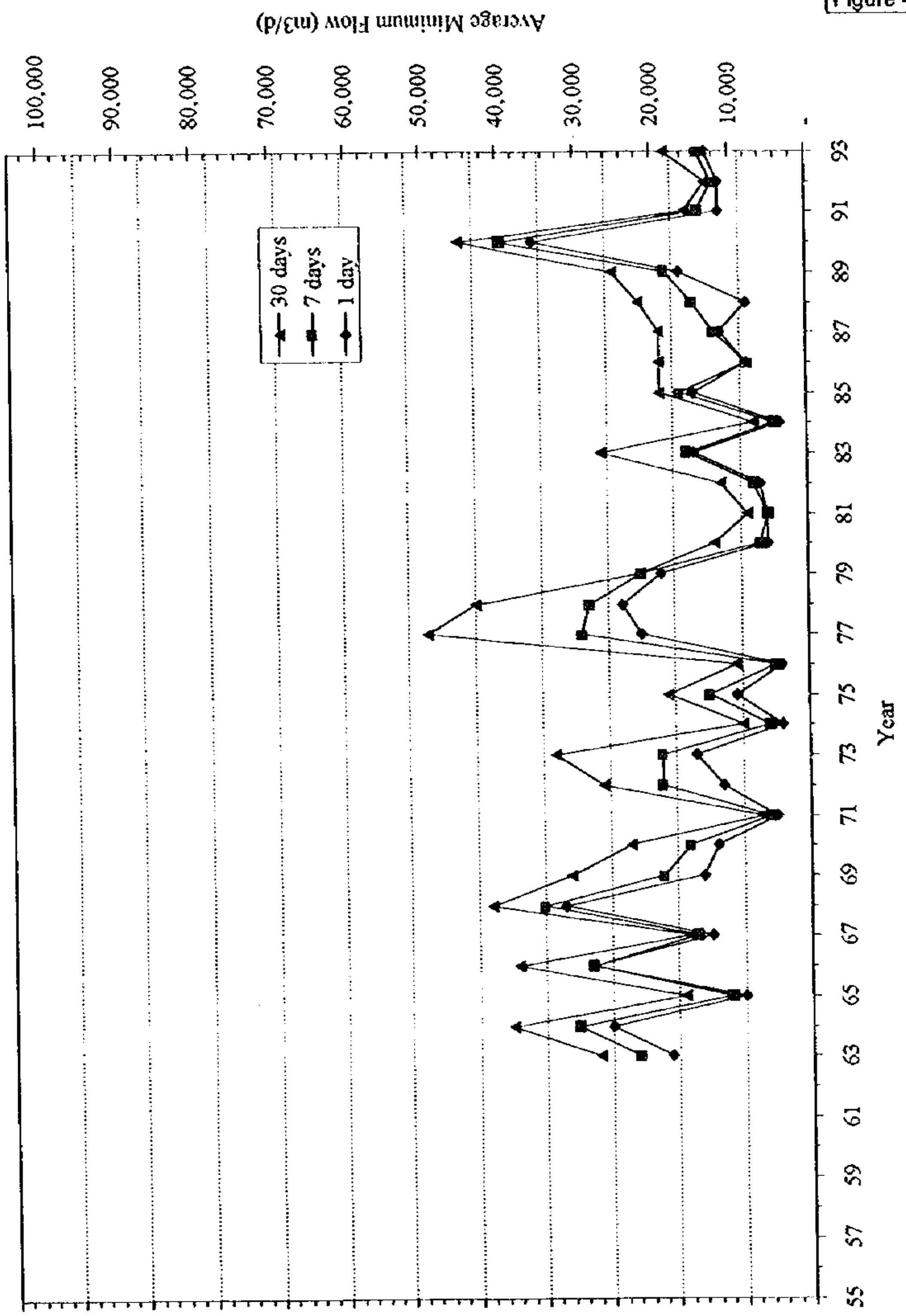

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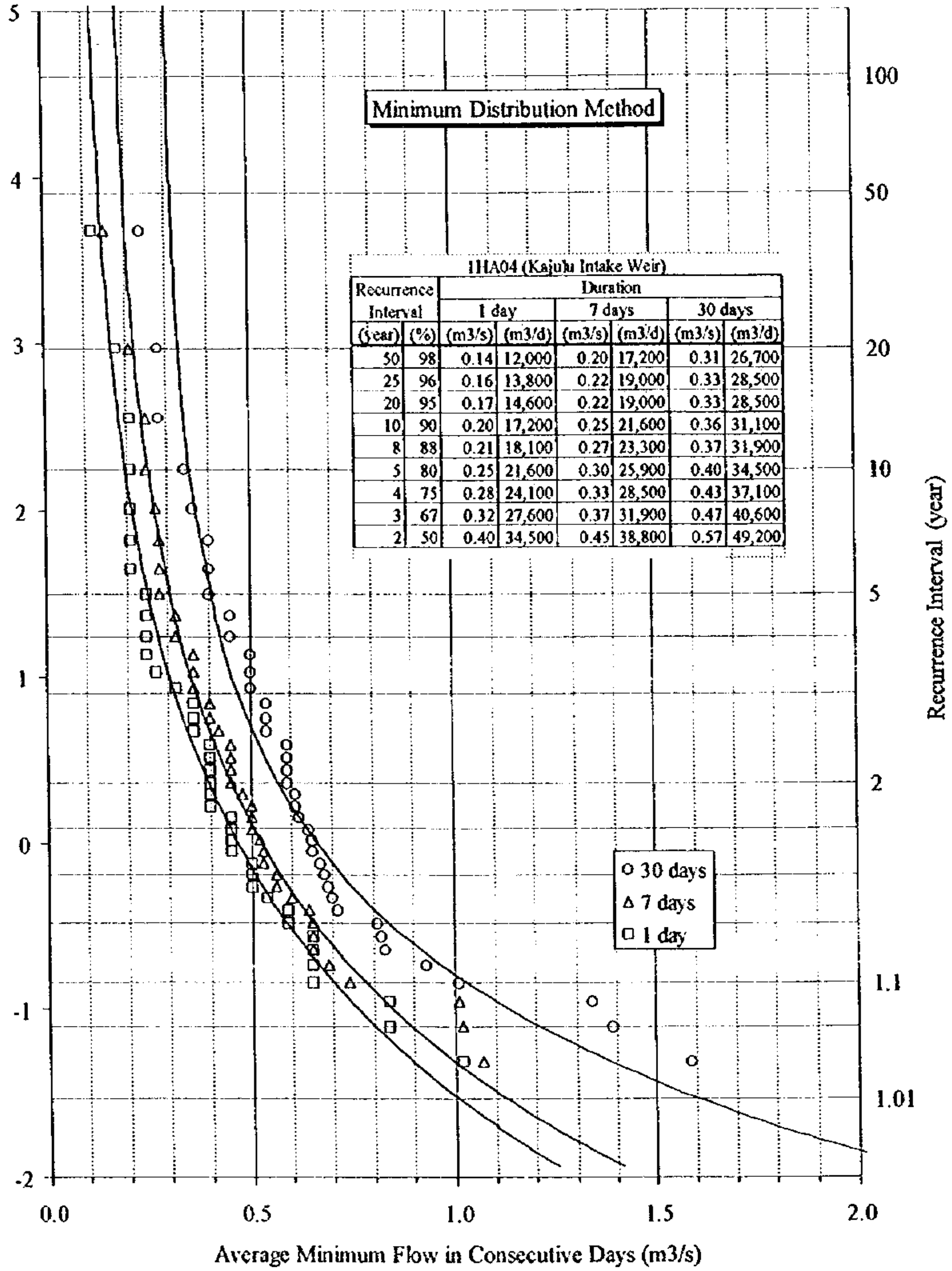
Figure 4-11 (1/2)



1HA04 (Kajulu Intake Weir)

Recurrence Interval		Duration					
		1 day		7 days		30 days	
(year)	(%)	(m3/s)	(m3/d)	(m3/s)	(m3/d)	(m3/s)	(m3/d)
50	98	0.14	12,000	0.20	17,200	0.31	26,700
25	96	0.16	13,800	0.22	19,000	0.33	28,500
20	95	0.17	14,600	0.22	19,000	0.33	28,500
10	90	0.20	17,200	0.25	21,600	0.36	31,100
8	88	0.21	18,100	0.27	23,300	0.37	31,900
5	80	0.25	21,600	0.30	25,900	0.40	34,500
4	75	0.28	24,100	0.33	28,500	0.43	37,100
3	67	0.32	27,600	0.37	31,900	0.47	40,600
2	50	0.40	34,500	0.45	38,800	0.57	49,200

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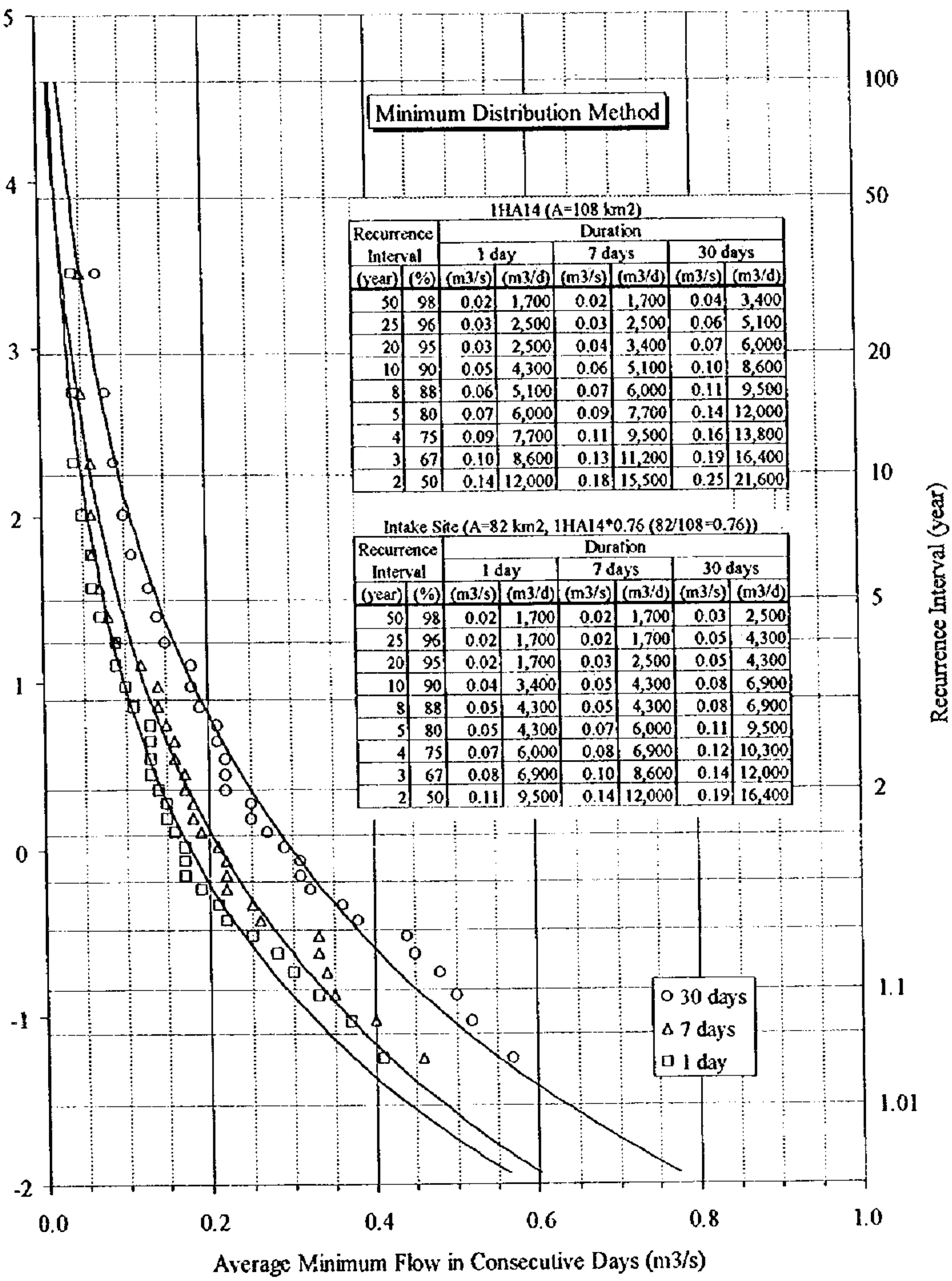
Figure 4-11 (2/2)



1HA14 (A=108 km2)

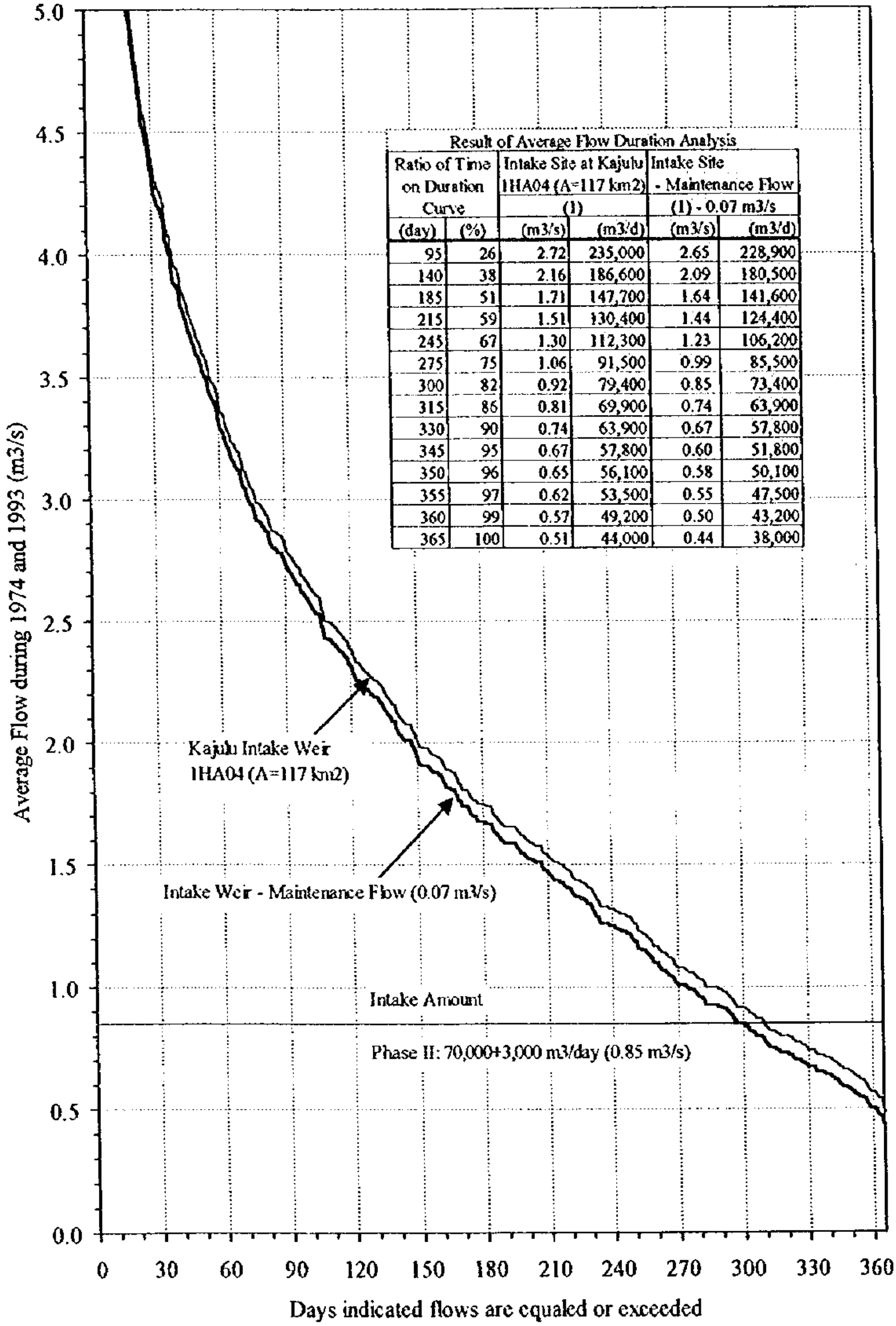
Recurrence Interval		Duration					
		1 day		7 days		30 days	
(year)	(%)	(m3/s)	(m3/d)	(m3/s)	(m3/d)	(m3/s)	(m3/d)
50	98	0.02	1,700	0.02	1,700	0.04	3,400
25	96	0.03	2,500	0.03	2,500	0.06	5,100
20	95	0.03	2,500	0.04	3,400	0.07	6,000
10	90	0.05	4,300	0.06	5,100	0.10	8,600
8	88	0.06	5,100	0.07	6,000	0.11	9,500
5	80	0.07	6,000	0.09	7,700	0.14	12,000
4	75	0.09	7,700	0.11	9,500	0.16	13,800
3	67	0.10	8,600	0.13	11,200	0.19	16,400
2	50	0.14	12,000	0.18	15,500	0.25	21,600

Intake Site (A=82 km2, 1HA14*0.76 (82/108=0.76))

Recurrence Interval		Duration					
		1 day		7 days		30 days	
(year)	(%)	(m3/s)	(m3/d)	(m3/s)	(m3/d)	(m3/s)	(m3/d)
50	98	0.02	1,700	0.02	1,700	0.03	2,500
25	96	0.02	1,700	0.02	1,700	0.05	4,300
20	95	0.02	1,700	0.03	2,500	0.05	4,300
10	90	0.04	3,400	0.05	4,300	0.08	6,900
8	88	0.05	4,300	0.05	4,300	0.08	6,900
5	80	0.05	4,300	0.07	6,000	0.11	9,500
4	75	0.07	6,000	0.08	6,900	0.12	10,300
3	67	0.08	6,900	0.10	8,600	0.14	12,000
2	50	0.11	9,500	0.14	12,000	0.19	16,400

THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Frequency of Minimum Flows (Awach River at 1HA14)

Figure 4-12 (1/2)

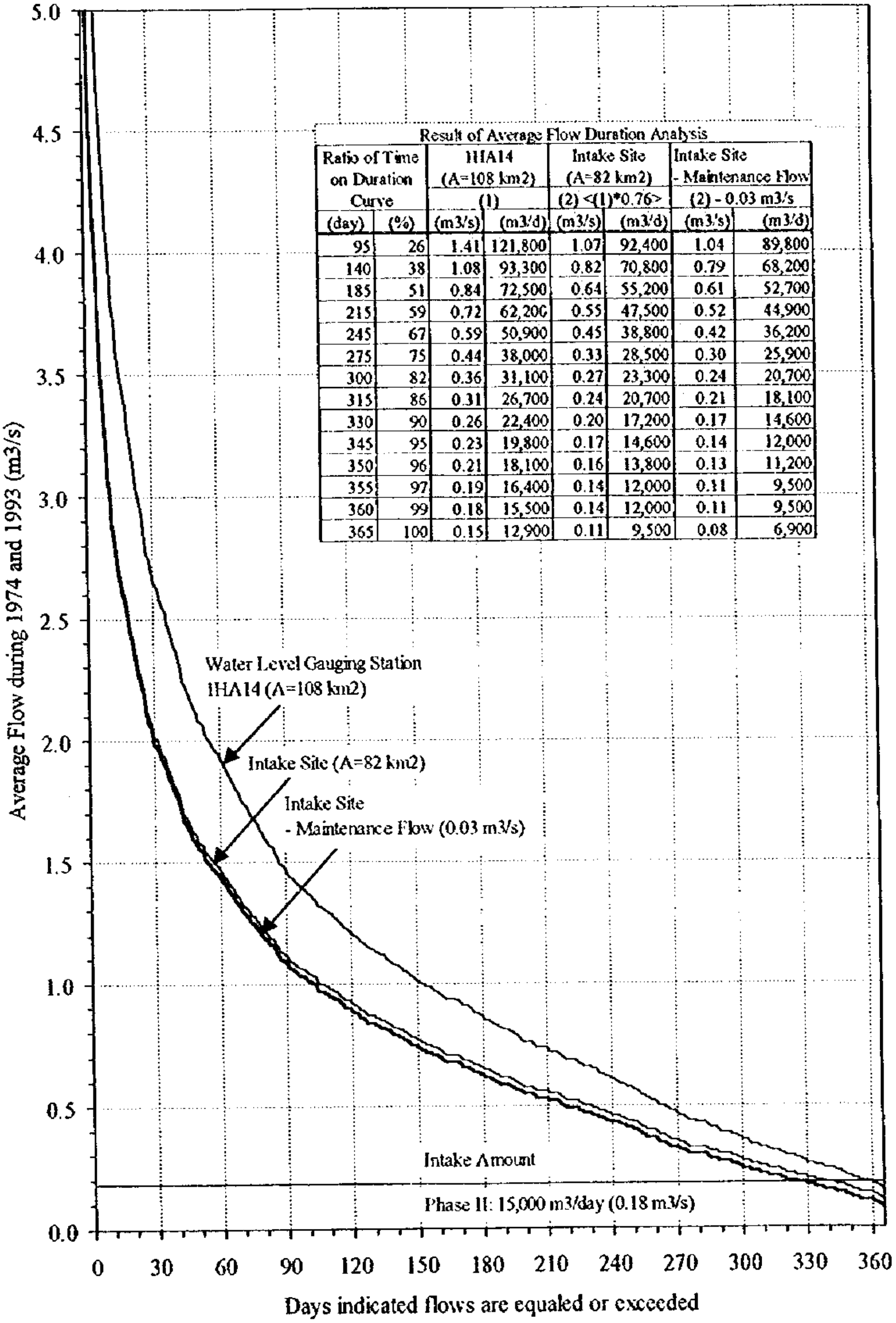


Result of Average Flow Duration Analysis

Ratio of Time on Duration Curve		Intake Site at Kajulu 1HA04 (A=117 km2) (1)		Intake Site - Maintenance Flow (1) - 0.07 m3/s	
(day)	(%)	(m3/s)	(m3/d)	(m3/s)	(m3/d)
95	26	2.72	235,000	2.65	228,900
140	38	2.16	186,600	2.09	180,500
185	51	1.71	147,700	1.64	141,600
215	59	1.51	130,400	1.44	124,400
245	67	1.30	112,300	1.23	106,200
275	75	1.06	91,500	0.99	85,500
300	82	0.92	79,400	0.85	73,400
315	86	0.81	69,900	0.74	63,900
330	90	0.74	63,900	0.67	57,800
345	95	0.67	57,800	0.60	51,800
350	96	0.65	56,100	0.58	50,100
355	97	0.62	53,500	0.55	47,500
360	99	0.57	49,200	0.50	43,200
365	100	0.51	44,000	0.44	38,000

THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Average Flow Duration Curves (Kibos River at 1HA04 (1974-1993))

Figure 4-12 (2/2)

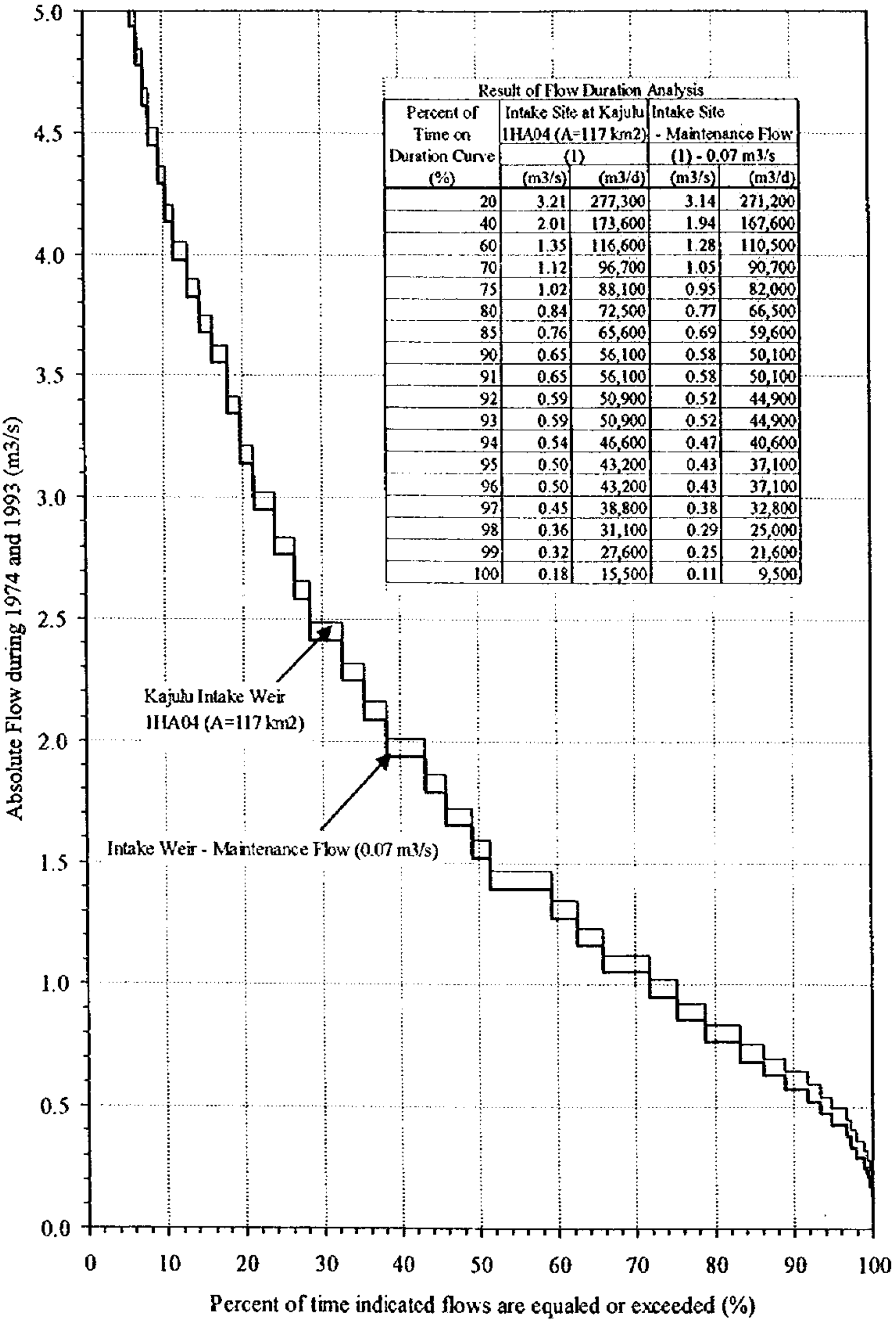


Result of Average Flow Duration Analysis

Ratio of Time on Duration Curve		1HA14 (A=108 km2) (1)		Intake Site (A=82 km2) (2) <(1)*0.76>		Intake Site - Maintenance Flow (2) - 0.03 m3/s	
(day)	(%)	(m3/s)	(m3/d)	(m3/s)	(m3/d)	(m3/s)	(m3/d)
95	26	1.41	121,800	1.07	92,400	1.04	89,800
140	38	1.08	93,300	0.82	70,800	0.79	68,200
185	51	0.84	72,500	0.64	55,200	0.61	52,700
215	59	0.72	62,200	0.55	47,500	0.52	44,900
245	67	0.59	50,900	0.45	38,800	0.42	36,200
275	75	0.44	38,000	0.33	28,500	0.30	25,900
300	82	0.36	31,100	0.27	23,300	0.24	20,700
315	86	0.31	26,700	0.24	20,700	0.21	18,100
330	90	0.26	22,400	0.20	17,200	0.17	14,600
345	95	0.23	19,800	0.17	14,600	0.14	12,000
350	96	0.21	18,100	0.16	13,800	0.13	11,200
355	97	0.19	16,400	0.14	12,000	0.11	9,500
360	99	0.18	15,500	0.14	12,000	0.11	9,500
365	100	0.15	12,900	0.11	9,500	0.08	6,900

THE REPUBLIC OF KENYA	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM	TITLE :
THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	JAPAN INTERNATIONAL COOPERATION AGENCY	Average Flow Duration Curves (Awach River at 1HA14 (1974-1993))

Figure 4-13 (1/2)

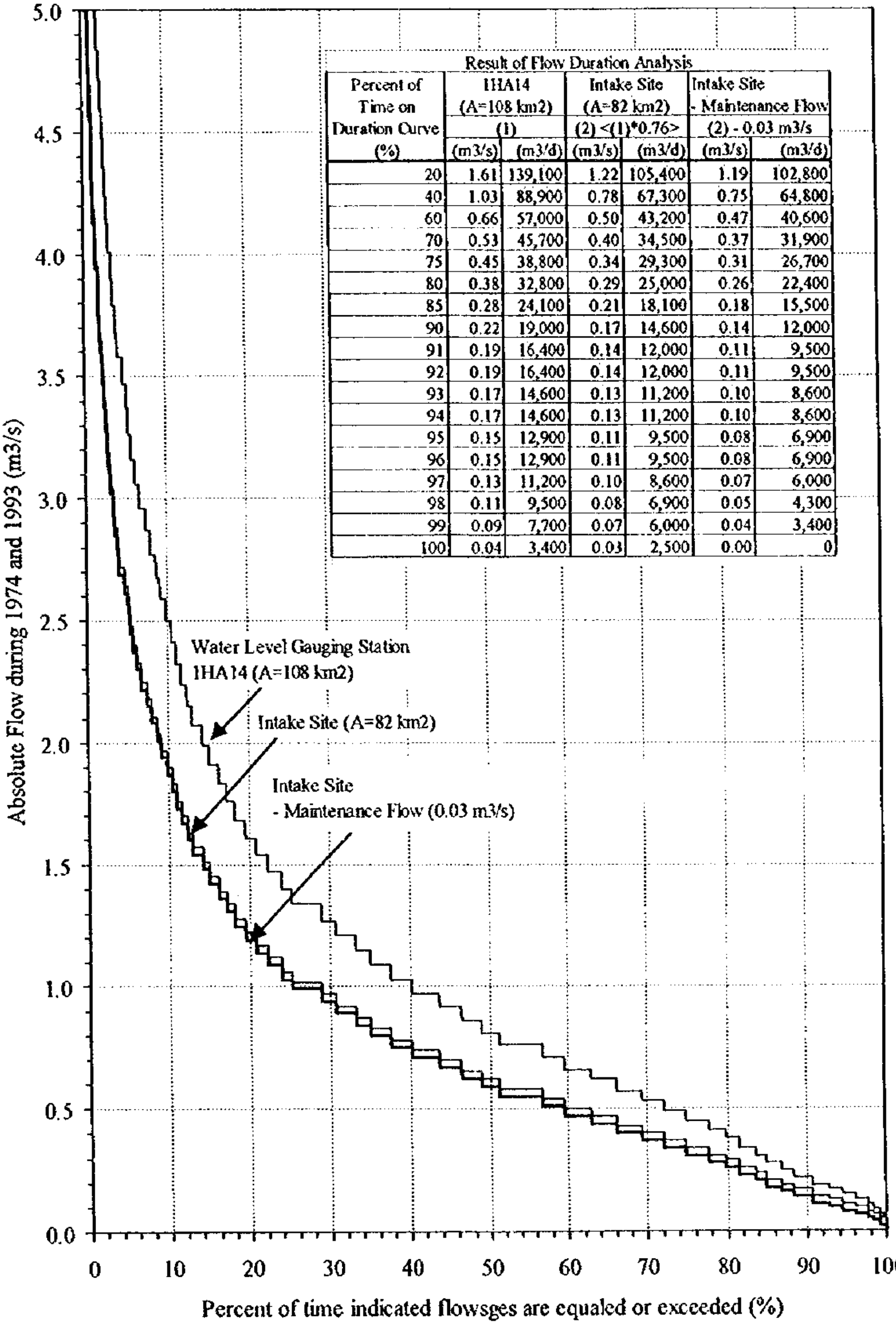


Result of Flow Duration Analysis

Percent of Time on Duration Curve	Intake Site at Kajulu 1HA04 (A=117 km2) (1)		Intake Site - Maintenance Flow (1) - 0.07 m3/s	
(%)	(m3/s)	(m3/d)	(m3/s)	(m3/d)
20	3.21	277,300	3.14	271,200
40	2.01	173,600	1.94	167,600
60	1.35	116,600	1.28	110,500
70	1.12	96,700	1.05	90,700
75	1.02	88,100	0.95	82,000
80	0.84	72,500	0.77	66,500
85	0.76	65,600	0.69	59,600
90	0.65	56,100	0.58	50,100
91	0.65	56,100	0.58	50,100
92	0.59	50,900	0.52	44,900
93	0.59	50,900	0.52	44,900
94	0.54	46,600	0.47	40,600
95	0.50	43,200	0.43	37,100
96	0.50	43,200	0.43	37,100
97	0.45	38,800	0.38	32,800
98	0.36	31,100	0.29	25,000
99	0.32	27,600	0.25	21,600
100	0.18	15,500	0.11	9,500

THE REPUBLIC OF KENYA	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM	TITLE :
THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	JAPAN INTERNATIONAL COOPERATION AGENCY	Sequential Flow Duration Curves (Kibos River at 1HA04 (1974-1993))

Figure 4-13 (2/2)



Result of Flow Duration Analysis

Percent of Time on Duration Curve	1HA14 (A=108 km2) (1)		Intake Site (A=82 km2) (2) <(1)*0.76>		Intake Site - Maintenance Flow (2) - 0.03 m3/s	
(%)	(m3/s)	(m3/d)	(m3/s)	(m3/d)	(m3/s)	(m3/d)
20	1.61	139,100	1.22	105,400	1.19	102,800
40	1.03	88,900	0.78	67,300	0.75	64,800
60	0.66	57,000	0.50	43,200	0.47	40,600
70	0.53	45,700	0.40	34,500	0.37	31,900
75	0.45	38,800	0.34	29,300	0.31	26,700
80	0.38	32,800	0.29	25,000	0.26	22,400
85	0.28	24,100	0.21	18,100	0.18	15,500
90	0.22	19,000	0.17	14,600	0.14	12,000
91	0.19	16,400	0.14	12,000	0.11	9,500
92	0.19	16,400	0.14	12,000	0.11	9,500
93	0.17	14,600	0.13	11,200	0.10	8,600
94	0.17	14,600	0.13	11,200	0.10	8,600
95	0.15	12,900	0.11	9,500	0.08	6,900
96	0.15	12,900	0.11	9,500	0.08	6,900
97	0.13	11,200	0.10	8,600	0.07	6,000
98	0.11	9,500	0.08	6,900	0.05	4,300
99	0.09	7,700	0.07	6,000	0.04	3,400
100	0.04	3,400	0.03	2,500	0.00	0

THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : Sequential Flow Duration Curves (Awach River at 1HA14 (1974-1993))

(6) Evaluation of Availability

a. 96% Probability Daily Low Flow

The safe yield for principal towns and urban centers with a population over 10,000 is defined by the Manual prepared by MOWR as follows:

> The 96 % probability daily low flow shall be regarded as the safe yield of a river. The flow-frequency analysis shall be made by using the lowest recorded daily flow of each calendar year for which records are available for the dry season.

The 96 % probability daily low flow means the minimum daily flow which could emerge with a probability of once in twenty-five years (1-(1/25)=0.96). According to the frequency analysis shown in Figure 4-11, the 96 % probability daily low flows at both intake sites are estimated as shown in Table 4-6.

Table 4-6 96 % Probability Daily Low Flow

River	Area	96 % Probability Daily Low Flow (1)		Maintenance Flow (refer to Table 4-4) (2)		(1) - (2)	
	(km2)	(m3/s)	(m3/d)	(m3/s)	(m3/d)	(m3/s)	(m3/d)
Kibos	117	0.16	13,800	0.07	6,100	0.09	7,700
Awach	82	0.02	1,700	0.03	2,600	0.00	0.00
Total	199	0.18	15,500	0.10	8,700	0.09	7,700

The safe yield, in this case, is assumed to be 15,500 m3/s (0.18 m3/s) in total. As mentioned earlier in this report, it is necessary to maintain a certain amount of water for conservation of natural riverine environments, although it is not mentioned in the MOWR's Manual. If the safe yield is taken as a balance between the 96 % probability daily low flow and the maintenance flow, the safe yield will be only 7,700 m3/s (0.09 m3/s) in total. In all cases, the safe yield falls far short of the Phase I water requirement of 45,500 (42,500 + 3,000) m3/d in the year 2005.

As already mentioned in the Master Plan, the concept of safe yield as defined by MOWR is too strict to apply for water striving Kisumu municipality without modifications. The Study Team therefore has developed an entirely different concept of "Dependability 96 %".

b. Dependability 96 % Possible Water Amount

If the municipal water supply system is allowed to operate with somewhat lower than its maximum capacity for only 2 weeks a year (dependability 96 % on flow duration curve), availability of water during the rest of the year will drastically increase. The flow duration analysis shown in Figures 4-12 and 4-13 indicates that water available from the Kibos and Awach rives will increase at least to a total of 52,700 m3/d as shown in Table 4-7.

Table 4-7 Dependability 96 % Possible Water Amount

Type of Flow Duration Curve	River	Area	Dependability 96 % Possible Water Amount (1)		Maintenance Flow (refer to Table 4-4) (2)		(1) - (2)		Ratio against 45,500 m3/d in Phase I
		(km2)	(m3/s)	(m3/d)	(m3/s)	(m3/d)	(m3/s)	(m3/d)	(%)
Average (1974-1993)	Kibos	117	0.65	56,100	0.07	6,100	0.58	50,100	-
	Awach	82	0.16	13,800	0.03	2,600	0.13	11,200	-
	Total	199	0.81	69,900	0.10	8,700	0.71	61,300	135
Sequential (1974-1993)	Kibos	117	0.50	43,200	0.07	6,100	0.43	37,100	-
	Awach	82	0.11	9,500	0.03	2,600	0.08	6,900	-
	Total	199	0.61	52,700	0.10	8,700	0.51	44,000	97

c. Water Requirements in Phase I and II

The total water requirement for the Phase II is estimated at 88,000 m3/d (85,000 m3/d for Kibuye WTW + 3,000 m3/d for Kajule WTW). The water source for the Phase II is proposed to be a combination of river water from the Kibos and Awach Rivers, and water from Lake Victoria. The allocation of intake volumes and the duration of water intake from each of the two rivers during rainy months are estimated as shown in Table 4-8 on the basis of the average flow duration curves shown in Figure 4-12. Evaluation of dependability is unnecessary for the Phase II, since any shortage of river water during dry months can be fully supplemented from Lake Victoria.

Table 4-8 Volumes and Duration of Water Intake in Phase II

River	Area	Water Amount		Ratio of Time on Average Duration Curve		
	(km2)	(m3/s)	(m3/d)	(day)	(month)	(%)
Kibos**	117	0.85	73,000	300	10	82
Awach	82	0.18	15,000	329	11	90
Total	199	1.03	88,000			

**: 73,000 m3/s = 70,000 m3/d +3,000 m3/d (Kajulu Intake)

The total water requirement for the Phase I is estimated at 45,500 m3/d (42,500 m3/d for Kibuye WTW + 3,000 m3/d for Kajulc WTW). The volumes of water taken from each of the two rivers are determined by applying the same ratio as used for the Phase II. As there is no alternative water source to supplement the shortage in Phase I, it is necessary to evaluate the dependability on the basis of the sequential flow duration curves shown in Figure 4-13. The results are shown in Table 4-9. The dependability, in this case, falls 94.9 % which is slightly lower than 96 %. However, any water shortage, if it ever happens, will be limited only in the year 2005, since water demand before the year 2005 will be lower than 45,500 m3/s and the Phase II work will be completed and ready for use by the year 2006. Besides, there is also a possibility that the year 2005 has more frequent rains than in normal years and there is no water shortage. It is therefore concluded that 94.9 % dependability is practically acceptable given the prevailing water crisis in Kisumu Municipality.

Table 4-9 Water Intake and Dependability in Phase I

River	Area	Water Amount		Dependability on Sequential Duration Curve	
	(km2)	(m3/s)	(m3/d)	(%)	(day)
Kibos**	117	0.45	38,600	94.9	19
Awach	82	0.08	6,900	96.0	15
Total	199	0.53	45,500		

**: 38,600 m3/s = 35,600 m3/d +3,000 m3/d (Kajulu Intake)

4.2.2 Availability of Raw Water from Lake Victoria

Lake Victoria is the second largest freshwater lake in the world. The availability capacity of raw water from Lake Victoria is unlimited. The present lake intake was established in 1956 at the Hippo point. The water is abstracted from the lake, pumped to the Lake WTW for water treatment and futher pumped to Kibuye reservoir for distribution. This water source is very important and can be used either as an individual source or a source combined with the Kibos/Awach Rivers. Due to its proximity to the supply area, combination of this source with the Kibos/Awach Rivers will increase the flexibility of water supply system.

4.3 COST FOR IMPROVEMENTS

4.3.1 Rehabilitation Works Component

The works included in the Rehabilitation Works Component were further grouped into several packages. Table 4-10 shows a summary of the costs estimated for each of those packages. Detailed breakdown of the costs are provided in Appendix R.

Table 4-10 Cost for Rehabilitation Works Component

Package No.	Description of Works Included	Construction Base Cost (US$)
RW-S1	• Supply and installation of equipment for rehabilitation of Kajulu and Lake WTWs	4,029,000
RW-C1	• Rehabilitation of Kajulu water intake and Kajulu WTW • Construction of Kajulu Distribution Reservoir (700 m3) • Construction of treated water transmission main (SP 200 mm, L=3.6 km) from Kajulu WTW to Kajulu Distribution Reservoir	273,000
RW-C2	• Rehabilitation of Lake water intake and Lake WTW • Construction of raw water transmission main (SP 450, L=1.2 km) from Lake water intake to Lake WTW • Construction of treated water transmission main (SP 550 mm, L=5.2 km) from Lake WTW to Kibuye Distribution Reservoir	3,650,000
Total		7,952,000

4.3.2 Expansion Works Component

The works included in the Expansion Works Component were also grouped into several packages. Table 4-11 presents a summary of the costs estimated for each of those packages. Detailed breakdown of the costs are provided in Appendix R.

Table 4-11 Cost for Expansion Works Component

Package No.	Description of Work Included	Construction Base Cost (US$)
EW-S1	• Supply and installation of equipment for construction of new Kibuye WTW	6,076,000
EW-C1	• Construction of new water intakes on Awach and Kibos rivers	1,680,000
EW-C2	• Construction of new raw water transmission mains (SP 400 to 900 mm, L=18.8 km) from new Awach and Kibos water intakes to Kibuye WTW, including construction of a junction well	7,443,500
EW-C3	• Construction of new Kibuye WTW (40,000 m3/day) including high lift distribution pump station at Kibuye WTW to pump treated water to Kanyakwar and Kogony Distribution Reservoirs, wastewater disposal facilities at Nyalenda, and wastewater disposal main from Kibuye WTW to Nyalenda (PVC 200 mm, L=4.0 km)	5,491,000
EW-C4	• Construction of new distribution reservoir at Kibuye (27,000 m3/day)	1,440,600
EW-C5	• Construction of new Kanyakwar Distribution Reservoir (5,000 m3) • Construction of new treated water transmission main (SP 350 mm, L=4.2 km) from Kibuye Distribution Reservoir to Kanyakwar Distribution Reservoir	1,022,200
EW-C6	• Construction of new Kogony Distribution Reservoir (3,500 m3) • Construction of new treated water transmission main (SP 400 mm, L=6.2 km) from Kibuye Distribution Reservoir to Kogony Distribution Reservoir	1,488,600
EW-C7	• Installation of new trunk distribution mains (PVC & SP 160 to 800 mm, L=49 km)	8,913,625
EW-C8	• Installation of new secondary distribution mains (PVC 63 to 110 mm, L=330 km) including construction of 223 communal taps (water kiosks)	5,022,000
Total		**38,577,525**

4.3.3 Total Cost for Water Supply Improvements

The total cost of the water supply improvement under the Phase I Project was estimated as a summation of the costs for the rehabilitation works component and for the expansion works component as shown in Table 4-12.

Table 4-12 Cost for Phase I Water Supply Improvements (1997 Price)

Work Component	Construction Base Cost (US$)
Rehabilitation	7,952,000
Expansion	38,577,525
Total	**46,529,525**

CHAPTER 5

SEWERAGE IMPROVEMENT PLANS AND COSTS

5 SEWERAGE IMPROVEMENT PLANS AND COSTS

5.1 IMPROVEMENT PLANS

5.1.1 Description of Proposed Improvement Plans

A sewerage improvement plan proposed under the Phase I Project is shown in Figure 5-1.

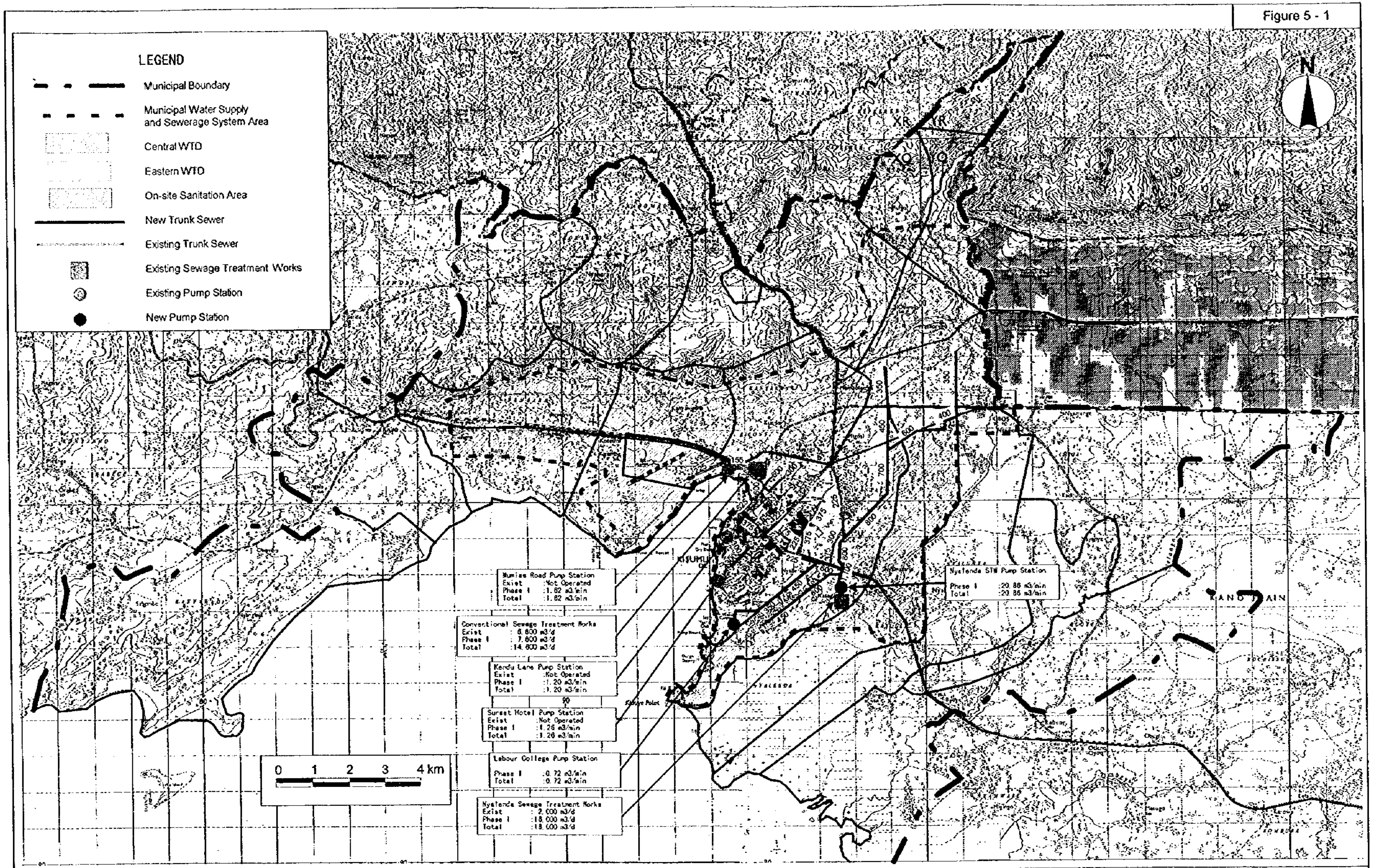
As can be seen in the figure, improvements proposed in Phase I will concentrate on the rehabilitation of the existing sewerage system rather than on the extension of the existing service area. Despite this, however, the service area proposed under Phase I covers almost the entire urban and peri-urban areas existing in Kisumu at present, where a substantial portion of water supplied from the municipal water supply system is being used.

The volume of wastewater increases as the capacity of water supply increases in the future. It is estimated that the total wastewater generation in Kisumu will increase to 38,900 m3/d in the year 2005, and that the sewerage scheme proposed under the Phase I Project will be able to collect 23,220 m3/d or 60 % of that total volume for treatment. This is almost thrice of 8,500 m3/d which is currently being collected by the municipal sewerage system.

Under the Phase I Project, the service area in the Central WTD will be extended to 437 ha from the present 385 ha. The wastewater management capacity in the district will be increased from the existing 6,800 to 14,600 m^3/d on a daily maximum flow basis. Major works involved in this expansion comprise:

- Extension of treatment capacity at the Conventional STW.
- Rehabilitation of the existing three pump stations which collect wastewater from low lying areas along the east coast of Lake Victoria.
- Replacement of the existing trunk sewers with new pipes 250 to 400 mm in diameter and 2.6 km in total length.

Figure 5 - 1



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sewerage System Improvement Plan Proposed under Phase I Project

In the Eastern WTD, the service area will also be increased from the existing 214 to 1,358 ha and the total wastewater management capacity in the district will be increased from the existing 2,000 m3/d to 18,000 m3/d on a daily maximum basis. Major works involved in this expansion include:

- Extension of treatment capacity at the Nyalenda STW.

- Installation of new sewers in the expanded service area, which will comprise 23.1 km of trunk sewers and 122.5 km of branch sewers.

- Construction of two new pump stations, i.e., Labour College pump station and Nyalenda STW pump station.

Labour College pump station will collect wastewater to be generated from a 40 ha area which extends in the south of Milimani while Nyalenda STW pump station is necessary to deliver all the wastewater collected in the district to the STW for treatment.

In addition, Phase I improvement will also include the installation of shallow sewer networks. These sewer networks will be installed in urban and peri-urban areas and collect domestic wastewater from medium to low income households whose water consumption is estimated at between 50 and 60 lcd, which is too low to be directly connected to the municipal sewerage system. These sewer pipes will be 100 mm in diameter and 91 km in total length and the cost for procurement of those pipe materials has been included in Phase I.

The improvement works proposed for the Phase I Project are classified into two components, i.e., rehabilitation and expansion, given the nature of the works involved.

5.1.2 Rehabilitation Works Components

(1) Wastewater Collection Facilities

a. Trunk Sewers

Existing broken/collapsed trunk sewers in the Eastern WTD, which are 375 mm in diameter and 420m in total length, will be replaced.

b. Pump Stations

Three existing pump stations in the Central WTD which are not operative at present will be rehabilitated. This will prevent the direct discharge of wastewater into Lake Victoria and sewage overflows from manholes upstream of the stations.

Table 5-1 shows a summary of pumps to be rehabilitated at each of the three pump stations.

Table 5-1 Pumps to be Rehabilitated

Item	Sunset Hotel P.S.	Kendu Lane P.S.	Mumias Road P.S.
Design Flow Rate (m^3/min)	1.26	1.20	1.62
Number of Units	2 (including. 1 Standby)	2 (including. 1 Standby)	2 (including. 1 Standby)
Pump Capacity per Unit (L/sec)	21	20	27
Total Head (m)	40	13	10
Pump Efficiency (%)	55	55	55
Motor Power (kW)	18.5	5.5	7.5

(2) Wastewater Treatment Facilities

a. Conventional Treatment Works

The Conventional STW is hydraulically and by BOD heavily overloaded. The BOD concentration of the final effluent is much too high (143-254 mg/l) and exceeds the design treated wastewater quality of BOD 20 mg/l. The sewage treatment is insufficient, and though the primary sedimentation tanks and the secondary sedimentation tanks are reasonably efficient the filters, which are the biological part of the plant are heavily overloaded and need extension. The rehabilitation work carried out on the plant in 1986 failed to attain the design standards. It is suggested that the contents of the industrial wastewater inhibited the biological breakdown process in the biofilters. The plant treats effluent emanating from Central WTD which includes the two major industries in Kisumu; Kenya Breweries and Kicomi.

The mechanical/electrical equipment needs rehabilitation/replacement to restore the works to its design capacity. The following works need to be carried out as detailed in the following paragraphs.

1) Inlet Works

i. Screen Cleaning Automation

At the time of the Study the automatic rake of the bar screen was not working. This was undesirable since a constant check had to be kept to avoid back-up of the inlet structure. It is recommended that this be replaced.

ii. Screenings Macerator

To overcome the task of collection and disposal of screenings which will increase as the inflow increases, a screenings macerator unit is proposed. This unit is designed to chop screenings into fine particles and return them to the flow upstream of the screen.

2) Oil Separator

The separator appears to be working in a fashion, however problems have been reported with the press and this needs to be replaced.

3) Biological Filters

None of the trickling filter arms were rotating at the time of inspection, the reason given was the breakdown of the recirculation pump station. The radial and axial ball bearings including lubrication units will need to be replaced for each rotating arm. Super rate (SR) media is proposed for uprating the stone media filters. Stone media has a BOD removal efficiency of 25% of the removal efficiency of super-rate media.

4) Primary and Secondary Sedimentation Tanks

The settling tanks appeared to be working have been rehabilitated in 1986. However the drive motors for the bridges will need replacing as well as various rubber wheels and scrapers.

5) Sludge Pumping Station

The sludge Mohno-pumps are not operating and need to be replaced. These have given many problems in the past, this may have been caused by dry-running of the pumps or poor operating procedures.

6) Sludge Digestors

The four digestors have only one recirculation unit working in each digestor. Each digestor normally has two recirculation units, the second unit has failed in each tank and will need replacing.

7) Workshop Equipment

There is little workshop equipment for day to day maintenance and this will need to be replaced.

8) Security Lighting and Fencing

The site is not secure, with poor fencing and not enough watchmen at night. In 1992 a major burglary took place in the Sewage Works and involved electric panels and switchgear from the sludge pumping station. This equipment was never replaced. It is recommended that an eight foot high chain link fence with razor wire is built around the compound and security lights added.

b. Nyalenda Waste Stabilization Ponds

The present conditions of the works illustrates the results of lack of maintenance with overgrown embankments, inoperable measuring equipment, dislodged anti-erosion slabs minor embankment collapse and nearly all ponds covered with water cabbage. Phase I Works proposals include improvements and remedial measures designed to return operations to a satisfactory level. The rehabilitation Works are outlined in the following paragraphs.

1) Desludging Ramps for Facultative Ponds

The existing concrete ramps for desludging have a very steep 1:2.5 incline with no extended base at the pond bottom. New desludging ramps are proposed for the facultative ponds positioned diagonally in the corner of the pond. The ramps will have a 150 mm thick concrete surface top and a slope of 1:6.

2) Replacement of Anti Erosion Slabs

The existing 600 x 600 x 50 mm thick precast concrete slabs for embankment protection have been fixed in position with one wooden peg for every two slabs and the pegs have been placed at the bottom of the slabs. A large number of the slabs have slipped down the embankments into the ponds.

It is proposed to replace the anti erosion slabs and fix each slab with one reinforced concrete peg being placed in the centre of the slab. This will ensure each one is fixed firmly.

3) Reconstruction of Collapsed Embankment

Some 50 m of division embankment between Maturation Ponds M2 and M3 has collapsed. This is to be reconstructed to the original dimensions and reprotected with anti erosion slabs.

4) Desludging of Facultative Ponds and Removal of Water Cabbage in all Ponds

The facultative ponds have not been desludged since being commissioned in 1978. Sludge removal can be readily achieved by using raft-mounted sludge pumps. There are readily available from the United Kingdom. Sludge can also be removed mechanically via the access ramps. Water cabbage which now covers most of the ponds and is spreading rapidly will also need to be removed when the ponds are drained.

5.1.3 Expansion Works Components

(1) Wastewater Collection Facilities

a. Trunk Sewers

In the Central WTD, some of the existing trunk sewers will be replaced as shown in Table 5-2. These existing trunk sewers are small in size and the replacement with a lager diameter is necessary to meet the estimated design flow in the year 2005.

Table 5-2 Summary of Trunk Sewers for Replacement in Central WTD

Diameter (mm)	Pipe Material	Total Length (km)	Type of Joint
250	uPVC	0.65	Rubber Ring
300	uPVC	0.76	Rubber Ring
350	uPVC	1.02	Rubber Ring
400	Concrete	0.16	Spigot & Socket
Total Length		2.59	

In the Eastern WTD, new trunk sewers will be installed as shown in Table 5-3. These pipes will be 23 km in total length and 125 to 1,100 mm in diameter.

Table 5-3 Summary of New Trunk Sewers to be Installed in Eastern WTD

Diameter (mm)	Pipe Material	Total Length (km)	Specifications
125	uPVC	0.53	Rubber Ring
250	uPVC	3.97	- ditto -
350	uPVC	4.16	- ditto -
400	Concrete	1.99	Spigot & Socket
450	Concrete	3.40	- ditto -
500	Concrete	0.40	- ditto -
600	Concrete	3.29	- ditto -
700	Concrete	1.21	- ditto -
800	Concrete	2.80	- ditto -
1,100	Concrete	0.90	- ditto -
Total Length		22.65	

b. Branch Sewers

Branch sewers 200 mm in diameter and about 127 km in total length will be installed in the Eastern and Central WTDs under the Phase I Project. Details of these pipes are summarised in Table 5-4. The length of branch sewers is estimated from the length of pipe required for per unit area and the total area to be serviced. The former is estimated from the length of roads per ha of similar residential areas in the Central and Eastern WTDs where existing branch sewers have been installed .

Table 5-4 Branch Sewers to be Installed

WTD	Unit Length (m/ha)	Area to be serviced (ha)	Total Length (km)
Eastern WTD		1,144.4	122.6
Sub-district A	80	369.5	29.6
Sub-district B	120	774.9	93.0
Central WTD	80	52.2	4.2
Total		1,196.6	126.8

Note :Sub-district A is Urban ; Sub-district B is Peri-urban

In addition to these branch sewers, shallow sewer pipes will also be installed in medium and low income residential areas in both Central and Eastern WTDs. These shallow sewer pipes will be 100 mm in diameter and 91 km in total length and installed within private premises to collect domestic wastewater from households whose water consumption rate is between 50 and 60 lcd. As discussed in Section 3.1.2 , it is estimated that a total population of 82,700 (13,785 households assuming 6 persons per household) will fall within this category. The length of shallow sewer pipe required for a household is estimated at 6.6 m. This unit length was obtained from simulation analyses where shallow sewer pipes were mapped out in areas of different population density in Nyalenda Sub-location. The total length of shallow sewer pipes to serve these households is thus estimated to be approximately 91 km.

c. Pump Station

A new pump station, namely Lobour College Pump Station, will be constructed in the Eastern WTD to collect sewage from 40 ha area in the south of Milimani.

Another pump station will be constructed at the inlet works of the Nyalenda STW. Without this pump station, sewage collected in the Eastern WTD will not be able to reach the STW for treatment.

The pumps to be installed at the above two pump stations are detailed in Table 5-5.

Table 5-5 Pumps to be Newly Installed

Item	Labour College PS	Nyalenda STW PS
Design Flow (m3/min)	0.72	35.30
Number of Units	2 (including one standby)	3 (including one standby)
Capacity per Unit (l/sec)	12	295
Total Head (m)	9	2
Pump Efficiency (%)	50	65
Motor Power (kw)	3.7	11.0

(2) Wastewater Treatment Facilities

a. Conventional Sewage Treatment Works

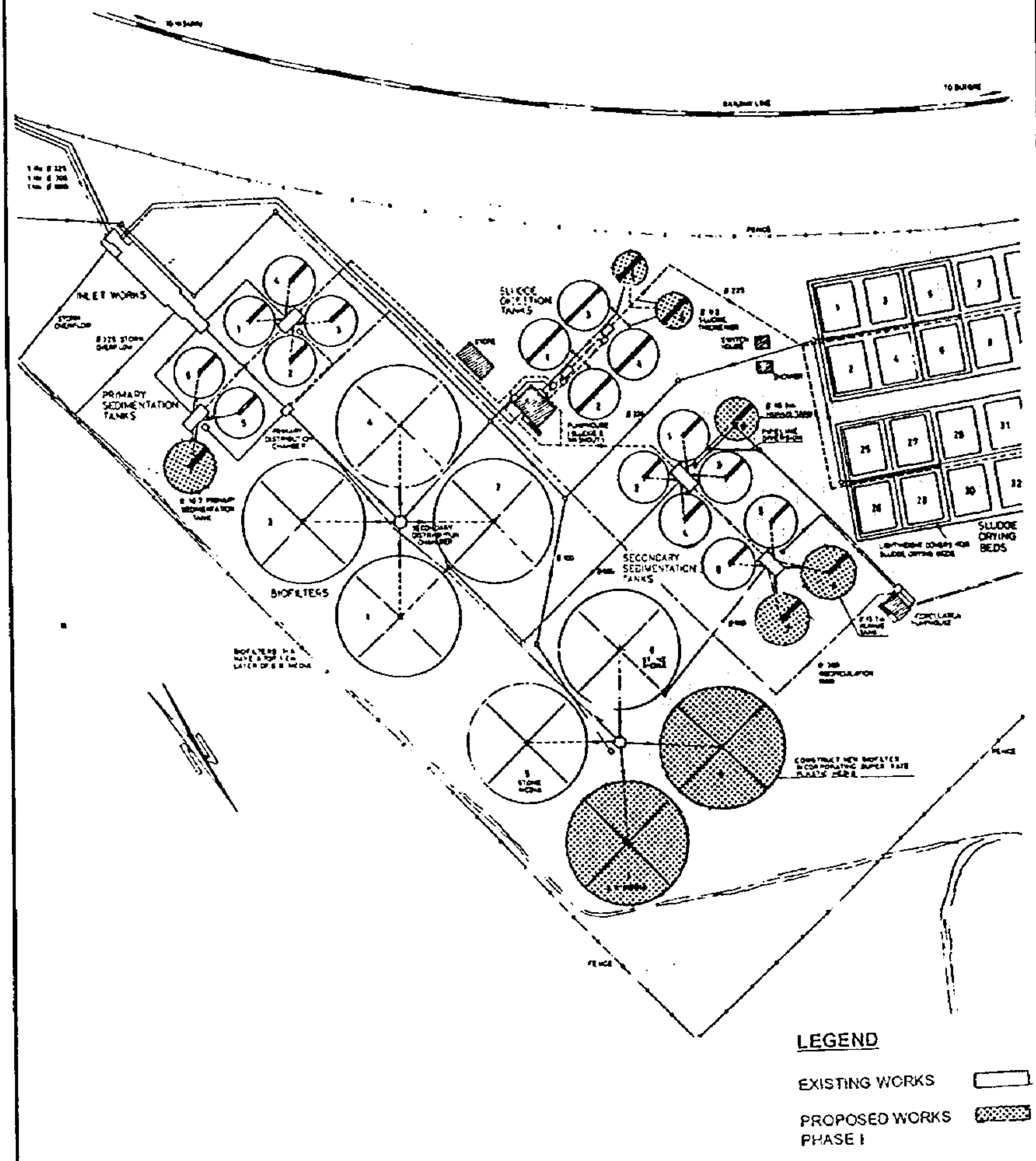
It is planned to expand the works to its ultimate design capacity under the Phase I Project. The works had originally been designed to treat a flow of 6,800 m^3/d. However further expansion is required to treat the projected inflows in year 2005. At the original design flows, the inlet, primary sedimentation tanks and secondary sedimentation (humus) tanks are operating within the design limits, however the biofilters are the limiting component and are operating at approximately twice the design loading and thereby achieving a very much reduced BOD removal rate. A layout of uprating the conventional treatment works to 2005 is shown in Figure 5-2.

1) Inlet Works

The grit channels and venturi flumes are adequate for projected future flows provided that 2 No. Channels are in operation at all times. The removal of grit from the channels is a hazardous and dirty operation. It requires opening a valve at head height, to alleviate this situation, extension downpipes need to be installed to the discharge pipes terminating about 200 mm above the collection area floor.

At present, the portion of inflow which is in excess of the design capacity passes through the screens and grit channels and is overflown downstream of the flumes over 2 No. Adjustable side weirs. It will be necessary to extend the existing inlet works by an adjustable overflow weir, incorporated into the proposed extensions (by-pass channel and wall rising).

Figure 5-2



THE REPUBLIC OF KENYA	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM	TITLE :
THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	JAPAN INTERNATIONAL COOPERATION AGENCY	CONVENTIONAL SEWERAGE TREATMENT WORKS UPRATING TO TREAT PHASE I INFLOWS

2) Primary Sedimentation

There are 6 No. 10.7 m diameter existing primary and sedimentation tanks arranged as follows; Nos. 1-4 to the West of the inlet works and Nos. 5 and 6 to the East of the inlet works.

An additional 10.7 m diameter primary sedimentation tank No. 7 adjacent to existing tanks 5 and 6 will be necessary to cope with ultimate flows. The present hydraulic arrangements where flow distribution is not in proportion to sedimentation area, can be retained without undesirable overloading of the eastern tanks.

3) Biofiltration and Secondary Sedimentation (Humus) Tanks

As noted previously all the existing treatment facilities are operating within limits except the biofilters which are operating above recommended capacity and hence not producing effluents to the requisite standards. At present there are 6 No. 30.0 m diameter x 1.8 m deep stone media filters and 6 No. 10.7 m diameter secondary sedimentation (humus) tanks. The required extensions to the biofilters to meet 2005 loads was considered and the option to construct 2 No. new biofilters (7 and 8) with SR media only and uprate filters 1-4 with 1.2 m layer of SR media and split flows 50% to 1-4 and 50% to 5-8 was chosen. The use of super rate (SR) plastic media which when compared to stone media is assumed to have an organic loading rate four times higher, i.e. for removal of a given weight of BOD, the volume of stone media required is four (4) times the required volume of SR plastic media. Three additional secondary sedimentation (humus) tanks will be required to meet the ultimate flows. Two tanks of 13.2 m and one tank of 10.9 m will need to be constructed.

4) Sludge Digestion

The existing sludge digestion system consists of 4 No. 12.2 m diameter x 4.7 m deep (liquid sidewall) open tanks providing standard rate anaerobic digestion of mixed primary and secondary (humus) sludges. Each digestor is fitted with 2 No. Submersible propeller mixing units. The existing digestor capacity is not adequate for ultimate flows by which time the retention times becomes too short for proper digestion. One method of overcoming the shortfall is to construct new digestors. However a different solution is proposed which is more economic. It is proposed that the combined sludges be thickened in thickening tanks prior to discharge into the digestors. The thickening tanks are similar to sedimentation tanks but are fitted with slowly rotating vertical thickening mechanisms (picket fence thickeners) which assist in sludge thickening and consolidation. It is estimated that the combined raw sludge can be thickened from less than 2% solids concentration to 4% thus effectively halving the bulk volume of sludge and precluding the construction of new digestors.

To meet ultimate flows 2 No. 9.2 m diameter thickening tanks will need to be constructed. Some alternations to the existing sludge pumping pipework will be necessary. However it should be possible to minimise any disruptions to digestor operations.

5) Sludge Drying

At present digested sludge is dried on 36 No. open drying beds with a total bed area of 4,320 m^2. During the 'dry season' the sludge dries to a friable cake within 1-2 days of being discharged onto the beds. The beds provide a mean drying time of 8.6 days at ultimate loadings (where sludge is thickened prior to digestion). Whilst these periods should prove adequate for most occasions, during periods of prolonged rainfall, difficulties may be experienced in drying sludge to a suitable consistency. To overcome these problems it is proposed that 10 lightweight moveable covers be provided. The covers would be constructed of corrugated perspex on a timber frame mounted on rollers or wheels to assist in moving units to various beds.

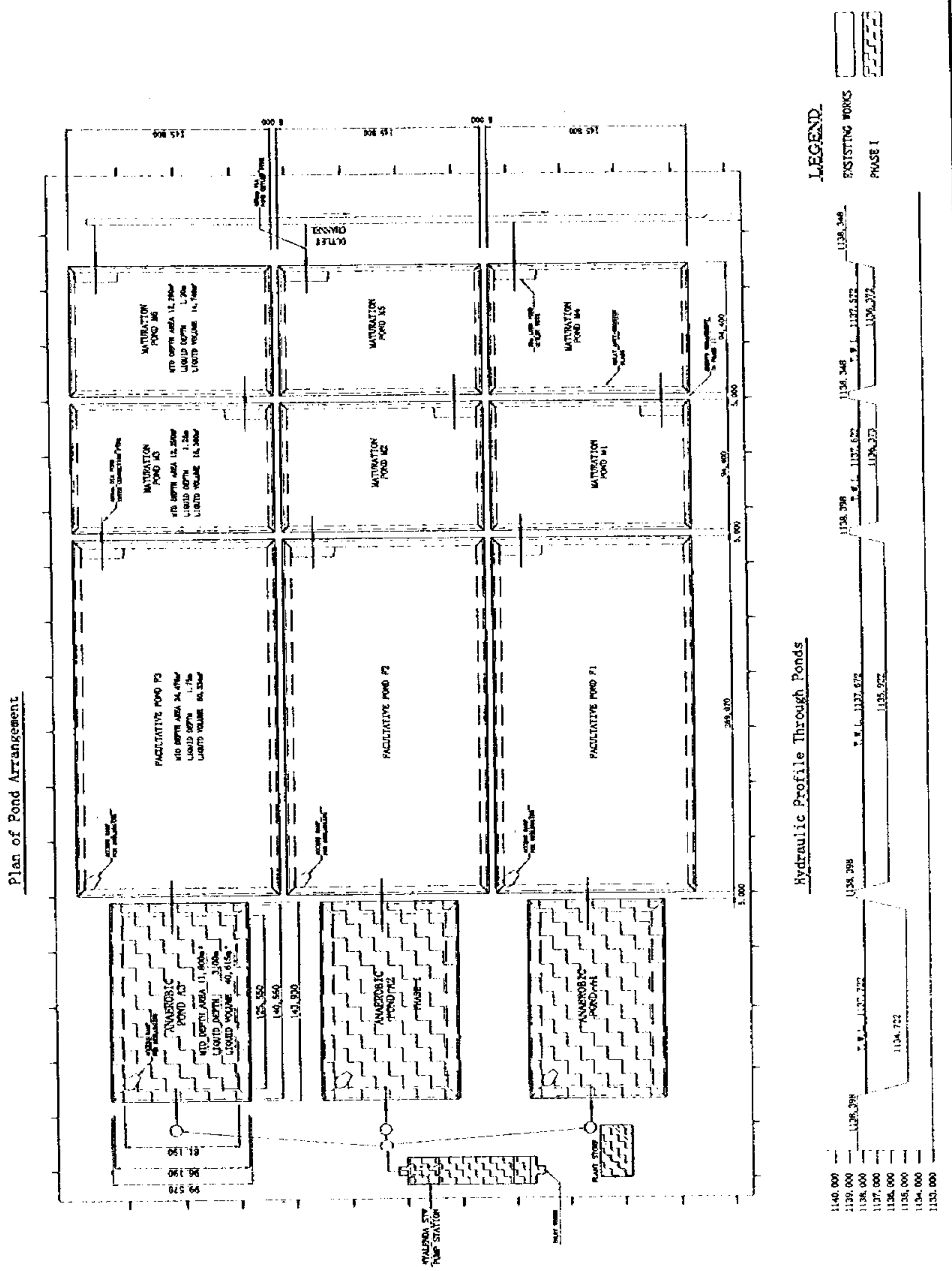
b. Nyalenda Waste Stabilisation Ponds

Extensions to these works will be undertaken Phase I to cover flows to year (2005). The Works need to be carried out as detailed in the following paragraphs. A plan of Phase I works is shown in Figure 5-3.

1) Inlet Works

The existing inlet works are characterized by their design eccentricities, a profusion of flow movement devices failing to achieve measurement or splitting. The parshall flume entrance attaining critical flow before the flume throat and the rectangular profile grit channels (controlled by the flumes) achieving mean velocities of less than 0.05 m/s at current mean inflow rates. It is essential that an inlet works be designed to remove screenings and grit and provide some method of flow measurement, be incorporated in the plant. As additional anaerobic ponds will be constructed under Phase I, new inlet works upstream of the new ponds need to be provided. These works will consist of 2 No. constant velocity grit channels, all controlled by 1 No. venturi flume. It is essential that the new inlet works, be designed to ensure minimum head losses thus allowing the new inlet and ponds to be inserted within the present hydraulic gradient. Flow division facilities will also be incorporated at the new inlet works.

Figure 5 - 3



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : NYALENDA WASTE STABILISATION PONDS PHASE I UPGRADING WORKS

2) Anaerobic Ponds

There are no anaerobic ponds at present at Nyalenda. It is proposed however, that for treating future inflows anaerobic ponds be employed upstream of the existing facultative ponds. Anaerobic ponds have the advantage of treating industrial wastewaters and significant destruction of faecal coliform. The design of anaerobic ponds has to be carefully controlled to minimise odour production and to allow desludging at reasonable intervals without overloading the downstream process. These aims should be achieved using the designated loading rates and retention periods. 3 No. Anaerobic ponds in parallel will be provided to suit 2005 demands. Each pond will be served individually from the new inlet works and will discharge to the downstream facultative ponds in series.

3) Facultative Ponds

At 2005 inflows with the upstream anaerobic ponds achieving 70% BOD removal, the existing ponds, despite a reduction in hydraulic retention time should produce an effluent of 50 mg BOD/l concentration. This will allow adequate polishing in the maturation ponds to ensure that the final effluent complies with the desired standards.

4) Maturation Ponds

Maturation ponds have two principal functions, firstly to polish the facultative pond effluent to the requisite BOD and SS concentrations, secondly to destroy faecal coliforms, and other bacteria, to protect the receiving watercourse. The existing 6 No. pond arrangement comprised of (3) parallel series of 2 No. Ponds will at present day loadings produce a final effluent of less than 20 mg BOD/l filtered and a FC concentration of around 1000 FC/100 ml.

The provision of anaerobic ponds for 2005 loadings sufficiently reduces the loadings on the maturation ponds producing a final effluent standard of less than 800 FC/100 ml concentration.

Because of the minimal hydraulic head available between the facultative and maturation ponds and between the maturation ponds in series it will be necessary to replace the existing ND 450 pond interconnection pipes with ND 600 mm pipes to cater for predicted 2005 flowrates.

5.2 COSTS FOR IMPROVEMENTS

5.2.1 Rehabilitation Works Components

The works included in the Rehabilitation Works Component were grouped into two packages. Table 5-6 shows a summary of the direct construction costs estimated for each of those packages. Detailed breakdown of the costs are provided in the Appendix R for each package.

Table 5-6 Cost for Rehabilitation Works Components (1997 price)

Package No.	Description of Work	Construction Base Cost (1,000 US$)
RS-S1	• Supply and Installation of Equipment for Rehabilitation of Existing Conventional STW, Nyalenda STW • Supply and Installation of Equipment for Rehabilitation of Existing Three Pump Stations, namely Sunset Hotel, Kendu Lane and Mumias Road Pump Stations	454
RS-C1	• Rehabilitation of Existing Conventional STW and Nyalenda STW • Rehabilitation of Existing Trunk Sewers in Eastern WTD (CP 375 mm, L=0.42 km)	934
Total		1,388

5.2.2 Expansion Works Components

The works included in the Expansion Works Component were also grouped into several packages. Table 5-7 summarizes the costs estimated for each of those packages. Detailed breakdown of the costs are provided in the Appendix R for each package.

Table 5-7 Cost for Expansion Works Component (1997 price)

Package No.	Description of Work	Construction Base Cost (1,000 US$)
ES-S1	• Supply and Installation of Equipment for Conventional STW and Nyalenda STW • Supply and Installation of Equipment for Construction of New Labour College Pump Station and Nyalenda STW Pump Station	957
ES-C1	• Installation of Trunk Sewers: Eastern WTD (uPVC & CP 125 to 1,100 mm, L=22.7 km) Central WTD (uPVC & CP 250 to 400 mm, L=2.6 km)	3,942
ES-C2	• Installation of Branch Sewers in Eastern and Central WTDs (uPVC 200 mm, L=127 km) • Supply of shallow sewer pipes (uPVC 100 mm, L=91 km)	5,524
ES-C3	• Expansion of Conventional STW and Nyalenda STW • Construction of Labour College Pump Station and Nyalenda STW Pump Station	2,423
Total		12,846

5.2.3 Total Costs for Sewerage Improvements

The total cost for the sewerage improvements under the Phase I Project was estimated as the summation of the costs for the rehabilitation component and expansion component. as shown in Table 5-8 .

Table 5-8 Cost for Phase I Sewerage Improvements (1997 price)

Work Component	Construction Base Cost (1,000 US$)
Rehabilitation Works Components	1,388
Expansion Works Components	12,846
Total	14,234

CHAPTER 6

STRENGTHENING OF INSTITUTIONAL CAPACITY

6. STRENGTHENING OF INSTITUTIONAL CAPACITY

6.1 PROJECT IMPLEMENTATION

The loan for the project will be on a government to government basis, with the ultimate borrower being KMC. KMC will therefore be the executing agency for the project and as such, responsible to MOLA for the implementation of the project.

Neither KMC nor the WSD have the capacity to provide for the proper implementation and control of a project of this magnitude, therefore a Project Implementation Unit (PIU) will have to be set up. This PIU may be established in a similar manner to the secretariat set up within MOLA to manage the KLGRP in association with a number of consultants.

As part of the Phase 1 project, consultancy services, computers, and other equipment is being provided for Management and Institutional improvement. This consultancy would combine well with the duties of the PIU which is to be responsible for the technical and financial co-ordination of the project.

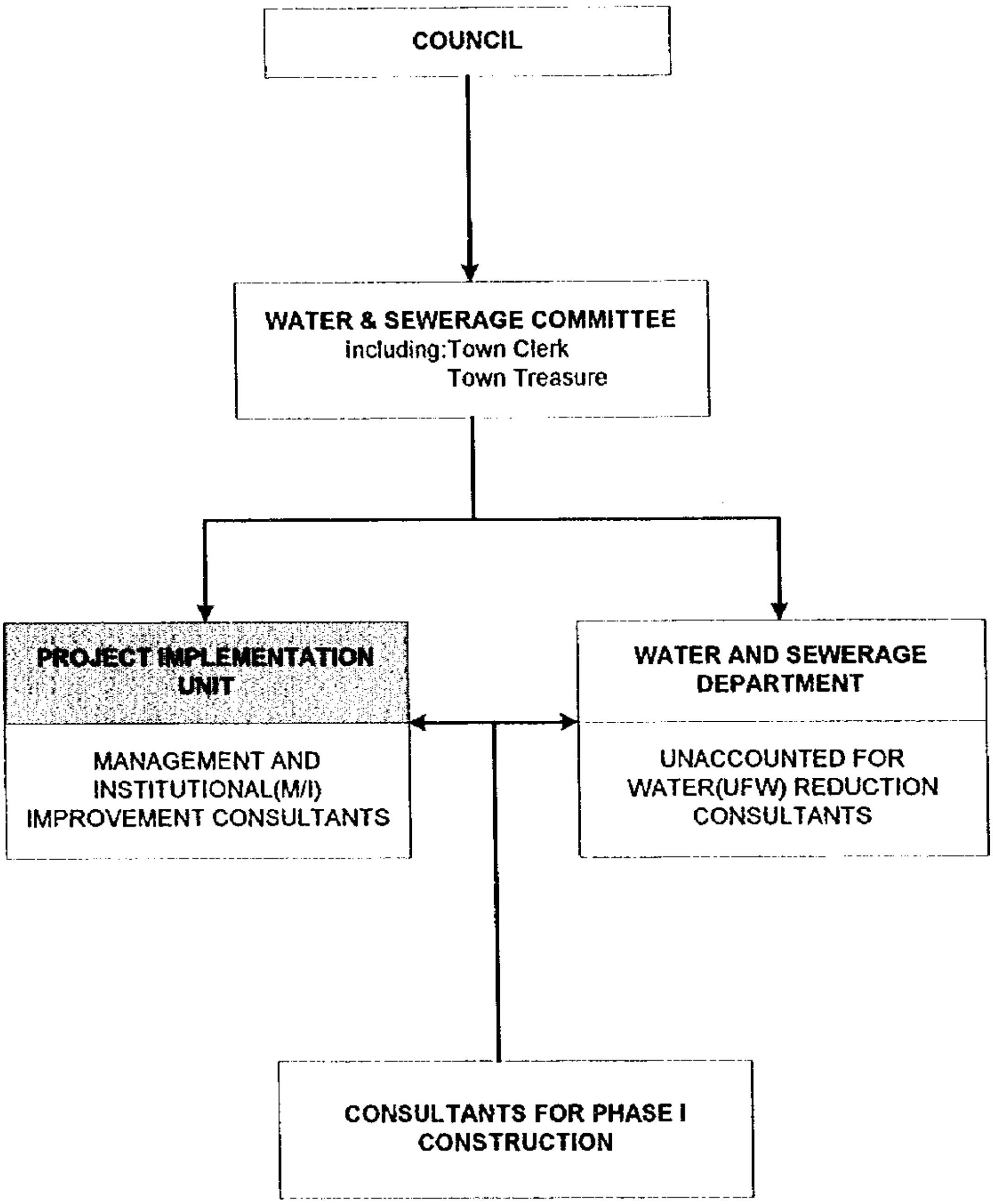
The PIU would be responsible to the water and sewerage committee, leaving the WSD free to concentrate on improving operation and maintenance, and to co-ordinate the Unaccounted for Water (UFW) Reduction Programme, which includes replacing all 11,000 existing water meters.

The Water and Sewerage Committee should include the Town Clerk and Town Treasurer amongst its members. Figure 6-1 shows the proposed institutional framework for project implementation.

KMC must progress with the formation of an autonomous WSD, and when this department has been strengthened sufficiently under the Management/Institutional improvement consultancy, it may then be converted to a commercialised company.

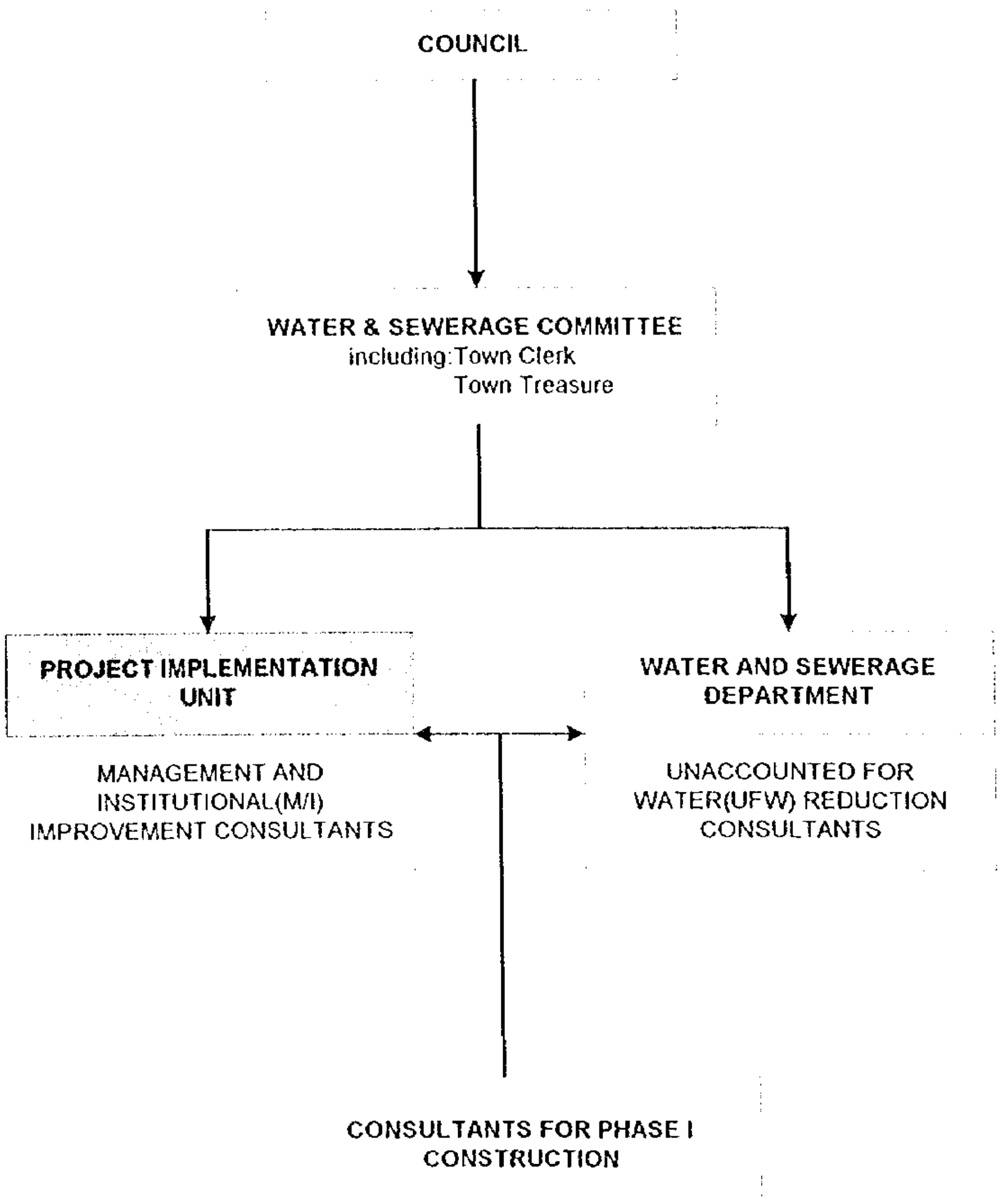
The proposed structure of the WSD, which may move forward to company status is given in Figure 6-2. The Engineering Division will not be required until the commissioning of Phase 1 since all WSD work up to that time will be augmented by the PIU and the M/I consultants, plus the UFW programme. Planning, design and construction will initially be required for the many individual household connections required from 2003 onward.

Figure 6-1



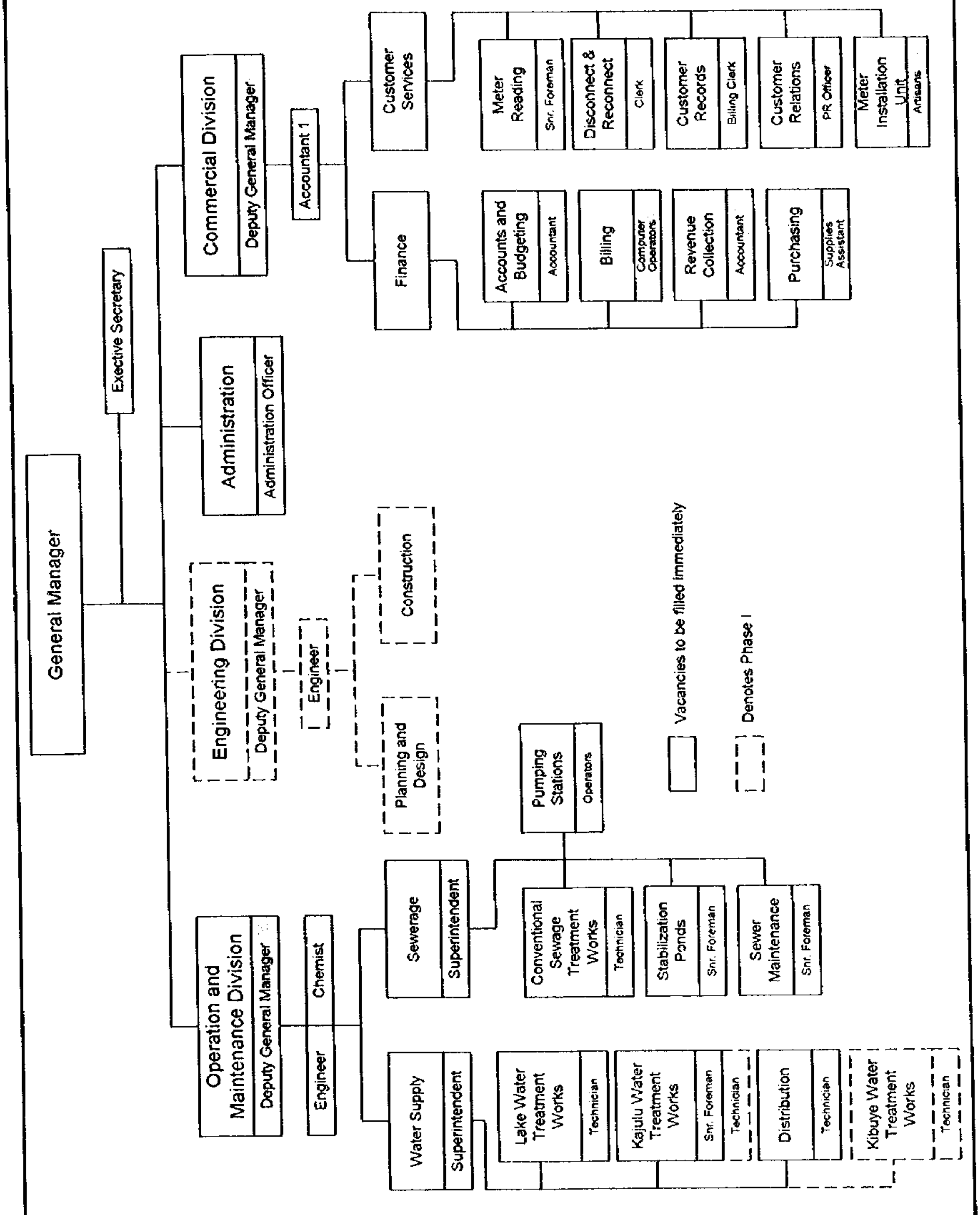
THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : PROPOSED INSTITUTIONAL FRAMEWORK FOR PROJECT IMPLEMENTATION

Figure 6-1



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL AUTHORITIES KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : PROPOSED INSTITUTIONAL FRAMEWORK FOR PROJECT IMPLEMENTATION

Figure 6-2



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : PROPOSED STRUCTURE OF THE WATER & SEWERAGE DEPARTMENT

6.2 OPERATION AND MAINTENANCE

(1) General

Operation and maintenance (O&M) has been a sadly neglected area for many years. Disillusionment has crept in and lack of funds over many years is often cited for the unacceptably poor state of affairs. Strengthening of capacity to deal with O&M will not only depend on the availability of finance but on correct staffing levels, transport and equipment, and also on the attitude of management and the workforce to the task in hand. O&M improvement is starting from a very low level and everyone will require motivating if rapid improvements are to take place.

(2) Water Supply

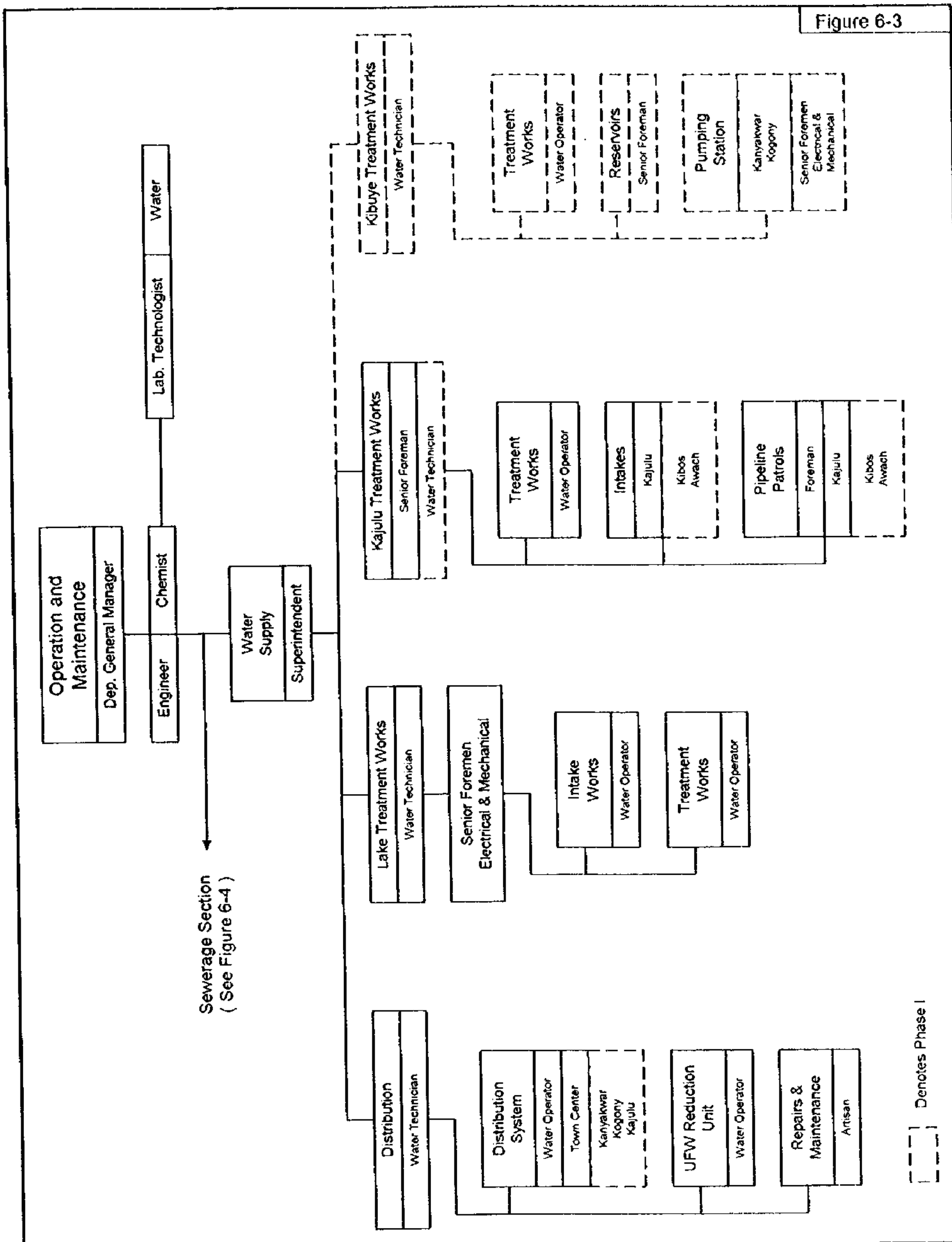
The proposed organisation chart is given in Figure 6-3. When key posts are filled, the Water Section will operate under the DGM (O&M), an Engineer and a chemist who are also responsible for the Sewerage Section. A Water Superintendent will be responsible for the day to day running of the entire water section. Capacity strengthening for each unit of the water supply section is described below.

- **Water quality**

An Operational plan must be developed by the laboratory technologist to effectively control, monitor, and record all water quality procedures. A detailed plan must be drawn up by the laboratory technologist for approval by the chemist and cover raw and treated water from all source works, samples from clear water tanks and reservoirs, and the distribution system. Tests should cover physical and chemical analysis, bac. testing and chlorine residual at the laboratory in the conventional Sewerage Treatment works which will require refurbishing. Some of the testing will have to be carried out at external institutions, until such times as adequate equipment is available through the Phase I project.

The initial quality control plan must detail the full laboratory requirements for purchase of the necessary equipment in Phase I.

Figure 6-3



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : PROPOSED STRUCTURE OF THE WATER SUPPLY SECTION

- **Lake Intake and Treatment Works.**

Day to day control of these facilities will be the responsibility of a Water Technician reporting to the Water Superintendent, who will advise on the treated water volume periodically required.

The water technician, in conjunction with relevant staff must draw up an operation procedure, and maintenance schedule for all items of plant under his supervision. This should be passed to the DGM (O&M) for approval.

These works are scheduled for rehabilitation and expansion in Phase I. Operating procedures and maintenance manuals will be provided for the new works, and staff will be trained on the job prior to the handing over of the works.

Responsibility for correct operation and regular routine maintenance will rest with the Water Technician.

- **Kajulu**

These works, being smaller than the lake facility and having less water treatment problems are currently under the control of a Senior Forman. Once again, operational procedures and maintenance schedules should be drawn up if the originals can not be found.

These works will be expanded in Phase I, and the Kibos and Awach Rivers will become the major source of water for Kisumu via two new intakes and new raw water pipelines to Kibuye, which will become the major location for water treatment.

The post at Kajulu should be upgraded to Water Technician at Phase I, and responsibilities will include the operation and upkeep of both new intakes and pipeline patrols on the new water mains, in addition to the expanded Kajulu facility.

- **Distribution**

The distribution network is to be headed by a Water Technician. At present a considerable area of the network is dry due to demand far outstripping supply, and the many connections off the lake treatment works rising main originally designed for direct pumping to Kibuye. Kibuye reservoir now rarely receives water in any significant amounts for distribution to consumers. No expansion is possible until further source works are developed.

During 1998/99, the concentration must be on an operational plan to restore direct pumping to Kibuye for fairer distribution of water to a greater number of consumers by a rationing system of intermittent supply. Following on, a task force must be created for the UFW reduction programme to commence in the year 2000.

In phase I, some 49 kms of trunk distribution mains and 330 kms of secondary main will be added to the system by 2002, as the supply is increased by about 50,000m3/day. It is therefore essential that the framework of the distribution sub-section be firmly established prior to year 2000. Areas of responsibility must be clearly defined for the senior foreman to control separate units for management of the distribution system for intermittent supply, UFW reduction and also repairs and maintenance. The old distribution system will be stressed when the new works come on stream and the whole system is once again pressurised.

Phase I will see the introduction of two new distribution zones to be fed from the new reservoirs at Kanyakwar and Kogony. Kajulu will also supply an isolated area.

- **Kibuye Treatment Works**

The new treatment works will be located at the present site of the Kibuye reservoirs and pumping stations. In Phase I, this area will become the nerve centre of operations with the reservoirs receiving treated water from the upgraded lake treatment works, and the treatment works receiving raw water from the new Kibos and Awach intakes. Water will mainly be distributed by gravity, but there will also be pumping facilities to supply Kogony and Kanyakwar zonal distribution reservoirs.

It is planned to locate the headquarters for the new WSC at this location, hence in-depth control of operations will be available, and the complex may be operated by a Water Technician. Staffing similar to that at the lake treatment works will be required.

An operational plan will be developed during the construction and commissioning of the new works to deal with the large increase in supply volume, which will require control of treatment works output and reservoir levels.

All new works will be handed over with operating procedures and maintenance schedules, and staff will be trained on the operations of the complex prior to handling over.

(3) Sewerage System

- General

The organisation chart is given in Figure 6-4. Currently the whole sewerage system is in a poor state of repair and poses a health hazard to the population as well as adding to the pollution of Lake Victoria. The sewerage collection system does not function correctly with many blockages, and neither the conventional treatment works nor the stabilisation ponds operate effectively.

An immediate improvement is required to the operation and maintenance of the system prior to the rehabilitation and expansion of the sewerage system in the Phase I works.

The sewerage section will operate under the DGM (O&M), an Engineer and a chemist who are also responsible for the water section. A Sewerage Superintendent will be responsible for the day to day running of the entire sewerage section. Capacity strengthening for each unit of the sewerage section is described below.

- **Quality Control**

The existing laboratory at the conventional works will be re-equipped as part of the Phase I works. This laboratory will be used as a central laboratory to cater for the water and sewerage sections.

A plan must be developed for the regular monitoring of the influent and effluent by sampling and testing. Each of the major industries must be visited and their pretreatment facilities (if any) inspected and tested. The existing pollution laws are scheduled to be strengthened and it should be possible to enforce strict control of industrial waste discharge. All industries must be advised of the standards to be met for discharge into water course, and into the piped sewerage system to enable the refurbished sewerage treatment works to operate effectively and achieve the effluent standards required.

- **Conventional Sewerage Treatment Works**

Overall operation of the works should be controlled by a sewerage technician whose responsibilities will also include operation and maintenance of the sewer network and the stabilisation ponds. Control of the works will rest with a senior foreman who must do his utmost to improve the quality of the effluent with the resources available prior to rehabilitation. A maintenance schedule is available and reproduced in Appendix K. This should be followed to improve the efficiency and effectiveness of the works.

Upon completion of rehabilitation and expansion, operating procedures and maintenance manuals will be prepared and the staff trained on the job prior to hand over of the works.

- **Nyalenda Stabilisation Ponds**

Control of the works rests with a senior forman under the guidance of the sewerage technician. Operation of the ponds must be brought back to normal with a programme to clear the water hyacinth and accumulated sludge. Clearly there has been no effective maintenance for many years to what originally was the easiest of labour intensive tasks. A pond maintenance record sheet, which may be followed now, is given in Appendix K. Rehabilitation of the works in Phase I will include operating and maintenance manuals and on the job training.

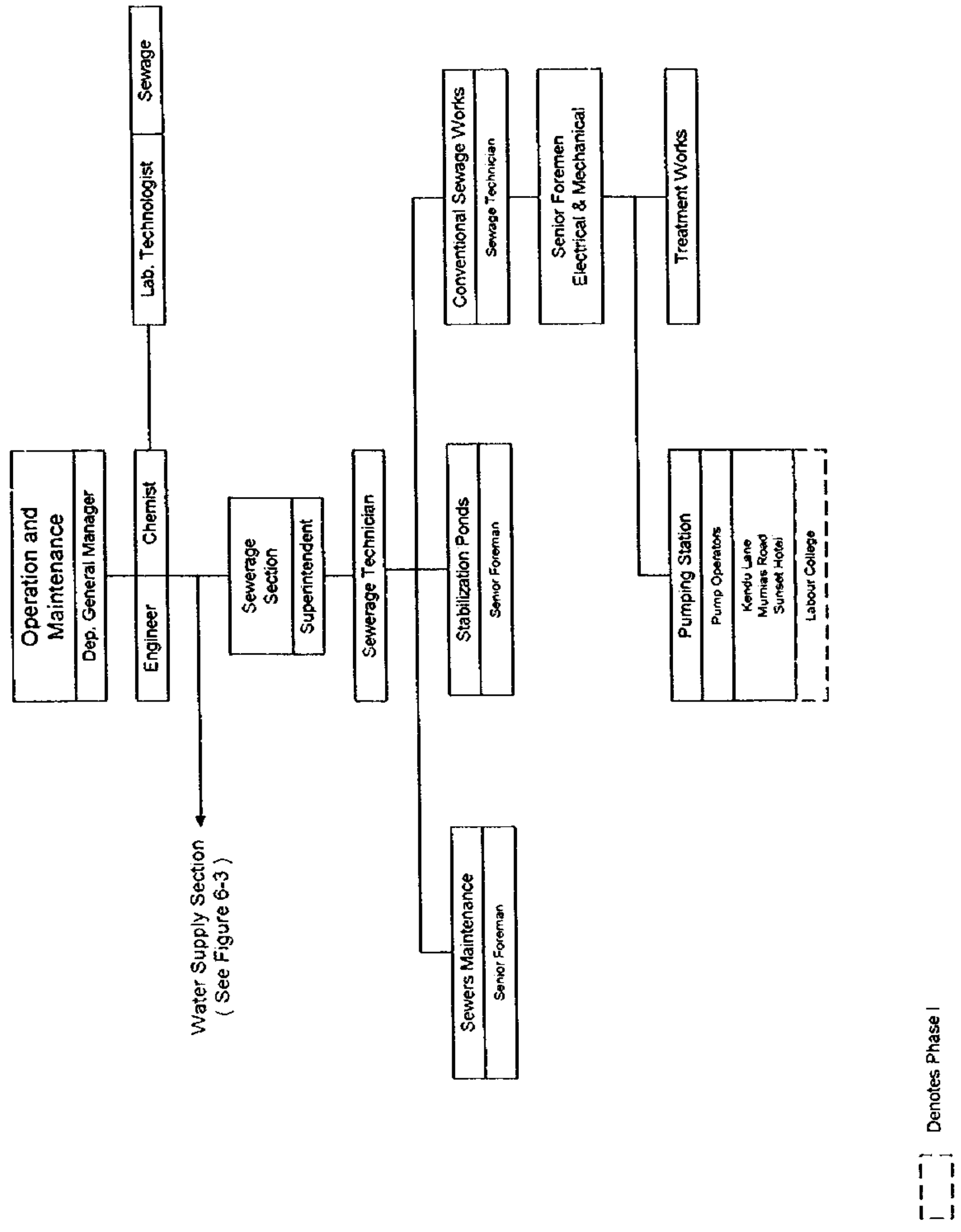
- **Sewers**

The operational area of the sewerage system has shrunk in line with the dry areas of the water distribution systems. The central wastewater treatment district (CWTD) functions reasonably well. However, if the plan to bring other districts back on the water supply by a system of rationing is a success, then more sewers will be activated in the CWTD with intermittent flow. There must be careful co-ordination with the water section on this matter and the sewerage section must be prepare to act on any malfunctioning of these sewers.

Wastewater from the CWTD is treated at the conventional sewerage works and three pumping stations are incorporated in the network. None of these station are operational and they will be rehabilitated in phase I and strengthened by the addition of the new labour college pumping station.

Most of industry and commerce is connected to this system and the operation and maintenance personnel should co-operate with the laboratory staff on industrial wastewater.

Figure 6-4



THE REPUBLIC OF KENYA THE MINISTRY OF LOCAL GOVERNMENT KISUMU MUNICIPAL COUNCIL	THE STUDY ON KISUMU WATER SUPPLY AND SEWERAGE SYSTEM JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE : PROPOSED STRUCTURE OF THE SEWERAGE SECTION

The Eastern Wastewater Treatment District (EWTD) discharges to the Nyalenda Stabilisation Ponds. The sewer network is in poor operational condition, with collapsed and overflowing sewers in many locations. This has created unacceptable health hazards and an urgent inspection and repair programme in required before the sewer network is extended in Phase I, and the trunk sewer to Nyalenda is rehabilitated.

The sewerage maintenance division is headed by a senior foreman who will report to the sewerage technician. The Sewerage Technician must carry out a systematic inspection of all sewers, and draw up a plan for the necessary remedial works to the network. The plan should be prioritised to attend to serious health hazard areas first.

6.3 COST RECOVERY

(1) General

Effective cost recovery is a prerequisite for the success of an autonomous, sustainable WSD which must provide an effective service to its customers. Although attempts at forming an autonomous department have been made, the WSD finances remain an integral part of the Town Treasurers Department. The Commercial Division is responsible for the financial well being of the WSD and the proposed organisation chart showing this division is given in Figure 6-2.

Based on the estimated treatment works output, monthly average billing could be increased from KES 11.5 million to KES 17.0 million per month, which would provide for adequate transfers to the council's General Fund, and increased finance for improved operation and maintenance. This clearly demonstrates the urgent need to correctly staff this division.

Critical to improvement of cost recovery are the meter section, billing and revenue collection, and these should be strengthened.

(2) Meter Reading

This is a major problem area in the WSD. It is badly run, poorly controlled, inadequately housed and ill equipped to function as the vital first step to cost recovery. The unit should be headed by a thoroughly reliable Senior Foreman who must be allowed to operate without interference to ensure the regular and accurate reading of all of the 1,000 or so water meters which appear to form the basis of the present revenue available to the WSD.

He should head a team of meter readers whose size will depend upon the availability of transport to the meter reading areas. Each person should be able to read about 20 meters per day now (about 500 per month), this will increase with better efficiency and transport.

The consultancy work currently in progress on Block Mapping will form a data base of the entire metering system. On completion of this exercise by late 1998, a programme of improvements to metering must be drawn up to increase the number of meters read, and to repair meters with minor faults.

When the plan to provide water on an intermittent basis is implemented, then staff numbers may be increased to cope with the increased number of meters to be read. By the end of 1999, the meter reading system should be in a state of readiness to facilitate the commencement of the meter replacement programme in Phase I which is scheduled to replace all 11,000 existing meters with 20% in year 2000, 40% in 2001, and 40% in2002. Replacement will be undertaken by a WSD special task force to be set up by the special consultant appointed for the Unaccounted for Water Reduction Programme.

When the Phase I project comes on stream at the end of 2002 suppressed demand can be satisfied and the number of connections is expected to increase to about 21,000 by 2003, 31,000 by 2004 and 42,000 by 2005. The demand for new connections will therefore be about 40 per day which would require a much increased task force. The use of private contractors to augment, or even replace the task force must be considered as a means of rationalising costs and encouraging private sector participation. Contractors would need only to be regulated and controlled by the WSD to ensure quality of materials and workmanship. Details of the replacement, installation and reading of water meters is shown in Table 6-1.

(3) Billing and Revenue Collection

Of equal importance to proper meter reading, is the billing process and revenue collection derived from it. The present system of multiple checking during computer processing is inefficient and ineffective in picking up errors and must be streamlined. The present computer system for billing will suffice in the short term, and will be replaced as part of the Phase I consultancy work.

The first step in strengthening these units is complete separation from the other activities of the Town Treasurers Department. It is possible to process the water accounts and collect the revenue separately whilst working within the present revenue section in the Town Hall. The next step must be the modification of the billing records from accurate information resulting from the block mapping exercise.

This should ensure a greater degree of billing accuracy and increased revenue collection during 1998/99 prior to the commencement of Phase I. As part of the Phase I project, a new computer system is to be purchased and the Management/Institutional consultant will include the preparation and introduction of a computerised commercial accounting system, which will ensure efficient revenue collection.

Table 6-1 SERVICE CONNECTIONS - WATER METER INSTALLATION AND READING

Note No.	ITEM	YEAR 1999	2000	2001	2002	2003	2004	2005
	Number of connections							
	Industry & Commerce	85	85	85	85	111	116	121
	Public	153	153	153	153	199	208	218
	Individual Households	10,762	10,762	10,762	10,762	21,059	31,415	41,769
	Total number of connections	**11,000**	**11,000**	**11,000**	**11,000**	**21,369**	**31,739**	**42,108**
1	Replace existing 11000 meters	Nil	2200	4400	4400			
	Instal new meters	Nil	Nil	Nil	Nil	10369	10370	10369
	Number of meters per day		**15**	**15**	**15**	**35**	**35**	**35**
2	- Insallation by WSD		15	15	15	8	8	8
3	- Installation by Private Sector					27	27	27
	Number of meters to read			11,000	11,000	21,369	31,739	42,108
	Number of meter readers			22	22	27	30	32
4	Meters read per person/day			20	20	30	40	50

Notes

1 Meter replacement commences second half of year 2000 under UFW Reduction Consultancy

2 Meter replacement 2000-2002 by 3 teams completing 5 per day
Meter Installation 2003-2005 by 4 teams completing 2 per day

3 Meter Installation 2003-2005 by private sector contractors to WSD

4 Improved transport and efficiency = more readings per day (Alternative - Contract out to private sector)

Table 6-2 LOCATION AND DETAILS OF COMMON TAPS - (WATER KIOSKS) AT YEAR 2005

Sub - location		Population served by Common Taps				Ave. Daily Domestic Water Demand				Total Ave. Water Demand	No. of Common Taps @	No. of Kiosks
		Urban	Peri-Urban & Rural			Urban	Peri- Urban & Rural					
		High 20 l/c/d	High 20 l/c/d	Medium 20 l/c/d	Low 15 l/c/d	High m3/day	High m3/day	Medium m3/day	Low m3/day	m3/day	6m3/tap/day	Maximum 4taps/Kiosk
Urban	Kibuye	3 101	0	0	0	62	0	0	0	62	12	3
	Milimani	1 635	0	0	0	33	0	0	0	33	7	2
	Kanyakwa	3 970	0	0	0	79	0	0	0	79	16	4
	Sub-total	**8 706**	**0**	**0**	**0**	**174**	**0**	**0**	**0**	**174**	**35**	**9**
Peri-Urban	Nyalenda	0	442	5 038	24 308	0	9	101	365	475	95	24
	Manyatta	0	519	6 736	32 497	0	12	135	487	634	127	32
	Kasule	0	191	2 179	10 514	0	4	44	158	206	41	10
	Wathorego	0	78	895	4 319	0	2	18	65	85	17	4
	Korando	0	172	1 958	9 447	0	3	39	142	184	37	9
	Kogony	0	180	2 054	9 908	0	4	41	149	194	39	10
	Sub-total	**0**	**1 664**	**18 860**	**90 993**	**0**	**33**	**377**	**1365**	**1776**	**355**	**89**
Total Urban & Peri-Urban		**8 706**	**1 664**	**18 860**	**90 993**	**174**	**33**	**377**	**1365**	**1949**	**390**	**97**
Rural	Chiga	0	2	18	88	0	0	0	1	1	0	0
	Nyalunya	0	10	114	550	0	0	2	8	10	2	1
	Kadero	0	9	102	492	0	0	2	7	9	2	0
	Okok	0	4	43	209	0	0	1	3	4	1	0
	Konya	0	44	500	2 410	0	1	10	36	47	9	2
	Sub-total	**0**	**69**	**777**	**3 749**	**0**	**1**	**16**	**56**	**73**	**15**	**4**
	Total	**8 706**	**1 723**	**19 637**	**94 742**	**174**	**34**	**393**	**1421**	**2022**	**404**	**101**

Notes

1 See Master Plan Fig. 1-1 for location

2 Ave. number of persons per tap per day = 250

3 No. of kiosks per sub-location may be increased if walking distance is excessive

4 Each multiple tap kiosk to be served by 1 water meter

5 Kiosks to be owned by WSD and leased to Agents or communities

6 Water tariff to be shs 25/m3; controlled selling price shs 50/m3 (shs 1/ 20 litres)

7 Kiosks to be constructed as part of Phase 1 project

8 Implementation; 100 kiosks in year 2001; 100 in 2002; 150 in 2003; balance in following years

6.4 UNACCOUNTED FOR WATER REDUCTION PROGRAMME

Presently, there is very little action in this vital area and a special programme is included as part of the Phase I project to strengthen and develop the capacity to deal with unaccounted for water (UFW).

This programme will comprise a special consultancy service for reduction of UFW in the municipal water supply system and the procurement of water meters and leakage detection/repair equipment.

Under the programme, a total of 11,000 analogue type water meters will be procured to replace about the same number of digital type water meters currently existing within the municipal water supply system. The replacement work itself will be undertaken by the WSD's own work force following the time schedule and area priority to be recommended under the special consultancy service. In addition, equipment for leakage detection/repair will also be procured under the programme. This equipment will be for use by the WSD's special task force for leakage reduction who will pursue the time schedule, area-wise priority and targetted reduction rates to be recommended under the consultancy services mentioned above.

The consultancy service will also produce recommendations with respect to the other components of UFW, such as illegal connections, meter reading, billing and revenue collection, all with a view to reducing the present high UFW in Kisumu. Where necessary, the recommendations will be accompanied by format specimens for recording and reporting.

6.5 CUSTOMER SERVICES AND PUBLIC RELATIONS

Customer services and public relations is a section of the Commercial division and presently comprises three units, being meter reading, disconnection and reconnection, and customer records. To strengthen this section a meter installation and repair unit, and public relations unit must be added.

As detailed in section 6.3 (ii) there will be rapid expansion of the number of meters, hence an increase in the work load of the disconnection/reconnection unit and customer records unit. This should not lead to an immediate increase in staff numbers as the present work load is low, except for customer records which must be updated in accordance with the block mapping exercise to be completed in late 1998, which will rationalise records for the existing 11,000 meters. The exercise on the existing system should be completed by the end of 1999.

On the commencement of the Phase I project the consultants responsible for the UFW reduction programme will play a leading role in recommending further changes to strengthen the customer services section, as their work will involve such matters as illegal connections and improved meter reading and billing.

An important addition to the section will be the Public Relations unit. A public relations officer should be appointed as soon as possible to develop a good relationship with customers. This is particularly important, as many issues will soon arise from the block mapping exercise, and on completion of Phase I, the public relations unit will also deal with the thousands of new connections required.

About 400 common taps will be installed as part of the Phase I project, by constructing about 100 multiple tap Kiosks. It is recommended that Kiosks be operated by Agents, or Communities. This will require the drawing up of lease agreements and the careful control of the operation, hours of opening, and the selling price. The location of, and information on, common taps and kiosks are shown in Table 6-2.

Phase I will also include the installation of sewers in the peri-urban areas suitable for connection to shallow sewer schemes. The installation of shallow sewer networks will require a high degree of community participation and there will a need for public relations to explain the costs and benefits to community groups. Shallow sewer schemes will commence in the year 2003 on completion of the sewerage system in Phase I.

6.6 TRAINING AND CONSULTANCY SERVICES

(1) Consultancy Services

The Phase I project provides for two important consultancies namely:

- Unaccounted for Water (UFW) Reduction Programme
- Management/Institutional (M/I) Improvement

The UFW reduction programme provides a unique opportunity for capacity building within the WSD. This programme, detailed in section 6.4, will establish special task forces for a complete meter replacement programme, and for leak detection and repair. These task forces will be particularly valuable when phase I comes on stream as a large programme for new connections is required, and system leakage is likely to increase considerably with increased pressure.

Under the M/I improvement programme, the PIU will be set up in close co-operation with the KLGRP secretariat of MOLA.

The most important service to be provided is a management consultancy to fully establish the WSD as a commercially oriented department which may be carried through to the formation of a commercialised company (WSC)

This consultancy will liaise closely with the UWASAM project of the UDD in MOLA, as they have already provided a framework for the establishment of WSC's in the pilot towns of Eldoret, Kericho, and Nyeri.

Services to be rendered under the management consultancy may be summarised as follows:

- Provide assistance in the recruitment of senior management for the WSD
- Finalise the staffing structure, terms and conditions of service, and salaries
- Assist and advise on the preparation of the annual budget
- Assist and advise on the preparation of a 5 year corporate plan
- Advise on commercial objectives and strategic plans
- Prepare and introduce a computerised accounting system

- Provide advice on management matters, business, and commercial accountancy

The M/I improvement programme will also provide the legal documentation for the change to a private company wholly owned by KMC, and for a valuation of assets and liabilities should this be necessary. Again a framework for these services already exists within UDD, such services having already been provided under the UWASAM programme for the three pilot towns.

(2) Training

The basic framework for training may be sub-divided into 3 major areas namely:-

- On the Job Training
- Local Training for Technical Staff
- Overseas Training for Management Staff.

On the Job (OTJ) training will be achieved by a variety on inputs. Initially, the Management/Institutional Consultants will liaise closely with the staff of the PIU and WSD on its services in the fields of recruitment, staffing structure, Annual Budget and Corporate Plan preparation, and the preparation and introduction of a computerised commercial accounting system.

In parallel with the above, OTJ training will be provided under the UFW reduction programme, with the establishment of the special task forces for meter installation and leak detection/repair. Training on personal computers for this programme will also be provided.

Further OTJ training will be provided during the Phase I project, when the staff of the WSD are seconded to the construction contracts. In addition, on completion of all new works, operatives will receive training on operation and maintenance during the commissioning period.

Training for the majority of the Technical Staff is available within Kenya and centered on the Kenya Water Institute (KEWI) in Nairobi. Due to the large number of vacancies that exist within the WSD, it is not possible to draw up a staff training list at this point in time, this will be done under the M/I improvement programme.

Capacity building at KEWI has been on going for sometime with a GTZ project, and more recently, the involvement of the French government in the training component of their overall Human Resources Development Plan.

As the staffing situation in the Kisumu WSD stabilises, technicians and operatives may be identified for short course available at GTZ/KEWI. Courses can be tailor made to suit the needs, and these highly appropriate and practical courses should commence as soon as staffing condition allow.

In addition to the specialised course referred to above , other course are, or will become available, at KEWI and other establishments and examples of these are given in the following tables.

Short courses which exist at present are as follows:-

POST	COURSE TITLE	*INSTITUTION
General Manager	Effective Management and Public Relations	KIM KIA ESAMI
	Water and Wastewater Management	Unai MoiU JKUAT KEWI
	Environmental Management	Unai MoiU JKUAT KENU
Deputy General Manager (Commercial)	Financial Management	KEWI, MMI KIA
Sewerage and Water Superintendents	Effective Management and Public Relations	KIA KCCT KIM
Meter Readers	Meter Reading	KEWI

*KIM	Kenya Institute of Management
KIA	Kenya Institute of Administration
ESAMI	East & Southern Africa Management Institute
UNai	University of Nairobi
MoiU	Moi University
JKUAT	Jomo Kenyatta University of Agric. & Tec.
KEWI	Kenya Water Institute
KenU.	Kenyatta University
MMI	Modern Management Institute
KCCT	Kenya College of Communication Tech.

The following Courses are being planned at KEWI

POST	COURSE TITLE
Sewerage Superintendent	Accounting
	Operating & Maintenance of Facilities
	Design
	Construction
	Safety Standards and Council By-Laws
Water Superintendent	Accounting
	Operation & Maintenance of Facilities
	Reduction of Unaccounted for water
	Design of Reticulation Systems
	Construction
Billing Clerk	Billing Procedures
Water Technician	Water Treatment
Water supply and sewerage	Operation and Maintenance of Facilities
Operators	Basic Plant Mechanics
Plant Mechanics	Repair and Maintenance of Pumps
Meter Repairer	Plumbing and Meter Repairs.

All of the above course are of one to three weeks duration and are suitable for the posts listed.

In addition, as and when a Public Relations officer is appointed KCCT will be offering a one week Public Relation course which should be attended.

Overseas training should consist of short study tours and be oriented to broadening the horizon of those in management positions.

It is important that management staff in Kisumu are exposed to the more global issues involved in water supply and sewerage systems operations and management, to ensure that the WSC does not operate in isolation.

Selection of candidates must be made at a later date when there is stability in the company and this training element may be financed by JICA.

6.7 COSTS FOR INSTITUTIONAL IMPROVEMENTS

Strengthening of the institutional capacity will be achieved by the consultancy services for Management/Institutional improvement at a cost of US$ 1,300,000.

In order to create an enabling environment for capacity building to take place, some basic facilities will also be provided at a cost of US$ 200,000. This amount will cover the provision of computers, laboratory equipment, and some basic requirements for transport, plant and equipment.

Capacity building will also be achieved through the UFW reduction programme at a consultancy cost of US$ 544,000. The WSD will also benefit from the provision of leak detection equipment and personal computers at a cost of US$ 48,000.

A breakdown of the costs is given in Appendix R.