1.3.1 Dakar Urban Area (A-1)

Ground elevation of this area is high except areas around the Dakar Port and the Gueul Tapee . Therefore, stormwater is drained quickly by the existing drainage systems and the roads. 26 areas were flooded by the 1989 flood, but total area affected was small and was for short duration.

1.3.2 Grand Yoff and Ouakam (A-2)

These areas constitute a basin surrounded by hilly areas and all stormwater concentrates to the lowest portion. Therefore, 1989 flood duration was long, 30 days for both of Grand Yoff and Ouakam. The maximum flood depth was 1.4 m for Grand Yoff and 0.5 m for Ouakam.

1.3.3 Ngor (A-3)

A large potential flood area is located in the south of Ngor with ground elevation of 0.5 m to 1.5 m. The reduction of discharge capacity of drainage channel, which carries stormwater from south of the airport, due to sedimentation, clogging and tidal effect has made the above mentioned area flood prone. Inclusion of the large catchment area, located in the south of the airport, into the original natural drainage area may be an another reason of flooding.

1989 flood duration of this area was as long as about six months. The maximum flood depth was about 1.0 m.

1.3.4 Pikine (A-6)

There are narrow and long "Niaye" areas in Pikine. Most of these areas were flooded in 1989 with flood duration of 3 days to 4 months and with flood depth of 0.4 m to 0.7 m.

The low areas along the coast near Thiaroye Sur Mer is a habitual flood affected area with long duration. The maximum flood depth was about 1 m. Most of the flood prone area is lower than high tide.

1.4 FINANCIAL CONDITIONS

The urban drainage projects in the study area are planned and executed by the government. The financial resources are shouldered and disbursed by the government.

After drainage facilities are constructed, the operation and maintenance of those facilities are assigned by the government to SONEES and CUD. SONEES takes care of closed channels, while CUD takes charge of open channels.

SONEES annually spends FCFA 121 to 147 million for the operation and maintenance of drainage pipes including the cleaning of drainage pipes, the cleaning and repair of grates and operation of pumping stations. The annual total costs of operation for the whole company come to FCFA 14 to 16 billion. Therefore, the share of drainage pipes in the total O&M costs works out at about 0.9%. CUD spends annually around 40 million FCFA for the operation and maintenance of open channels (including those in Rafisque) at pre-devaluation prices. The expenditure budget of CUD in 1991/1992 was 5,900 million FCFA. Therefore, O & M costs of drainage channels accounted for 0.7% of the total expenditure budget.

TABLE C.1.1 MONTHLY AVERAGE RAINFALL (1947-1992) (DAKAR-YOFF AIRPORT)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1947	0.0	0.0	0.0	0.0	0.0	1.8	22.8	126.6	220.0	8.9	2.7	0.0	382.8
1948	0.0	1.5	0.0	0.0	0.0	25.3	30.1	350.8	54.5	10.6	0.0	0.0	472.8
1949	0.0	0.0	0.0	0.0	0.0	0.5	110.8	196.1	124.9	22.2	0.0	1.5	456.0
1950	0.0	0.0	0.0	0.0	1.0	5.0	75.0	411.2	259.7	50.3	0.0	0.0	802.2
1951	0.0	0.1	0.0	0.0	15.5	4.9	89.6	217.9	304.4	250.0	18.6	0.0	901.0
1952	0.0	0.0	0.0	1.3	9.4	1.5	67.0	174.7	329.9	29.8	0.0	0.0	613.6
1953	0.0	0.1	0.0	0.0	0.0	11.0	138.5	71.3	157.1	30.7	0.4	0.0	409.1
1954	0.4	20.3	0.0	0.0	0.0	33.4	138.0	382.7	154.1	9.3	22.4	0.0	760.6
1955	0.0	0.0	0.0	0.0	0.6	17.9	272.5	234.6	134.2	13.9	0.0	0.0	673.7
1956	0.3	0.0	0.0	0.0	0.0	2.1	183.6	112.0	97.4	23.7	0.0	58.1	477.2
1957	6.5	0.0	0.0	0.0	0.0	4.6	32.7	141.8	224.6	196.3	0.0	8.8	615.3
1958	0.0	0.0	0.0	0.0	0.0	4.0	75.3	493.1	159.9	86.1	0.0	0.0	818.4
1959	0.0	0.0	0.0	0.0	0.0	5.9	63.3	122.5	77.4	0.0	4.0	0.0	273.1
1960	0.3	0.0	0.0	0.0	0.0	2.4	97.7	298.6	131.3	52.3	0.0	0.0	582.6
1961	0.0	0.0	0.0	0.0	0.0	33.9	223.1	137.5	219.8	0.0	0.0	0.0	614.3
1962	0.0	0.6	0.0	0.0	0.0	13.9	53.3	413.4	55.9	171.8	0.0	0.0	708.9
1963	0.0	0.0	0.0	0.0	0.0	3.5	33.6	200.8	114.1	99.5	0.0	0.0	451.5
1964	3.9	0.0	0.0	0.0	0.0	4.0	142.4	277.0	142.8	0.0	0.0	0.0	570.1
1965	0.0	4.0	0.0	0.0	0.0	5.4	14.8	204.9	170.8	11.8	0.0	0.0	411.7
1966	0.0	0.0	0.0	0.0	0.2	32.4	2.9	139.0	267.3	153.2	0.0	0.0	595.0
1967	0.0	0.0	0.0	0.0	0.0	2.0	86.6	258.1	365.3	183.4	0.0	0.0	895.4
1968	0.0	11.8	0.0	0.0	0.0	2.4	39.2	20.4	129.9	56.0	0.0	0.0	259.7
1969	0.0	0.0	0.0	0.0	0.0	0.0	176.4	279.1	233.1	62.0	0.0	0.7	751.3
1970	0.0	0.0	0.0	0.0	0.0	0.0	6.0	110.1	58.4	2.5	0.0	0.0	177.0
1971	0.0	0.0	0.0	0.0	0.0	12.7	63.7	195.6	68.4	26.3	0.0	0.0	366.7
1972	0.1	0.0	0.0	0.0	0.0	8.7	0.7	31.5	66.0	6.2	0.0	0.0	113.2
1973	0.0	0.7	0.0	0.0	0.0	4.5	59.1	169.7	52.9	0.1	0.0	0.0	287.0
1974	0.0	0.0	0.0	0.0	0.0	0.0	50.7	135.8	148.8	31.0	0.0	0.0	366.3
1975	0.0	0.0	0.0	0.0	0.0	0.0	205.9	179.0	161.2	17.9	0.0	0.0	564.0
1976	0.0	0.5	0.0	0.0	0.0	0.0	17.1	119.1	191.4	43.5	7.6	8.6	387.8
1977	0.0	0.0	0.0	0.0	0.0	1.9	8.4	48.7	112.2	0.0	0.0	0.0	171.2
1978	0.0	0.0	0.0	0.2	0.0	0.0	57.0	149.6	76.1	19.5	19.7	1.3	323.4
1979	50.5	0.0	0.0	0.0	0.0	75.9	81.2	81.7	51.8	0.0	0.0	0.0	341.1
1980	0.0	0.8	0.0	0.0	0.0	0.2	25.7	109.9	226.7	13.8	0.0	0.7	377.8
1981	3.5	0.0	0.0	0.0	0.0	23.5	72.1	175.4	53.1	10.6	0.0	0.0	338.2
1982	0.0	0.0	0.0	0.0	0.3	0.0	104.7	114.5	46.8	43.2	0.0	0.0	309.5
1983	0.0	0.0	0.0	0.0	0.0	10.0	0.4	81.6	62.9	0.0	0.0	0.0	154.9
1984	0.0	0.0	0.0	0.0	0.0	7.7	18.8	69.9	133.5	4.5	0.0	0.0	234.4
1985	0.6	0.0	0.2	0.0	0.0	13.9	72.4	260.1	143.9	15.5	0.0	0.5	507.1
1986	0.0	1.9	0.4	0.0	0.0	0.0	23.5	95.0	260.6	8.4	0.0	0.0	389.8
1987	0.0	0.0	0.0	0.0	0.0	3.7	53.8	247.3	118.8	19.4	0.0	0.0	443.0
1988	0.4	10.5	0.0	0.0	0.0	18.9	9.1	204.9	205.3	22.9	0.0	0.1	472.1
1989	0.0	0.0	0.0	0.0	0.0	27.1	86.2	338.9	92.2	4.4	1.1	0.0	549.9
1990	12.3	0.0	0.0	0.0	0.0	3.4	25.4	99.5	99.7	29.0	0.0	0.0	269.3
1991	0.0	0.0	0.0	0.0	0.0	0.0	26.2	102.2	118.8	23.3	0.0	0.0	270.5
1992	0.0	3.7	0.0	0.0	0.6	0.0	39.2	86.6	48.9	0.8	0.3	1.2	181.3
	1.7	1.2	0.0	0.0	0.6	9.3	71.2	184.1	146.2	40.5	1.7	1.8	458.5

Unit : mm

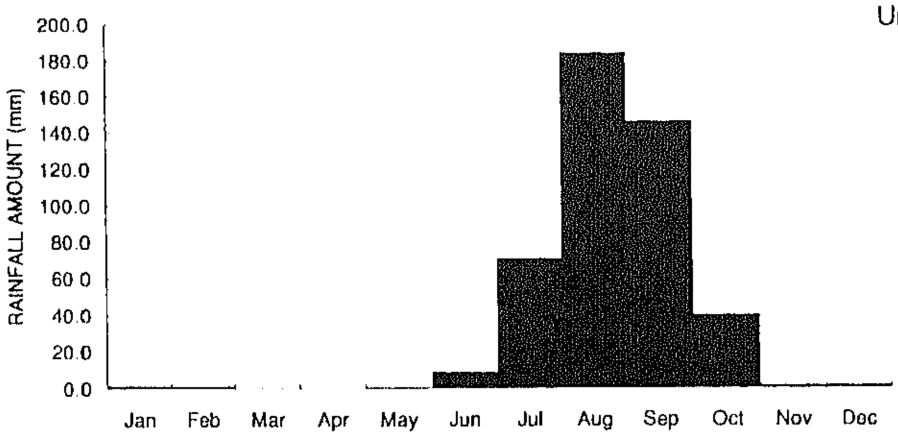


TABLE C.1.2 TIDE TABLE OF DAKAR PORT

TABLE HIGH SPRING TIDE OF DAKAR PORT

Unit : m

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1989	1.70	1.75	1.80	1.75	1.70	1.75	1.75	1.80	1.80	1.70	1.65	1.60	
	1.65	1.60	1.55	1.55	1.60	1.70	1.85	1.90	1.90	1.85	1.80	1.75	1.73
1990	1.60	1.70	1.65	1.55	1.55	1.60	1.70	1.80	1.85	1.80	1.80	1.75	
	1.70	1.70	1.70	1.70	1.75	1.80	1.85	1.85	1.80	1.65	1.60	1.60	1.71
1991	1.80	1.75	1.70	1.65	1.75	1.80	1.95	1.95	1.90	1.80	1.70	1.60	
	1.60	1.65	1.65	1.60	1.60	1.65	1.75	1.75	1.75	1.75	1.75	1.75	1.73
1992	1.60	1.60	1.60	1.55	1.65	1.75	1.85	1.95	1.70	1.65	1.65	1.70	
	1.80	1.80	1.75	1.65	1.65	1.70	1.70	1.75	1.90	1.75	1.70	1.65	1.71
1993	1.75	1.80	1.80	1.75	1.75	1.75	1.75	1.80	1.75	1.65	1.65	1.60	
	1.60	1.60	1.55	1.55	1.65	1.75	1.85	1.95	1.90	1.85	1.80	1.75	1.73
AVERAG	1.68	1.70	1.68	1.63	1.67	1.73	1.80	1.85	1.83	1.75	1.71	1.68	1.72

TABLE LOW SPRING TIDE OF DAKAR PORT

Unit : m

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1989	0.25	0.15	0.10	0.15	0.25	0.40	0.45	0.50	0.45	0.45	0.45	0.45	
	0.35	0.30	0.30	0.35	0.45	0.45	0.40	0.35	0.30	0.25	0.30	0.30	0.34
1990	0.40	0.25	0.25	0.30	0.40	0.50	0.50	0.40	0.35	0.30	0.30	0.30	
	0.30	0.20	0.15	0.20	0.30	0.35	0.40	0.40	0.40	0.45	0.45	0.45	0.35
1991	0.25	0.20	0.20	0.25	0.30	0.35	0.35	0.35	0.35	0.35	0.40	0.45	
	0.35	0.25	0.25	0.35	0.45	0.55	0.50	0.45	0.40	0.35	0.35	0.25	0.35
1992	0.40	0.35	0.30	0.30	0.30	0.35	0.35	0.30	0.45	0.45	0.40	0.35	
	0.20	0.15	0.15	0.25	0.35	0.55	0.50	0.50	0.30	0.30	0.35	0.35	0.34
1993	0.20	0.15	0.10	0.15	0.25	0.40	0.45	0.50	0.45	0.45	0.45	0.40	
	0.35	0.30	0.30	0.35	0.40	0.40	0.35	0.30	0.30	0.25	0.30	0.30	0.33
AVERAG	0.31	0.23	0.21	0.27	0.35	0.43	0.43	0.41	0.38	0.36	0.38	0.36	0.34

Source: Dakar Port Authority
Note: Mean Sea Level (M.S.L.) =1.01m

TABLE C.1.3 DISCHARGE CAPACITIES OF EXISTING DRAINAGE CHANNELS

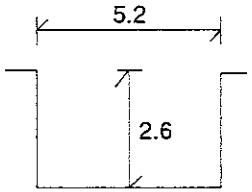
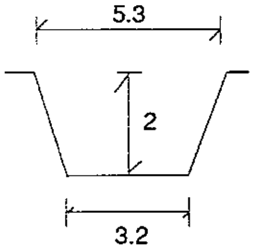
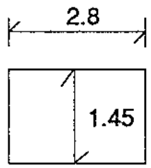
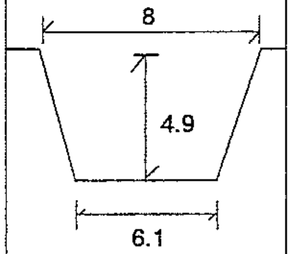
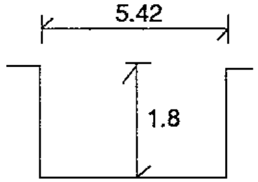
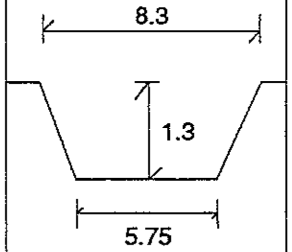
Name of Channel		CANAL IV	CANAL IV-3	CANAL V	CANAL VI	GUEUL TAPEE	AIRPORT SOUTH
Shape of the Channel (m)							 Earth Channel
Slope		1/660	1/800	1/520	1/500	0.8/1000	1/1000
Cross Sectional area (m^2)		13.5	8.5	4.06	34.5	10.1	9.16
Flow Velocity (m/s)		1.85	1.26	1.34	2.97	1.20	1.03
Discharge Capacity (m^3/s)		25.0	10.7	5.4	102.5	12.2	9.5
Peak Dis-charge	Q 10 m^3/s	45	27	-	31	18	26
	Q 5 m^3/s	37	22	15	26	15	22

TABLE C.1.4 (1) SUMMARY OF FLOOD CONDITION (1)

			1989 Flood						
			Flood Area (ha)	Nos. Houses	Max. Flood Depth (cm)	Ave. Flood Depth (cm)	Max. Duration of Inundation	Ave. Duration of Inundation	
1	Lansaar	R-L	17.7	140	170	56	210	112.5	
2	Diamaguene Diaksao	R-L/C	12.8	115	80	50	90	39.9	
			2.7	30	80	60	90	67.5	
			10.1	85	40	33	3	3.0	
3	Wakhinane	R-L	-	-	-	-	-	-	
4	Medina Gounass, Mousdalifa, 3 Mbars	R-L	8.7	580	130	93	180	160.0	
5	Darou Rahmane, Guediawaye	R-L	8.6	100	100	82	90	61.0	
			2.4	30	100	100	90	90.0	
			6.2	70	45	45	3	3.0	
6	Djida 2, Pikine	R-L	7.6	510	85	59	180	69.5	
			1.5	100	85	83	180	135.0	
			6.1	410	50	35	7	4.0	
7	Thiarooye sur Mer	R-L	52.0	485	90	56	30	13.6	Pikine
8	Ganaw-Rail, Wakhinane	R-L	4.7	150	80	68	90	55.5	
			1.1	35	80	80	90	90.0	
			3.6	115	55	55	21	21.0	
9	Nass Roulah	R-L	5.5	20	80	-	120	-	
10	Thiaroye SOTRAC	R-L	5.6	15	100	80	180	130.0	
11	Citee Pepiniere Pikine	R-L/C	4.6	75	80	80	14	14.0	
12	Dillfort	R-L	-	-	-	-	-	-	
13	Entree Tally Boubess	R-L/C	14.2	150	80	49	10	4.5	
14	Traversiere	R-L	-	-	-	-	-	-	
15	Pikine Rue 10	R-L	10.3	85	60	41	7	4.6	
16	Rond Point Maison du Parti, Rue 13, Rocade Fann Bel Air, Colobane Autor	C	Road	small shop	50	29	5	3.5	
17	Rue 10, ENAM, Zone B, Rue G	R-H	Road	-	-	-	-	-	
18	Rue 11	R-H/C	0.8	30	55	48	30	15.0	
19	Sicap Amitie 1, Rue 10	R-M	0.6	20	25	25	3	3.0	
20	Ave. Bourguiba + Rue 9, Rue 9 bis	R-M&H	-	-	-	-	-	-	Dakar
21	Route de Ouakam + Bourguiba + Lycee	R-H	-	-	-	-	-	-	
22	Mermoz Terrain Basket	R-H&M	1.3	35	30	30	3	3.0	
23	Corniche Ouest + Route de 10, Pyrotechn	R-H&M	Road	-	45	45	90	90.0	
24	Sicap Baobab, Bue Biyar	R-M&H	Road	-	-	-	1	1.0	
25	Sucao Baibabs + Rue 12	R-H&M	-	-	-	-	-	-	
26	Rue 13 + Avenue de la Liberte	C	1.9	Bus Terminal	30	30	3	3.0	
27	Derkle	R-M	-	-	-	-	-	-	
28	Route de front de Terre + Bourguiba	R	Road	-	-	-	-	-	
29	Station de pompage Castors, Sodia, Bourguiba	R/C	1.0	5	35	35	6	6.0	
30	Bopp Rue D, Rue de Mboul, Rue 2	R-M	5.3	55	30	28	6	6.0	
31	HLM 6 Terrain	R-H&M/C	4.5	soccer field / small shop	15	15	14	7.7	
32	Point E Boulevard Sud + Rue 3	R-H	1.6	15	50	50	-	-	
33	Point E Rue 4 + Rue C	R-H	2.3	20	40	40	90	90.0	
34	Route de Ouakam, Ecole Manguiers	R	-	-	-	-	-	-	
35	Fass Rue 22b, Fass cote Canal 4	R-L	7.1	150	45	35	14	9.3	
36	Bd. Gueule Tapee + Rue 34 & Rue 10	R-M	Road	-	35	35	3	3.0	
37	Gendarmerie Colobane	R-L, M&H	7.9	100	30	30	6	6.0	
38	Place de Bakou, Rocade Fann Bel Air	R/C	Road	-	50	50	10	10.0	
39	Gueule Tapee Rue 54	R-M&L	Road	-	20	20	6	6.0	
40	Bd. Gr. de Gaulle, Rue 11, Route de Champ de Courses P1	C	-	-	-	-	-	-	
41	Ecole El Hadji Malick Sy	R-C	Road	-	30	30	5	5.0	
42	Ouakam	R-L&M	12.4	95	40	30	7	5.8	
43	Ngor	R-H&M / C	5.0	40	100	66	180	81.3	
44	Grand Yoff	R-M&L	5.8	165	140	100	30	16.4	
45	Yoff	R-L&M	-	-	-	-	-	-	
46	Medine	R-L&M	7.6	280	50	30	3	3.0	
47	Sud-Est de Medine	R-L&M	1.7	110	50	45	8	7.5	
48	Medina Gounass	R-L	2.2	150	50	45	360	190	days

R-L : Residentia Low **R-M : Residentia Middle**
R-H : Residential High **C : Commercial**

TABLE C.1.4 (2) SUMMARY OF FLOOD CONDITION (2)

		Annual Flood							Remarks
		Flood Area (ha)	Nos. Houses	Frequency of Inundation	Max. Flood Depth (cm)	Ave. Flood Depth (cm)	Max. Duration of Inundation	Ave. Duration of Inundation	
1	Lansaar	10.8	55	E.R	20	10	2	1.5	
2	Diamaguene Diaksao	0.6	small shop	E.R	30	25	4	3.3	
3	Wakhinane	-	-	-	-	-	-	-	
4	Medina Gounass, Mousdalifa, 3 Mbars	6.2	415	E.R	40	35	4	4.0	
5	Darou Rahmane, Guediawaye	2.4	30	E.R	45	40	10	7.0	
6	Djida 2, Pikine	4.0	265	E.R	25	20	2	1.3	
7	Thiarooye sur Mer	13.4	235	1 or 2	35	20	3	2.3	
8	Ganaw-Rail, Wakhinane	1.2	40	E.R	20	10	1	1.0	
9	Nass Roulah	2.4	-	E.R	50	-	30	-	
10	Thiaroye SOTRAC	5.6	15	E.R	40	30	60	31.0	SOTRAC BUS GARAGE
11	Citee Pepiniere Pikine	2.3	155	E.R	30	20	4	3.5	
12	Dilifort	-	-	-	-	-	-	-	
13	Entree Tally Boubess	6.4	80	E.R	55	40	6	2.3	
14	Traversiere	-	-	-	-	-	-	-	
15	Pikine Rue 10	6.7	55	1 or 2	40	27.5	1	1.0	
16	Rond Point Maison du Parti, Rue 13, Rocade Fann Bel Air, Colobane Autor	Road	small shop	E.R	30	18	6	2.7	
17	Rue 10, ENAM, Zone B, Rue G	Road	-	-	-	-	-	-	
18	Rue 11	Road	-	E.R	20	20	5	3.7	
19	Sicap Amitie 1, Rue 10	0.2	10	E.R	10	5	1	1.0	
20	Ave. Bourguiba + Rue 9, Rue 9 bis	-	-	-	-	-	-	-	
21	Route de Ouakam + Bourguiba + Lycee	Road	-	10	10	10	3	3.0	
22	Mermoz Terrain Basket	1.3	35	E.R	15	15	1	1.0	
23	Comiche Ouest + Route de 10, Pyrotechn	Road	-	-	-	-	-	-	
24	Sicap Baobab, Bue Biyar	-	-	-	-	-	-	-	
25	Sucao Baibabs + Rue 12	-	-	-	-	-	-	-	
26	Rue 13 + Avenue de la Liberte	0.9	Bus Terminal	E.R	10	10	1	1.0	
27	Derkle	-	-	-	-	-	-	-	
28	Route de front de Terre + Bourguiba	Road	-	-	-	-	-	-	
29	Station de pompage Castors, Sodia, Bourguiba	-	-	-	-	-	-	-	
30	Bopp Rue D, Rue de Mboul, Rue 2	1.5	10	E.R	15	15	2	1.5	
31	HLM 6 Terrain	4.5	soccer field / small shop	E.R	10	10	2	1.5	
32	Point E Boulevard Sud + Rue 3	0.6	5	2	10	10	1	1.0	
33	Point E Rue 4 + Rue C	1.1	10	10	40	20	60	60	
34	Route de Ouakam, Ecole Manguiers	-	-	-	-	-	-	-	
35	Fass Rue 22b, Fass cote Canal 4	2.8	60	E.R	25	15	8	4.5	
36	Bd. Gueule Tapee + Rue 34 & Rue 10	-	-	-	-	-	-	-	
37	Gendarmerie Colobane	-	-	-	-	-	-	-	
38	Place de Bakou, Rocade Fann Bel Air	Road	-	-	-	-	1	1.0	
39	Gueule Tapee Rue 54	-	-	-	-	-	-	-	
40	Bd. Gr. de Gaulle, Rue 11, Route de Champ de Courses P1	-	-	-	-	-	-	-	
41	Ecole El Hadji Malick Sy	-	-	-	-	-	-	-	
42	Ouakam	3.6	Road /soccer field	1 or 2	10	10	1	1.0	
43	Ngor	3.8	25	E.R	30	22	10	4.3	
44	Grand Yoff	1.6	45	E.R	40	35	15	11.7	
45	Yoff	-	-	-	-	-	-	-	
46	Medine	5.1	140	E.R	50	15	7	1.0	
47	Sud-Est de Medine	1.0	55	E.R	50	25	8	7.0	
48	Medina Gounass	1.5	50	E.R	45	30	7	3.5	
			Note E.R : Every Big Rain				days	days	

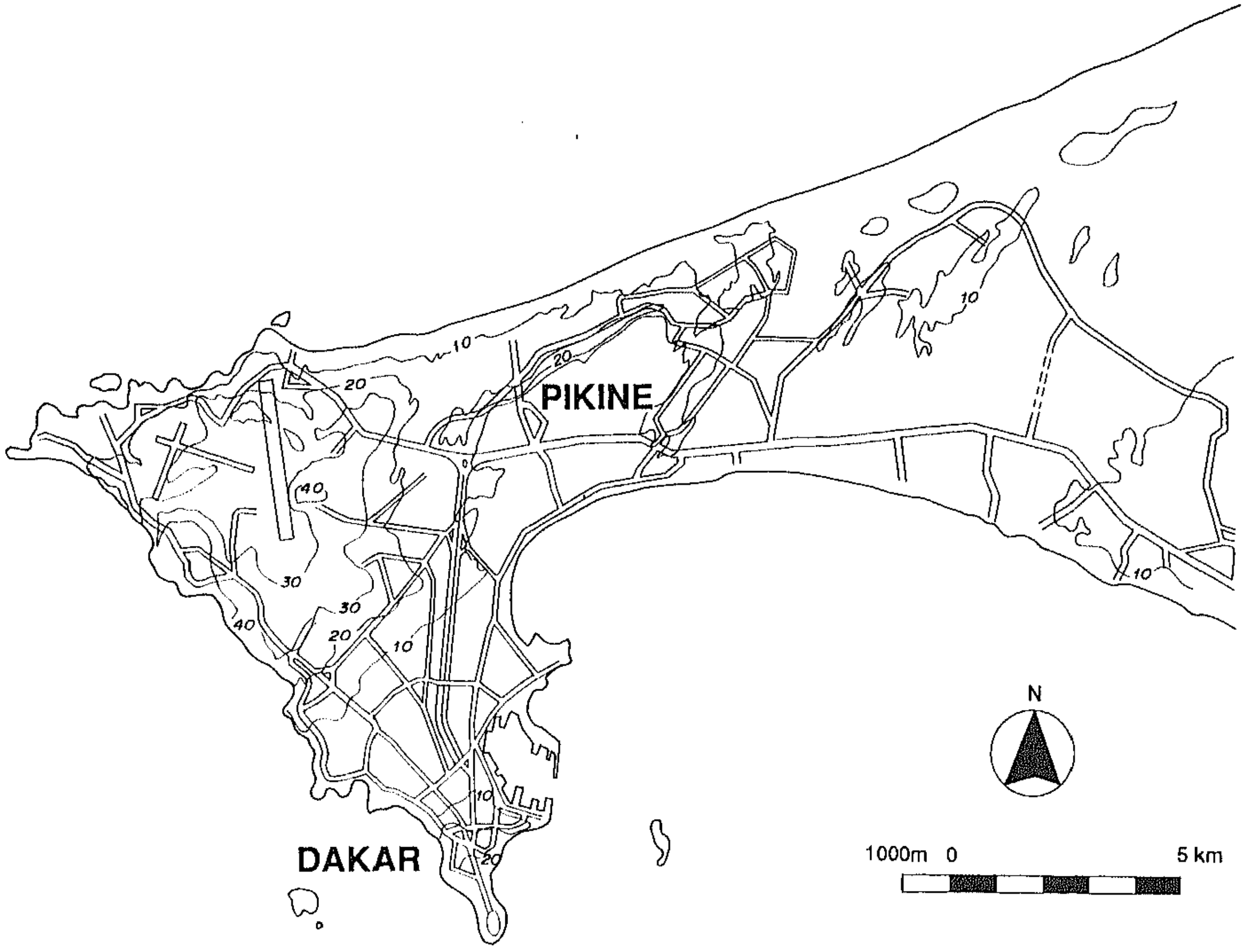


FIGURE C.1.1 TOPOGRAPHIC CHARACTERISTICS OF THE STUDY AREA

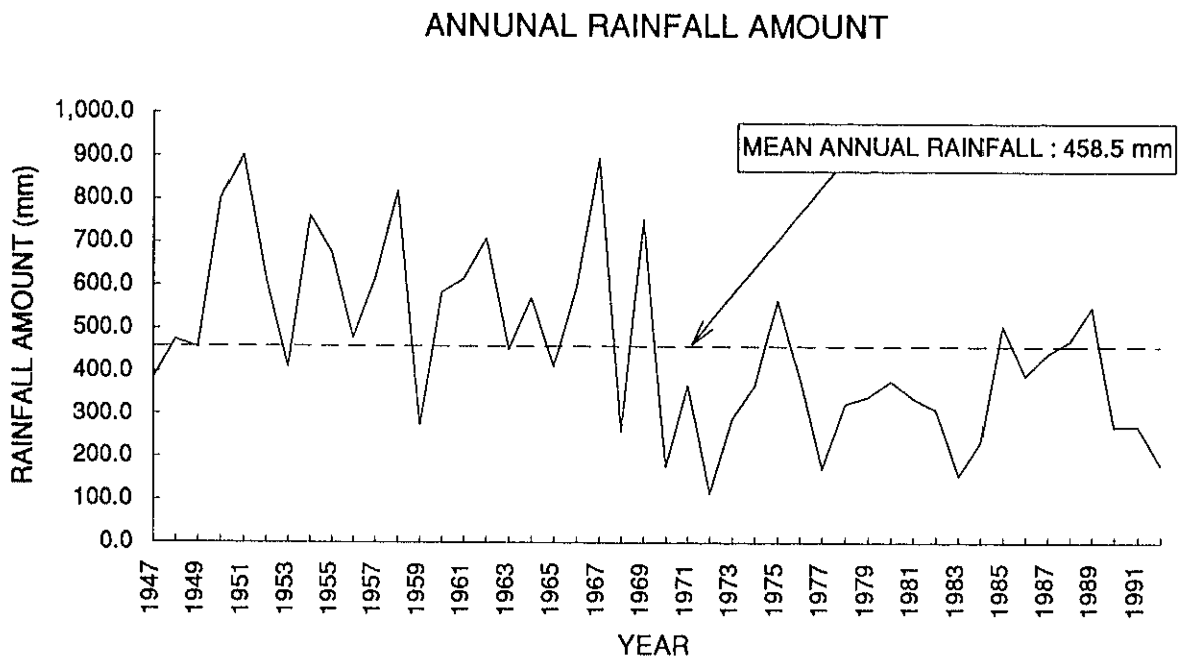
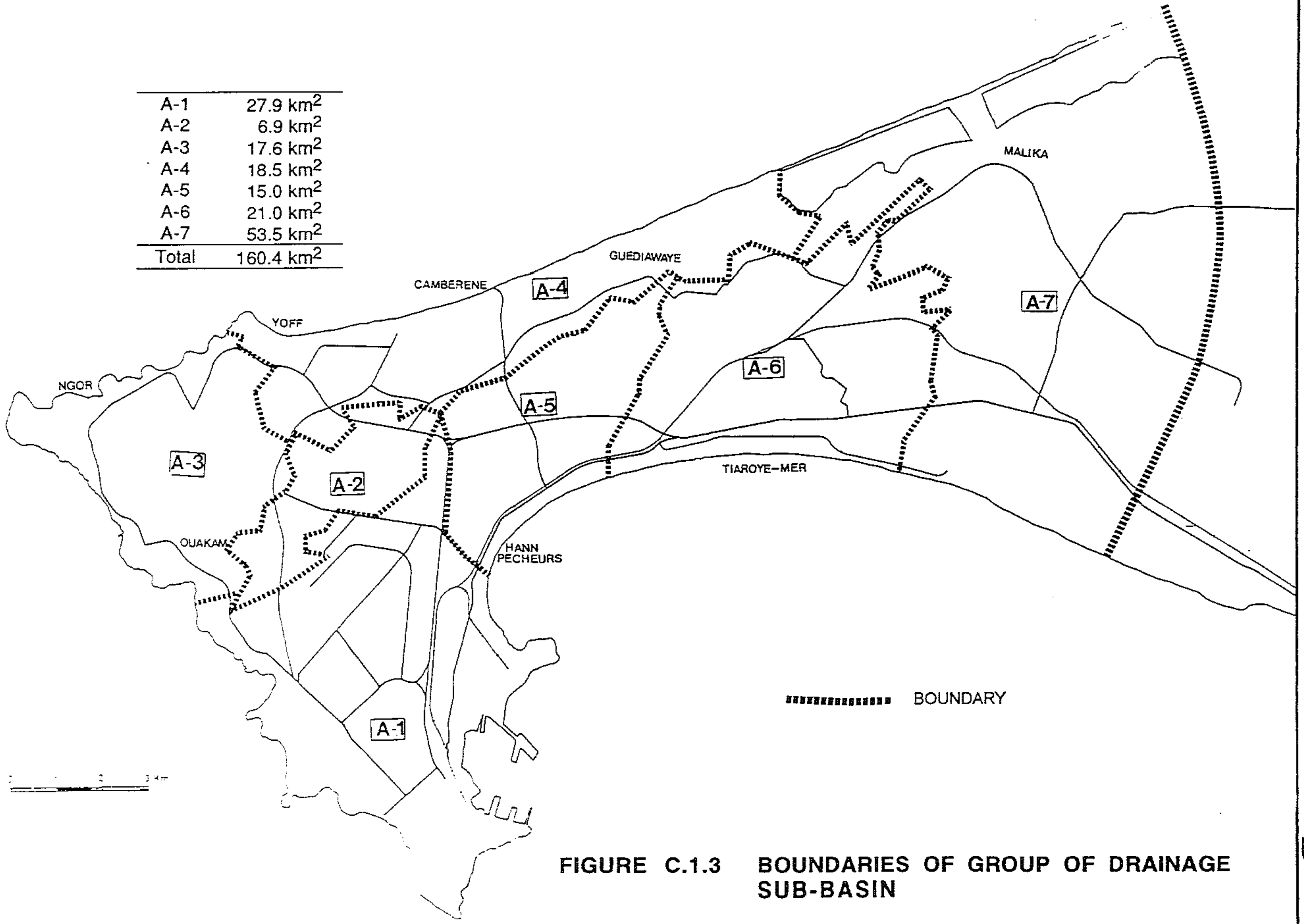


FIGURE C.1.2 RECORD OF ANNUAL RAINFALL (1947-1991) (DAKAR-YOFF AIRPORT)



A-1	27.9 km^2
A-2	6.9 km^2
A-3	17.6 km^2
A-4	18.5 km^2
A-5	15.0 km^2
A-6	21.0 km^2
A-7	53.5 km^2
Total	160.4 km^2

FIGURE C.1.3 BOUNDARIES OF GROUP OF DRAINAGE SUB-BASIN

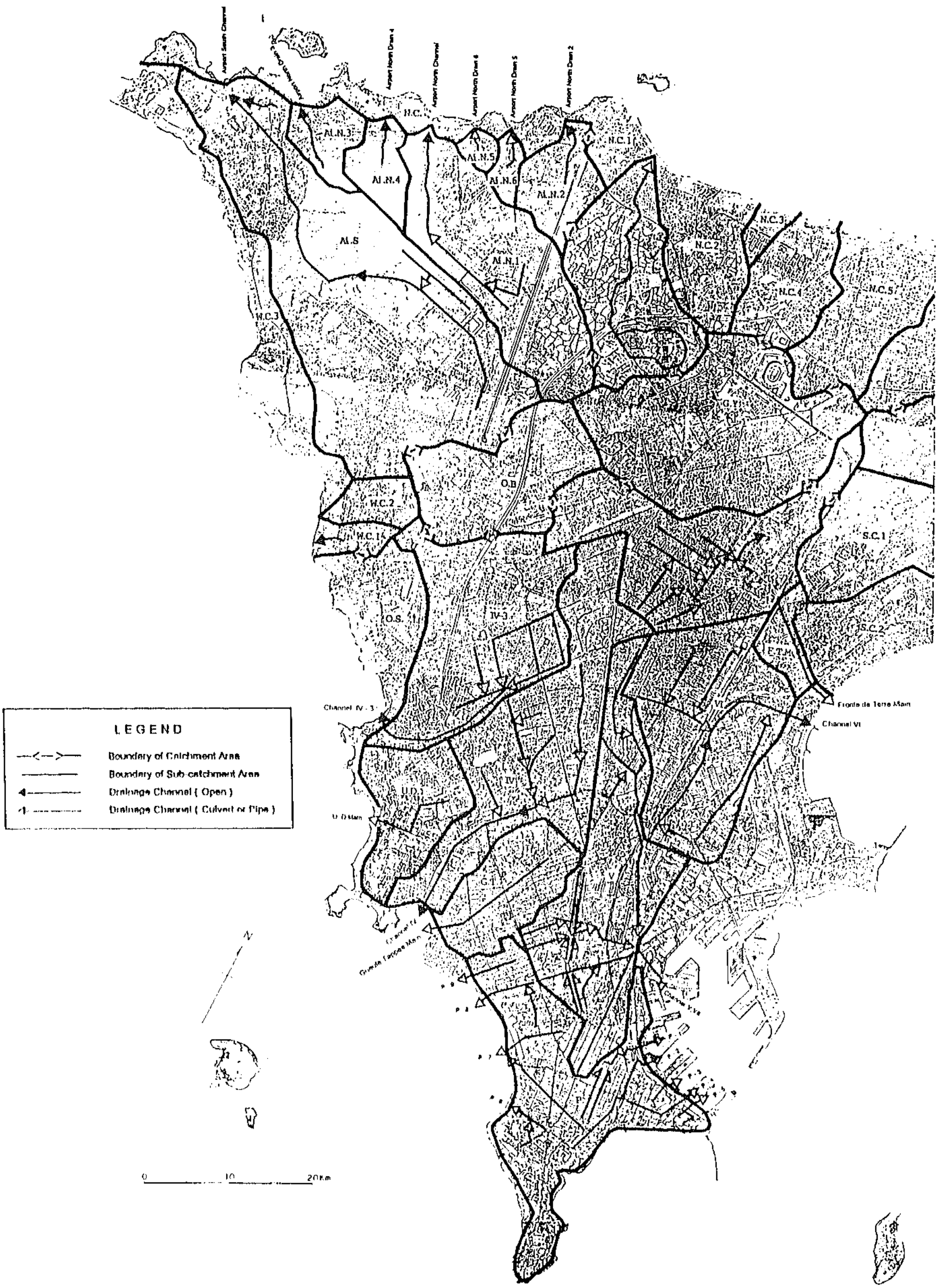


FIGURE C.1.4 (1) EXISTING DRAINAGE SYSTEM (DAKAR)

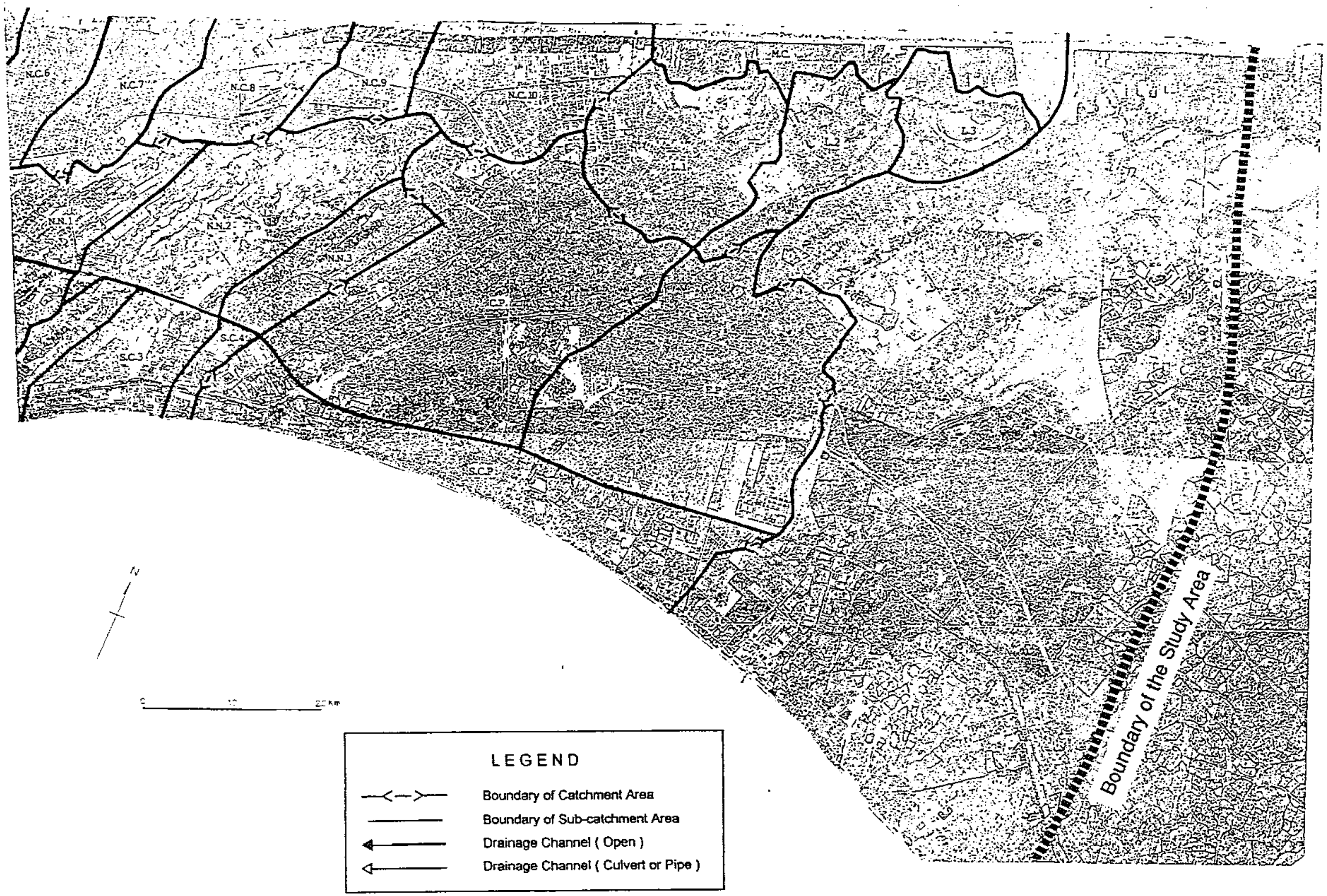


FIGURE C.1.4 (2) EXISTING DRAINAGE SYSTEM (PIKINE)

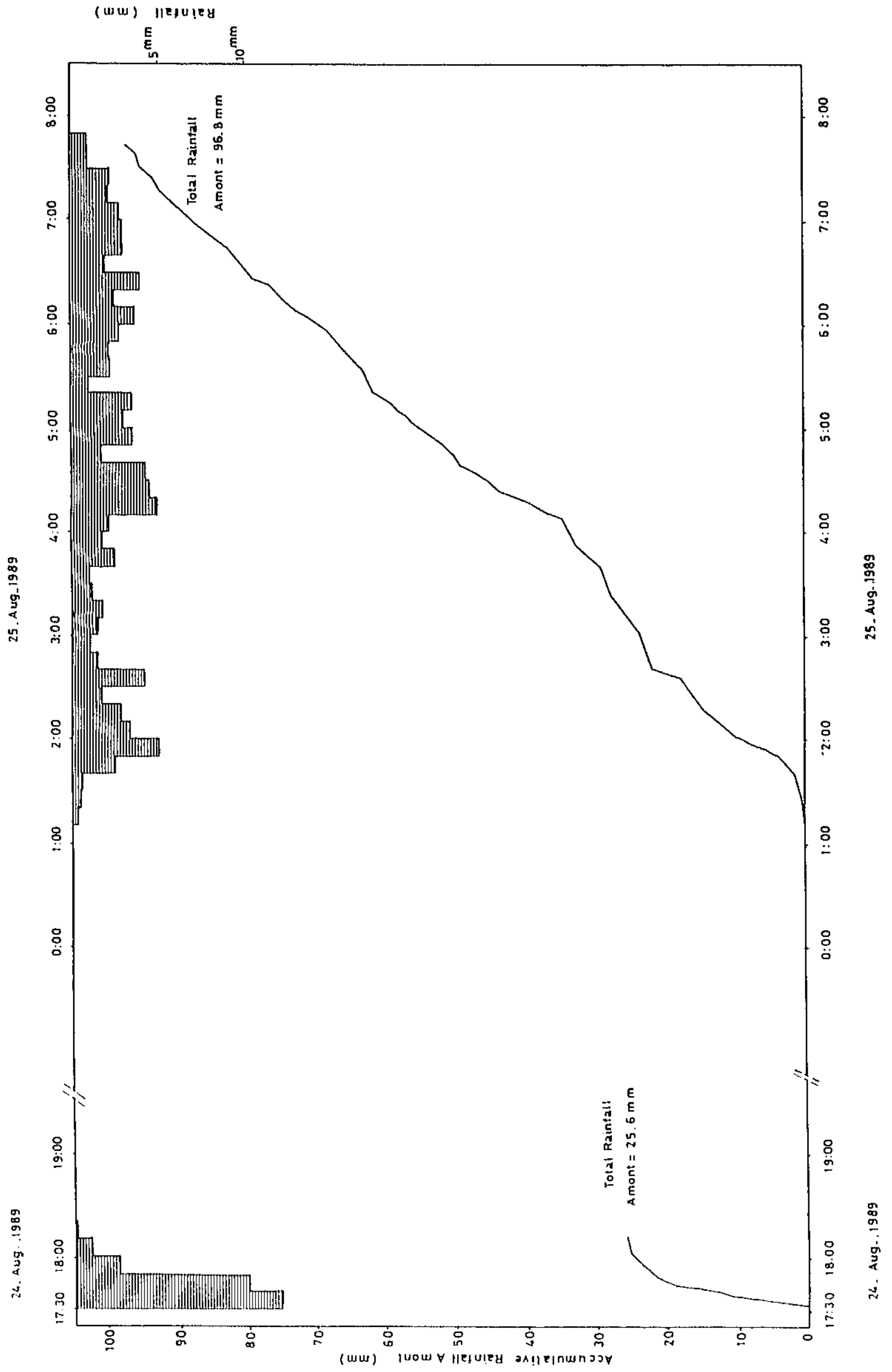
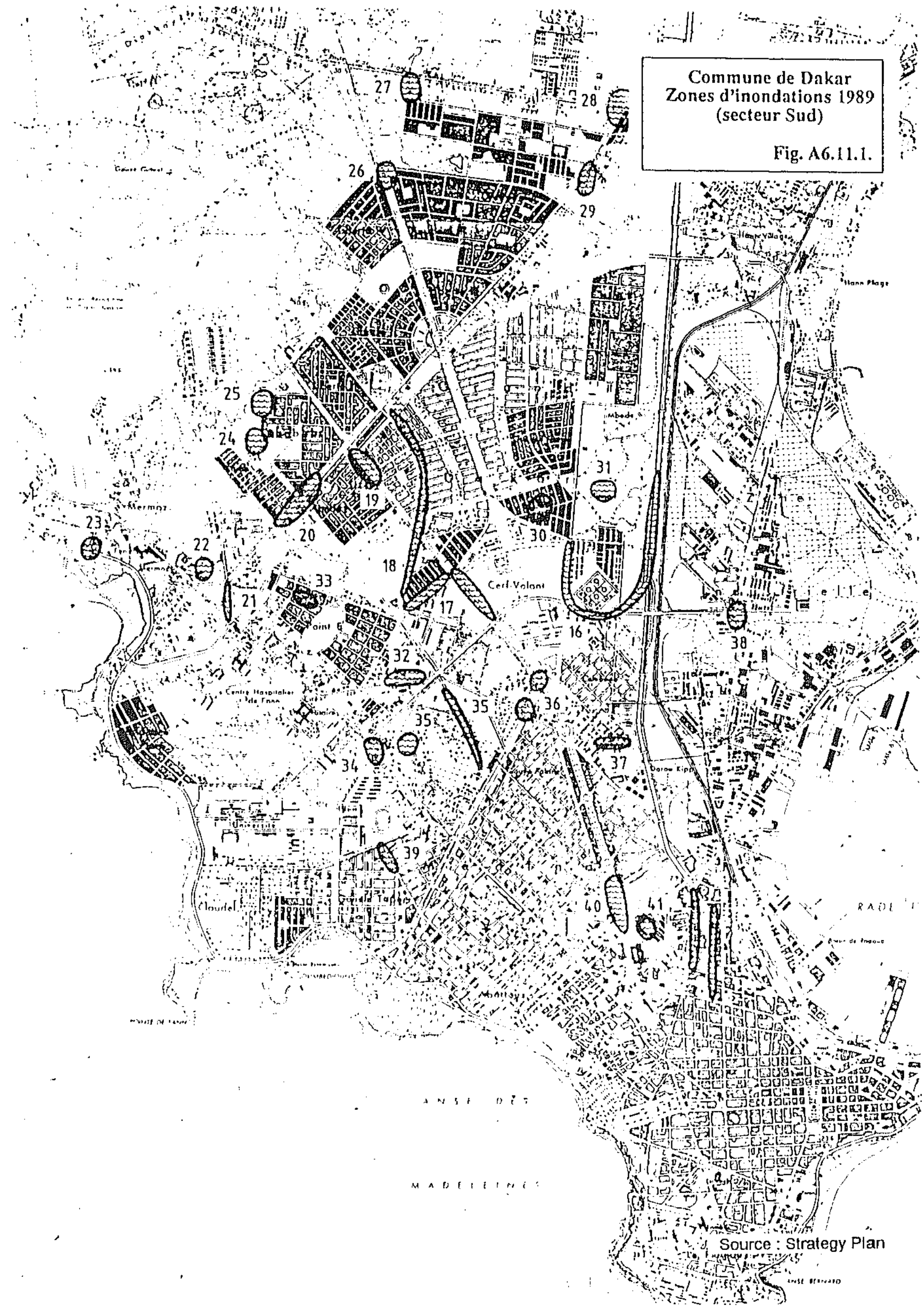


FIGURE C.1.5 HOURLY RAINFALL DISTRIBUTION OF AUGUST 1989 FLOOD



Source : Strategy Plan

FIGURE C.1.6 (1) FLOOD AREAS IN AUGUST 1989 (1)

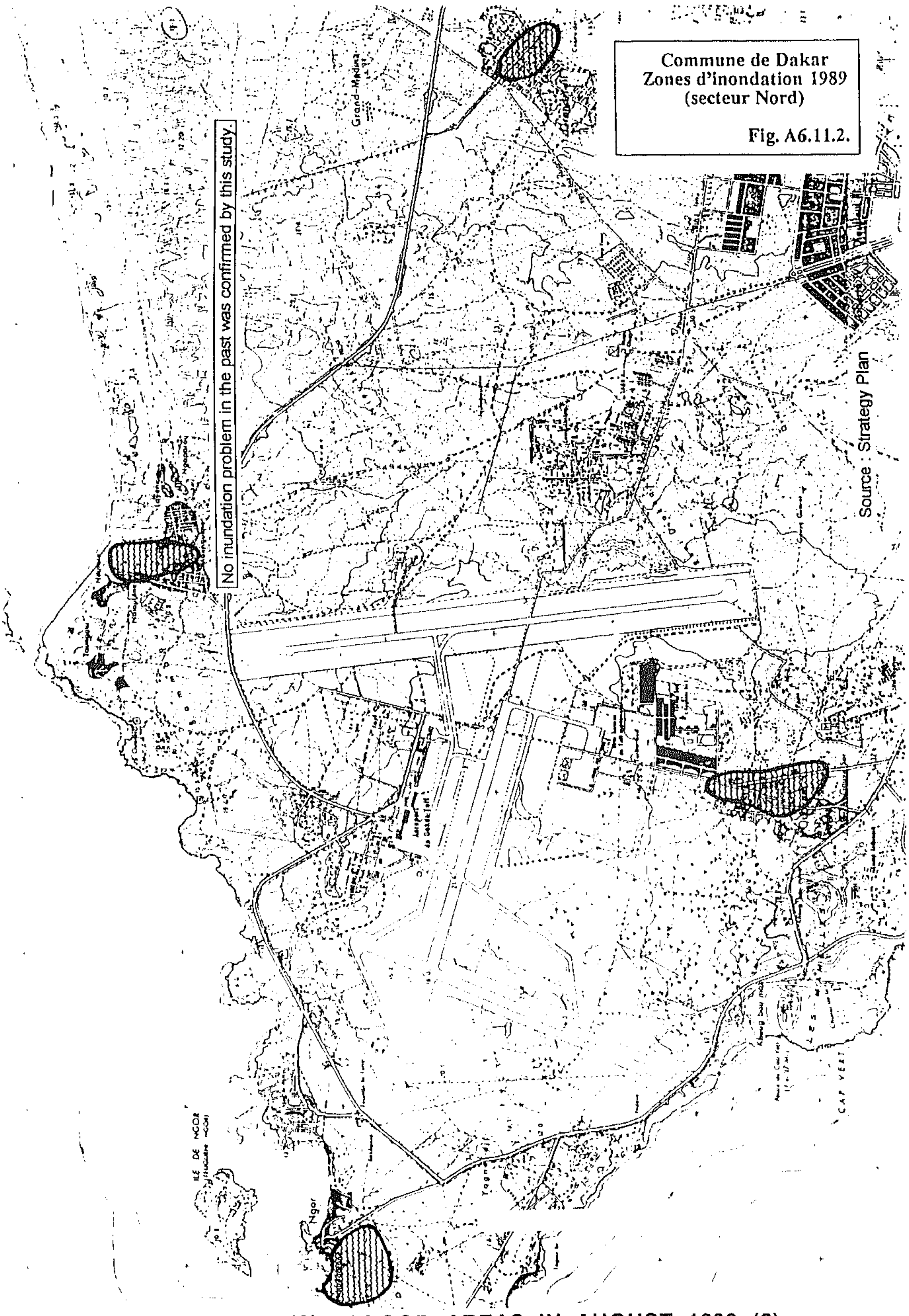


FIGURE C.1.6 (2) FLOOD AREAS IN AUGUST 1989 (2)

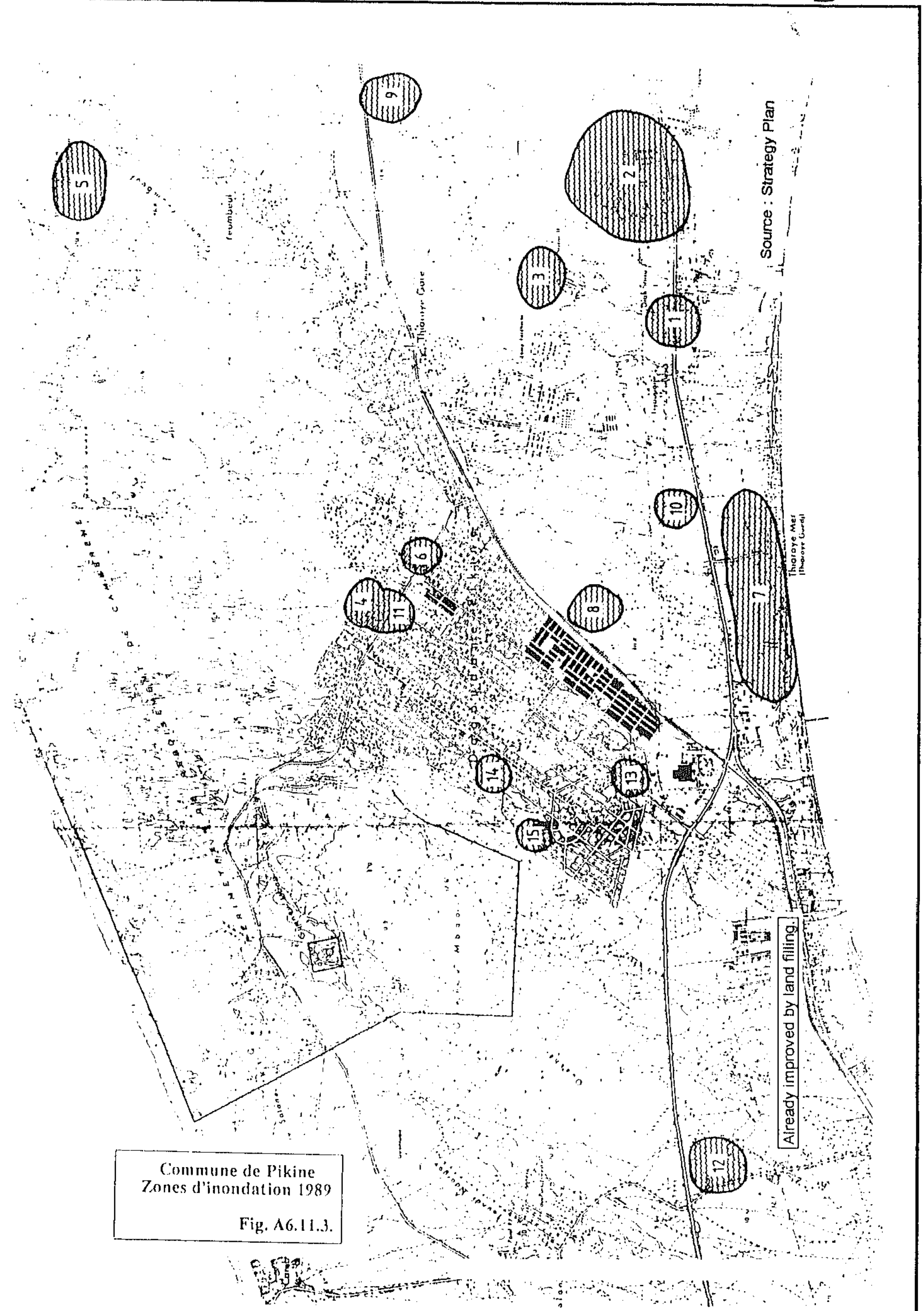


FIGURE C.1.6 (3) FLOOD AREAS IN AUGUST 1989 (3)

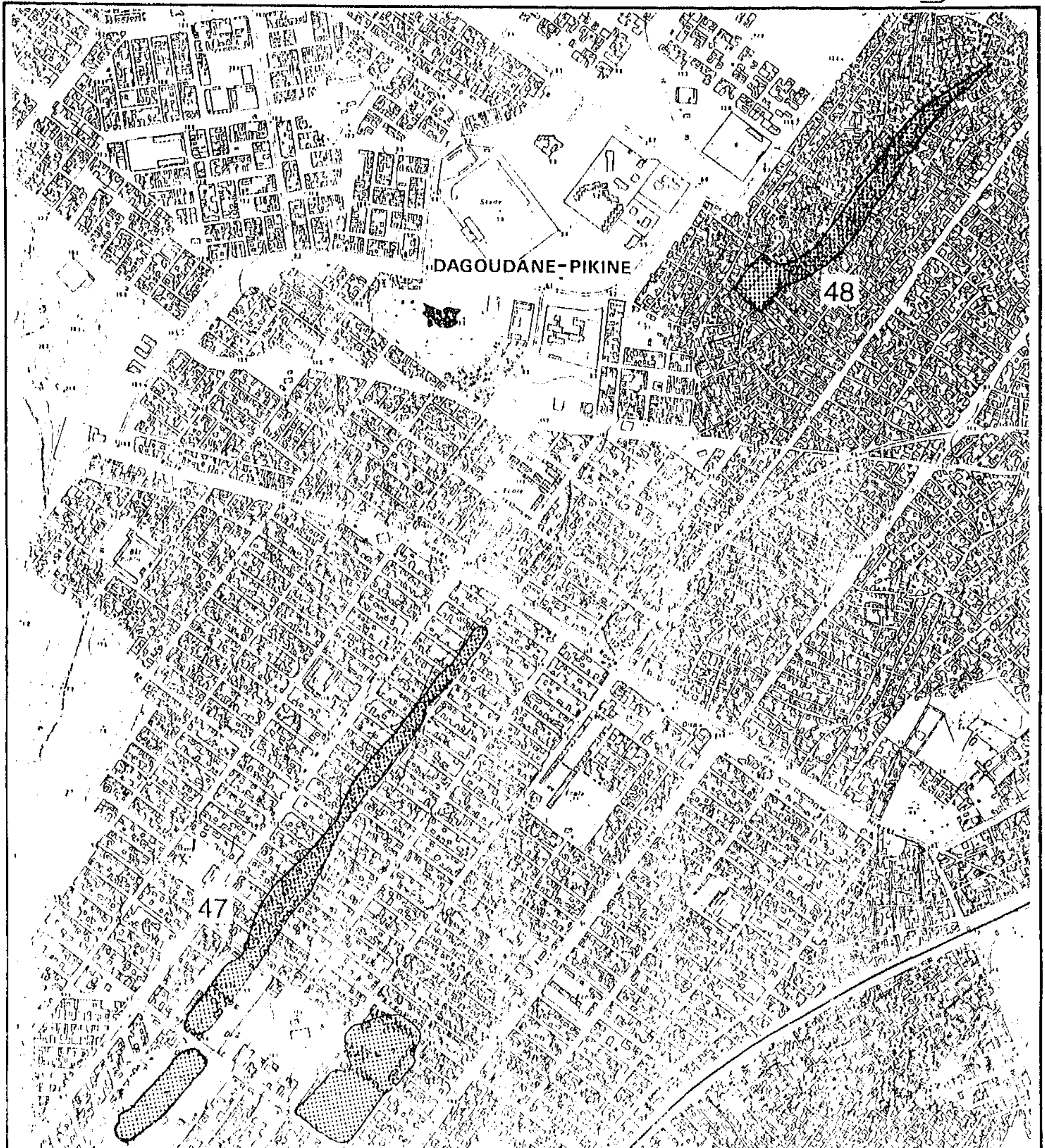


FIGURE C.1.7 FLOOD AFFECTED AREA IDENTIFIED BY JICA SURVEY

CHAPTER 2 PLANNING CONDITIONS

2.1 LAND USE

The land use plan for the year 2010 is applied for the urban drainage planning (refer to *Figure C.2.1*).

Planned land use composition of the Study Area is as follows:

Land Use Category	Area (sq. km)
Housing (Village, Spontaneous-irregular)	24.2
Housing (Spontaneous-regular, Planned)	41.3
Housing (Detached house, Flat)	12.1
Equipment (Public Facility)	15.0
Park, Cemetery, Military (Camp)	14.4
Industrial	14.6
Agricultural	24.3
Open Space	3.4
Reforestation	11.1
Total	160.4

Most of the Study Area is expected to be urbanized by 2010 except a part of Grand Niaye, Lacs, reforestation areas, and some part of eastern Pikine.

2.2 DESIGN DISCHARGE

2.2.1 Design Return Period of Rainfall

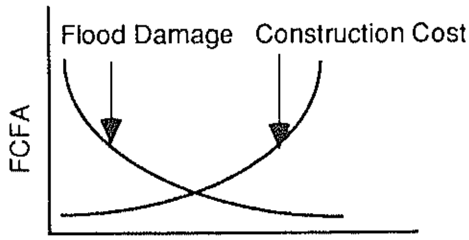
The design return period of rainfall for the drainage facilities are decided as follows:

- Five years return period for the drainage channels
- Ten years return period of 24 hours rainfall for pumping station and retention/infiltration ponds

The design return period is decided considering following items:

Relation between construction cost and decrease in flood damage:

A longer design return period results in higher construction cost but and lesser probability of occurrence of flood damage. Generally, the rate at which construction cost increases with return period is larger than the rate at which flood damage decreases with return period as can be seen from the schematic representation shown below. Therefore, theoretically the design return period can be determined by analyzing balance between the construction cost and the expected size of flood damage and it depends highly on the value of assets in the area.



It is, however, a widely accepted method to set the design return period within a range of 2 to 10 years without the actual analysis of the balance, since past studies and experiences teach that design return period usually falls in a such range. Although it is supposed that the return period of 2 years would be enough for the study area, 5 years is selected as the design return period for the study area considering importance of the area which is a capital of country.

Table below shows examples for the design scale (i.e. return period of rainfall, depth of rainfall etc.) for urban drainage in several countries:

City/Country	Design Scale for Urban Drainage
Tokyo/Japan	50 mm (3 to 5 year equivalent)
Cotonou/Benin	2 years
Manila/Philippines	5 year with no flood and 10 years with allowable flood depth of 0.2m
Malaysia	2 to 10 years depending on importance of urban area
Dhaka/Bangladesh	5 years

Design scale of existing drainage facilities:

When setting design scale for a new drainage facility, it is important to consider design scale of the existing one and setting a design scale in accordance with the existing one.

As shown in *Table C.1.3*, the existing drainage channels have capacity of less than 5 year return period of rainfall except Canal IV. Therefore, it is considered that 5 years is suitable for the study area as the design return period of rainfall.

Design return period of rainfall for drainage channels/pipes and retention/infiltration ponds:

Different design return period of rainfall for drainage channels/pipes and retention/infiltration ponds are applied in this study with the consideration of damage due to excess flood.

Rainfall exceeding the design return period for pipes and channels would cause flooding due to lack of enough discharge capacity, but its duration would be at best in hourly order. On the contrary, in case when the rainfall exceeds the design capacity for pumping stations and retention/infiltration ponds, overflowing form the facilities would occur resulting in flooding of the surrounding areas, which would be at least in daily order, because the stormwater concentrates to these facilities. Since the design return period for pipes, channels and pumping stations has been selected to be 5 years as mentioned above, the design return period for retention/infiltration ponds is selected to be of a longer period, say 10 years.

2.2.2 Flood Run-off Calculation

1) Run-off Calculation Method

Drainage Channels/Pumping Stations

There are several methods for flood run-off analysis such as the Rational Method, the Unit Hydrograph Method, the Storage Function Method, etc. The Rational Method is applied in this study for calculation of the design run-off due to following reasons:

- The facilities in the study area have comparatively small basins.
- To design cross section of drainage channel, only peak discharge is needed. To calculate peak discharge, the Rational Method is commonly used .
- Since peak discharge can be calculated by using only three factors such as catchment area, rainfall intensity and run-off coefficient, the Rational Method is useful for planning of these facilities.
- Runoff coefficients can easily be evaluated by land use category.

In the Rational Method, peak discharge is calculated using the following formula.

$$Q = \frac{1}{3.6} F \cdot I \cdot A$$

where, Q : Peak Discharge (m^3/s)

F : Run-off Coefficient
I : Average Rainfall Intensity within the Time of Concentration "T" (mm/hr)
A : Catchment Area (km^2)

The value of I for duration T is calculated by using the following Talbot Formula:

$$I = \frac{b}{T + a}$$

where, I : Rainfall intensity (mm/hr)
T : Duration of rainfall (min.)
a, b : Constants

The constants a and b for each return period is calculated by solving the simultaneous equations using probable rainfall depths analyzed in section 1.1.2. The results of calculation for 5 years and 10 years return periods are as follows :

$$I(5) = \frac{5271.4}{T + 36.9}$$

$$I(10) = \frac{6385.7}{T + 36.9}$$

(1) Run-off Coefficient (F)

The run-off coefficient for each land use category is recommended considering intensity of rainfall, geology and land surface condition and is mentioned below:

Land Use Category	Value of F
Residential Area	
High density	0.40
Medium density	0.30
Low density	0.20
Industrial Area	0.30
Agricultural Area	0.10
Public Facility Area	0.20
Park, Cemetery, etc.	0.20

(2) Time of Concentration (T)

The time of concentration (T) is defined as the time required for the rainfall to reach the exit of the basin since the onset of rainfall. "T" is determined as the sum of time elapsed from the beginning of rainfall until rainwater enters into the relevant channel (time of inlet: T1) and the time elapsed as rainwater flows down to the downstream end through the channel (time of flow T0).

$$T = T1 + T0$$

a) Time of Inlet (T1)

Time of inlet is controlled by many factors such as form and area of basin, slope of ground surface, etc.

Generally, 20 to 30 min. is used as the time of inlet for flat residential area like Dakar and Pikine urban area. With the consideration of the condition of the study area and safety of the drainage facilities, 20 min. is used in this study.

b) Time of Flow (T0)

The time of flow is defined as the time elapsed since the rainwater entered into a watercourse at its upstream end reaches the point for which the discharge calculation is to be made.

The time of flow is calculated using length of the drainage channel and average flow velocity that is controlled by the conditions of the drainage basin. To assume the average flow velocity, flow velocity of existing drainage channels are calculated (refer to *Table C.1.3*). As shown is the Table, the flow velocity of existing drainage channels is calculated about 2 m/s in average. Therefore 2 m/s is used as the average flow velocity in this study.

Infiltration/Retention Ponds

To design the infiltration/retention ponds, it is necessary to know the stormwater volume discharged from the relevant basin. The discharged stormwater volume is calculated using the following formula.

$$V = F*R*A*1000$$

where, V : Discharged Volume (m^3)
R : Amount of Rainfall (mm)
A : Catchment Area (km^2)
F : Run-off Coefficient

2) Design Rainfall

(1) Drainage Channel

The design rainfall intensity for drainage channels is calculated by using rainfall intensity and duration equation for the 5 years return period of storm.

(2) Pumping Station

The design rainfall pattern for pumping stations is determined by using 24 hours' rainfall amount and intensity-duration equation for the 10 years return period of storm.

The design rainfall pattern for pumping stations is shown in *Figure C.2.2*.

(3) Retention/Infiltration Ponds

The design rainfall amount for retention/infiltration ponds is 24 hours' rainfall amount of 10 years return period.

2.3 DESIGN TIDE LEVELS

The design tide levels, as an outlet condition, for the drainage facilities are recommended as follows (refer to *Table C.1.2*):

- Mean high spring tide in August of 0.85 m above mean sea level for the drainage channels and pumping stations.

- Mean sea level for long term drainage, say more than one day.

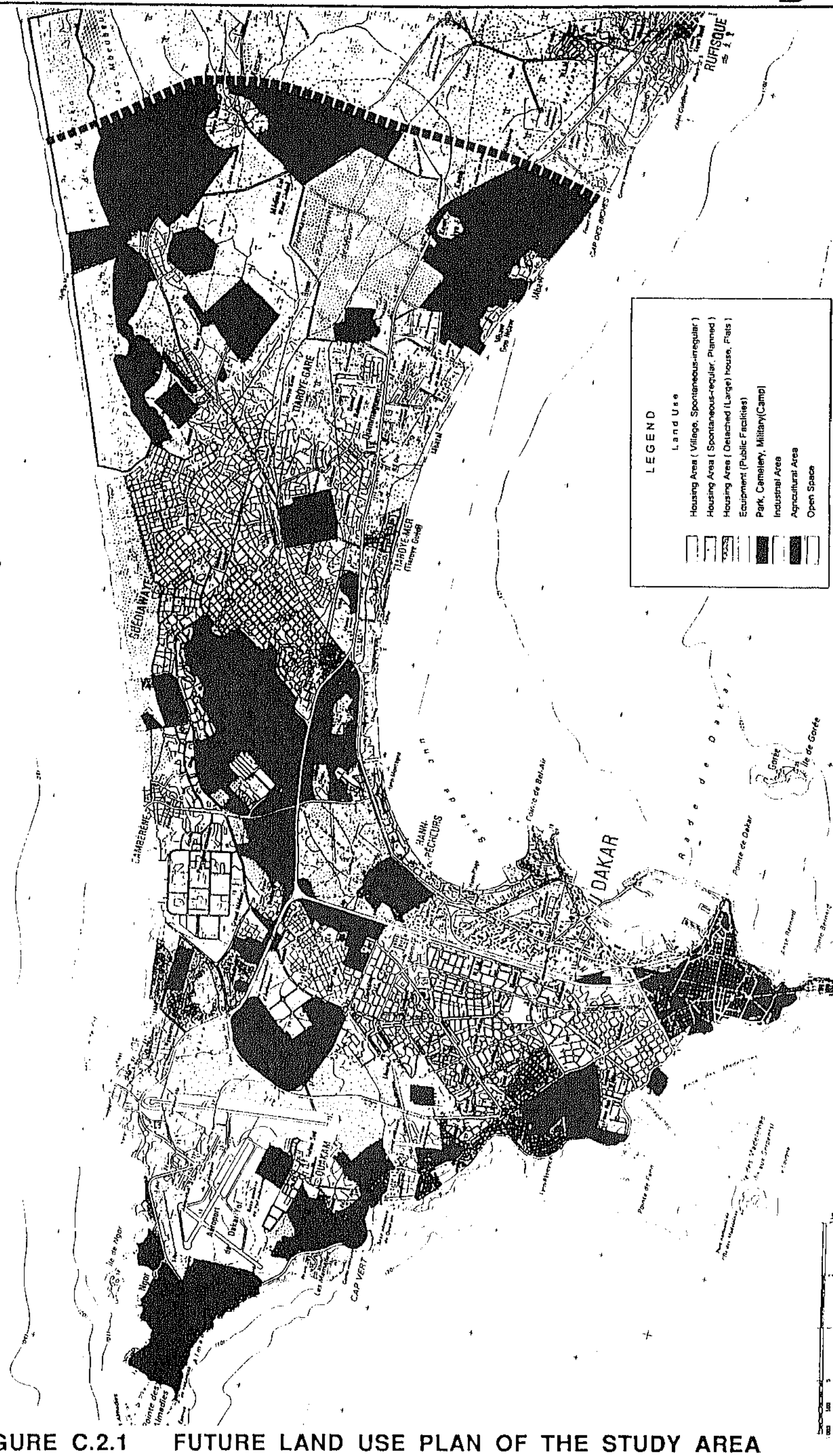
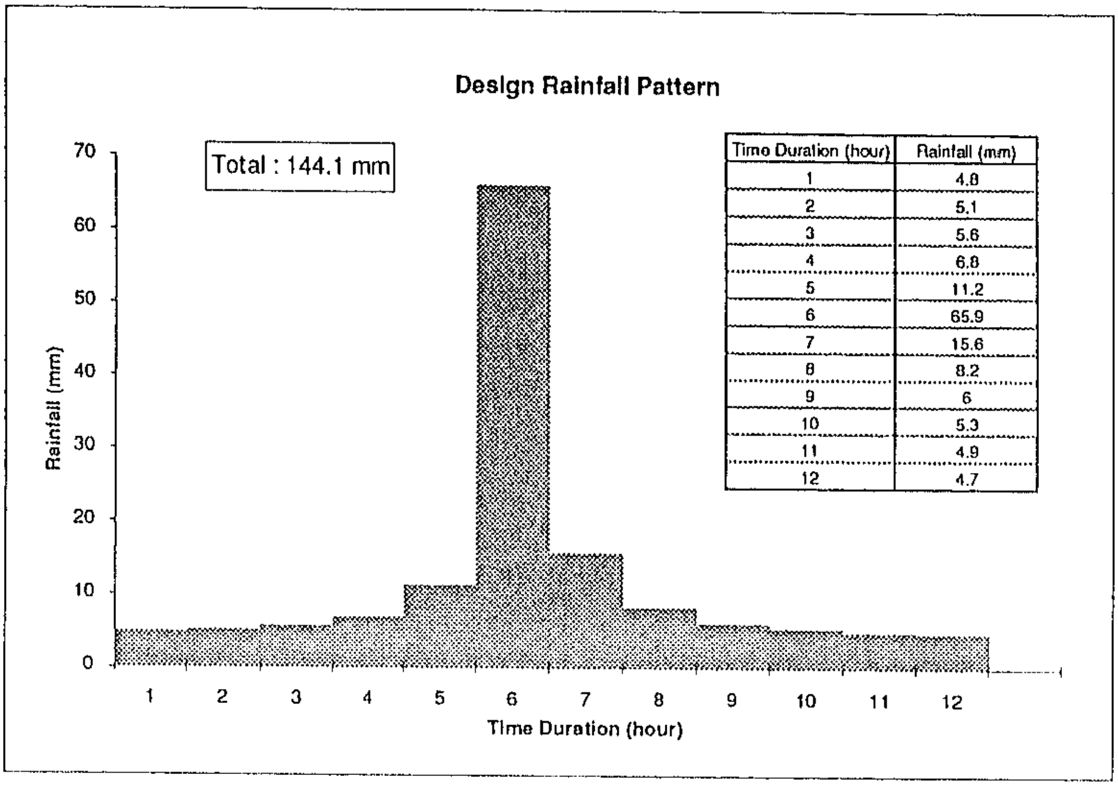


FIGURE C.2.1 FUTURE LAND USE PLAN OF THE STUDY AREA



Time Duration (hour)	Rainfall (mm)
1	4.8
2	5.1
3	5.6
4	6.8
5	11.2
6	65.9
7	15.6
8	8.2
9	6
10	5.3
11	4.9
12	4.7

FIGURE C.2.2 DESIGN RAINFALL PATTERN

CHAPTER 3 URBAN DRAINAGE MASTER PLAN

3.1 GENERAL

The stormwater drainage system of the study area is proposed based on the following concepts:

- Target year of this proposed drainage improvement plan is 2010.

- Drainage sub-areas shall be decided mainly based on the natural topography, in order to save the cost of construction and operation/maintenance.

- Stormwater shall be infiltrated as much as possible as a groundwater source.

- Natural gravity flow drainage shall be applied to the maximum extent and pumping drainage shall be minimized.

- Each drainage sub-area shall have an outlet. Existing wet lands such as Niayes, Lacs, inland depressed areas and the Marigot will be used as the receiving bodies.

- Drainage channel crossing large roads should be avoided in principle.

- The concrete facility plans are considered as structural measures for the areas which had inundation problem in 1989 flood. For sandy areas with high ground elevation (say more than 5m), non-structural measures such as infiltration, land use regulation of depressed areas, etc. should be applied.

The proposed drainage system of each sub-area is described in the following sections.

3.2 DRAINAGE SYSTEM PLAN

3.2.1 Dakar Urban Area (A-1)

This area can be drained by the existing drainage systems of Plateau, Gueule Tappee, Channel IV, Channel V, Channel VI and University of Dakar. The maintenance works which is proposed in the Strategy Plan, is also proposed for this area, except the boundary areas of Fronte de Terre and Channel IV-3, because of the following reasons:

- This area has a high topography and therefore, drainage to the sea by gravity flow is possible.

- Flooding of this area is not severe i.e. flood affected area is small and of short duration.

The boundary areas of Fronte de Terre and Channel IV-3 are proposed to drain as follows.

1) Fronte de Terre Drainage Area

The improvement plan proposed in the Strategy Plan is modified based on the topography and the existing drainage networks as described below:

- Southern area of the Fronte de Terre Main is drained to Hann Bay by using existing Fronte de Terre Main. Northern area is drained to Hann Bay by other drains. (*Figure C.3.1*)

- Drainage area of the infiltration facility (Centre de Captage des Eaux) is included in the Fronte de Terre Channel. (*Figure C.3.1*)

2) Channel IV-3 Drainage Area

The Channel IV-3 does not have enough capacity to drain the whole catchment due to gentle slope of its downstream reach. An additional drainage main, which covers the western area of the catchment, is proposed. The remaining area will be drained by a new drain.(see Figure *C.3.2*)

3.2.2 Grand Yoff and Ouakam Area (A-2)

1) Grand Yoff

Flood prone area of Grand Yoff is located in the lowest portion of the basin with ground elevation of 9 m.

The proposed drainage improvement plan by the Community of Dakar, mentioned in 1.2.2, is basically applied for the drainage of Grand Yoff basin. The proposal is modified as follows (see *Figure C.3.1*)

- Northern part of the highway is proposed to be combined with the Interceptor which drains to the western part of Grand Niaye.
- A drainage network drain by gravity flow to the Infiltration Area is proposed which will minimize the pump drainage area.
- A small pond is proposed for flood prone area in Grand Medina.
- Pump drainage area is proposed to be drained to the nearest Infiltration Area (Centre de captage de Eausc).

2) Ouakam Basin

This area is high with the minimum ground elevation of about 20 m surrounded by higher ridges. In order to drain to the sea by gravity flow, a long tunnel of high cost will be required.

Though this area is not urbanized yet, a housing development is proposed. Some open spaces for retention/infiltration ponds shall be provided in the development. Pump drainage to the sea or to the Airport South Channel will be considered, when the capacity of the pond is unexpectedly not sufficient in the future. The ponds are proposed on both sides of the airport property (see *Figure C.3.1*).

3.2.3 Dakar-Yoff Airport and Its Surrounding Area (A-3)

The narrow coastal areas, located in the north and west of the airport, can be drained by gravity through the existing natural and artificial waterways.

The drainage improvement plan for the Ouakam town proposed by the Community of Dakar is applied without any modification (see *Figure C.3.3*). Downstream reach of the Airport South Channel with a length of about 2.8 km from the estuary to the runway is proposed to be improved by expanding the existing channel. The developments in the low area near Ngor should be done by reclaiming up to at least 2 meters above mean sea level.

The Airport North Channel (2) from the estuary to the runway with a length of 1300 m is proposed to be improved.

3.2.4 Yoff-Guediawaye Coastal Area (A-4)

1) Yoff Channel Drainage Area

The Yoff Channel is proposed to be improved for a length of about 2.85 km extending from the estuary to the outlet from International Trade Center. A small area of Airport North (1) catchment located in the east of the highway is proposed to be added in the Yoff Channel (see *Figure C.3.3*).

2) Other Coastal Areas

It is proposed that drainage of this area will be made mainly by infiltration because of the following reasons:

- Ground elevation is high and soil is sand having high permeability. Therefore, infiltration is not difficult.

- For groundwater recharging.

- There are many depressed areas in inland side and it is costly to drain the stormwater to the sea or to other wet land by gravity or by pumping.

The depressed lands in the urbanized area shall be kept as open spaces for retention and infiltration of stormwater. The surplus water, which can not be drained by infiltration, will be drained by gravity if it is near the sea and by potable pumping car for inland areas.

3.2.5 Grand Niaye Area (A-5)

Grand Niaye is an important area for drainage and for groundwater recharge. Therefore, the wet land should not be urbanized in principle.

1) Grand Niaye North

Northern part of the national road (Route de Rufisque) is to be kept as it is in principle according to the land use plan. The low strip located in the western edge is proposed to be used for retention/infiltration of stormwater from Grand Yoff catchment (see *Figure C.3.1*). The eastern edge area has been developed and suffered from flooding. The area is proposed to be drained to Grand Niaye by small open channels provided at the lowest part.

The eastern part of Grand Niaye is planned to be reclaimed for the area of industrial complex by the Technopole Project.

An area of reclamation proposed by the project is about 85 ha, that is only 1/10 of catchment area of Grand Niaye, and would not affect the Grand Niaye's receiving capacity for Stormwater because existing water surfaces and depressed areas of the Grand Niaye are planned to be kept as it is in the project's plan.

Grand Niaye is also a receiving body of stormwater discharged from a part of A-6. The area of receiving body is large enough to absorb the additional water. The rising of water level of Grand Niaye by them is estimated only about 10 to 15 cm for 10-year flood, about 5cm for annual flood, and it is negligibly small.

Therefore, the Technopole project would not cause any problem for the drainage plan of area A-5 and A-6.

2) Grand Niaye South

An area around Patte d'Oie is planned to be developed. Main low areas are proposed to reserve for drainage. For other low areas, reclamation should be done at least 2 m higher than mean sea level if those are urbanized.

An open channel is proposed along the south side of national road to collect the stormwater.

3.2.6 Pikine Area (A-6)

1) Central Pikine

In the central Pikine, low strips (Niayes) with elevation of 2 m to 4 m are frequently flooded. These areas are proposed to drain into Grand Niaye by pumping with small retention ponds. The stormwater will be pumped up to the top of sand dune and will be drained to Grand Niaye by gravity flow. The stormwater of the adjacent Niaye will be drained to the main pumping station by similar method (see *Figure C.3.4*).

2) Thiaroye Sur Mer

The low areas along the national road in Thiaroye Sur Mer are frequently flooded. Some areas are lower than mean sea level and they can be used for retention ponds. This area is proposed to drain into the sea by gravity with small open channel or by a pumping station with retention ponds mentioned above. An open channel along the north side of the national road is proposed to collect the stormwater (see *Figure C.3.4*).

3) Other Areas

There is no occurrence of severe flood except in some depressed areas. Proposed drainage method of those areas is basically infiltration and some depressed area should be used as retention/infiltration lands.

3.2.7 Eastern Pikine Area (A-7)

Drainage of this area is proposed to be by infiltration and to be by discharging into the low areas of Lacs, Niayes, Marigot de Mbaw and other depressed areas. Narrow coastal area will be drained to the sea through the creeks around Mbaw. An open channel is proposed along the north side of national road to collect the stormwater.

The flood affected area in Nimzat will be drained to Tiourour by the proposed drains(see *Figure C.3.4*). The planned Malika development shall have stormwater retention areas in the existing Niayes. Lac Mbeubeusse shall have some spaces for stormwater retention without reclamation by solid waste.

3.3 FACILITY PLAN

3.3.1 General

The stormwater drainage facilities to be provided in the master plan stage are the drainage channels, pumping stations and infiltration/retention ponds as listed in *Table C.3.1*.

Main features of these facilities are described below.

3.3.2 Drainage Channels

The design peak discharge is calculated by the Rational Formula (see 2.2.2). The results are shown in *Table C.3.2*.

The size of the channel is determined by the following formula.

$$Q = V \cdot A$$

where, Q : peak discharge (m^3/s)
A : flow area (m^2)
V : average flow velocity (m/s)

Average flow velocity is assumed by the Manning Formula.

$$V = \frac{1}{n} R^{2/3} I^{1/2}$$

where, n : coefficient of roughness
I : slope of water surface
R : hydraulic radius (m) expressed by A/P,
P : wetted perimeter (m)

The sizes of the proposed drainage channels are shown in *Table C.3.2* and *Figure C.3.5* to *C.3.7*.

3.3.3 Pumping Stations

Each pumping station shall have a pond for favorable operation and for saving cost of the pumps.

The pump capacity Cp is decided in relation to the effective storage volume of the pond Vp. The storm run-off of 24 hours with 10 years return period is proposed to drain within 24 hours and within the capacity of pond. Land area of the ponds are proposed taking account of the site condition to avoid compensation problem.

The pump capacity and required area for the ponds are shown in *Table C.3.3*. The typical plan and section of the proposed pumping stations are shown in *Figure C.3.8*.

Transmission pipes associated with the pump stations are designed to have enough capacity to carry the pumped discharge following the existing land profile.

3.3.4 Infiltration / Retention Ponds

The capacity of these ponds are calculated to have an effective water volume to store the stormwater of 24 hours with 10 years return period. The ponds are proposed to be evacuated by evaporation and by infiltration before next rainy season.

The required area for infiltration and retention ponds are shown in *Table C.3.4*.

3.3.5 On-site Infiltration

Infiltration of stormwater is the most effective and desirable non-structural drainage method that supports the structural ones. The infiltration is applicable to drain water from the roof, garden, road surface and other surfaces which are not polluted so much. It is applicable to sandy areas having ground elevation of higher than 5 m. An example of calculation for required area to infiltrate the stormwater from roofs in one hector of residential area is shown below:

1) Assumption

- Area of roofs and roads = 55 % (15 % for road, 40 % for roof)
- Infiltration capacity = 1.5m^2/hr
- Rainfall depth in 1 hour = 37.1mm (2 years return period)

2) Stormwater Volume

Volume of stormwater in 1 hour = 37.1mm x 0.9 x 5500m^2 = 184m^2

3) Required Infiltration

Requirement of infiltration depends on storage capacity and area of infiltration. Examples of the infiltration methods are shown in Figure *C.3.9*.

Possible areas of the infiltration are along the pedestrian road, in the house yard/garden, play ground, etc.

3.4 PROJECT COST

3.4.1 Basis of Cost Estimates

The project cost consists of the following components:

- Construction cost
- Land acquisition and compensation cost
- Government administration cost
- Engineering service cost
- Physical contingency

The project cost is estimated based on the following assumptions:

The construction cost, land acquisition/compensation cost are estimated based on the unit price and cost for each work item prepared by the Ministry of Hydraulics, SONEES and other agencies concerned. The unit price/cost for work items are shown in *Table C.3.5*.

The Government administration expenses are estimated at 1.5% of total of construction and land acquisition/compensation costs, to cover the cost of supervision and management of the Project.

The cost of engineering services is estimated at 7% of the construction cost.

The physical contingency is provided to cope with the unforeseen conditions, such as change in site condition, etc. and is assumed to be 10% of total of construction cost, land acquisition cost, compensation cost, Engineering service, and Government administration.

3.4.2 Local and Foreign Components

The costs are divided into a foreign currency portion and a local currency portion with referring to the similar project, as follows:

Item	F.C. (%)	L.C. (%)
Concrete Lining Open Channel	15	85
Earth Channel	15	85
Box Culvert	60	40
Storm Sewer	85	15
Storm Water Pumping Station	75	25
Storm Water Transmission Pipe	85	15
Infiltration/Retention Pond	15	85
Secondary Drain	50	50
Engineering Service	70	30
Others	0	100

Note : F.C. : Foreign Currency
L.C. : Local Currency

3.4.3 Project Cost

The project cost is estimated at FCFA 24,143 million in total at 1994 price. The detailed work volume and breakdown of the cost are given in *Tables C.3.6 , C.3.7* and *C.3.8*.

3.5 IMPLEMENTATION PROGRAM

3.5.1 Priority of Sub-Projects

1) General

The proposed program of stormwater drainage improvement in the study area consists of sub-projects in the areas of Dakar IV-3, Ouakam Basin, Grand Yoff, Dakar-Yoff Airport, Yoff Channel, Central Pikine and Lac 1 catchment areas.

Priority of the sub-projects is proposed taking the following factors into account.

- Present severeness of flooding
- Anticipated flood problems in the future due to urbanization
- Required cost of drainage and efficiency of the sub-project
- Difficulty of solution if the sub-project is not conducted
- Progress of the sub-project such as study, design, etc.

2) Project Priority

Judging from the factors mentioned above, priority of the sub-projects is proposed as summarized below.

a) 1st Priority

The first priority is given to the densely populated areas with severe flooding.

a. Grand Yoff : already developed, flood depth is large with long duration, drainage is under planning

b. Central Pikine : already developed, flood depth is large with long duration, a drainage channel has been constructed in Thiaroye Sur Mer, drainage by the pumping was proposed in the Strategy Plan.

b) 2nd Priority

The second priority is given to the developing areas where flooding is not so severe.

a. Dakar-Yoff Airport : drainage improvement plan of Ouakam town has been completed and will be implemented, flood depth is large with long duration in Ngor and would be affected by the drainage improvement of the upstream area (Ouakam town).

b. Lac 1 (Tiourour) : flooding is a constraint for development

c) 3rd Priority

The third priority is given to the areas planned to be developed and anticipated that the flood problem will occur.

a. Ouakam Basin : urbanization is planned and there is a flood prone area with long flood duration.

b. IV-3 Channel and Ouakam South : planned to be urbanized

c. Yoff Channel : northern part of the highway has been developed

3.5.2 Implementation Schedule

Implementation schedule of the sub-projects is proposed for smooth development in the study area depending on the urbanization of each sub-area. Therefore, the flood prone areas in the existing urban areas require an urgent drainage improvement. Some partial works of a sub-project will be conducted depending on cost and efficiency.

Implementation schedule of the project until the year 2010 is proposed as shown in *Figure C.3.10* and cost disbursement schedule is shown in *Table C.3.9*. The implementation schedule is decided, based on the following ideas.

- Since construction of the pumping stations is the most effective work to solve the problem for the 1st priority areas, it should be implemented urgently.
- Implementation program of the works for the 2nd priority areas is prepared with the consideration of existing and future urbanization.
- The works for the 3rd priority areas are proposed to be completed by the year 2010.

3.6 ECONOMIC ANALYSIS

3.6.1 Basis of Economic Evaluation

Implementation of the urban drainage project proposed in the Master Plan will mitigate inundation and resultant damage and loss including direct damage to houses and other properties of the study area. If the project is not implemented, such damage and loss will continue to occur and moreover, they will increase as population grows. The former situation is termed as "with project" case whereas the latter is termed as "without project" case.

Benefits of the drainage project is evaluated by comparing flood damage for "with-project" and "without project" cases.

Thus, project implementation brings about benefits in the form of flood damage mitigation. On the other hand, project implementation means construction of drainage facilities which involves initial cost and also post-implemented recurrent annual cost for operation, maintenance and replacement of the facilities.

In the economic evaluation, benefits and costs have been converted into economic terms which means that the evaluation is made from the standpoint of national economy. The annual economic benefits and costs have been calculated for the project life period of 50 years and is tabulated in the form of cost benefit streams.

Using the cost benefit streams, Economic Internal Rate of Return (EIRR) has been calculated. The value of EIRR has been compared with the Opportunity Cost of Capital (OCC). The OCC is assumed to be 10%. Considering all the benefits that are not quantitatively taken into consideration, the economic feasibility of the project is evaluated.

3.6.2 Economic Costs

Initial cost amounting to 24,143 million FCFA is estimated to be required to implement the project proposed in the Master Plan. It will be composed of foreign component of 10,270 million FCFA (42.5%) and local component of 13,873 million FCFA (57.5%). Duties are not imposed on the imports related to the project. The amount of foreign components is 100% the economic cost i.e. 10,270 million FCFA. For local components, Standard Conversion Factor (SCF) of 0.8981 is applied to them resulting in economic cost of 12,459 million FCFA. (For calculation basis of SCF refer to *Table C.3.10*)

Thus, the initial cost for project implementation is estimated to be 22,729 million FCFA. The year-wise distribution of this amount for the project implementation period of 1995 to 2010 is shown in *Table C.3.11*.

Annual operation and maintenance (O & M) cost in the year 2011 and afterwards is estimated to be 95 million FCFA. SCF has been applied to O & M cost. The yearly distribution of O & M cost for the project life period is shown in *Table. C.3.11*.

It is assumed that durable life of vehicles, electro-mechanical equipment and other facilities be 10, 15 and 50 years respectively. In accordance with this assumption replacement cost has been allocated as shown in *Table 14.9*.

3.6.3 Economic Benefits

In order to evaluate benefits of the project, flood damage and loss for "without project" case has been estimated.

Flood damage and loss take many forms such as direct damage to houses, household effects, commercial and industrial establishments, institutions, agricultural crops, and infrastructures such as roads, loss in earnings of commerce/industry due to stoppage of operation, traffic damage deriving from longer driving time and consumption of more fuel, outbreak of water-borne epidemics, psychological sufferings, etc.

However, out of them the direct damage has been taken up for economic evaluation because they are the major and representative ones and can quantitatively be estimated in an established way.

It is required to estimate year-wise distribution of annual average flood damage for the project implementation period of 1995 to 2010 and afterwards. For that, average annual flood damage for three crucial years of 1993, 2000 and 2010 have been estimated first and on the basis of these flood damage amounts for intermediate years have been estimated. Yearly flood damage for 2010 onward is assumed to be the same as that for 2010.

The 1989-scale flood with a 10-year return period and the annual flood for the estimated year with a rainfall frequency of three times per annum have been used to estimate average annual flood damage for 1993 (, 2000 or 2010). Probability theory has been used to calculate the average annual flood damages.

To estimate flood damage expected under the 1989-scale flood and the annual flood in 1993, the followings were estimated: depth and duration of inundation, number of houses and other properties in the 48 inundated areas identified in the study area that are expected under the two floods in the same year. The estimation was done by interviewing people concerned combined with theoretical calculation. It is shown in *Table C.1.4*. The depth and duration of inundation in 2000 and 2010 will be virtually the same as in 1993. The number of houses and other properties in the inundation areas will increase in proportion to growth of population in those areas.

It can be said that damages to houses and other properties will increase in proportion to the depth and duration of inundation. Thus to establish mathematical relationships between inundation depth/duration and damage ratio (the ratio of damage to total value of a unit property) questionnaire survey was conducted through asking the people concerned about the conditions of inundation and damage experienced during the 1989 flood. The number of samples was 135 for households and 75 for commerce/institution/industry.

By analyzing the data from the questionnaire survey it is found that there exists statistically significant relationships between depth of inundation and damage ratio of residential buildings, household effects, commercial/industrial establishments and institutions (refer to *Table C.3.12*). However, no formulation could be made out that relates duration of inundation with damage ratio.

In the above-mentioned questionnaire survey the value of building and household effect per house for each type of housing was asked and the results are shown in *Table C.3.13*. (The survey was conducted before the devaluation. To convert the values to the post-devaluation one, it has to be multiplied by 1.4.) Through the questionnaire survey it was found that the value of a commercial establishment/institution is 3.29 times that of a house. In the same way value of an industrial establishment is 5.50 times that of a house.

Thus, combining

a. inundation depths and number of houses and other properties in the 48 inundation areas under the 1989-scale flood and the annual flood in 1993, 2000 and 2010;

b. mathematical relationships between inundation depth and damage ratio of houses and other properties; and

c. unit prices of houses and other properties;

flood damages to houses and other properties in the 48 inundation areas under the 1989-scale flood and annual flood in 1993, 2000 and 2010 have been estimated.

Regarding flood damages to gardening crops, firstly area of gardening crops expected to be inundated in 1993 under the 1989-scale flood have been estimated based on the data obtained from the above-mentioned questionnaire survey and theoretical calculation. The estimated area is 9.7 ha in total for the study area. Secondly, average damage ratio of gardening crops for 1993 under the 1989-scale flood has been estimated based on the questionnaire survey data. It is found to be 69.7% on average. Thirdly, average net income of gardening crops per ha has been estimated based on the data collected from the government organizations concerned (refer to *Table C.3.14*). (It is to be noted that the average net income is to be increased by 40% to have the post-evaluation value.) Finally, combining these three steps flood damages to gardening crops for 1993 under the 1989-scale flood have been estimated. It is assumed that damage for 2000 and 2010 will be the same as estimated for 1993. No flood damage to gardening crops is estimated for annual flood.

Results of flood damage estimation as explained above are shown in *Tables C.3.15* to *C.3.18*. By using them average annual flood damages in 1993, 2000 and 2010 are estimated to be 1,368 million, 1,704 million and 2,185 million FCFA respectively on condition that flood bigger than the 1989-scale will not occur up to 2010. Average annual flood damages for intermediate years can be estimated by applying linear time-series equations satisfying values for three years.

These damages expected for the "without project" case will turn into benefits for the "with project" case on condition that the designed facilities can prevent inundation for rainfall of up to the design return period of 10 years.

SCF has been applied to benefits as well and the resultant annual economic benefit for the project life period of 50 years are shown in *Table C.3.11*.

3.6.4 Economic Evaluation

Using the cost benefit streams in *Table C.3.11* the economic analysis of the project has been performed and EIRR of 8.7% was obtained. This value is by 1.3 point lower than the OCC of 10%. However, the urban drainage project is essentially a public project like road project. It is not proper to stick too much to the value of EIRR in evaluating such project.

Moreover, considering other benefits such as the prevention of direct flood damage to infrastructures like roads, the prevention of the losses of earnings in commercial/industrial enterprises due to stoppage of operation, prevention of traffic damage such as longer driving time and consumption of more fuel, prevention of the outbreak of water-borne epidemics and freedom from psychological sufferings, it can reasonably be surmised that the EIRR of the project can be in reality higher than 10%. Thus, the project is judged to be economically feasible.

3.6.5 Financial Aspect

The urban drainage facilities are to be constructed in an area so that they can benefit all the people in that area. In this way the beneficiaries cannot usually be specified or identified. It leads to the notion that charges cannot directly be collected from the beneficiaries of such facilities. The undertakings which are to be done is for the benefit of unspecified people such as external flood mitigation, road and bridge projects of which all are usually financed by the state, that is, by the taxes.

Thus, the urban drainage project is essentially not a revenue-generating undertaking unlike the sewerage project. It is a common practice not to collect any charge from the beneficiaries of the urban drainage facilities.

Therefore, the urban drainage sector shall stay public. The state will essentially plan, finance and execute the urban drainage project proposed under the Master Plan. After project implementation the operation & maintenance of the facilities will be done by new organization to be established in near future, but the cost concerned will be taken care by the state. There will be virtually no revenue involved.

3.7 ORGANIZATIONS AND MANAGEMENT

3.7.1 General Description of Organizations/Institution Related to Urban Drainage

The French word of sanitation is "assainissement", which concerns wastewater, rain water and solid wastes. Out of them the sectors directly related to this study are wastewater and rain water.

In Senegal the wastewater and rain water have been in principle treated as one entity in organizational and institutional terms.

Below is given a very short briefing on the existing organizations/institution concerned:

The organizations directly and indirectly related to urban drainage are :

a. SONEES : Service Assainissement in SONEES is in charge of the operation and maintenance of urban drainage facilities excluding open channels, which are operated and maintained by CUD.

b. CUD

c. Ministere de l'Hydraulique (MH) : La Direction du Genie Rural et de l'Hydraulic (DGRH) belongs to MH and La Division du Hydraulique Urbaine et de l'Assainissement (DHUA) belongs to DGRH. This DHUA is responsible for the planning and execution of urban drainage projects.

d. Ministere de l'Economie, des Finances et du Plan (MEFP)

e. Ministere de l'Environnement et de la Protection de la Nature (MEPN)

f. Ministere de l'Ulbanisme et de l'Habitat (MUPH)

g. Ministere de l'Energie, des Mines et de l'Industrie (MEMI)

h. Ministere de la Sante Publique et de l'Action Sociale (MSPAS)

i. Ministere de l/Equipement et des Transports

j. Ministere de la Ville (MV)

Laws and regulations directly or indirectly related to urban drainage are:

a. Projet de Loi portant Code de l'Assainissement : has the provisions concerning the definition of rain water, collection and drainage of rain water, etc.

b. Projet de Loi portant Code de l'Environnement : provides decrees that determine the conditions in which the discharging, running, dumping and depositing of water or materials and more generally all that are likely to alter the quality of surface, ground and sea water are regulated and forbidden.

c. Loi portant Code de l'Eau : has provisions applicable to the discharging, running, dumping and depositing of materials and more generally all that are likely to provoke or increase the degradation of surface and ground water.

d. Loi portant Code de l'Hygiene

e. Loi portant Code de l'Urbanisme

f. Cahier des Clauses et des Conditions Generales du Service Public de l'Eau et de l'Assainissement et ses Annexes : stipulates that the state can confer on SONEES by means of particular contracts the right to assure the collection and discharge of rain water and that every connection for wastewater and rain water gives rise to the payment of the cost by the applicant.

g. Deuxieme Contrat-Plan Etat-SONEES : SONEES is obliged to assure the good functioning of the collection, treatment and discharge facilities for wastewater and rain water.

The first five codes are the general laws of the state and the last two are the regulations stipulating the duties and responsibilities of SONEES.

3.7.2 Characteristics of Urban Drainage and Recommendation

In case of urban drainage facilities usually beneficiaries cannot accurately be specified or identified unlike sewerage facilities. Rain water indiscriminately and evenly fall over the area concerned and urban drainage facilities benefit all the people in that area. In this sense they resemble roads.

As charges are not collected from the vehicles on the road except the toll way, so no bill can be asked from the beneficiaries of urban drainage network except those who have connections to it.

However, the road is one of the most important infrastructures enabling the rapid transportation and exchange of goods and people, thus supporting the economic activities of an area. Likewise, the urban drainage protects the people from the damage to properties and sufferings due to inundation, thus saving the economic and psychological loss in the related area.

Both do not usually earn anything financially, but they are important investments in terms of the economy. The state intervenes in this public realm.

As the urban drainage sector is essentially not a revenue generating one, it will be not proper to give SONEES the obligations or the right in this sector the same as recommended in the sewerage sector.

Accordingly the following recommended regarding the position of the urban drainage sector in SONEES: items are

a. The state will be responsible for the planning and execution of urban drainage project.

b. SONEES will be in charge of operation & maintenance of the urban drainage facilities (excluding open channels).

c. The capital and operation & maintenance costs will be borne by the state.

d. The organization for the urban drainage sector will be incorporated in the proposed Operation and Maintenance Department.

The operation & maintenance of the open drainage channels will be done by CUD. In short the team does not come up with any new proposals with regard to this sector.

3.8 PROJECT EVALUATION

The proposed urban drainage Master Plan covers entire study area either by structural measures or by non-structural measures. Under this plan, all the flood areas, flooded by the 1989 August flood, will be protected from inundation against the same level of rainfall.

The plan has identified developing activities that do not concern topographic conditions as a major cause of the inundation problems. Therefore, non-structural measures, such as to reserve low lands for infiltration for development in the future, are strongly recommended while structural measures are proposed for the areas where urbanization has already occurred or expected to occurs.

Negative impacts of the project are expected to occur during construction of the proposed facilities. However, these are expected to be small because the facilities are small in scale.

The total project cost is estimated at 24,143 million FCFA and the economic internal rate of return (EIRR) is calculated to be 8.7 %. This concludes that the project is highly beneficial to the economy of Senegal.

3.9 RECOMMENDATION

- The existing drainage channels in Dakar urban area shall be maintained as proposed in the strategy plan.

- Stormwater should be infiltrated into the ground at each house lot, factory, etc. for groundwater recharge and to reduce the surface run-off.

- The low areas of Grand Niaye should not be urbanized as they serve as receiving bodies of the stormwater.

- The depressed areas in Yoff-Guediawaye Coastal Area, Central Pikine and Eastern Pikine should be kept for retention/infiltration of stormwater. The minimum required area is estimated to be 1 ha for drainage area of 1 km^2.

- The low areas in Central Pikine and Eastern Pikine such as Lacs, Niayes, etc. where stormwater is concentrated, should not be urbanized. Some parts of Lac Mbeubeussé should not be reclaimed by garbage for drainage of the adjacent towns.

- The economic internal rate of return (EIRR) of the project turns out to be 8.7%. When other qualitative benefits are taken into account, it is clear that the EIRR will surpass 10%, that is, the estimated opportunity cost of capital. What it all means is that the project is highly beneficial to the economy of Senegal. It is recommended therefore that the government realize the project as soon as possible.

- The status/power of SONEES vis-a-vis the Government in connection with the urban drainage sector should remain the same as at present because of the public nature of the urban drainage project.

- The state will continue to plan, finance and execute the urban drainage project. The operation & maintenance (O & M) of the facilities will be done by new organization to be established in near future. However, the O & M cost will be borne by the state.

3.10 SELECTION OF PRIORITY PROJECT FOR FEASIBILITY STUDY

The proposed drainage Master Plan identifies two areas, namely Grand-Yoff and Central Pikine, as the 1st priority areas. Both areas require earlier implementation of the projects because they have been urbanized and flood damage is severe. There is no decisive factors to select one from the above two areas. However, it was confirmed during the study, that the feasibility study conducted by the Government for Grand-Yoff area has shown the similar idea and there was an indication of commitment by a foreign agency to finance the project for Grand-Yoff. Therefore, the project for Central Pikine is determined as the priority project for the drainage project. Project components will be as follows:

- Construction of pumping stations with a retention pond at each station

- Construction of C.P.1 drainage channels

- Construction of C.P.2 drainage channels

- Construction of retention ponds

TABLE C.3.1 (1) PROPOSED FACILITIES FOR STORMWATER DRAINAGE IMPROVEMENT PLAN (1)

Area	Proposed Facilities			Total
A-1				
IV-3 II	Construction of Drainage Channel			L= 2,300 m
		Box Culvert (3m x 2.6m)		(800 m)
		Concrete Lining Open Channel (1.5m x 1.5m, 0.5)		(1,300 m)
OS	Construction of Drainage Channel			L= 800 m
		Box Culvert (1.5m x 1.8m)		(800 m)
F.T.	Construction of Grand-Yoff Infiltration Pond 1			A= 5 ha
A-2				
O.B.	Construction of Ouakam Infiltration Ponds (2 pls)			A= 3.24 ha
	Construction of Drainage Channel			L= 2,050 m
		Concrete Lining Open Channel (1.5m x 1.5m, 0.5)		(2,050 m)
G.Y.				
G.Y. 1	Drain to Grand Niaye			
	Construction of Drainage Channel			L= 3,850 m
		Concrete Lining Open Channel (3.0m x 1.7m, 0.5)		(2,800 m)
		Concrete Lining Open Channel (1.5m x 1.5m, 0)		(1,050 m)
	Construction of Patte d'Oie Infiltration Pond (2 pls)			A= 4 ha
G.Y. 2	Drain to Grand-Yoff Infiltration Pond			
	Construction of Drainage Channel			L= 1,200 m
		Box Culvert (2m x 2m x 2)		(500 m)
		Concrete Lining Open Channel (2m x 2m, 0.5)		(700 m)
	Stormwater Pumping Station (Q=1.5 m3/s)			1 place
	Stormwater Transmission Pipe (DCIP d=1,100mm)			L= 300 m
	Construction of Grand-Yoff Infiltration Pond 2			A= 2.25 ha
A-3				
Ai S	Construction of Drainage Channel			L= 6,150 m
		Earth Channel (9m x 2m, 2)		(2,850 m)
		Concrete Lining Open Channel (2.5m x 1.6m, 0.5)		(3,300 m)
Ai N1	Construction of Airport Infiltration Pond			A= 1 ha
Ai N2	Improvement of Existing Channel			L= 1,300 m
		Concrete Lining Open Channel (2m x 1.2m, 0)		(1,300 m)
C.Y.	Improvement and Construction of Drainage Channel			L= 3,500 m
		Concrete Lining Open Channel (2m x 1.6m, 0.5)	Construction	(2,850 m)
		Concrete Lining Open Channel (2m x 1.6m, 0.5)	Improvement	(650 m)

TABLE C.3.1 (2) PROPOSED FACILITIES FOR STORMWATER DRAINAGE IMPROVEMENT PLAN (2)

Area	Proposed Facilities			Total
A-6				
CP EP	Construction of Main Drainage Channel along National Road			L= 3,610 m
	Concrete Lining Open Channel (3m x 1.5m,1)			
CP				
CP 1	Drain to Grand Niaye			
	Construction of Storm Sewer		2 Systems Total	L= 4,460 m
	C.P.1-1			(L=2,970m)
		d=1,100mm CP		(250m)
		d=1,000mm CP		(1,050m)
		d=900mm CP		(620m)
		d=800mm CP		(1,050m)
	C.P.1-2			(L=1,490m)
		d=1,100mm CP		(260m)
		d=1,000mm CP		(550m)
		d=600mm CP		(680m)
	Construction of open channel (2m x 0.4 - 0.6m, 1)		2 Systems Total	L = 400m
	C.P.1-1			(100 m)
	C.P.1-2			(300 m)
	Stormwater Pumping Station		2 Systems Total	7 pls
	C.P.1-1 (1.0 m3/s 2pls, 0.3 m3/s 1pls)			3 pls
	C.P.1-2 (1.5 m3/s , 1.0 m3/s, 0.5m3/s, 0.3m3/s)			4 pls
	Stormwater Transmission Pipe (Ductile Iron Pipe)		2 Systems Total	L= 2,630m
	C.P. 1-1			(L=690m)
		d=600mm DCIP		(420m)
		d=800mm DCIP		(270m)
	C.P. 1-2			(L=1,940m)
		d=600mmDCIP		(570m)
		d=1100mm DCIP		(920m)
		d=801mm DCIP		(450m)
CP 2	Drain to Sea			
	Construction of main Drainage Channel (1-3m x 0.4-1.6m, 1)			L = 2,940 m
	Improvement of Existing Drainage Channel (3m x 0.9m, 1)			L= 770 m
	Stormwater Pumping Station (1.5 m3/s)			1 Place
	Retention Pond		Total	5 .1ha
A-7				
L1	Construction of Drainage Channel			L= 1,750 m
	Concrete Lining Open Channel (4.5m x 1.5m, 0.5)			

TABLE C.3.2 RESULTS OF RUN-OFF CALCULATION/SIZES OF THE DRAINAGE CHANNELS

Name	Run off Calculation					Dimension of Drainage Channel						
	Catchment Area (km2)	Run-off Coefficient (f)	Time of Concentration (min.)	Rainfall Intensity (mm/hr)	Peak Discharge (m3/s)	Width (m)	Depth (m)	Bank Slope	Bed Slope	Roughness Coefficient	Discharge Capacity (m3/s)	Remarks
IV-3 ii	1.673	0.3	44.0	65.16	9.08	3.0	2.3	0	1/800	0.025	9.92	Box Culvert
Ouakam South	0.743	0.3	26.5	83.15	5.15	1.8	1.5	0	1/100	0.025	5.66	Box Culvert
Ouakam Basin	0.91	0.3	30.3	78.44	5.95	1.5	1.5	0.5	1/300	0.025	6.11	Open Channel
Grand Yoff 1 1	2.955	0.3	44.5	64.76	15.94	3.0	1.7	0.5	1/250	0.025	16.13	Open Channel
Grand Yoff 1 2	0.472	0.3	29.0	79.99	3.15	1.5	1.5	0	1/200	0.025	3.59	Open Channel
Grand Yoff 2 1	0.771	0.3	25.6	84.34	5.42	2.5	2.0	0	1/500	0.025	6.11	Open Channel
Grand Yoff 2 2	0.771	0.3	25.6	84.34	5.42	2.0	1.7	0	1/800	0.025	3.01	Box Culvert x2
Grand Yoff 3 1	8.295	0.3	71.3	48.72	33.68	9.0	2.0	2.0	1/1000	0.03	35.09	Earth Channel
Grand Yoff 3 2	2.221	0.3	47.9	62.16	11.51	2.5	1.6	0.5	1/250	0.025	12.16	Open Channel
Airport North 2	0.923	0.3	30.6	78.09	6.01	2.0	1.2	0	1/100	0.025	6.04	Open Channel
Yoff Channel	2.867	0.3	49.3	61.15	14.61	2.0	1.6	0.5	1/100	0.025	15.48	Open Channel
Lac 1	0.952	0.2	34.6	73.73	3.90	1.5	1.5	0.5	1/500	0.025	4.74	Open Channel

TABLE C.3.3 PUMP CAPACITY AND REQUIRED AREA FOR POND

Name		Total Catchment (km^2)	Pump Capacity (m^3/s)	Storage Volume (m^3)	Required Area for Pond
Grand-Yoff		0.90	1.5	12,650	65m x 65m x 3.0m
Central Pikine 1	1	1.26	1.0	13,300	67m x 67m x 3.0m
	2	0.74	1.0	6,700	47m x 47m x 3.0m
	3	0.18	0.3	1,900	25m x 25m x 3.0m
	4	1.86	1.5	17,800	77m x 77m x 3.0m
	5	0.67	1.0	5,500	43m x 43m x 3.0m
	6	0.19	0.3	2,000	26m x 26m x 3.0m
	7	0.45	0.5	5,500	43m x 43m x 3.0m
Central Pikine 2		2.09	1.5	81,100	233m x 233m x 1.5m

TABLE C.3.4 REQUIRED STORAGE VOLUME AND AREA FOR INFILTRATION POND

Name		Total Catchment (km^2)	Storage Volume (m^3)	Infitration Surface (ha)	Required Area
Ouakam	1	2.3	17,200	2.25	150m x 150m x 1.0m
	2		7,700	0.99	110m x 90m x 1.0m
Patte d'Oie	1	3.4	20,600	2.00	200m x100m x 1.3m
	2		20,600	2.00	200m x100m x 1.3m
Grand Yoff	1	5.3	32,900	5.00	250m x 200m x 1.0m
	2		16,000	2.25	150m x 150m x 1.0m
Airport North (1)		0.8	10,400	1.00	100m x 100m x 1.3m

TABLE C.3.5 UNIT PRICE/COST FOR WORK ITEMS

Item	Unit	Unit Price/Cost
Open Channel		
Earth Channel		
Type I (B=9m, H=2m, m=2)	m	207,700
Concrete Lining Open Channel		
Type I (B=4.5m, H=1.5m, m=0.5)	m	295,300
Type III (B=3m, H=1.7m, m=0.5)	m	271,280
Type IV (B=3m, H=1.7m, m=1)	m	311,000
Type V (B=2.5m, H=1.6m, m=0.5)	m	226,710
Type V (B=2m, H=2m, m=0)	m	310,650
Type VI (B=2m, H=1.6m, m=1)	m	196,000
Type VII (B=2m, H=1.6m, m=0.5)	m	190,000
Type VIII (B=2m, H=1.2m, m=0)	m	164,600
Type IX (B=1.5m, H=1.5m, m=0.5)	m	188,900
Type X (B=1.5m, H=1.5m, m=0)	m	176,150
Type XI (B=1m, H=1.m, m=1)	m	162,000
Box Culvert		
Type I (B=3m, H=2.6m)	m	640,800
Type II (B=1.8m, H=1.5m)	m	387,960
Type III (B=3m, H=2.5m x 2)	m	1,226,480
Storm Sewer		
Type I (d=600mm Concrete Pipe)	m	316,000
Type II (d=800mm Concrete Pipe)	m	378,000
Type III (d=900mm Concrete Pipe)	m	413,000
Type IV (d=1,000mm Concrete Pipe)	m	466,000
Type V (d=1,100mm Concrete Pipe)	m	525,000
Infilteration Pond	ha	31,680,000
Retention Pond	ha	42,500,000
Storm Water Pumping Station		
Type I (0.3 m2/s)	pls	209,800,000
Type II (0.5 m3/s)	pls	242,800,000
Type III (1.0 m3/s)	pls	311,800,000
Type IV (1.5m3/s)	pls	395,900,000
Transmission Pipe Line		
Type I (d=600mm Ductile Iron Pipe)	m	283,700
Type II (d=800mm Ductile Iron Pipe)	m	387,300
Type III (d=1,100mm Ductile Iron Pipe)	m	608,600
Land Acquisition	m2	1,650

TABLE C.3.6 WORK VOLUME (MASTER PLAN)

Item	Unit	A-1			A-2			A-3				A-6			A-7
						G.Y.							CP		
		IV-3 ii	OS	F.T.	O.B.	G.Y.1	G.Y.2	Ai S	Ai N1	Ai N2	C.Y.	EP	CP1	CP2	L1
Open Channel															
Earth Channel															
Type I (B=9m, H=2m, m=2)	m							2,850							
Concrete Lining Open Channel															
Type I (B=4.5m, H=1.5m, m=0.5)	m														1,750
Type III (B=3m, H=1.7m, m=0.5)	m					2,800									
Type IV (B=3m, H=1.5m, m=1)	m											2,850		2,710	
Type V (B=2.5m, H=1.6m, m=0.5)	m							3,300							
Type V (B=2m, H=2m, m=0)	m						700								
Type VI (B=2m, H=1.6m, m=1)	m												400	300	
Type VII (B=2m, H=1.6m, m=0.5)	m										3,500				
Type VIII (B=2m, H=1.2m, m=0)	m									1,300					
Type IX (B=1.5m, H=1.5m, m=0.5)	m	1,300			2,050										
Type X (B=1.5m, H=1.5m, m=0)	m					1,050									
Type XI (B=1m, H=1.m, m=1)	m													700	
Box Culvert															
Type I (B=3m, H=2.6m)	m	800													
Type II (B=1.8m, H=1.5m)	m		800												
Type III (B=3m, H=2.5m x 2)	m						500								
Storm Sewer															
Type I (d=600mm Concrete Pipe)	m												680		
Type II (d=800mm Concrete Pipe)	m												1,050		
Type III (d=900mm Concrete Pipe)	m												620		
Type IV (d=1,000mm Concrete Pipe)	m												1,600		
Type V (d=1,100mm Concrete Pipe)	m												510		
Infilteration Pond	ha			5.00	3.24	4.00	2.25		1.00						
Retention Pond	ha												2.50	5.10	
Storm Water Pumping Station															
Type I (0.3 m2/s)	pls												2		
Type II (0.5 m3/s)	pls												1		
Type III (1.0 m3/s)	pls												3		
Type IV (1.5m3/s)	pls						1						1	1	
Transmission Pipe Line															
Type I (d=600mm Ductile Iron Pipe)	m												1,190		
Type II (d=800mm Ductile Iron Pipe)	m												990		
Type III (d=1,100mm Ductile Iron Pipe)	m						300						450		
Land Acquisition	m2			60,000	39,000	48,000	32,000		12,000				25,000	51,000	

TABLE C.3.7 PROJECT COST (MASTER PLAN)

Item	Unit	Unit Price/Cost (FCFA)	A-1			A-2			A-3				A-6			A-7	Dakar and Pikine	Total
							G.Y.							CP				
			IV-3 II	OS	F.T.	O.B.	G.Y.1	G.Y.2	AI S	AI N1	AI N2	C.Y.	EP	CP1	CP2	L1		
I. Direct Construction Cost																		
1 Open Channel																		
Earth Channel																		
Type I (B=9m, H=2m, m=2)	m	207,700							591,945									591,945
Concrete Lining Open Channel																		
Type I (B=4.5m, H=1.5m, m=0.5)	m	295,300														516,775		516,775
Type II (B=3m, H=1.7m, m=0.5)	m	271,280					759,584											759,584
Type III (B=3m, H=1.7m, m=1)	m	311,000											886,350		842,810			1,729,160
Type IV (B=2.5m, H=1.6m, m=0.5)	m	226,710							748,143									748,143
Type V (B=2m, H=2m, m=0)	m	310,650						217,455										217,455
Type VI (B=2m, H=1.6m, m=1)	m	196,000												78,400	58,800			137,200
Type VII (B=2m, H=1.6m, m=0.5)	m	190,000										665,000						665,000
Type VIII (B=2m, H=1.2m, m=0)	m	164,600									213,980							213,980
Type IX (B=1.5m, H=1.5m, m=0.5)	m	188,900	245,570			387,245												632,815
Type X (B=1.5m, H=1.5m, m=0)	m	176,150					184,958											184,958
Type XI (B=1m, H=1.m, m=1)	m	162,000													113,400			113,400
2 Box Culvert																		
Type I (B=3m, H=2.6m)	m	640,800	512,640															512,640
Type II (B=1.8m, H=1.5m)	m	387,960		310,368														310,368
Type III (B=3m, H=2.5m x 2)	m	1,226,480						613,240										613,240
3 Storm Sewer																		
Type I (d=600mm Concrete Pipe)	m	316,000												214,880				214,880
Type II (d=800mm Concrete Pipe)	m	378,000												396,900				396,900
Type III (d=900mm Concrete Pipe)	m	413,000												256,060				256,060
Type IV (d=1,000mm Concrete Pipe)	m	466,000												745,600				745,600
Type V (d=1,100mm Concrete Pipe)	m	525,000												267,750				267,750
4 Infiltration Pond	ha	31,680,000			158,400	102,643	126,720	71,280		31,680								490,723
5 Retention Pond	ha	42,500,000												106,250	216,750			323,000
6 Storm Water Pumping Station																		
Type I (0.3 m2/s)	pls	209,800,000												419,600				419,600
Type II (0.5 m3/s)	pls	242,800,000												242,800				242,800
Type III (1.0 m3/s)	pls	311,800,000												935,400				935,400
Type IV (1.5m3/s)	pls	395,900,000						395,900						395,900	395,900			1,187,700
7 Transmission Pipe Line																		
Type I (d=600mm Ductile Iron Pipe)	m	283,700												337,603				337,603
Type II (d=800mm Ductile Iron Pipe)	m	387,300												383,427				383,427
Type III (d=1,100mm Ductile Iron Pipe)	m	608,600						182,580						273,870				456,450
8 Secondary Drain			227,463	93,110	47,520	146,966	321,378	444,137	402,026	9,504	64,194	199,500	265,905	1,516,332	488,298	155,033		4,381,367
Sub-Total of (I)			985,673	403,478	205,920	636,855	1,392,640	1,924,592	1,742,114	41,184	278,174	864,500	1,152,255	6,570,772	2,115,958	671,808		18,985,922
II. Pumping Car																	500,000	500,000
III. Land Acquisition/Compensation																		
1 Land Acquisition	m2	1,650			99,000	64,350	79,200	52,800		19,800				41,250	84,150			440,550
2 Compensation	m3	1,650			99,000	64,350	79,200	52,800		19,800				41,250	84,150			440,550
Sub-Total of (II)					198,000	128,700	158,400	105,600		39,600				82,500	168,300			881,100
IV. Engineering Service		(7% of I)	68,997	28,243	14,414	44,580	97,485	134,721	121,948	2,883	19,472	60,515	80,658	459,954	148,117	47,027		1,329,015
V. Government Adminstration		(1.5% of I+III)	14,785	6,052	6,059	11,483	23,266	30,453	26,132	1,212	4,173	12,968	17,284	99,799	34,264	10,077		298,005
VI. Physical Contingency		(10% of I+III+IV+V)	106,946	43,777	42,439	82,162	167,179	219,537	189,019	8,488	30,182	93,798	125,020	721,303	246,664	72,891		2,149,404
VII. Project Cost			1,176,401	481,551	466,833	903,780	1,838,969	2,414,902	2,079,214	93,367	332,001	1,031,781	1,375,216	7,934,328	2,713,303	801,802	500,000	24,143,447

M/PCOST-2

TABLE C.3.8 BREAKDOWN OF PROJECT COST

	CONSTRUCTION COST		
	FC	LC	TT
1st Priority			
a. Grand-Yoff			
1) Survey, Design, Contract Process	172,634	73,986	246,620
2) Land acquisition / Compensation	0	462,000	462,000
3) Pumping station / Pond	452,118	126,362	578,480
4) G.Y.1 drainage channels	141,681	802,861	944,542
5) G.Y.2 drainage channels	400,568	430,127	830,695
6) Infiltration pond	53,460	302,940	356,400
7) Government Administration	0	47,582	47,582
8) Physical contingency	0	346,632	346,632
Sub-total	1,220,461	2,592,590	3,812,951
b. Central Pikine			
1) Survey, Design, Contract Process	425,650	182,422	608,072
2) Land acquisition / Compensation	0	250,800	250,800
3) Pumping station / Pond	2,637,865	746,635	3,384,500
4) C.P.1 drainage channels	1,610,772	348,819	1,959,591
5) C.P.2 drainage channels	152,252	862,758	1,015,010
6) Retention pond	48,450	274,551	323,001
7) Secondary Drain	1,002,314	1,002,315	2,004,629
8) Government Administration	0	134,063	134,063
9) Physical contingency	0	967,967	967,967
Sub-total	5,877,302	4,770,420	10,647,631
2nd Priority			
Survey, Design, Contract Process	133,931	57,399	191,330
Land acquisition / Compensation	0	39,600	39,600
a. Dakar-Yoff airport			
1) Ouakam town drainge	112,221	635,922	748,143
2) Airport South channel	88,792	503,153	591,945
3) Airport North channel	32,097	181,883	213,980
4) Infiltration pond	4,752	26,928	31,680
b. Lac 1 Drainage Channels			
1) Construction cost	77,516	439,259	516,775
Government Administration	0	32,132	32,132
Physical contingency	0	236,558	236,558
Sub-total	449,309	2,512,851	2,602,142
3rd Priority			
Survey, Design, Contract Process	198,095	84,898	282,993
Land acquisition / Compensation	0	128,700	128,700
a. Channel IV-3			
1) Channel IV-3.2	344,420	413,790	758,210
2) O.S. drainage channel	186,221	124,147	310,368
b. Ouakam Basin			
1) Drainage channels	58,087	329,158	387,245
2) Infilteration pond	15,396	87,247	102,643
c. Yoff Channel			
1) Construction cost	99,750	565,250	665,000
d. Channel Along the Road (E.P.)			
1) Construction cost	132,952	753,398	886,350
Government Administration	0	48,578	48,578
Physical contingency		357,009	357,009
Sub-total	1,034,921	2,892,285	3,927,095
Secondary Drain & On-site Infiltration pond			
Construction cost	1,188,369	1,188,369	2,376,737
Government Administration	0	35,651	35,651
Physical contingency	0	241,239	241,239
Sub-total	1,188,369	1,465,300	2,653,627
Pumping Car	500,000	0	500,000
Total	10,270,362	14,233,446	24,143,446

FC = Forign Currency Portion
LC = Local Currency Portion
TT = Total Currency Portion

TABLE C.3.9 COST DISBURSEMENT SCHEDULE FOR DRAINAGE IMPROVEMENT PROJECT

Unit : FCFA 1000

	Construction Cost			O/M	
	F.C.	L.C.	Sub-Total	O/M Cost	Total
1995	251,188	143,536	394,724	0	394,724
1996	251,188	408,817	660,005	0	660,005
1997	2,435,873	1,160,882	3,596,755	0	3,596,755
1998	2,377,531	1,725,655	4,103,186	13,530	4,116,716
1999	689,886	1,668,460	2,358,346	30,398	2,388,744
2000	502,397	1,231,912	1,734,308	40,509	1,774,817
2001	506,006	1,338,250	1,844,255	47,610	1,891,865
2002	393,357	710,716	1,104,074	55,303	1,159,377
2003	479,462	788,349	1,267,811	59,866	1,327,677
2004	479,462	788,349	1,267,811	65,377	1,333,188
2005	372,110	621,330	993,440	70,887	1,064,328
2006	351,021	485,447	836,468	75,169	911,638
2007	458,547	516,503	975,050	78,748	1,053,798
2008	241,568	729,268	970,836	81,829	1,052,665
2009	240,383	777,806	1,018,189	86,009	1,104,198
2010	240,383	777,806	1,018,189	90,469	1,108,658
2011				94,930	94,930
Total Cost (1995-2010)	10,270,362	13,873,084	24,143,446		

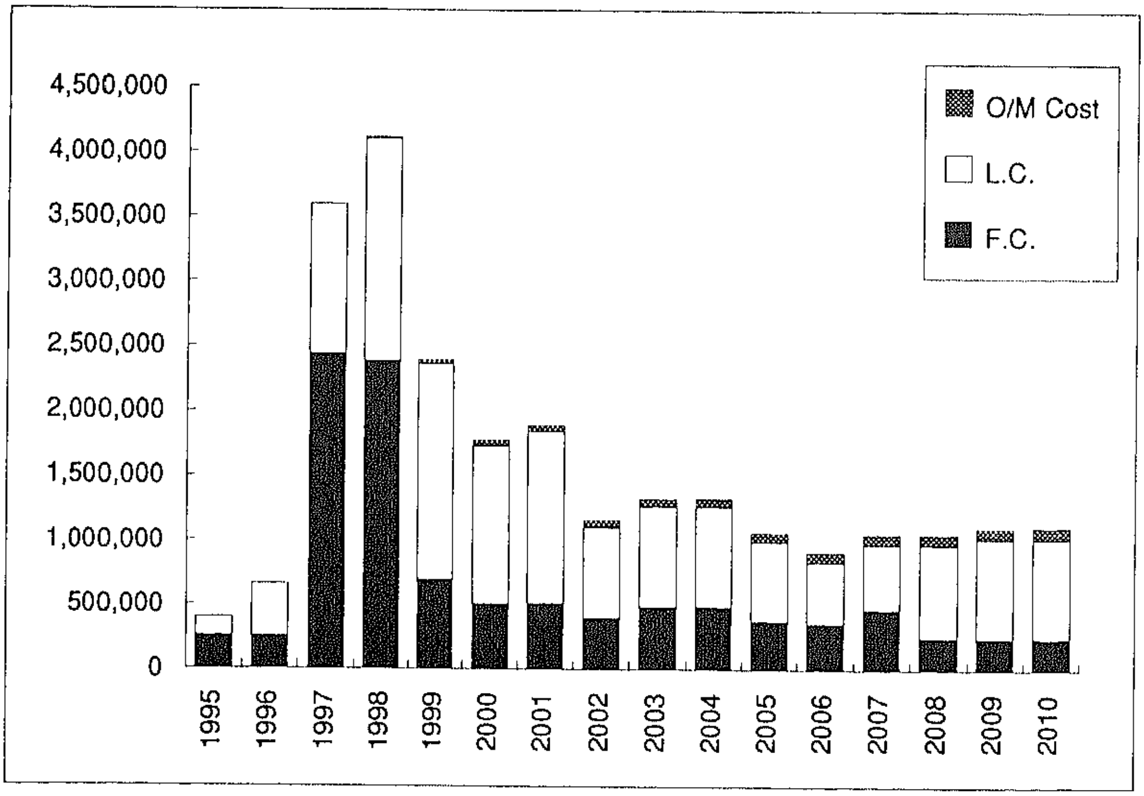


TABLE C.3.10 CALCULATION OF STANDARD CONVERSION FACTOR

1. Imports/Exports

(Unit: FCFA million)

Year	Imports	Exports
1990	473,900	399,600
1991	494,500	411,000
1992	492,900	401,900

Source: Dirction de la Prevision de la Statistique, Ministere de l'Economie, des Finances et du Plan

2. Import/Export Duties and Taxes

(Unit: FCFA million)

Year	Duties and Taxes	
	Import	Export
1990	97,152	847
1991	103,322	716
1992	113,227	1,470

Source: Bureau des Recettes et des Statistiques Douanieres (B.R.S.D), Direction Generale des Douanes, Ministere de l'Economie, des Finances et du Plan

3. Calculation of Standard Conversion Factor

1) Formula

$$SCF = (M + X) / ((M + tm) + (X - tx))$$

where, SCF: Standard conversion factor
M : Imports
X : Exports
tm : Import duties and taxes
tx : Export duties and taxes

2) Results

Year	SCF
1990	0.9072
1991	0.8982
1992	0.8890
Average	0.8981

TABLE C.3.11 COST BENEFIT STREAMS

CC=Capital Costs; OM=O/M Costs; CS=Costs; BF=Benefits
CF=Cash Flow (=BF - CS)

(Unit:FCFA Million)

NO.	YEAR	CC	OM	CS	BF	CF
1	1995	380	0	380	0	-380
2	1996	618	0	618	0	-618
3	1997	3478	0	3478	0	-3478
4	1998	3927	12	3939	578	-3362
5	1999	2188	27	2216	1190	-1026
6	2000	1609	36	1645	1275	-370
7	2001	1708	43	1751	1364	-387
8	2002	1032	50	1081	1455	374
9	2003	1187	54	1241	1549	308
10	2004	1187	59	1246	1646	400
11	2005	930	64	994	1746	753
12	2006	787	68	855	1790	935
13	2007	922	71	993	1833	840
14	2008	897	73	970	1876	906
15	2009	939	77	1016	1919	903
16	2010	939	81	1020	1962	942
17	2011	0	85	85	1962	1877
18	2012	1180	85	1266	1962	697
19	2013	676	85	762	1962	1201
20	2014	0	85	85	1962	1877
21	2015	0	85	85	1962	1877
22	2016	0	85	85	1962	1877
23	2017	250	85	335	1962	1627
24	2018	0	85	85	1962	1877
25	2019	0	85	85	1962	1877
26	2020	0	85	85	1962	1877
27	2021	0	85	85	1962	1877
28	2022	0	85	85	1962	1877
29	2023	0	85	85	1962	1877
30	2024	0	85	85	1962	1877
31	2025	0	85	85	1962	1877
32	2026	0	85	85	1962	1877
33	2027	250	85	335	1962	1627
34	2028	676	85	762	1962	1201
35	2029	0	85	85	1962	1877
36	2030	0	85	85	1962	1877
37	2031	0	85	85	1962	1877
38	2032	0	85	85	1962	1877
39	2033	0	85	85	1962	1877
40	2034	0	85	85	1962	1877
41	2035	0	85	85	1962	1877
42	2036	0	85	85	1962	1877
43	2037	250	85	335	1962	1627
44	2038	0	85	85	1962	1877
45	2039	0	85	85	1962	1877
46	2040	0	85	85	1962	1877
47	2041	0	85	85	1962	1877
48	2042	1180	85	1266	1962	697
49	2043	676	85	762	1962	1201
50	2044	0	85	85	3543	3457

TABLE C.3.12 RELATIONSHIPS BETWEEN INUNDATION DEPTH AND DAMAGE RATIO

1. Houses

1) Building(s)

DR1 = -2.997597 + 0.2644106 * DP

where, DR1: Damage ratio of building(s) (the ratio of the value of flood damages to the the value of buildings) in %.

DP : Depth of inundation in cm.

No. of samples = 59
Correlation coefficient = 0.605348
T - value = 5.741840

2) Household Effects

DR2 = 2.790765 + 0.8420461 * DP

where, DR2: Damage ratio of household effects (the ratio of the value of flood damages to the value of household effects) in %.

DP : Depth of inundation in cm.

No. of samples = 59
Correlation coefficient = 0.694268
T - value = 7.282878

2. Commercial/Industrial Establishments & Institutions

DR3 = 1.529148 + 0.6389940 * DP

where, DR3: Damage ratio of commercial/industrial establishments & institutions (the ratio of the value of flood damages to the value of property (buildings, equipment/machinery and inventory)) in %.

DP : Depth of inundation in cm.

No. of samples = 34
Correlation coefficient = 0.626877
T - value = 4.551493

Source: Results of the questionnaire survey conducted by JICA

TABLE C.3.13 VALUE OF BUILDINGS AND HOUSEHOLD EFFECTS PER HOUSE BY TYPE OF HOUSING

(Unit: FCFA)

Type of Housing	Value at 1993 Prices	
	Building(s)	Household Effects
Village	3,412,500	338,740
Spontaneous, irregular	521,429	80,947
Spontaneous, regular	3,663,729	413,777
Planned	7,630,909	712,525
Detached (large) houses	17,624,930	2,051,433
Flats	10,592,610	1,034,662
Average	4,408,299	460,236

Sources: Results of the questionnaire survey conducted before the devaluation by JICA

Note : To convert the values to the post-devaluation one, it has to be multiplied by 1.4. Because it is estimated that general prices in Senegal will rise by 40% on average by the end of 1994.

TABLE C.3.14 DATA/INFORMATION ON GARDENING CROPS IN THE REGION OF DAKAR

1. Productivity and Producers' Price of Major Gardening Crops

Type of Crops	Area (ha)	Production (tonne)	Productivity (tonne/ha)	Producers' Price (FCFA/kg)
Potato	558	4,727	8.47	96
Onion	431	3,255	7.55	116
Cabbage	293	5,909	20.17	122
Tomato	554	7,635	13.78	63
Egg Plant	66	1,510	22.88	57
Total	1,902	23,035	12.11	92

Note: The figures of the area and production are the average figures for 1985/86 to 1991/92. Producers' price is the 1990 price.

Source: CDH (Centre de Developpement de l'Horticulture)/ ISRA (Institut Senegalais de Recherches Agricoles)

2. Cost of Input and Net Income for Major Gardening Crops

(Unit: FCFA/ha)

Type of Crops	Cost of Input	Producers' Price	Net Income
Potato	769,480	813,120	43,640
Onion	711,620	875,800	164,180
Cabbage	750,600	2,460,740	1,710,140
Tomato	774,500	868,140	93,640
Egg Plant	714,373	1,304,160	589,787
Average	753,040	1,114,202	361,162

Note :
1) Cost of input is at the 1991 prices. It includes the costs of seeds, organic manure, chemical fertilizer, pesticides, labor, water and others. It is the average cost of the traditional and modern farming.
2) Average net income is to be increased by 40% to have the post-devaluation value

Source : Service regional de l'Agriculture, Hann, Dakar and DH/ISRA

TABLE C.3.15 ESTIMATED FLOOD DAMAGE IN 1993 BY TYPE OF PROPERTY AND BY INUNDATION AREA UNDER 1989-SCALE FLOOD

Legend:
RSBLD=Residential Buildings, HHEFF=Household Effects, CM/IN=Commerce & Institutions, INDUS=Industry, GDCRP=Gardening Crops

(Unit: FCFA million)

Code No.	Name of Inundation Areas	RSBLD	HHEFF	CM/IN	INDUS	GDCRP
1	Lanssar	12.1	7.9	1.1	82.6	0.0
2	Diamaguene, Diaksao	50.1	25.4	4.3	7.1	0.1
3	Wakhine	0.0	0.0	0.0	0.0	0.0
4	Medina, Gounass, etc.	91.4	46.9	7.8	0.0	0.0
5	Darou, Rakhnane, etc.	95.8	41.3	7.7	0.0	1.4
6	Djidda II, Pikine	155.0	78.0	13.2	0.0	0.0
7	Thiaroye sur Mer	273.6	114.9	21.9	80.9	0.0
8	Ganaw Rail	16.4	10.2	1.5	0.0	0.0
9	Nass Roulah	0.0	0.1	0.0	0.0	0.0
10	Thiaroye SOTRAC	2.0	1.2	0.2	14.7	0.0
11	Cite Pepiniere Pikine	43.1	19.5	3.5	0.0	0.0
12	Dalifort	0.0	0.0	0.0	0.0	0.0
13	Entree Tally Boubess	76.6	38.3	6.5	0.0	0.9
14	Traversiere	0.0	0.0	0.0	0.0	0.0
15	Rue 10	34.2	18.4	3.0	0.0	0.0
16	Rond Point	0.0	0.0	0.0	0.0	0.0
17	Rue 10, ENAM, Zone B Rue G	0.0	0.0	0.0	0.0	0.0
18	Rue 11	31.1	12.9	2.5	0.0	0.0
19	SICAP Amitie I Rue 10	7.7	4.8	0.7	0.0	0.0
20	Av. Bourguiba	0.0	0.0	0.0	0.0	0.0
21	Route de Ouakam	0.0	0.0	0.0	0.0	0.0
22	Mermoz Terrain Basket	18.5	9.8	1.6	0.0	0.0
23	Corniche Ouest	0.0	0.0	0.0	0.0	0.0
24	SICAP Baobabs Rue Biyar	0.0	0.0	0.0	0.0	0.0
25	SICAP Baobabs + Rue 12	0.0	0.0	0.0	0.0	0.0
26	Rue 13	0.0	0.0	0.0	0.0	0.0
27	Derkle	0.0	0.0	0.0	0.0	0.0
28	Route du Front de Terre	0.0	0.0	0.0	0.0	0.0
29	Station de Pompage Castors	3.3	1.6	0.3	3.0	0.0
30	Bopp Rue D	25.9	14.5	2.3	0.0	0.0
31	H.L.M. 6 Terrain	0.0	0.0	0.0	0.0	0.0
32	Point E Boulevard Sud	37.8	19.3	3.2	0.0	0.0
33	Point E Rue 4 + Rue C	37.4	20.9	3.3	0.0	0.0
34	Route de Ouakam	0.0	0.0	0.0	0.0	0.0
35	Fass Rue 22b	100.3	48.3	8.4	0.0	0.0
36	Bd Gueule Tapee	0.0	0.0	0.0	0.0	0.0
37	Gendarmerie Colobane	52.7	28.0	4.6	0.0	0.0
38	Place de Bakou	0.0	0.0	0.0	0.0	0.0
39	Gueule Tapee Rue 54	0.0	0.0	0.0	0.0	0.0
40	Bd G. de Gaulle	0.0	0.0	0.0	0.0	0.0
41	Ecole El Hadji Malick Sy	0.0	0.0	0.0	0.0	0.0
42	Ouakam	22.4	12.6	2.0	0.0	0.0
43	N'gor	27.6	11.1	2.2	0.0	0.0
44	Grand Yoff	198.4	68.2	15.1	0.0	0.0
45	Yoff	0.0	0.0	0.0	0.0	0.0
46	Medine	70.9	45.5	6.6	0.0	0.0
47	Sud-Est de Medine	50.2	25.9	4.3	0.0	0.0
48	Medina Gounass	9.7	6.9	0.9	0.0	0.0
	Total	1,544.3	732.4	128.5	188.3	2.4

Source: Results of the on-the-spot questionnaire survey conducted by JICA

TABLE C.3.16 ESTIMATED FLOOD DAMAGE IN 1993 BY TYPE OF PROPERTY AND BY INUNDATION AREA UNDER ANNUAL FLOOD

Legend:
RSBLD=Residential Buildings, HHEFF=Household Effects, CM/IN=Commerce & Institutions, INDUS=Industry, GDCRP=Gardening Crops

(Unit: FCFA million)

Code No.	Name of Inundation Areas	RSBLD	HHEFF	CM/IN	INDUS	GDCRP
1	Lanssar	0.0	1.1	0.1	10.7	0.0
2	Diamaguene, Diaksao	0.8	0.6	0.1	0.2	0.0
3	Wakhine	0.0	0.0	0.0	0.0	0.0
4	Medina, Gounass, etc.	19.0	15.2	1.9	0.0	0.0
5	Darou, Rakhnane, etc.	10.8	5.9	0.9	0.0	0.0
6	Djidda II, Pikine	14.8	15.4	1.7	0.0	0.0
7	Thiaroye sur Mer	13.7	11.6	1.4	8.0	0.0
8	Ganaw Rail	0.0	0.5	0.0	0.0	0.0
9	Nass Roulah	0.0	0.0	0.0	0.0	0.0
10	Thiaroye SOTRAC	0.5	0.5	0.1	5.8	0.0
11	Cite Pepiniere Pikine	2.7	2.7	0.3	0.0	0.0
12	Dalifort	0.0	0.0	0.0	0.0	0.0
13	Entree Tally Boubess	26.3	14.3	2.3	0.0	0.0
14	Traversiere	0.0	0.0	0.0	0.0	0.0
15	Rue 10	12.1	8.3	1.2	0.0	0.0
16	Rond Point	0.0	0.0	0.0	0.0	0.0
17	Rue 10, ENAM, Zone B Rue G	0.0	0.0	0.0	0.0	0.0
18	Rue 11	0.0	0.0	0.0	0.0	0.0
19	SICAP Amitie I Rue 10	0.0	0.5	0.0	0.0	0.0
20	Av. Bourguiba	0.0	0.0	0.0	0.0	0.0
21	Route de Ouakam	0.0	0.0	0.0	0.0	0.0
22	Mermoz Terrain Basket	3.6	5.4	0.5	0.0	0.0
23	Corniche Ouest	0.0	0.0	0.0	0.0	0.0
24	SICAP Baobabs Rue Biyar	0.0	0.0	0.0	0.0	0.0
25	SICAP Baobabs + Rue 12	0.0	0.0	0.0	0.0	0.0
26	Rue 13	0.0	0.0	0.0	0.0	0.0
27	Derkle	0.0	0.0	0.0	0.0	0.0
28	Route du Front de Terre	0.0	0.0	0.0	0.0	0.0
29	Station de Pompage Castors	0.0	0.0	0.0	0.0	0.0
30	Bopp Rue D	1.6	2.4	0.2	0.0	0.0
31	H.L.M. 6 Terrain	0.0	0.0	0.0	0.0	0.0
32	Point E Boulevard Sud	0.0	1.8	0.1	0.0	0.0
33	Point E Rue 4 + Rue C	5.4	5.4	0.6	0.0	0.0
34	Route de Ouakam	0.0	0.0	0.0	0.0	0.0
35	Fass Rue 22b	6.1	9.1	0.9	0.0	0.0
36	Bd Gueule Tapee	0.0	0.0	0.0	0.0	0.0
37	Gendarmerie Colobane	0.0	2.8	0.2	0.0	0.0
38	Place de Bakou	0.0	0.0	0.0	0.0	0.0
39	Gueule Tapee Rue 54	0.0	0.0	0.0	0.0	0.0
40	Bd G. de Gaulle	0.0	0.0	0.0	0.0	0.0
41	Ecole El Hadji Malick Sy	0.0	0.0	0.0	0.0	0.0
42	Ouakam	0.0	1.5	0.1	0.0	0.0
43	N'gor	4.1	3.1	0.4	0.0	0.0
44	Grand Yoff	14.6	8.5	1.3	0.0	0.0
45	Yoff	0.0	0.0	0.0	0.0	0.0
46	Medine	7.0	12.5	1.1	0.0	0.0
47	Sud-Est de Medine	10.2	7.6	1.0	0.0	0.0
48	Medina Gounass	1.8	1.6	0.2	0.0	0.0
	Total	155.3	138.2	16.6	24.7	0.0

Source: Results of the on-the-spot questionnaire survey conducted by JICA

TABLE C.3.17 ESTIMATED FLOOD DAMAGE IN 1993, 2000 AND 2010 BY INUNDATION AREA UNDER 1989-SCALE FLOOD

(Unit: FCFA million)

Code No.	Name of Inundation Areas	1993	2000	2010
1	Lanssar	104	132	173
2	Diamaguene, Diaksao	87	116	158
3	Wakhine	0	0	0
4	Medina, Gounass, etc.	146	175	217
5	Darou, Rakhnane, etc.	146	186	244
6	Djidda II, Pikine	246	308	397
7	Thiaroye sur Mer	491	625	815
8	Ganaw Rail	28	32	37
9	Nass Roulah	0	0	0
10	Thiaroye SOTRAC	18	23	30
11	Cite Pepiniere Pikine	66	83	108
12	Dalifort	0	0	0
13	Entree Tally Boubess	122	155	201
14	Traversiere	0	0	0
15	Rue 10	56	70	91
16	Rond Point	0	0	0
17	Rue 10, ENAM, Zone B Rue G	0	0	0
18	Rue 11	46	55	66
19	SICAP Amitie I Rue 10	13	15	19
20	Av. Bourguiba	0	0	0
21	Route de Ouakam	0	0	0
22	Mermoz Terrain Basket	30	34	40
23	Corniche Ouest	0	0	0
24	SICAP Baobabs Rue Biyar	0	0	0
25	SICAP Baobabs + Rue 12	0	0	0
26	Rue 13	0	0	0
27	Derkle	0	0	0
28	Route du Front de Terre	0	0	0
29	Station de Pompage Castors	8	10	12
30	Bopp Rue D	43	50	61
31	H.L.M. 6 Terrain	0	0	0
32	Point E Boulevard Sud	60	76	99
33	Point E Rue 4 + Rue C	62	78	101
34	Route de Ouakam	0	0	0
35	Fass Rue 22b	157	180	212
36	Bd Gueule Tapee	0	0	0
37	Gendarmerie Colobane	85	85	85
38	Place de Bakou	0	0	0
39	Gueule Tapee Rue 54	0	0	0
40	Bd G. de Gaulle	0	0	0
41	Ecole El Hadji Malick Sy	0	0	0
42	Ouakam	37	47	61
43	N'gor	41	49	60
44	Grand Yoff	282	369	494
45	Yoff	0	0	0
46	Medine	123	156	202
47	Sud-Est de Medine	80	102	132
48	Medina Gounass	18	21	26
	Total	2,596	3,233	4,143

Source: Results of the on-the-spot questionnaire survey conducted by JICA

TABLE C.3.18 ESTIMATED FLOOD DAMAGE IN 1993, 2000 AND 2010 BY INUNDATION AREA UNDER ANNUAL FLOOD

(Unit: FCFA million)

Code No.	Name of Inundation Areas	1993	2000	2010
1	Lanssar	12	15	20
2	Diamaguene, Diaksao	2	2	3
3	Wakhine	0	0	0
4	Medina, Gounass, etc.	36	43	54
5	Darou, Rakhnane, etc.	18	23	30
6	Djidda II, Pikine	32	40	51
7	Thiaroye sur Mer	35	44	58
8	Ganaw Rail	1	1	1
9	Nass Roulah	0	0	0
10	Thiaroye SOTRAC	7	9	12
11	Cite Pepiniere Pikine	6	7	9
12	Dalifort	0	0	0
13	Entree Tally Boubess	43	54	71
14	Traversiere	0	0	0
15	Rue 10	22	27	36
16	Rond Point	0	0	0
17	Rue 10, ENAM, Zone B Rue G	0	0	0
18	Rue 11	0	0	0
19	SICAP Amitie I Rue 10	0	1	1
20	Av. Bourguiba	0	0	0
21	Route de Ouakam	0	0	0
22	Mermoz Terrain Basket	10	11	13
23	Corniche Ouest	0	0	0
24	SICAP Baobabs Rue Biyar	0	0	0
25	SICAP Baobabs + Rue 12	0	0	0
26	Rue 13	0	0	0
27	Derkle	0	0	0
28	Route du Front de Terre	0	0	0
29	Station de Pompage Castors	0	0	0
30	Bopp Rue D	4	5	6
31	H.L.M. 6 Terrain	0	0	0
32	Point E Boulevard Sud	2	2	3
33	Point E Rue 4 + Rue C	11	14	19
34	Route de Ouakam	0	0	0
35	Fass Rue 22b	16	18	22
36	Bd Gueule Tapee	0	0	0
37	Gendarmerie Colobane	3	3	3
38	Place de Bakou	0	0	0
39	Gueule Tapee Rue 54	0	0	0
40	Bd G. de Gaulle	0	0	0
41	Ecole El Hadji Malick Sy	0	0	0
42	Ouakam	2	2	3
43	N'gor	8	9	11
44	Grand Yoff	24	32	43
45	Yoff	0	0	0
46	Medine	21	26	34
47	Sud-Est de Medine	19	24	31
48	Medina Gounass	4	4	5
	Total	335	418	536

Source: Results of the on-the-spot questionnaire survey conducted by JICA

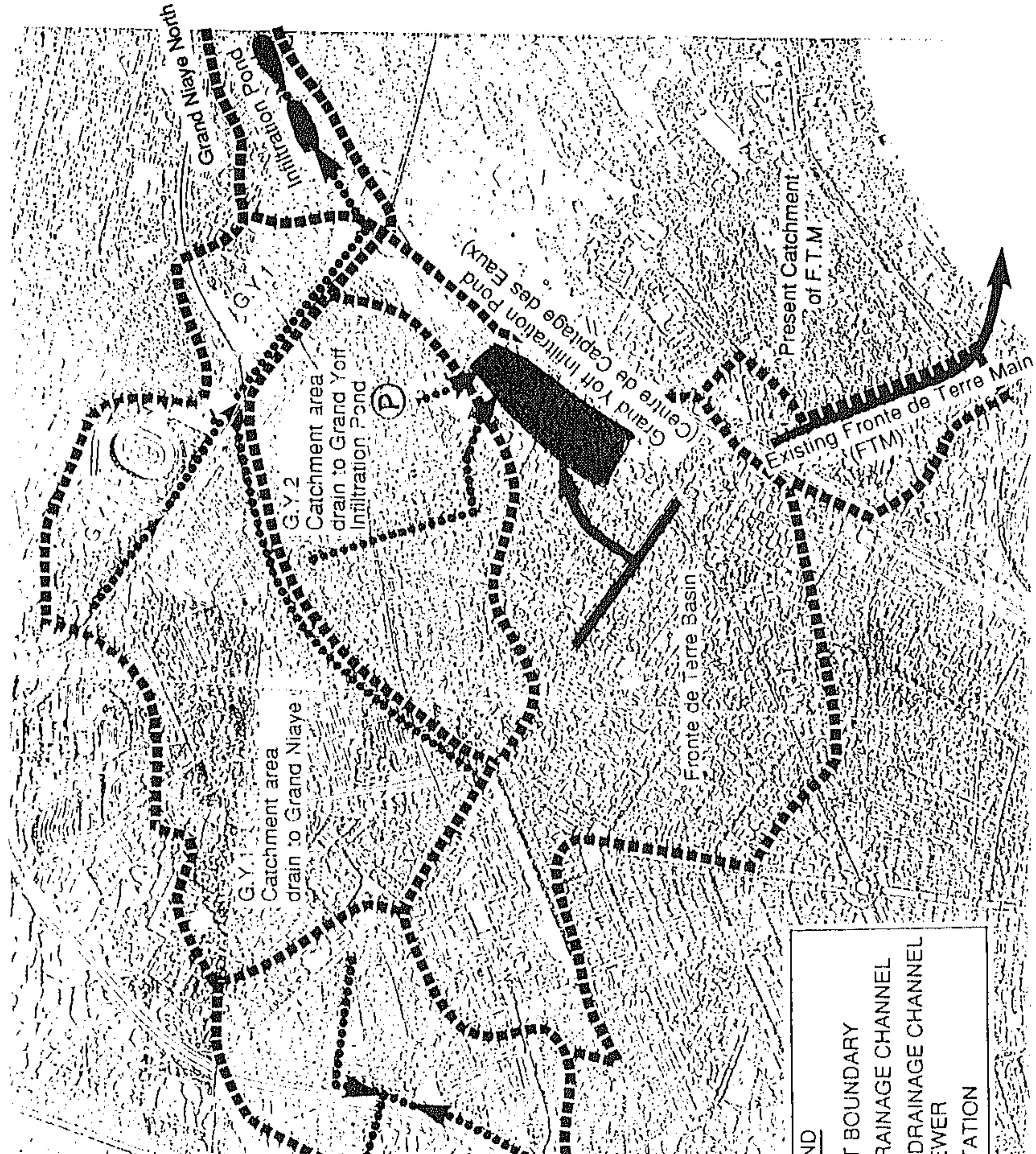


FIGURE C.3.1 PROPOSED DRAINAGE IMPROVEMENT PLAN
(FRONTE DE TERRE, GRAND YOFF, OUAKAM)

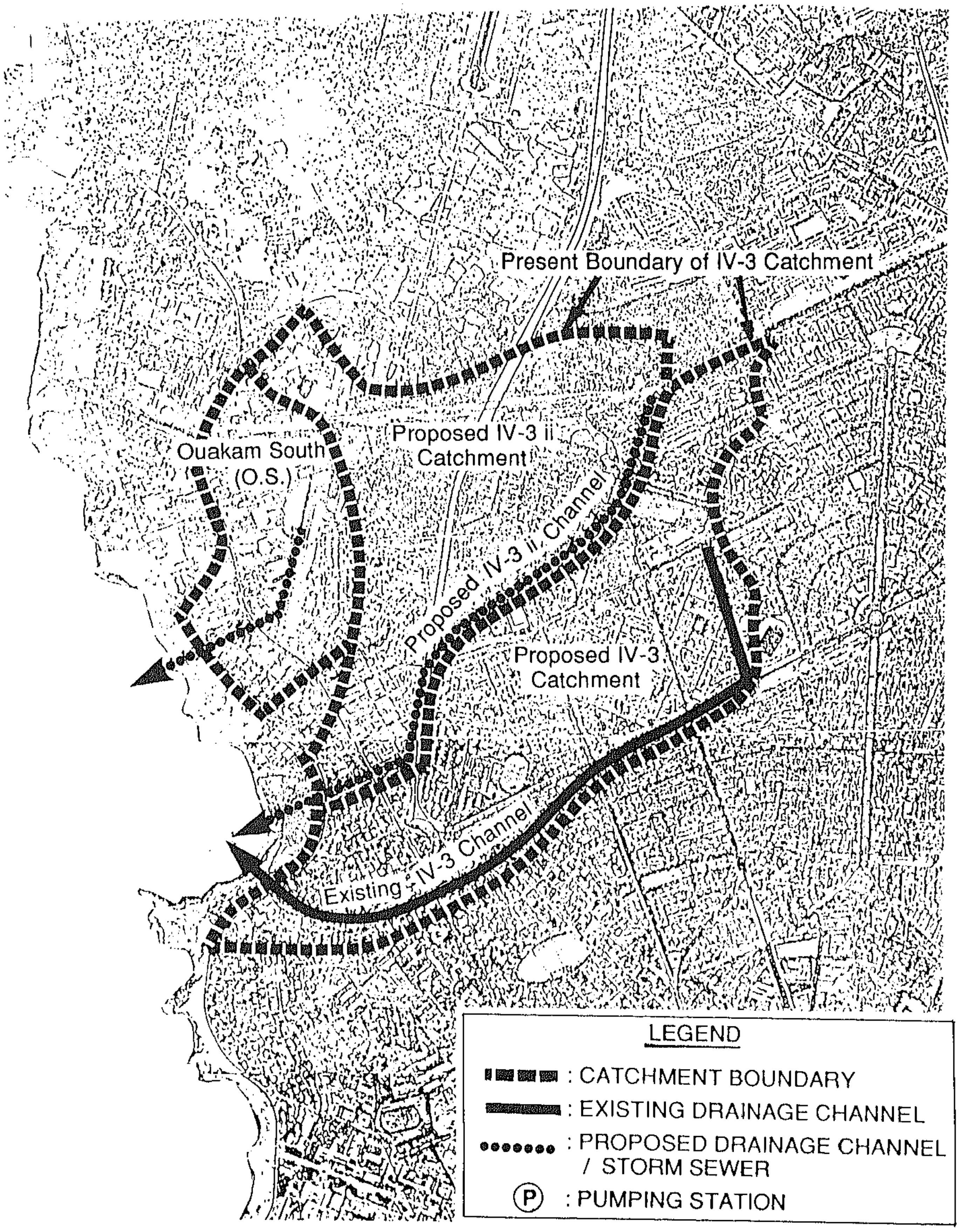


FIGURE C.3.2 PROPOSED DRAINAGE IMPROVEMENT PLAN (IV-3 ii CHANNEL, OUAKAM SOUTH)

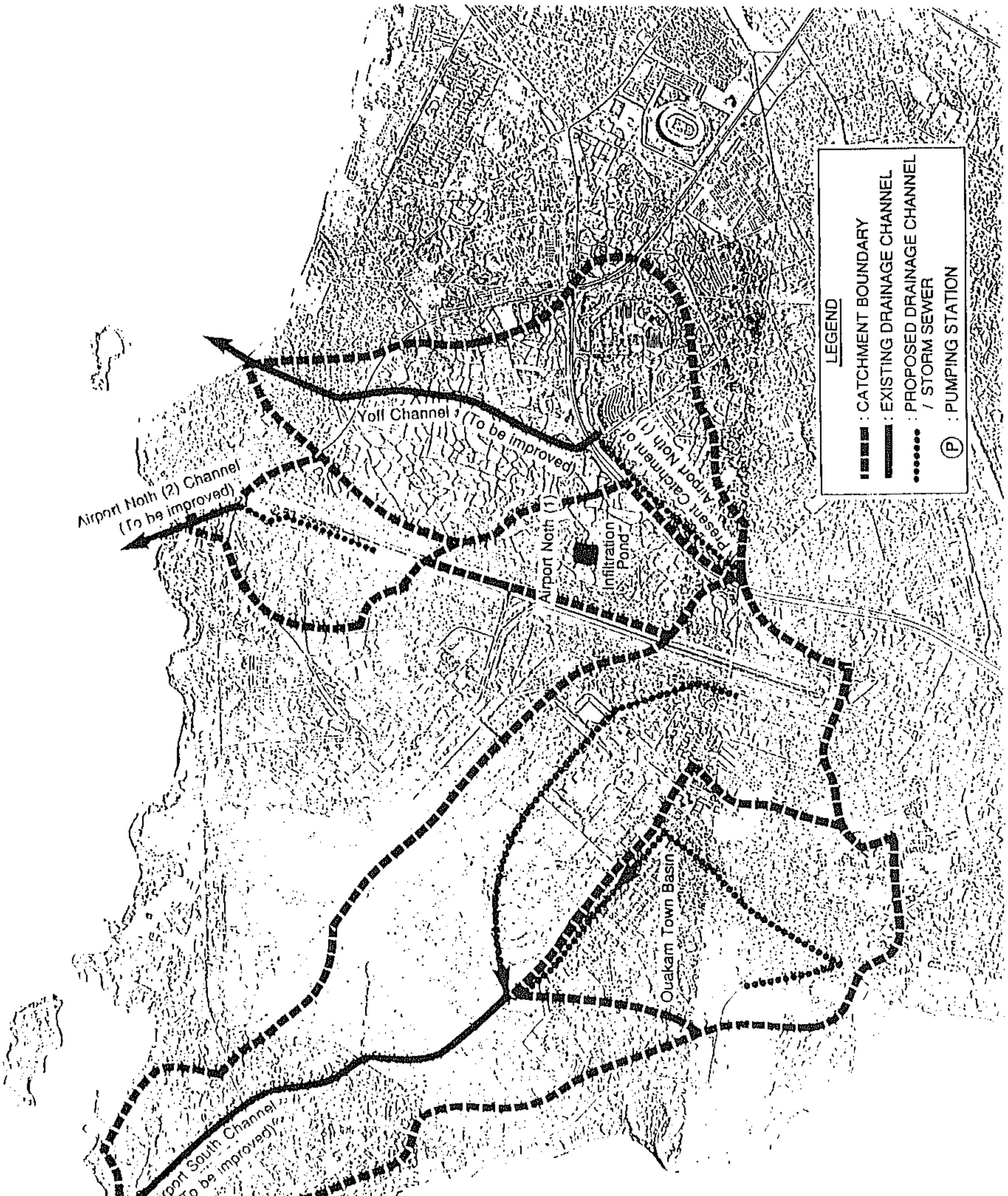


FIGURE C.3.3 PROPOSED DRAINAGE IMPROVEMENT PLAN (DAKAR-YOFF AIRPORT)

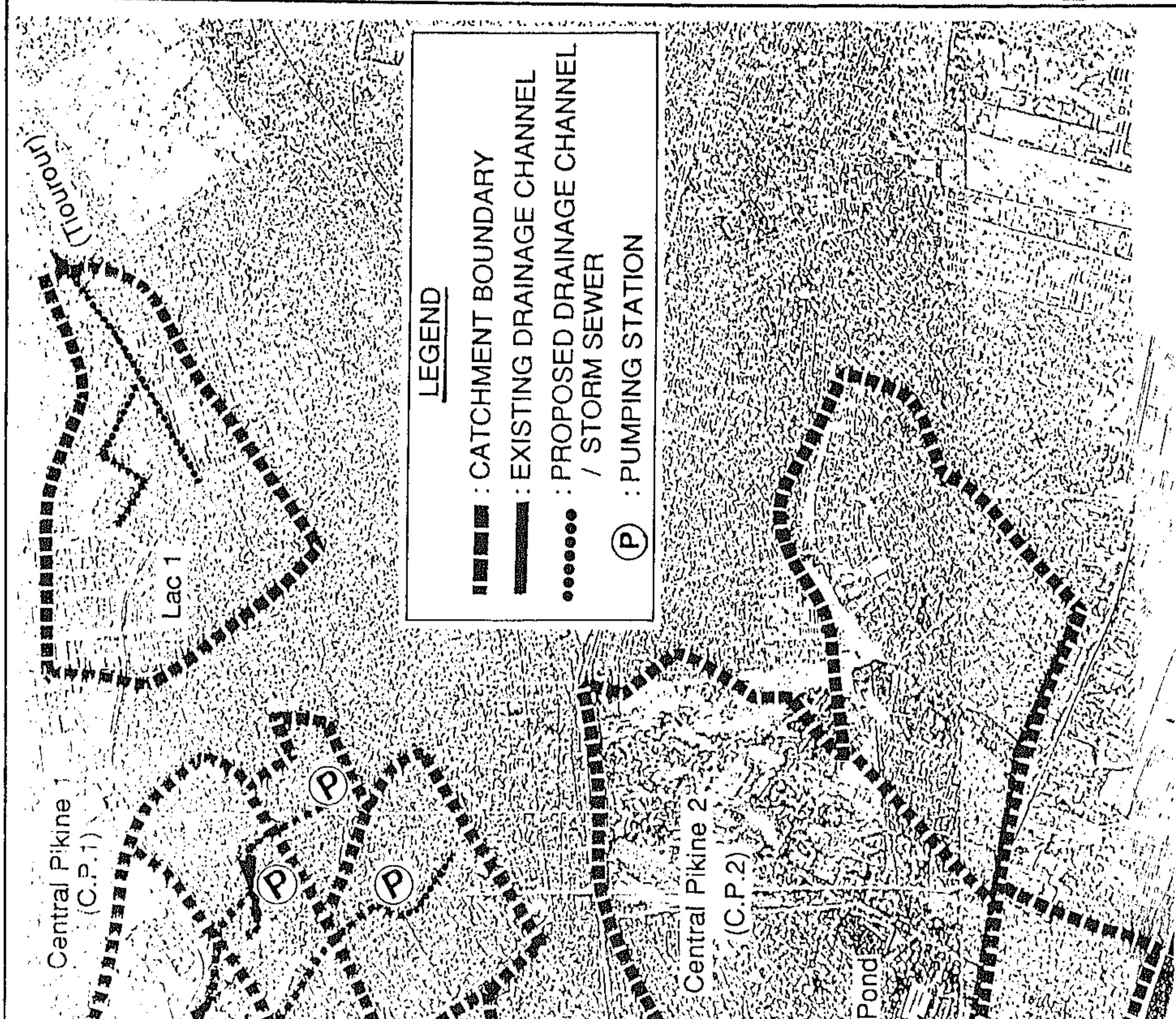


FIGURE C.3.4 PROPOSED DRAINAGE IMPROVEMENT PLAN (PIKINE)

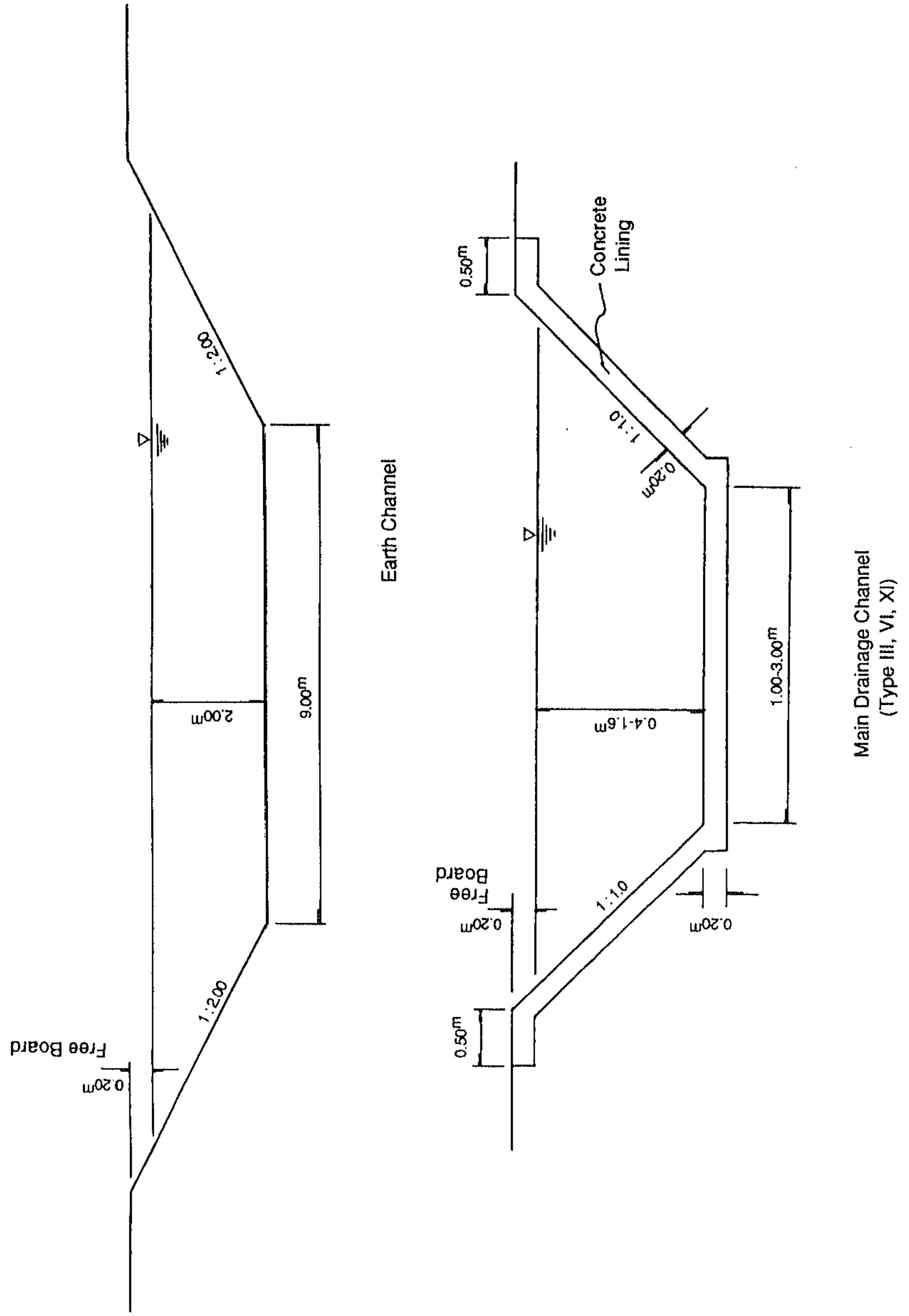
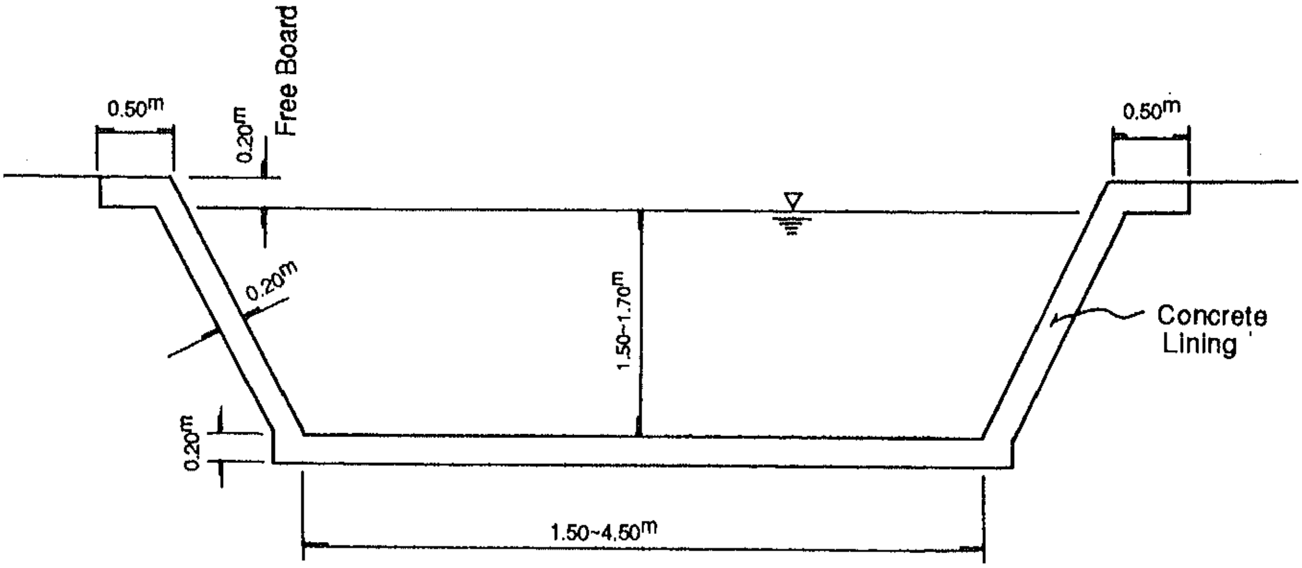
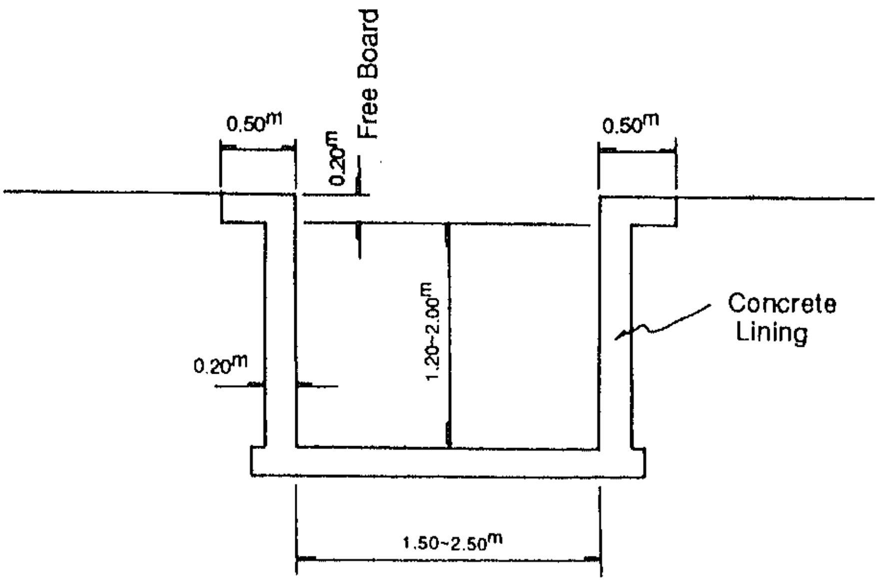


FIGURE C.3.5 PROPOSED CROSS SECTION OF DRAINAGE CHANNEL (1)
(EARTH CHANNEL, MAIN DRAINAGE DITCH)



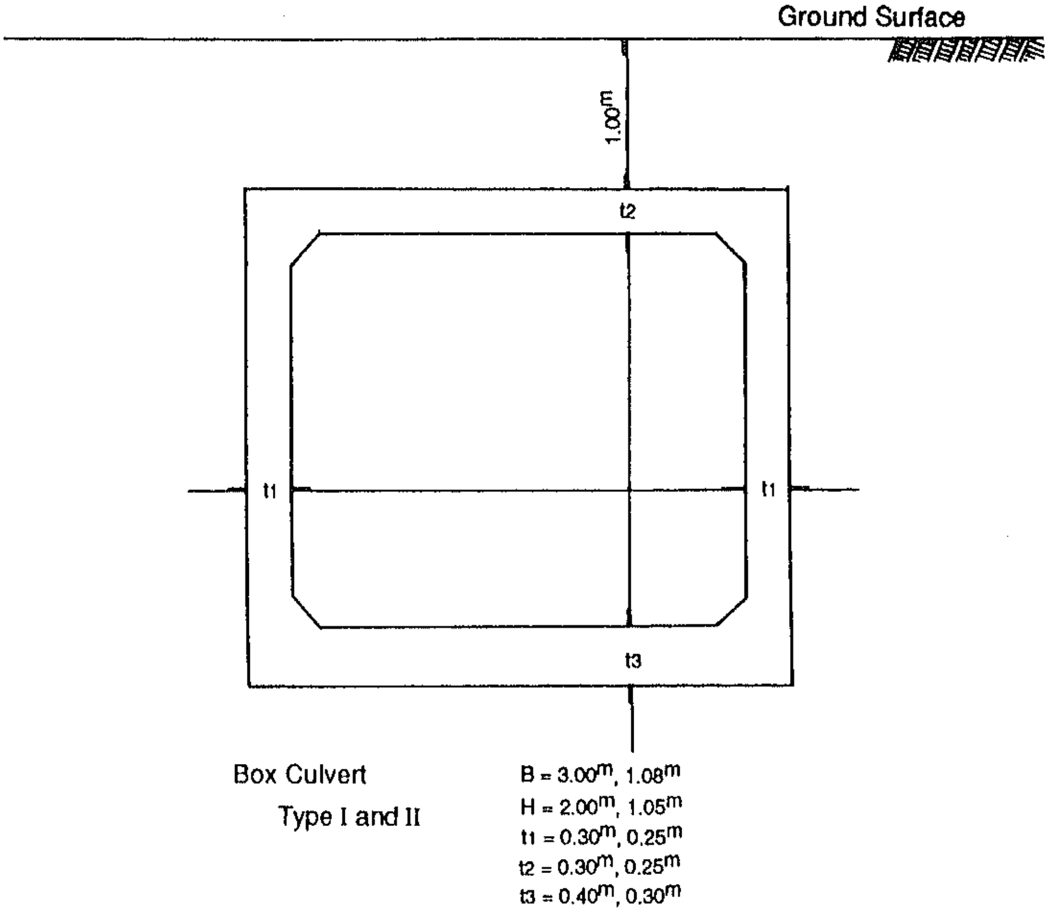
Concrete Lining Open Channel

Type I, II, IV, VII, IX



Concrete Lining Open Channel
Type V, VIII

FIGURE C.3.6 PROPOSED CROSS SECTION OF DRAINAGE CHANNEL (2) (CONCRETE LINING OPEN CHANNEL)



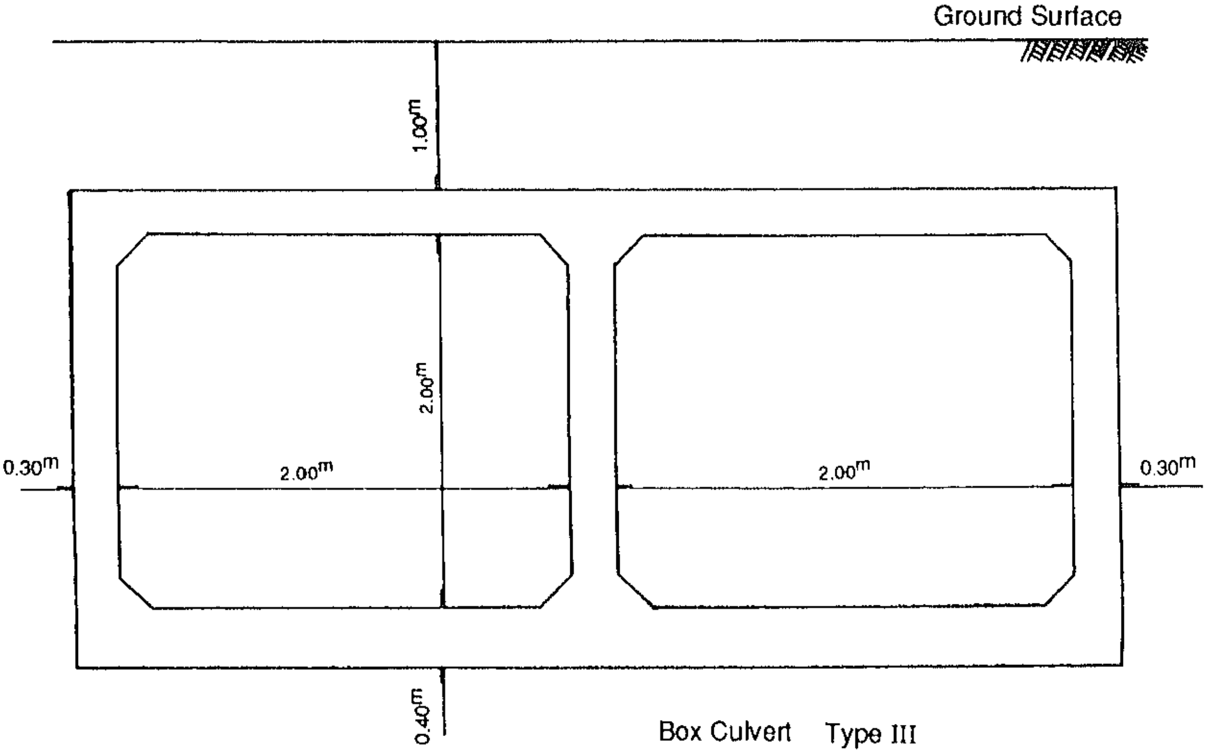


FIGURE C.3.7 PROPOSED CROSS SECTION OF DRAINAGE CHANNEL (3) (BOX CULVERT)

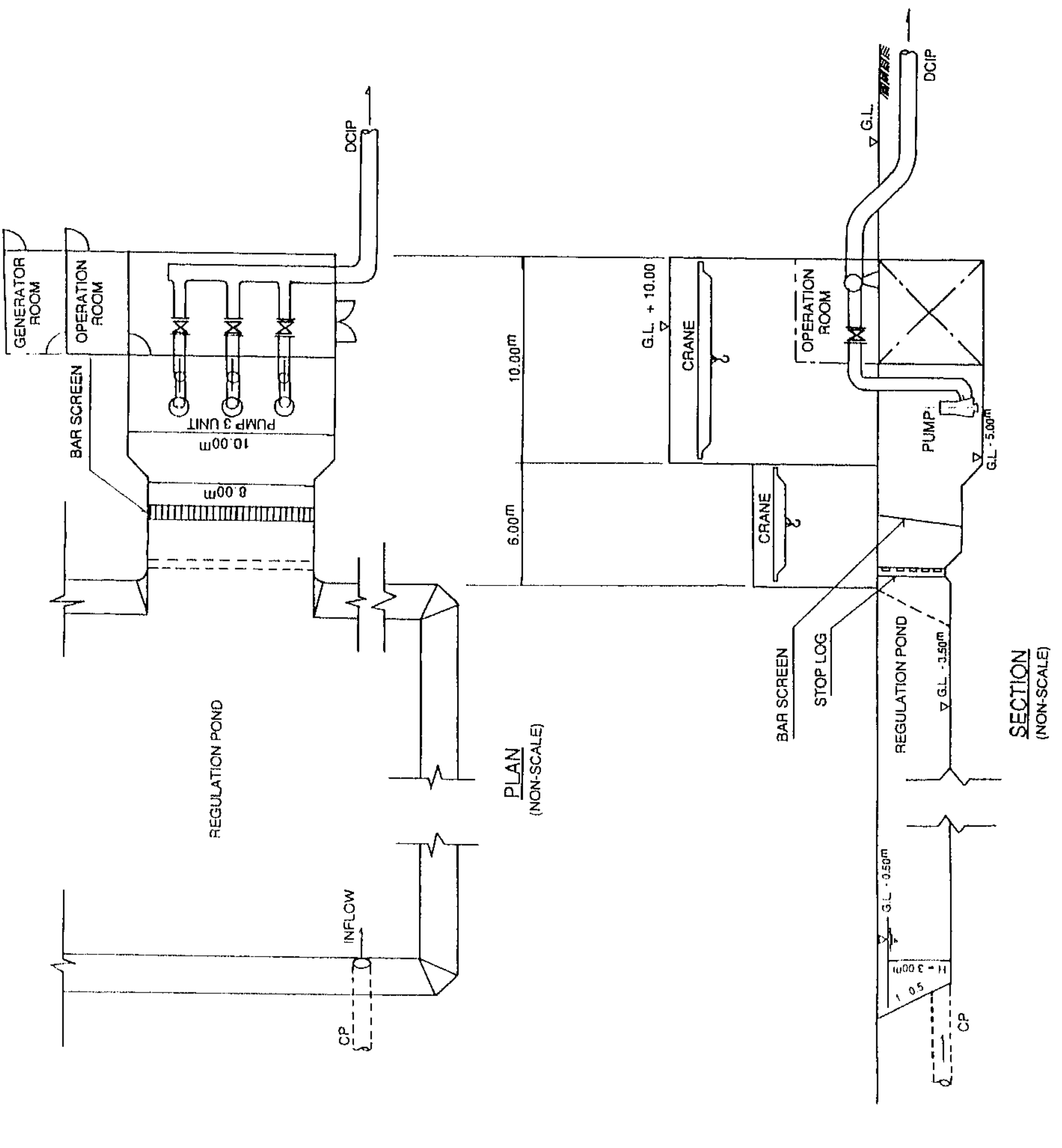
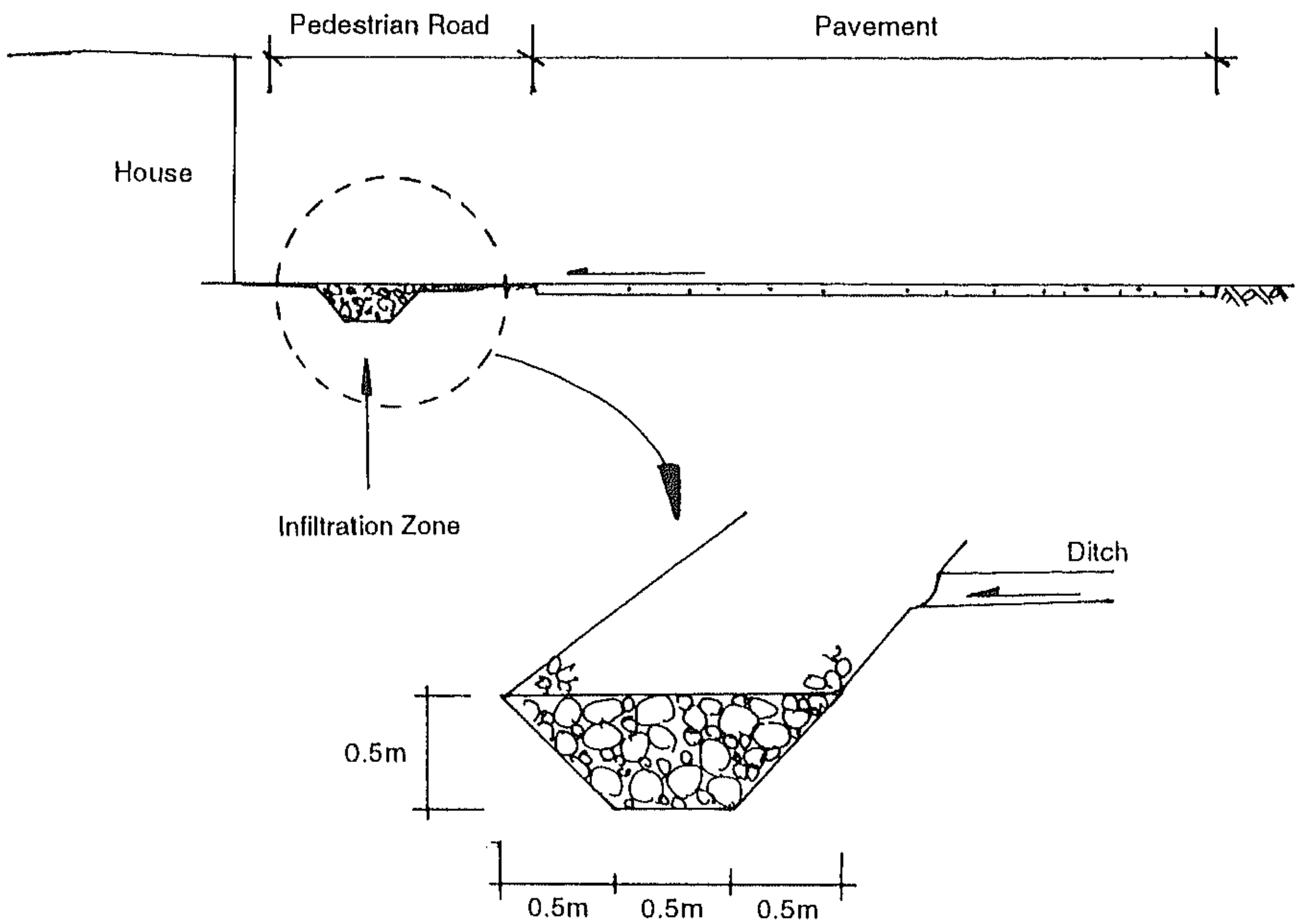


FIGURE C.3.8 TYPICAL PLAN AND SECTION OF PROPOSED STORMWATER PUMPING STATION

(1) Along Road



(2) In House Garden

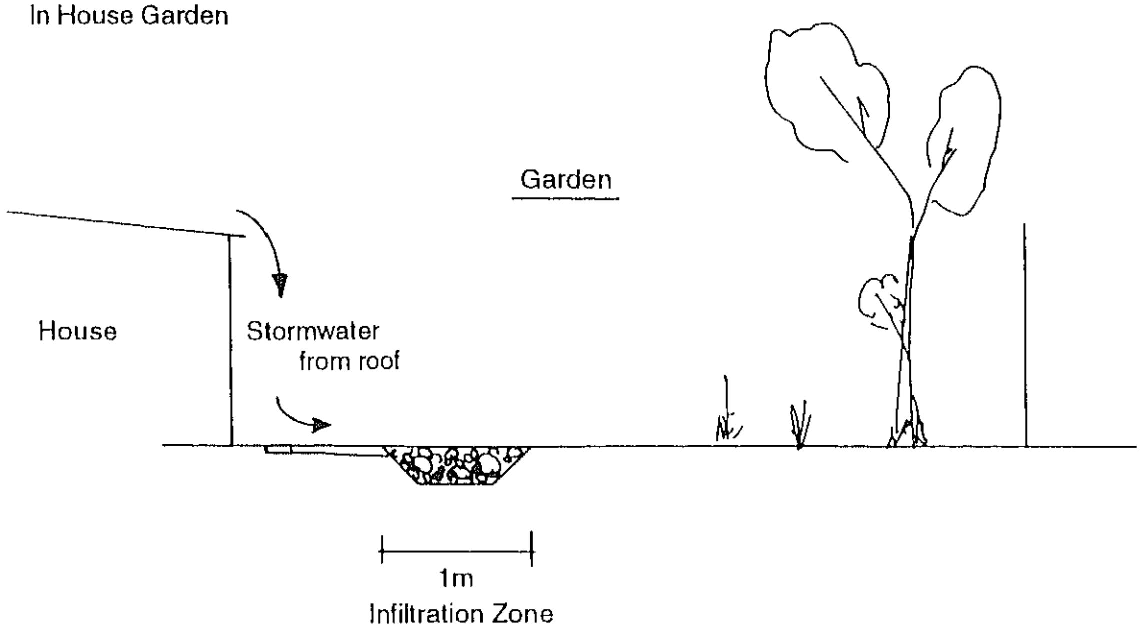
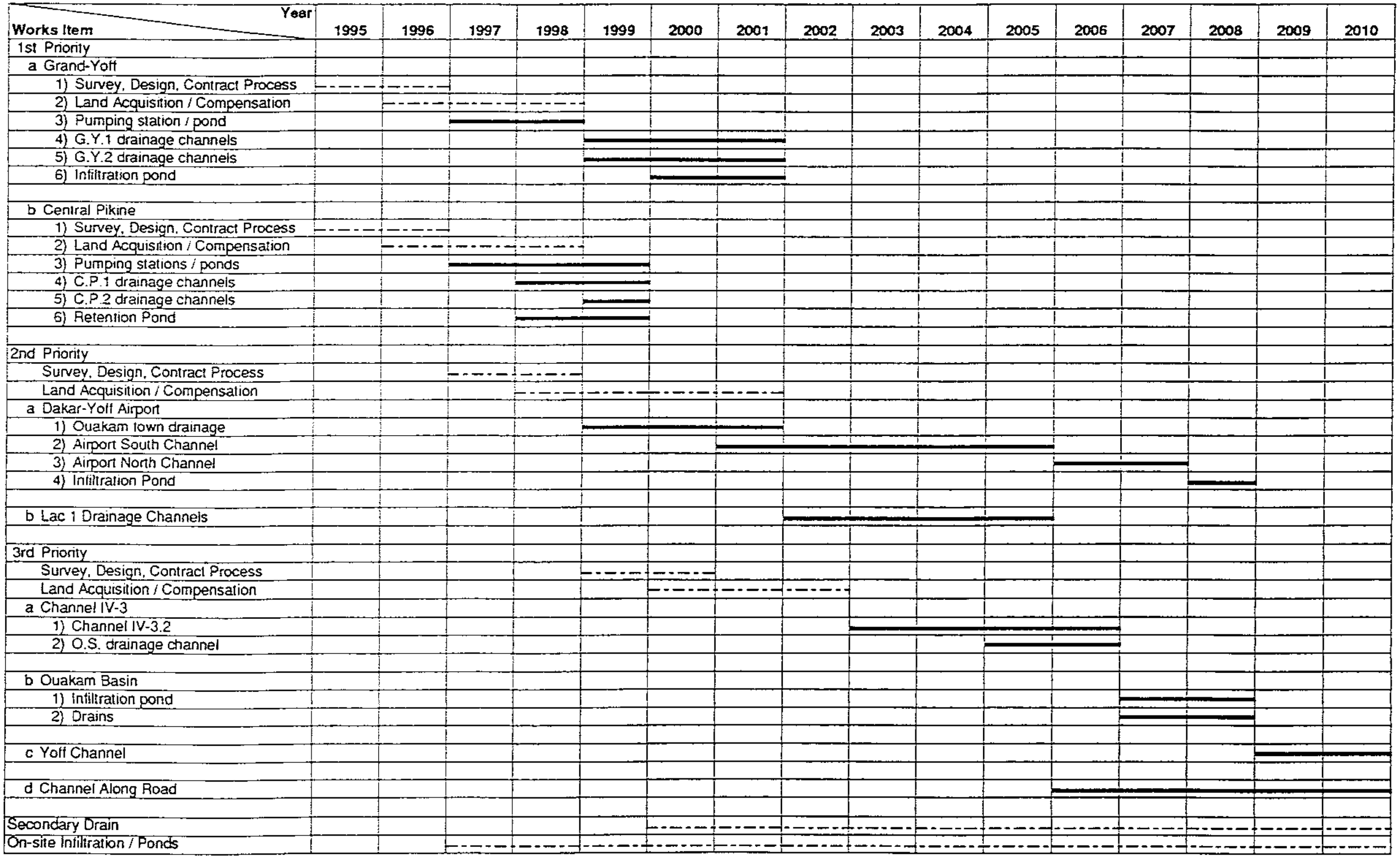


FIGURE C.3.9 EXAMPLES OF INFILTRATION METHODS

FIGURE C.3.10 IMPLEMENTATION SCHEDULE FOR STORMWATER DRAINAGE IMPROVEMENT PROJECT



CHAPTER 4 FEASIBILITY STUDY ON URBAN DRAINAGE OF PRIORITY PROJECT

4.1 PROJECT AREA

4.1.1 Feasibility Study Area

The feasibility study area covers the Central Pikine (C.P.) recommended by the Master Plan as the first priority area and a part of its surroundings and is shown in *Figure C.4.1*. Total area for the feasibility study covers an area of 11.3 sq. km. Through the discussion between the Senegalese side and the study team, the drainage channel proposed along the National Road, a part of main channels of the proposed pump drainage system, was included because of on-going development in its catchment area, therefore an area of E, a catchment of the drainage channel, is included to the feasibility study area. An area of W and O is included to the feasibility study area with consideration of the location of pumping stations and drainage channels.

4.1.2 Existing Drainage Conditions

The study area consists of sandy areas and the topography is flat with the maximum elevation of 23 m. Areas lower than mean sea level are located in Thiaroye. The western urban area has four major lines of sand dunes with the top elevation of 6 m to 12 m . The low strips (Niayes) between these sand dunes have ground elevations of 2 m to 9 m. Flood prone areas are located in the Niayes of eastern urban area having elevations of less than 4 m and the low areas in Thiaroye having elevations of less than 2 m. Existing drainage conditions are shown in *Figure C.4.2*.

4.1.3 Underground Water Supply Facilities

Location maps of the existing and the proposed water supply pipes and collectors for a part of Pikine have been collected, however, exact positions of the pipes are not shown. According to SONEES staff, the pipes are provided about 1 to 1.2 m under ground surface.

4.2 DRAINAGE SYSTEM PLAN

The drainage system proposed for Central Pikine area in the Master Plan was reviewed based on the newly collected data, field reconnaissance and detailed study for the feasibility study. In order to establish the drainage system for the area, the design criteria proposed in the Master Plan are basically applied and other required criteria are to be added.

The drainage system proposed in the Master Plan is applied without any remarkable change.

4.2.1 Drainage Sub-Basin

The feasibility study area has been divided into 20 drainage sub-areas based on the topographic conditions. The drainage sub-areas are shown in *Figure C.4.3* and details are given in *Table C.4.1*.

4.2.2 Drainage Method

Three drainage methods such as drain by gravity, by pump and by infiltration, were proposed in the Mater Plan. Since the stormwater discharged from the feasibility study area is impossible to drain to the sea or Grand Niaye by gravity flow, pump and infiltration drainage method will be applied for the area. Pump drainage method will be applied for the areas already urbanized, affected by flood and difficult to drain without pumping station. For other areas outside pump drainage area infiltration method will be applied. *Figure C.4.4* shows the classified drainage area for the feasibility study.

4.2.3 PUMP DRAINAGE SYSTEM

Two alternative drainage systems, shown in *Figure C.4.5*, were studied. The advantages and disadvantages of each alternative are described below :

	Alternative I (Alt. I)	Alternative II (Alt. II)
Advantage	– Less pumping stations (Lower Construction cost for P.S)	– Avoiding storm sewer crossing the main road – Less excavation for storm sewers – Avoiding re-construction of storm sewer for the area of S2
Disadvantage	– Storm sewer crossing the main road – Much excavation for storm sewers – Necessary to re-construct storm sewer for the area of S2 and N4	– Many pumping stations (Higher construction cost for P.S)

Although construction cost for the pumping station of Alt. II is higher than that of Alt. I, Alt. II is recommended due to following reasons.

- Excess cost for construction of pumping stations for Alt. II is 20% of that of Alt. I
- Crossing of main road is avoided in Alt. II
- Deep excavation for storm sewers are avoided in Alt. II
- Judging from a progress of re-development of Pikine irregular, it is better to drain the stormwater discharged form S2 to N4 by pumping avoiding re-construction of storm sewer.

Accordingly, three pump drainage systems, namely, two in Pikine urban area (C.P.1-1, C.P.1-2) and one in Thiaroye (C.P.2), are proposed (*Figure C.4.4*). These pump drainage areas are divided into several sub-drainage areas (see *Figure C.4.3*) named as;

C.P.1	Pikine Urban South (C.P1-1):	S1, S2, S3, S4, S5
	Pikine Urban North (C.P.1-2):	N1, N2, N3, N4
	Outlet:	OS, ON1, ON2
C.P.2	Thiaroye:	W1, W2, W3, W4, W5, E1, E2

A brief description of the three drainage systems is given below:

1) Pikine Urban South (regular, C.P.1-1)

- Three (3) pumping stations with a pond at each site
- Drainage channels with a total length of 3,760 m

Figure C.4.6 shows the proposed pump drainage system for C.P.1-1 pump drainage area.

2) Pikine Urban North (regular and irregular, C.P.1-2)

- Four (4) pumping stations with a pond at each site
- Drainage channels with a total length of 3,730 m

Figure C.4.6 shows the proposed pump drainage system for C.P.1-2 pump drainage area.

3) Thiaroye (C.P.2)

- One pumping station with a pond
- Drainage channel along the National Road with the total length of 2,940 m
- Drainage channel to the pumping station with a total length of 770 m
- One retention pond with a total area of about 5.1 ha

Figure C.4.7 shows the proposed pump drainage system for C.P.2 pump drainage area.

4.2.4 OTHER AREAS OUTSIDE THE PUMP DRAINAGE AREAS

Other areas other than the pump drainage areas in Central Pikine are proposed to be drained by infiltration in principle. For these areas, the following non-structural measures are recommended from view point of urban drainage:

1) Depressed areas in every independent catchment should be kept for infiltration/retention and on-site infiltration (see *Figure C.3.9*) should be applied as much as possible.

2) There are small scale possible flood areas in Pikine irregular area, having ground elevation of less than 4 m, in the north of the proposed pump drainage area. These areas should be reclaimed for easy infiltration when the areas are redeveloped.

3) Wide low laying area is spread along the Rufisque Road and areas lower than 2 m and 1m in the north and south of the road respectively are flood prone. These areas should be reclaimed if developed.

4) A depressed area located at the northern edge of the Central Pikine is an important place for drainage and should not be urbanized.

4.3 FACILITY PLAN

4.3.1 GENERAL

The facilities proposed for the drainage of Central Pikine are pumping stations of small capacities, retention ponds, open channels and storm sewers. These facilities are not special ones and can be constructed by ordinary methods using the materials imported and available in Senegal. The facilities are planned based on the following strategic concepts:

1) Precast concrete pipes for the drainage channels of the Pikine Urban pump drainage area (C.P.1) are proposed because they are of small sizes.

2) Concrete lined open channels for the main drainage channels of the Thiaroye pump drainage area (C.P.2) are proposed in principle because,

   - Proposed sites are not urbanized yet and land acquisition is not difficult.
   - Ease of maintenance
   - Lower cost than box culvert type, and other reasons.

   Comparison of the open channel and the box culvert types is shown in *Table C.4.2*.

3) Submergible type for the pumps is recommended taking the capacities and the required total heads into account. At least two units of pumps are proposed in one pumping station for ease of operation/maintenance and for economy. One generator having a capacity for driving of one pump unit is proposed to provide. The generator will be used in emergency case when electricity is not available.

4) Agricultural activity is considered in the planning of each retention pond.

5) The drainage pipes are proposed to provide, in principle, along the roads with earth cover of about 1.0 m. Provision of the pipes with large depth is avoided because of difficulty in construction and operation/maintenance. Therefore, a transmission pipe to lift the flood water by pumping to the highest point is proposed at each required site.

4.3.2 HYDRAULIC DESIGN

Hydraulic requirements such as pump capacity, storage capacity of retention pond, size of storm sewer and drainage channel, etc. are calculated by the methods and criteria described in the Master Plan.

1) Pump Capacities and Retention Ponds

Pump capacity and storage capacity of each pumping station are calculated by trial and error method as follows:

- The difference between IN (run-off of 10 years return period from the drainage area) and OUT (pump capacity) is stored in the pond.
- The capacity of pond shall have enough storage volume to be drained by the pumps without flooding, or within a allowable flooding (say, within flood depth of 0.2 m and flood duration of 2 hours).
- Compensation of large scale is avoided.

Pump capacities and required volume of retention ponds are shown in *Table C.4.3*.

2) Sizes of Storm Sewers

Size of a storm sewer is calculated to have enough capacity to discharge the design peak discharge of 5 years return period with run-off coefficient of 0.25. The discharge capacity of the pipe is calculated by Manning Formula assuming that coefficient of roughness is 0.013 (pre-cast concrete pipes).

The results of run-off calculation and the sizes of the storm sewers are shown in *Table C.4.4* and *C.4.5* respectively.

3) Sizes of Transmission Pipes

Size of a transmission pipe is designed to have the same capacity as pump capacity. The flow velocity shall be less than 2 m/sec. The pipes are designed to follow the existing land slope maintaining about 1.0 m earth cover.

The capacities of transmission pipes are shown in *Table C.4.6* and details of them are shown in *Table C.4.7*.

4) Sizes of Open Channels

The sizes of open channels are decided by using Manning Formula with roughness coefficient of 0.025.

Table C.4.4 presents the peak discharges for designing of open channels and the details of the open channels are shown in *Table C.4.8*.

4.3.3 MAIN FEATURES OF PROPOSED FACILITIES

Main features of the of the proposed facilities are summarized based on the hydraulic design as explained below. The results are shown in *Table C.4.9*, the profiles of the drainage channels are shown in *Figures C.4.8* to *C.4.17* and Figures *C.4.18* to *C.4.22* show the typical designs for other drainage facilities (pumping station, retention pond etc.).

1) Pikine Urban South System (C.P.1-1)

The main pumping station (P/S-S1, Q=1.0 m^3/s) is proposed in a Niaye located beside the sewerage pumping station of SONEES. The retention pond (R/T-S, A=1.2 ha) of this pumping station will be provided mainly by excavation works.

The sub-pumping station (P/S-S2, Q=1.0 m^3/s) is proposed underground in the football play ground since there is no suitable site nearby and another sub-pumping station (P/S-S3, Q=0.3 m^3/s) is also proposed underground and small scale flooding may be occurred during big rainfall due to small capacity of its pond. The four storm sewers (S-S1 to S4, L=2,720 m) are proposed to be pre-cast concrete pipes.

Three transmission pipes (T-S1 to T-S3, L=690 m) are proposed to be ductile pipes.

2) Pikine Urban North System (C.P.1-2)

The main pumping station (P/S-N1, Q=1.5 m^3/s) is proposed in a wide Niaye located near the stadium. The retention pond (R/T-N, A=1.3 ha) of this pumping station will be provided mainly by excavation works.

Three sub-pumping stations (P/S-N2, N3, N4, Q=1.0 m^3/s, Q=0.3 m^3/s, Q=0.5 m^3/s) are proposed at the lowest sites of the flood prone areas having a bared land at each site. The storm sewers (S-N1 to N5, L=1,040 m) to collect storm water from the catchment to the sub-pumping stations by gravity flow are designed to be pre-cast concrete pipes.

Ductile pipes are proposed for the transmission pipes (T-N1 to N4, L=1,940 m) considering high pressure exerted on them.

3) Outlet of Pikine Urban System

Two outlet systems, one for C.P.1-1 consisting storm sewer S-OS (L=250 m) and open channel C-OS (L=100 m) and another for C.P.1-2 consisting storm sewer S-ON (L=450 m) and open channel C-ON (L=300 m) are proposed to discharge the drained water from C.P1-1 and C.P.1-2 respectively up to the retention pond R/P-O. The retention pond (R/P-O) is proposed to be constructed by excavation only and it will receive all storm water from the two main pumping stations. The stored water will be finally spilt away to Grand Niaye through an earth channel.

4) Thiaroye System

This drainage system is proposed to be consisted of drainage channel along the National Road, retention pond and a pumping station.

Pump house of the proposed pumping station (P/S-Th., Q=1.5 m^3/s) requires foundation piles. The piles will be friction piles to strengthen the foundation soils slightly.

The retention pond (R/P-Th., A=5.1 ha) is proposed to provide in the low Niaye areas near the Rufisque Road by excavation. Ground elevations of the pond are decided considering the following:

- Storage volume of storm water in relation to the pump capacity.
- Convenience for agricultural activity in the pond area.

The main channels from the west (C-1, L=1,000 m) and east (C-2, L=1,940 m) to their intersection along the National Road and from their intersection to pumping station (C-3, L=770 m) are proposed to be open channels with concrete facing. A two celled box culvert is proposed along C-2 where it crosses the road.

Pumped water from the pumping station will be discharged into Hann Bay.

4.4 CONSTRUCTION PLAN AND COST ESTIMATE

4.4.1 GENERAL

The construction works for the drainage project consists of earth works, concrete works, pipe works, mechanical/electrical works for the pumping stations and other miscellaneous works. These works will be executed by ordinary methods of construction using construction equipment available in Senegal. This will facilitate in equipment maintenance and supply of spare parts as well.

Major works are planned to be carried out by mechanical power. However, in order to enhance employment opportunity, man power will be used to the maximum extent wherever possible.

4.4.2 CONSTRUCTION PLAN

1) Construction Method

Construction methods of major works are expected as follows:

- Excavation of retention ponds
- Excavation for storm sewers
- Installation of precast concrete pipes for storm sewers
- Back filling of soil for storm sewers
- Excavation of drainage open channels
- Concrete casting

2) Required Construction Period

Construction period will depend on rainfall and holidays. In Dakar, however, number of rainy days with depth of more than 10 mm in one year is only about 20 days. Therefore, yearly workable days for construction are large.

Required construction period for each work is estimated as follows:

Pikine Urban South System (C.P. 1-1) :

Pumping stations	6 months
Retention ponds	6 months
Drainage pipes	12 months

Pikine Urban North System (C.P. 1-2) :

Pumping stations	6 months
Retention ponds	6 months
Drainage pipes	12 months

Thiaroye System (C.P. 2) :

Pumping station	12 months
Retention Ponds	24 months
Drainage channels	18 months

3) Sequence of works is proposed as follows:

- The facilities should be constructed from the downstream toward the upstream.
- The pumping stations in one drainage system should be constructed at the same time for convenience of installation and training.
- The storm sewers flowing into the sub-pumping stations should be constructed later.

4.4.3 COST ESTIMATE

1) Basis of Cost Estimate

The project cost consists of (1) construction cost, (2) land acquisition/compensation cost, (3) administration cost, (4) engineering service cost and (5) contingency and is estimated based on the following conditions:

- The estimation is made on the assumption that all construction works will be contracted to general contractors by international tendering.
- All costs are expressed under the economic conditions that prevailed in March 1994.
- The exchange rates of currencies are as follows:
  F. 1.00=F.CFA 100.0
- The cost is classified into foreign and local currency portions and the rates of currency portion estimated in the Master Plan is applied (refer to 3.4.2 of Chapter 3).

- Administration cost is assumed to be 1.5 % of the total of construction and land acquisition/ compensation costs.
- Engineering cost is assumed to be 7 % of the total of construction cost .
- Physical contingency is assumed to be 10 % of the total of construction, land acquisition/compensation, administration and engineering service costs.
- Price escalation is not counted.

2) Cost Estimate

The construction cost is estimated by multiplying the quantity of work (*Table C.4.10*) by unit price based on the data obtained from SONEES, Ministry of Hydrology and other agencies.

The unit prices include site expenses, contractors overhead, profit and tax. Unit prices and construction costs are shown in *Table C.4.11*.

The total project cost, including land acquisition/compensation cost, engineering service, government administration and physical contingency, is estimated at FCFA 10,647 million consisting of the local currency portion of FCFA 4,770 million and foreign currency portion of FCFA 5877 million at March 1994 prices. Breakdown of the project cost is given in *Tables C.4.12* and *C.4.13*.

Annual operation and maintenance cost of the project facilities after construction is assumed to be 0.5 % of the construction cost.

4.5 IMPLEMENTATION PROGRAM

Sequence of the construction works is planned taking the following considerations into account in addition to the construction plan described in the previous section.

4.5.1 SEVERENESS OF FLOODING

Severe flooding has been occurred in the areas of Pikine Urban North system followed by other two systems.

4.5.2 FUTURE DEVELOPMENT

- In Thiaroye, urban development will be taken place in near future.
- In Pikine irregular area, redevelopment is on-going.

4.5.3 EFFICIENCY OF DRAINAGE

The main pumping station systems covering the retention ponds in Grand Niaye, three main pumping stations and the drainage pipes from the pumping stations to the retention ponds are the most effective drainage facilities and form the basis for the whole pump drainage system.

The sub pumping station systems in C.P.1 area and the main channels in Thiaroye are effective to reduce future flooding and are urgently required.

The storm sewers into the pumping stations are to be constructed after completion of all other works.

4.5.4 Procedure Required in Pre-Construction Stage

Detailed design period of 12 months and tendering process of 12 months are assumed in pre-construction stage of the project.

Proposed implementation schedule of the project works is shown in *Figure C.4.23*.

Annual disbursement of the required project cost is prepared based on the implementation schedule as shown in *Table C.4.14*.