3.3 Result and Discussion

Results of the experiment for the stabilization effect are shown in Table B-22. The indoor experiments from No. 1 through No. 8, resulted in non-growth of plankton due to insufficient light, whereas the outdoor experiments from No. 9 through 16 were observed a growth of plankton.

Although no plankton growth was observed in the indoor experiments, a great deal of pollutants removal was found probably due to sedimentation mechanism. For example, 80 - 90% of BOD removal was attained for the community domestic wastewater, whereas the Kedah wastewater, which has a BOD concentration of 4 mg/l, remains unchanged (No. 6). Generally, the experiment effluent is clean with only a few mg/l of BOD.

Growth of plankton was not visually observed during the indoor experiment. The non-growth can be further inferred by the fact that both DO and pH values were not changed during the period of experiment.

Contrary to the indoor experiment, a variety of growth rates of plankton was obtained according to different kinds of wastewater tested indoors. Among then the Sg. Raja wastewater gave highest growth rate (Nos. 15 and 16), whereas the wastewater from the housing community resulted in lowest (Nos. 9 and 10). Further, the Kedah wastewater gave little sign of growth; obviously, the wastewater was not so polluted as compared to other kinds of effluents.

It is worthy to noted that coliform bacteria were completely diminished the all experiment effluents outdoors by the growth of plankton, whereas the removals of BOD of all the indoor experiment were attained only by sedimentation, with removal rates of 90%.

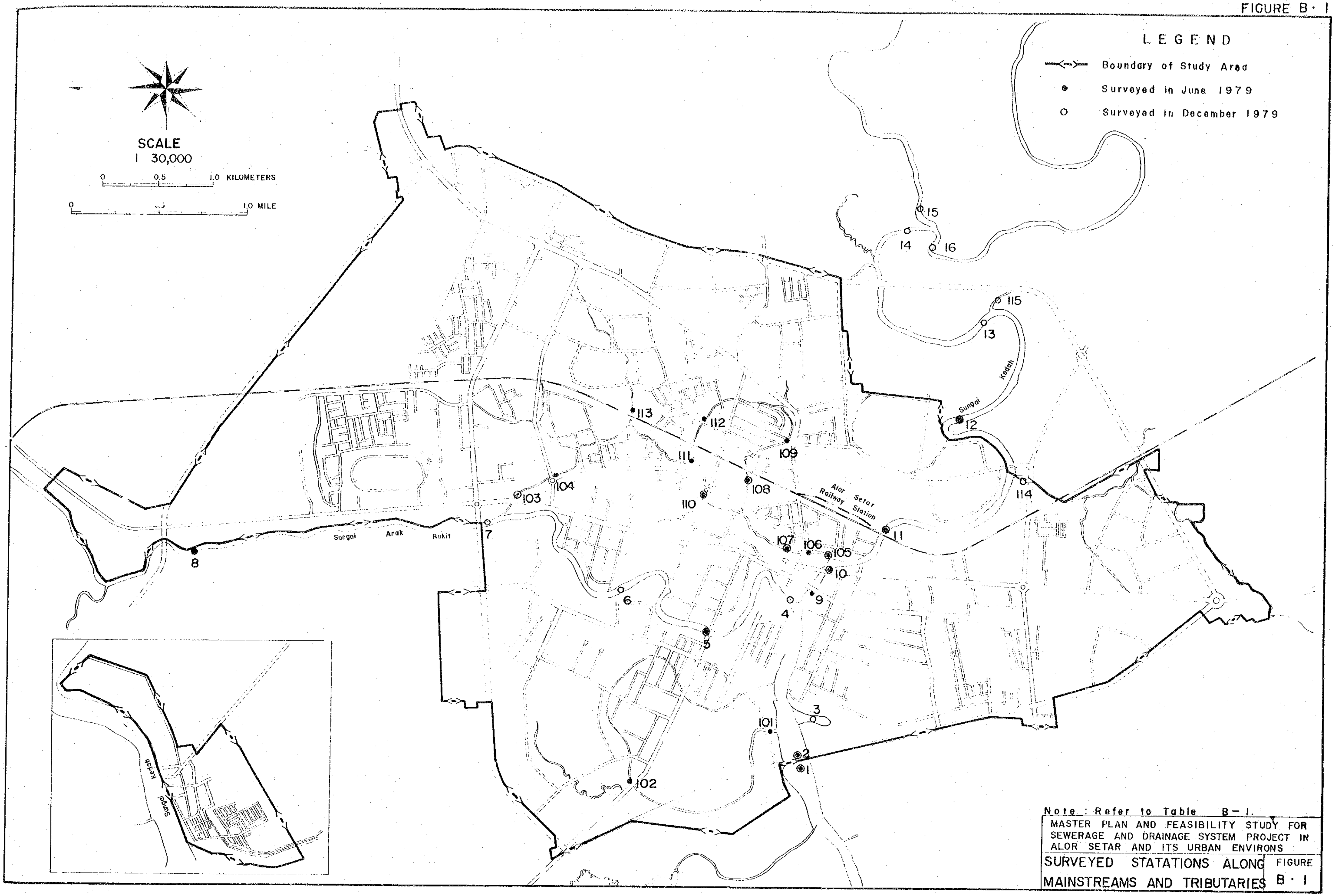
Table B-22 Experimental Results by Quasi-Stabilization Pond

Sample No.		After 1.5 days (12:00 a.m.)				After 3 days (18:00 p.m.)			After 6 days (18:00 p.m.)		After 10 days (18:00 p.m.)			
	Temp. (°C)	pH	DO (mg/l)	BOD (mg/l)	Coliform (C/ml)	pH	Trans (cm)	Coliform (C/ml)	Coliform (C/ml)	Temp. (°C)	pH	DO (mg/l)	BOD (mg/l)	Coliform (C/ml)
1. (1)	26.3	7.4	0	200	30,240	7.0	7.5	> 4,000	15,000	27.2	6.8	0	39.0	- *
2. (2)	26.3	7.0	0	210	12,400	6.8	6.0	> 4,000	17,600	27.2	6.8	0	25.0	-
3. (3)	26.3	6.4	0.8	27	5,130	6.4	> 23	240	0	27.2	6.6	2.3	9.3	-
4 (4)	26.3	6.8	2.3	19	650	6.4	> 23	190	17	27.2	6.6	1.7		-
5. (5)	26.3	7.2	1.2	29	13,520	6.8	> 23	172	27	27.2	6.6	6.2	11.4	-
6. (6)	26.3	6.2	6.2	4	45	5.8	> 23	6	0	27.2	6.4	5.8	2.1	-
7. (7)	26.3	6.6	2.1	15	2,610	6.4	> 23	5	2	27.2	6.4	3.1	9.9	-
8. (8)	26.3	6.6	1.5	17	3,240	6.4	> 23	15	1	27.2	6.4	3.5	22.5	-
9. (1)	33.5	7.0	0	142	31,000	7.0	11.0	60	> 4,000	34.8 (32.0)	> 8.2	16.2		0 **
10. (2)	33.0	7.0	0	145	31,000	6.8	5.5	3,680	200	34.8 (31.8)	8.2	20.8		0
11. (3)	33.2	7.2	7.9	29	15,440	6.8	12.0	96	5	34.0 (32.0)	7.6	15.8	19.0	0
12. (4)	33.3	7.0	17.3	19	31,040	6.8	> 23	304	1	34.0 (32.0)	> 8.2	20.8	21.0	0
13. (5)	33.3	7.2	10.8	29	23,040	6.8	> 23	90	22	34.0 (32.0)	7.0	12.9	5.5	0
14. (6)	33.3	6.2	11.0	7	115	6.2	> 23	0	0	34.0 (33.5)	6.6	8.9	6.0	0
15. (7)	33.3	7.8	19.3	17	2,610	6.4	> 23	1	-	34.0 (33.5)	6.6	6.2		0
16. (8)	33.3	8.2	28.8	23	2,980	7.8	11.5	0	-	34.0 (32.0)	7.8	[illegible]	18.5	0
17. (9)	33.1	> 8.2	27.9	45	53	8.2	4.0	0	-	34.0	> 8.2	18.5		0

Note: (1) Experimental setting for the 17 conditions was completed at 18:00 hr of Dec. 23, 1979.

(2) Experimental for Nos. 1 through 8 was performed indoors, and the rests outdoors.

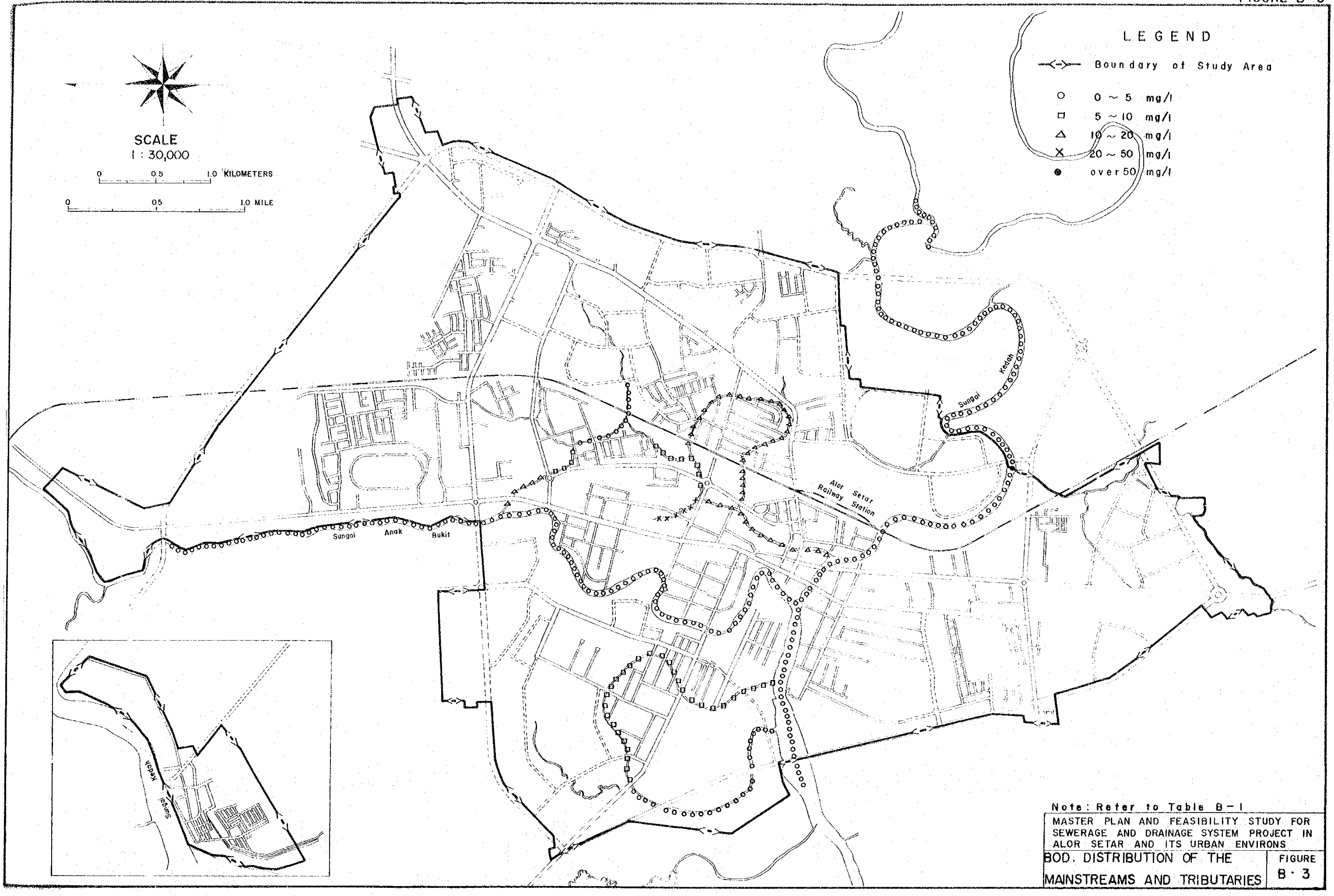
(3) * (-) indicates that no testing is made and ** (0) indicates the value of the testing result.



Note : Refer to Table B－1.

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

SURVEYED STATATIONS ALONG MAINSTREAMS AND TRIBUTARIES	FIGURE B・1

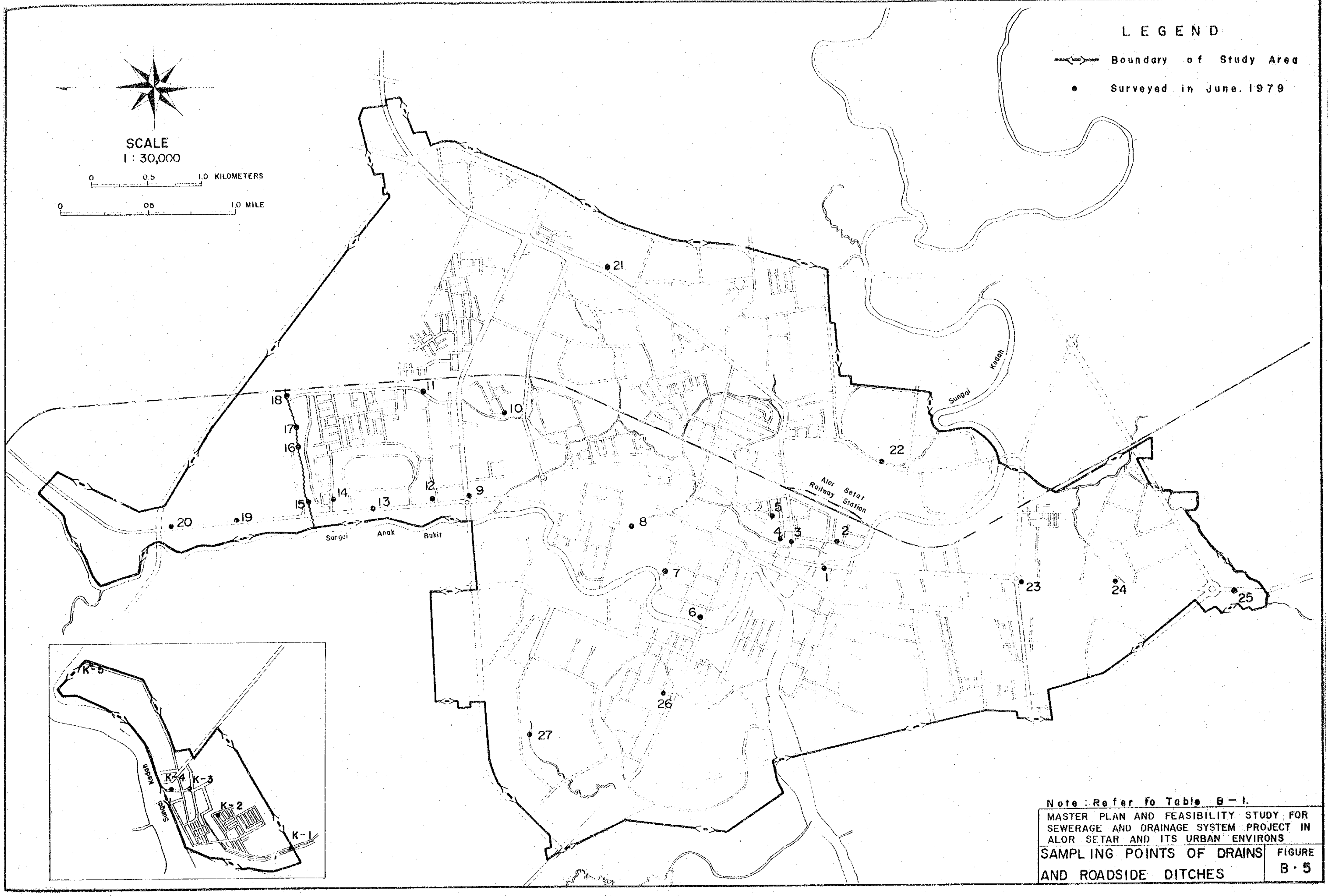


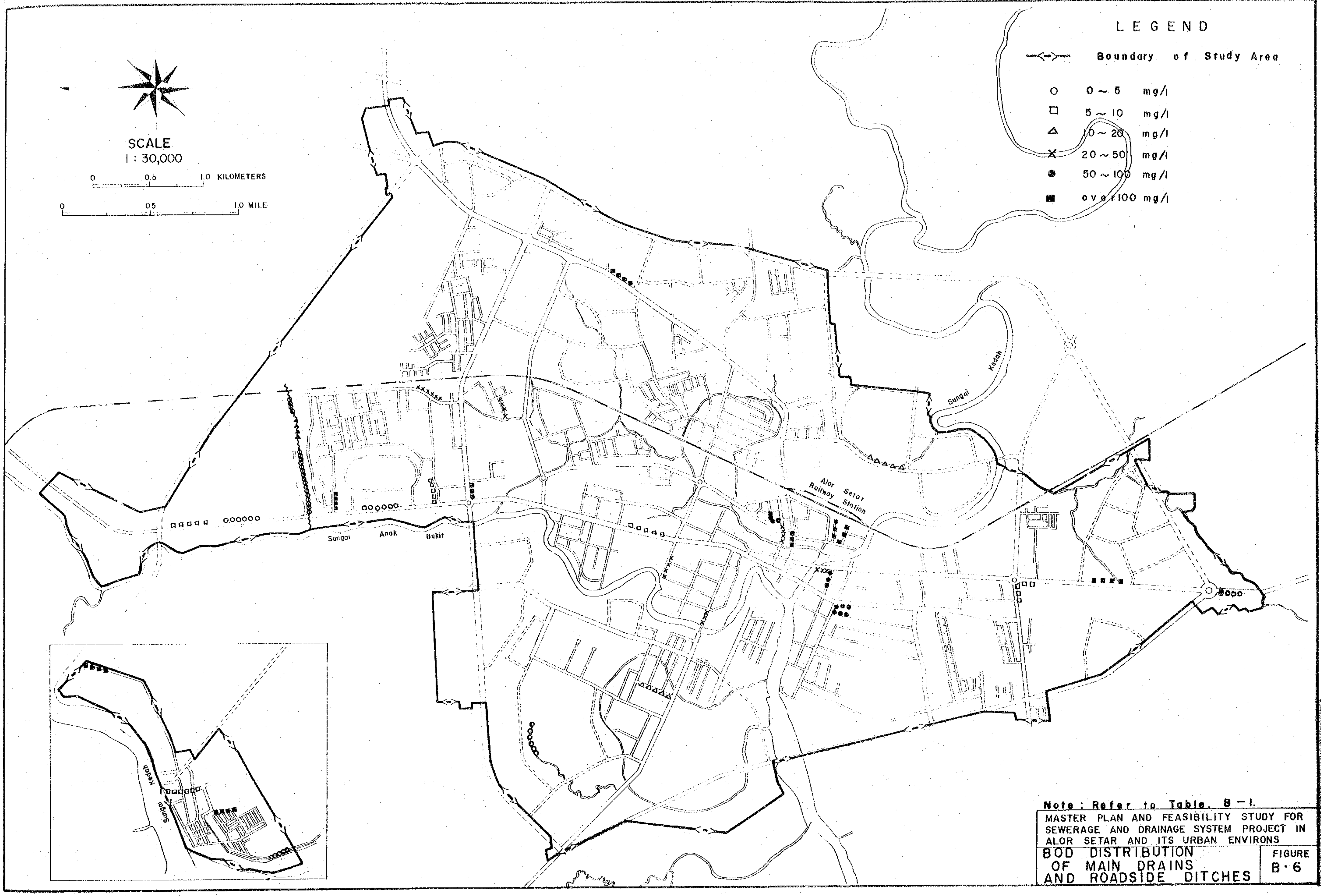
Note: Refer to Table B-1

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

BOD. DISTRIBUTION OF THE MAINSTREAMS AND TRIBUTARIES

FIGURE B·3

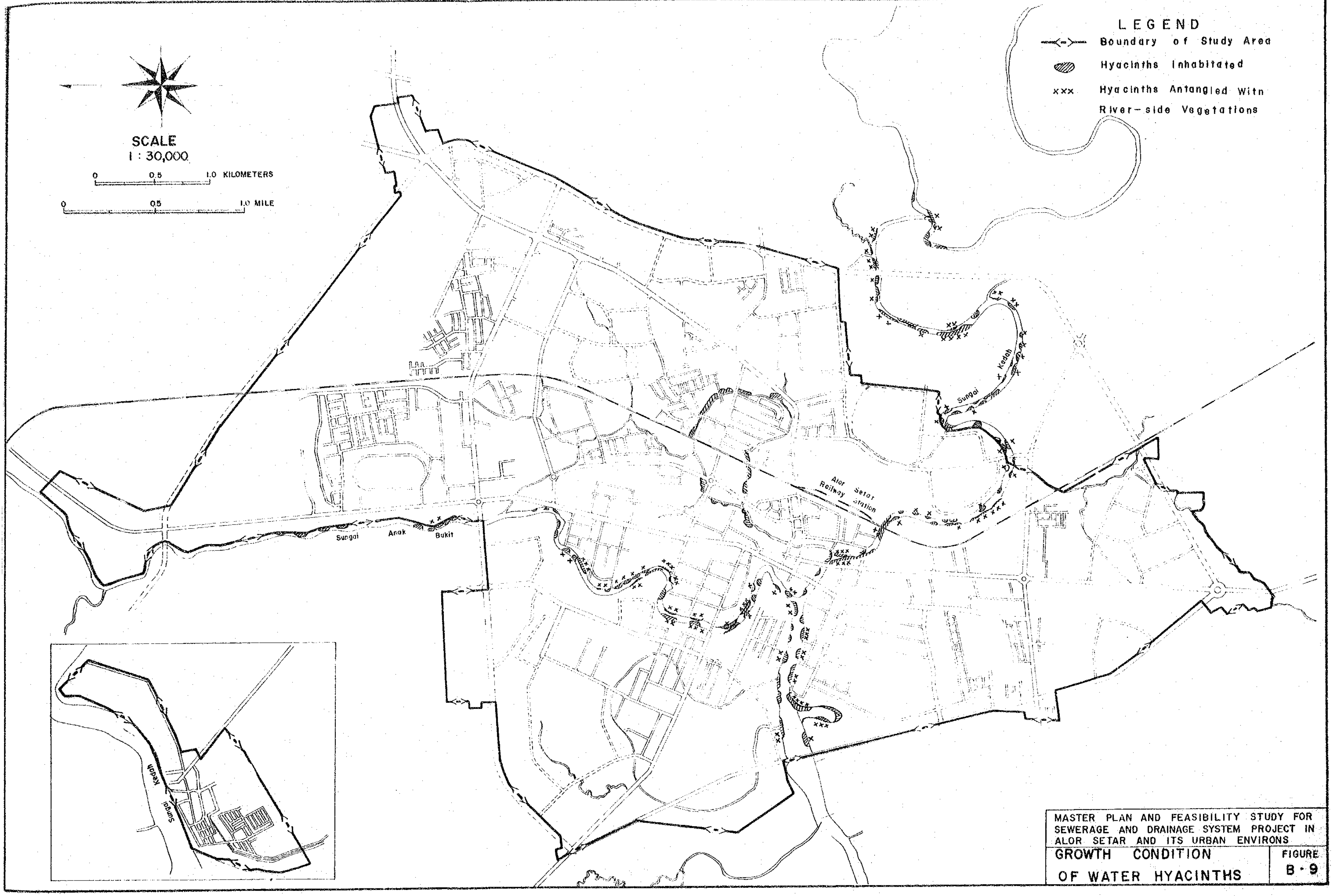

LEGEND
Boundary of Study Area
Surveyed in June, 1979
SCALE
1 : 30,000
0 0.5 1.0 KILOMETERS
0 0.5 1.0 MILE
Alor Setar Railway Station
Sungai Kedah
Sungai Anak Bukit
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
K-1
K-2
K-3
K-4
K-5
Kedah
Sungai
Note : Refer to Table B-1.
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS
SAMPLING POINTS OF DRAINS AND ROADSIDE DITCHES
FIGURE B・5



Note : Refer to Table. B−1.

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

BOD DISTRIBUTION OF MAIN DRAINS AND ROADSIDE DITCHES	FIGURE B・6



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

GROWTH CONDITION OF WATER HYACINTHS

FIGURE B・9

APPENDIX C

LAND USE AND POPULATION

1. Present Population and its Distribution

1.1 Present Population

According to the 1970 census, 1970 population in the Study Area is calculated as 100,439 persons including both Alor Setar and Kuala Kedah areas.

The population distribution is shown in Table C-2 and Figure C-2 on the basis of the census population in the enumeration blocks.

Then present population (1979) in the Study Area is estimated to be 139,600 on the assumption that overall annual growth rate, composite of both natural and social growth rates, is assumed to be 3.5% between 1970 and 1975, and 4.0% between 1975 and 1979 as shown below;

Year	Annual Growth Rate (%)			Population in Study Area (persons)
	Natural	Social	Composite	
1970				* 100,439
1970–1975	2.7	0.8	3.5	
1975				119,300
1975–1979	2.7	1.3	4.0	
1979				139,600

Note: (1) * based on the 1970 Census
(2) Refer to Table C-2 for population in 1970 and 1979

The natural annual growth rate between 1970 and 1979 is taken to be approximately 2.7% applying the same percentage rate for Kota Setar in the Kedah-Perlis Development Study Report (Ref. No.1, Appendix A), thus becoming a total of 27,216 persons between the years.

The social growth population, which is estimated to be approximately three-fourths of the population, by a currency survey, based on the residing population of 11,900 persons (≒ 2,875 x 5.5 x 3/4 based on Table C-1) in the newly built houses between 1970 and 1979.

The number of newly built houses between 1970 and 1979 are listed in Table C-1 with reference numbers in Figure C-1.

Table C-1 No. of Houses Built and Population Density in Developing Area from 1970 and 1979

Ref. No. in Figure C-1	Name of Existing Housing Development Area	Area (ha)	No. of Houses Built			Ultimate Population Density (Persons/ha)
			Before 1969	Between 1970 - 79	Including future plan	
1.	Taman Tunku Habsah	1.95	0	66	66	186
2.	Taman Thean Peng	1.88	0	68	68	199
3.	Taman Sentosa	6.87	0	70	70	56
4.	Taman Sofiah	1.77	0	28	28	87
5.	Kawasan Perumahan Taman Lumba Kuda	7.70	0	221	242	173
6.	Taman Uda	21.57	0	235	235	60
7.	Kawasan Perumahan Jalan Kampung Pisang	0.87	0	18	18	118
8.	Taman Sri Manis	2.91	0	39	80	151
9.	Taman Datin Noorkiah	3.00	0	66	66	121
10.	Taman Selamat	4.23	0	120	120	156
11.	Taman Bunga Raya	2.30	0	72	72	172
12.	Taman Syed Mohamad	5.66	0	54	54	52
13.	Taman Stadium	3.01	0	53	66	121
14.	Taman Muhibbah	10.68	0	274	282	145
15.	Taman Golf	7.97	0	166	178	123
16.	Taman Merbok	1.63	0	20	38	128

to be continued

Table C-1 No. of Houses Built and Population Density in Developing Area from 1970 and 1979

Ref. No. in Figure C-1	Name of Existing Housing Development Area	Area (ha)	No. of Houses Built			Ultimate Population Density (Persons/ha)
			Before 1969	Between 1970 - 79	Including future plan	
17.	Taman Air Puteh	1.48	0	43	63	238
18.	Taman Nyior Setali	1.71	0	49	49	158
19.	Taman Darulaman	3.16	0	20	44	77
20.	Taman Setia Berjaya	2.33	0	77	124	293
21.	Taman Jaya	4.61	0	82	82	98
22.	Taman Dato' Kumbar	3.85	0	99	99	142
23.	Taman Berjaya	23.15	0	98	494	117
24.	Taman Tunku Abdul Majid	1.59	0	24	42	145
25.	Taman Mahawangsa	7.93	0	114	114	79
26.	Rumah Pangsa	1.20	0	144	144	660
A	Taman Malaysia	5.45	70	9	79	80
B	Taman Pumpong	1.16	20	0	20	95
C	Rancangan Rumah Murah Jl. Sultanah	8.58	147	0	147	94
D	Sri Taman	5.09	115	1	128	138
E	Taman Mahkota	4.17	30	0	30	40

to be continued

Table C-1 No. of Houses Built and Population Density in Developing Area from 1970 and 1979

Ref. No. in Figure C-1	Name of Existing Housing Development Area	Area (ha)	No. of Houses Built			Ultimate Population Density (Persons/ha)
			Before 1969	Between 1970 - 79	Including future plan	
F	Taman Loh Joo Huat	1.72	30	18	48	153
G	Kawasan Perumahan Jl. Ambar	10.61	127	107	245	127
H	Taman Lam Sun	8.88	107	144	268	166
J	Kawasan Perumahan Jl. Shariff	12.75	129	116	272	117
K	Kawasan Perumahan Batu 2, Jl. Langgar	5.92	130	0	152	141
L	Kawasan Perumahan Sbg. Jl. Putera	18.76	266	22	318	93
(M N)	Taman Lam Fong Taman Malik	4.46	92	7	99	122
P	Taman Bahagia	5.73	26	107	133	128
Q	Taman Bee Bee	10.56	259	12	271	141
R	Kawasan Perumahan Jl. Tunku Abdul Halim	1.13	26	12	38	185
S	Lorong Merpati	2.90	53	0	53	101
T	Kawasan Perumahan Jl. Ghouse	8.21	82	0	82	55
U	Rancangan Rumah Murah TongKang Yard	1.50	59	0	59	217
	Total :	252.54	1,768	2,875	5,380	117.2

1.2 Population Distribution in 1979

The 1979 population estimated at 139,600 persons is distributed on the bases of the following considerations:

(1) 1970 census enumeration blocks are used for population distribution.

(2) The population in the newly built houses between 1970 and 1979 in Table C-1 and Figure C-1 is distributed in the blocks where houses were built as shown in (2) of Table C-2.

(3) The remaining population (subtracting the population in (2) above from the total population of 39,161 [= 139,600 - 100,439] increased between 1970 and 1979) is distributed in the 1970 census enumeration blocks in proportion to those in 1970.

The population distributed in line with the above consideration is shown in Table C-2 and Figure C-2, together with area and population density of each enumeration block.

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Social Growth Population from 1971 to 1979 (2)	Total Population in 1979 (1) + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
1.	1,459	332	1,791	29.54	61	C.R.
2.	2,464	561	3,025	9.55	317	R.
3.	2,005	456	2,461	13.54	182	C.R.
4.	934	213	1,147	11.45	100	R.
5.	270	243	27	21.78	1	I.
6.	533	121	654	39.14	17	R.P.
7.	0	539	539	20.00	27	R.P.
9.	873	199	1,072	36.14	30	R.P.
10.	259	59	318	10.76	30	R.P.
11.	580	132	712	20.19	35	R.P.
12.	269	61	330	31.60	10	P.
13.	641	146	787	18.30	43	R.P.
14.	910	207	1,117	3.76	297	R.
15	789	180	969	3.94	246	R.

Note: (1) refer to Figure C-2
(2) R: Residential C: Commercial I: Industrial P: Paddy S: School
M: Mosque & Other religious use V: Vacant & Open Space

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Social Growth Population from 1971 to 1979 (2)	Total Population in 1979 (1) + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
16.	1,300	296	1,596	12.25	130	R.P.
17.	405	92	497	30.23	16	P.
18.	160	36	196	12.80	15	P.
19.	308	70	378	11.62	33	R.
20.	63	14	77	9.53	8	P.
21.	801	182	983	23.91	41	R.S.
22.	26	550	576	28.22	20	R.P.
23.	572	130	702	19.26	36	R.M.
24.	381	87	468	9.64	49	R.P.
25.	889	626	1,515	38.02	40	R.P.
26.	1,210	1,420	2,630	17.66	149	R.
27.	1,064	1,226	2,290	23.87	96	R.
28.	458	104	562	109.71	5	R.P.
29.	626	1,386	2,012	21.34	94	R.P.

Note: (1) refer to Figure C-2
(2) R: Residential C; Commercial I; Industrial P; Paddy S: School
M: Mosque & Other religious use V: Vacant & Open Space

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Social Growth Population from 1971 to 1979 (2)	Total Population in 1979 (1) + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
30.	592	1,642	2,234	93.25	24	R.P.S.
31.	379	86	465	47.56	46	P.
32.	1,287	293	1,580	61.32	26	R.P.
33.	522	119	641	38.52	17	R.V.
34.	340	77	417	17.62	24	R.V.
35.	501	114	615	14.04	44	R.V.
36.	563	128	691	78.28	9	P.
37.	317	72	389	86.98	4	P.
38.	319	73	392	25.98	15	P.
39.	835	-117	718	45.20	16	P.
40.	768	175	943	18.20	52	P.I.
41.	1,070	615	1,685	43.60	30	V.I.
42.	731	204	935	6.65	141	R.I.
43.	623	180	803	7.00	115	I.

Note: (1) refer to Figure C-2
(2) R: Residential C: Commercial I: Industrial P: Paddy S: School
M: Mosque & Other religious use V: Vacant & Open Space

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Social Growth Population from 1971 to 1979 (2)	Total Population in 1979 (1) + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
44.	225	96	321	10.54	30	R.V.
45.	1,818	788	2,606	16.17	161	R.
46.	499	741	1,240	21.18	59	R.
47.	709	359	1,068	19.99	53	R.P.
48.	835	388	1,223	14.56	84	R.P.
49.	906	794	1,700	11.98	142	R.
50.	892	203	1,095	6.04	181	R.
51.	589	134	723	16.48	44	R.
52.	701	397	1,098	10.24	107	R.
53.	729	435	1,164	8.52	137	R.
54.	874	199	1,073	4.81	223	R.
55.	793	1,204	1,997	49.45	40	R.P.
56.	518	333	851	15.47	55	R.
57.	587	173	760	6.39	119	R.

Note: (1) refer to Figure C-2
(2) R: Residential C: Commercial I: Industrial P: Paddy S: School
M: Mosque & Other religious use V: Vacant & Open Space

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Social Growth Population from 1971 to 1979 (2)	Total Population in 1979 (10 + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
58.	340	231	571	20.87	27	R.P.
59.	385	88	473	3.20	148	R.
60.	90	20	110	10.56	10	S.
61.	525	120	645	10.31	63	R.
62.	642	146	788	2.35	335	R.
63.	398	157	555	18.03	31	R.
64.	683	156	839	10.40	81	R.
65.	677	154	831	6.06	137	R.
66.	1,023	233	1,256	8.01	157	R.
67.	1,142	260	1,402	6.02	233	R.
68.	671	153	824	5.17	159	R.
69.	939	214	1,153	5.63	205	R.
70.	646	147	793	6.45	123	R.
71.	381	87	468	3.14	149	R.

Note: (1) refer to Figure C-2
(2) R: Residential C: Commercial I: Industrial P: Paddy S: School
M: Mosque & Other religious use V: Vacant & Open Space

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Social Growth Population from 1971 to 1979 (2)	Total Population in 1979 (1) + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
72.	895	204	1,099	14.44	76	R.V.
73.	795	181	976	8.43	116	R.V.
74.	459	105	564	6.62	85	R.S.
75.	753	171	924	8.37	110	R.S.
76.	811	185	996	4.02	248	R.
77.	951	217	1,168	6.84	171	R.C.
78.	1,507	343	1,850	6.30	294	R.C.
79.	311	71	382	6.36	60	R.C.
80.	818	186	1,004	13.23	76	R.
81.	2,362	538	2,900	13.23	219	R.
82.	1,260	287	1,547	8.72	177	R.V.
83.	834	190	1,024	4.71	217	R.
84.	1,034	240	1,274	6.12	208	C.
85.	674	153	827	4.67	177	C.

Note: (1) refer to Figure C-2
(2) R: Residential C: Commercial I: Industrial P: Paddy S: School
M: Mosque & other religious use V: Vacant & Open Space

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Socail Growth Population from 1971 to 1979 (2)	Total Population in 1979 (1) + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
86.	768	175	943	9.00	105	C.
87.	782	178	960	7.81	123	R.C.
88.	738	168	906	5.83	155	R.
89.	635	145	780	12.00	65	Railway
90.	678	154	832	4.10	203	R.
91.	814	185	999	17.61	57	R.P.
92.	458	104	562	18.04	31	S.R.
93.	798	182	980	11.08	88	R.
94.	573	130	703	5.63	125	R.
95.	717	163	880	9.90	89	R.
96.	787	179	966	12.44	78	R.S.
97.	602	137	739	7.18	103	R.
98.	630	528	1,158	12.14	95	R.
99.	668	152	820	7.00	117	R.

Note: (1) refer to Figure C-2
(2) R: Residential C: Commercial I: Industrial P: Paddy S: School
M: Mosque & other religious use V: Vacant & Open Space

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Social Growth Population from 1971 to 1979 (2)	Total Population in 1979 (1) + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
100.	616	140	756	9.46	80	R.
101.	842	192	1,034	9.71	106	R.
102.	744	169	913	5.56	164	R.
103.	1,101	251	1,352	13.71	99	C.
104.	764	174	938	12.73	74	C.R.
105.	858	195	1,053	4.23	249	C.
106.	183	757	940	12.88	73	C.
107.	616	140	756	4.96	152	C.
108.	632	144	776	7.47	104	C.
109.	772	176	948	7.15	133	C.
110.	635	145	780	2.79	280	C.
111.	645	147	792	5.07	156	C.
112.	931	212	1,143	6.21	184	C.R.
113.	968	220	1,188	6.24	190	C.R.

Note: (1) refer to Figure C-2
(2) R: Residential C: Commercial I: Industrial P: Paddy S: School
M: Mosque & other religious use V: Vacant & Open Space

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Social Growth Population from 1971 to 1979 (2)	Total Population in 1979 (1) + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
114.	1,208	275	1,483	8.69	171	C.
115.	918	209	1,127	12.20	92	C.
116.	1,301	296	1,597	20.89	76	R.C.S.
117.	1,256	286	1,542	5.09	303	R.
118.	255	58	313	3.24	97	R.
119.	781	310	1,091	7.27	150	R.
120.	793	280	1,073	12.56	85	R.V.
121.	1,043	638	1,681	38.58	44	R.
122.	943	215	1,158	8.74	132	R.
123.	1,615	896	2,511	44.14	57	R.V.
124.	880	200	1,080	17.08	63	R.
125.	213	49	262	11.16	23	R.
126.	552	126	678	27.85	24	V.
127.	387	88	475	5.89	81	V.

Note: (1) refer to Figure C-2
(2) R: Residential C: Commercial I: Industrial P: Paddy S: School
M: Mosque & other religious use V: Vacant & Open Space

Table C-2 1979 Population and its Density in the Census Enumeration Blocks

Census Enumeration Block No.	Population in 1970 (1)	Natural and Social Growth Population from 1971 to 1979 (2)	Total Population in 1979 (1) + (2)	Area (ha)	Population Density (Person/ha)	Classification by land use
128.	64	15	79	4.75	17	V.
129.	481	110	591	16.97	35	R.
130.	643	146	789	12.55	63	R.
131.	560	128	688	6.37	108	R.
132.	440	150	590	12.66	47	R.V.
133.	611	139	750	20.66	36	R.P.
134.	254	2,187	2,441	78.89	31	R.
135.	497	113	610	19.39	31	R.
136.	315	72	387	8.74	44	R.
137.	790	180	970	5.22	186	R.
138.	509	122	631	15.16	42	R.
139.	19	1,296	1,315	28.18	47	R.
140.	925	211	1,136	7.03	162	R.
141.	454	400	854	26.06	33	R.S.
Paddy, River Railway, etc.	0	0	0	910.01	0	
TOTAL	100,439	39,161	139,600	3,300.0	58.4	

Note: (1) refer to Figure C-2
(2) R: Residential C: Commercial I: Industrial P: Paddy S: School
M: Mosque & other religious use V: Vacant & Open Space

2. Future Population Forecasts in Previous Study Reports

Future population forecasts in the previous study reports are shown in Table C-3

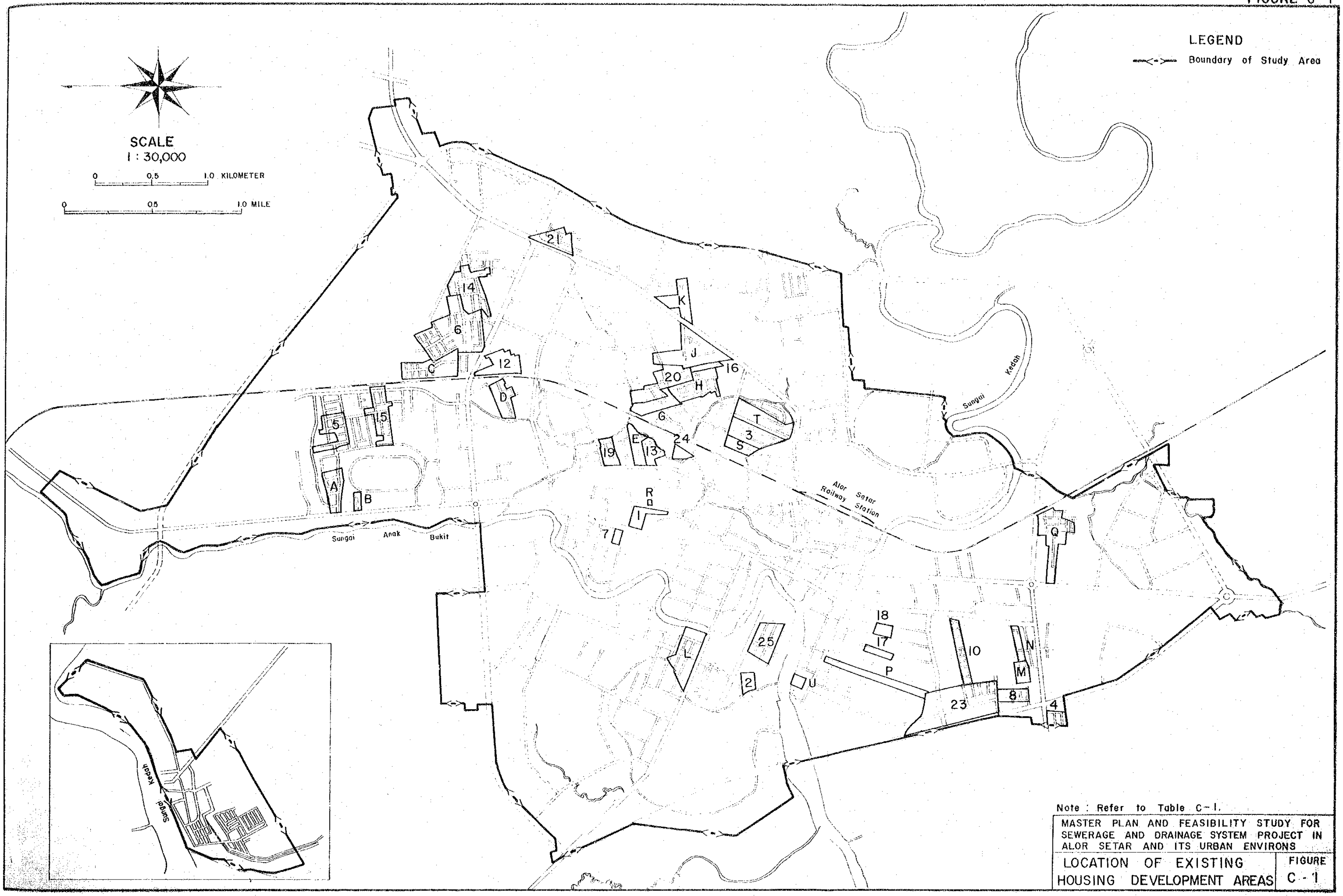
Table C-3 Population Forecast of Alor Setar Area in the Previous Study Reports

Year	Population of Alor Setar estimated in Kedah-Perlis Development Study		Population of Study Area estimated in Preliminary Study for Sewerage (**)		Population of Alor Setar in Urban Sewerage Survey, WHO (***)	
	Population	Annual Growth Rate (%)	Population	Annual Growth Rate (%)	Population	Annual Growth Rate (%)
1980	150,300	-	138,800	-	102,000	-
1985	-	-	177,100	5.0	131,000	5.0
1990	222,500*	-	215,500	4.0	167,000	5.0
1995	-	-	256,000	3.0	203,000	4.0
2000	-	-	296,800	3.0	235,000	3.0

Note: (1) *: Area of the population forecast is 2,208 ha (or 5,520 acres), but the area is not identical.

(2) **: Population of Kuala Kedah and Mergong Industrial area are not included.

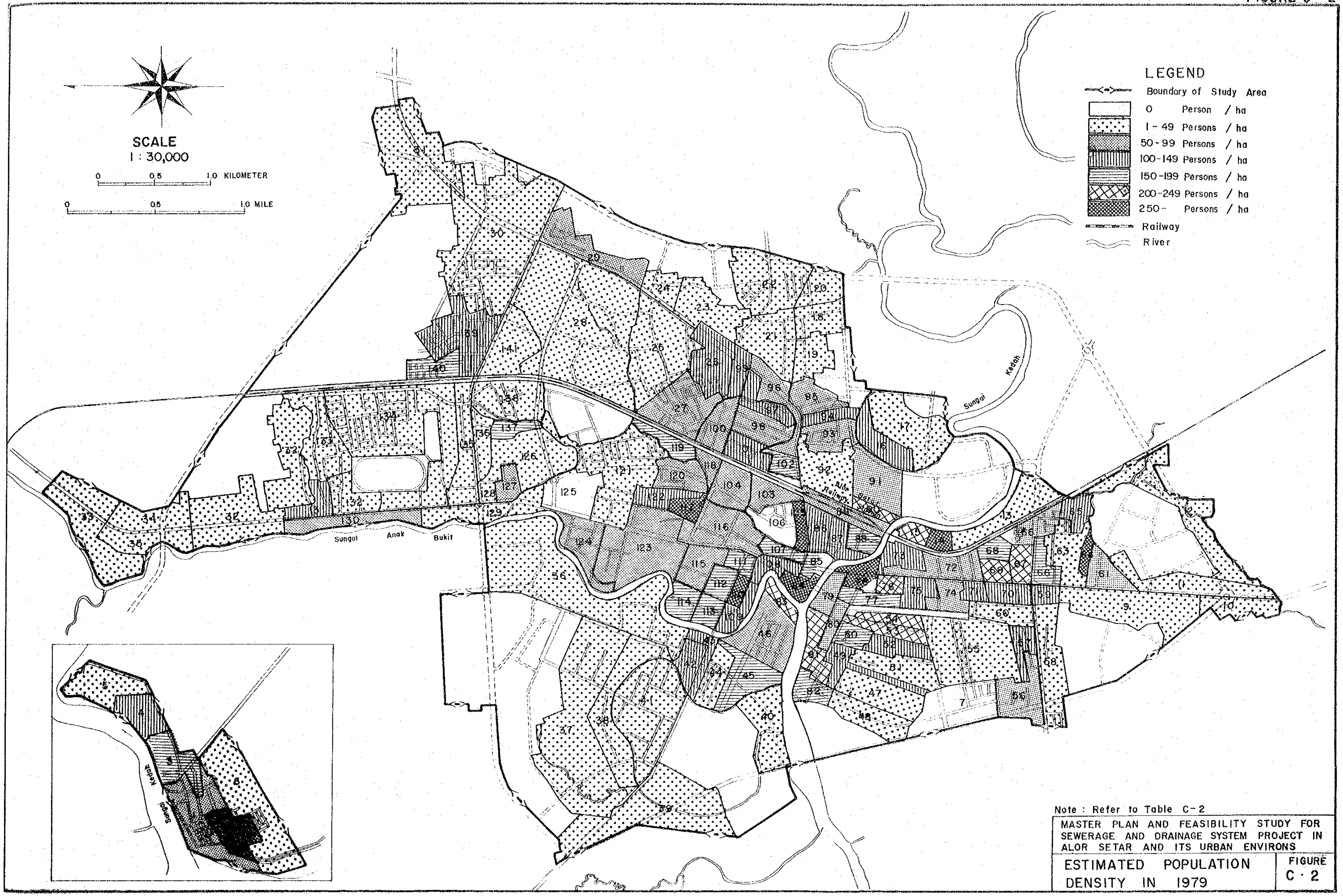
(3) ***: Area of the population forecast is not identical.



Note : Refer to Table C-1.

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

LOCATION OF EXISTING HOUSING DEVELOPMENT AREAS	FIGURE C - 1



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

ESTIMATED POPULATION DENSITY IN 1979

FIGURE C・2

APPENDIX D

WASTEWATER QUANTITIES AND QUALITIES

1. Domestic

Three typical residential sections in the Study Area were selected as shown in Figure D-1 and per capita water consumption rates were collected based on the JKR's metre reading record for the past one year as resulted in Table D-1.

Table D-1 Water Consumption Rates in Typical Residential Sections

Name of Place	Type of House	No. of House Unit	Average Per Cap. Water Consumption (l/cap./day)	Range of Per Cap. Water Consumption (Max.-Min.) (l/cap./day)
Kg. Alor Merah	Kampung house	52	173	56 - 345
Taman Uda Taman Muhibbah	Terrace, Semi-detached and isolated houses	52	158	24 - 322
Taman Malaysia	Semi-detach	52	157	26 - 358
Average		-	163	-

Note: Average number of people in a family is assumed to be 5.5.

Considering additional per capita water consumption rate data, one is obtained from JKR in Alor Setar to be 163 litres per day and the other from the house visiting survey on various types of houses to be in average 185 litres per day as shown in Table D-2, the rate considered for sewerage plan is 170 litres per day for present condition.

The 2000-year per capita water consumption rate is set to be 230 litres per day considering expected future consumption increase by upgraded of living conditions including use for flush toilet system, and further referring to various design criteria sited in Table D-3.

Table D-2 Per Capita Water Consumption Rates Obtained from Various Types of Houses by House Visiting

Water Consumption (l/day/cap.) \ *Type	Number of Households					
	Type I	Type II	Type III	Type IV	Type V	Total
Less than 100	0	0	3	2	1	6
101 - 150	4	1	5	2	2	14
150 - 200	3	1	0	1	1	6
201 - 250	1	3	2	4	1	11
251 - 300	2	2	0	3	1	8
301 - 350	0	0	1	0	1	2
351 - 400	1	1	0	2	0	4
More than 400	0	0	0	3	2	5
Total Household No.	11	8	11	17	9	56
Total of Population (Person)	69	65	78	97	43	352
Average Per Capita Water Consumption (l/day/cap.)	181	176	166	228	259	185

Notes: * House Type

I : Kampung house (wooden)
II : One-story attached terrace house
III : Two-story attached terrace house
IV : Semi-detached house
V : Isolated terrace house

Table D-3 Comparison of Design Criteria for Various Cities

Name of City (or country)	Target Year	BOD (mg/l)	SS (mg/l)	BOD (g/d/c)	SS (g/d/c)	Flow (l/d/c)	Remarks
Butterworh	2000	200	200	46	46	230	Design criteria
Ipoh	2020	200	250	45	54	227	Design criteria
Kuala Lumpur (*)	2002	222	-	60	-	270	Desgin criteria
Seoul	1985	312	374	59	73	232	Design criteria
Japan (**)	2000	-	-	65	59	350	Design manual

Note: (1) * Kuala Lumpur Master Plan for Sewerage and Sewage Disposal; D. Balsour & Sons (1975)

(2) ** Japanese Design Manual for Sewerage System (1972)

2. Commercial

For commercial area, water consumption data were taken from 59 units of various kinds of business in a typical commercial section as shown in Figure D-1 from the JKR's metre reading record for the past one year as resulted in Table D-4.

Table D-4 Water Consumption Rates in Typical Commercial Sections

Name of Place	No. of House Unit	Average Per Cap. Water Consumption (l/cap./day)	Per Cap. Water Consumption (Max.-Min.) (l/cap./day)
Jalan Mahsuri Jalan Putera	59	340	261 - 397

Notes: (1) The present population density in the commercial area is 154 persons per ha.

(2) Average number of people in a family is assumed to be 5.5.

Per capita wastewater rate generated from the commercial area in the year 2000 is assumed to be 460 litres per day, by the same way in the case of residential area in the above section.

3. Institutional

Water consumption rates from typical institutional buildings as shown in Figure D-1 were collected as resulted in Table D-5.

It is noted that the present per capita consumption rate of 23 litres per day is considered to continue up to the year 2000.

Table D-5 Water Consumption Rates in Typical Institutional Sections

Government Office	Water Consumption (l/day)	Permanent Staff	Per Cap. Water Consumption (l/cap./day)
MPKS, TCP, JKR (Building Section)	5,505	202	27.3
DID, JKR	13,564	704	19.3
LLN	7,390	317	23.3
Average	-	-	Appro. 23

4. Industrial

A total of 106 existing industrial factories is found in the Study Area as summarized in Table D-6;80 factories in the North Mergong Industrial area, 3 factories in the Kuala Kedah Industrial area, and remaining 23 factories in other areas, especially along the main roads such as Jl. Sg. Korok and Jl. Langgar.

In addition, several large scale factories are being built in the South Mergong Industrial area.

The data in Table D-6 reveal that kinds of industries differ significantly between the Kuala Kedah and the North Mergong Industrial area, thus discussions are developed independently hereafter.

Table D-6 Distribution of Major Industrial Factories in the Study Area

Category No.	Kind of Industry or Product	Distribution of Major Factories							
		K. Kedah		N. Mergong		Other Area		Total	
		No. of Facotry	Prorata Ratio	No. of Factory	Prorata Ratio	No. of Factory	Prorata Ratio	No. of Factory	Prorata Ratio
01	Foodstuffs	3	100.0	7	8.8	10	43.5	28	18.9
02	Chemical					1	4.3	1	1.0
03	Plastic and Rubber			4	5.0	1	4.3	5	4.7
04	Metal Works			6	7.5	3	13.1	9	8.5
05	Electrical			4	5.0			4	3.8
06	Mechanical			2	2.5	1	4.3	3	2.8
07	Others			10	12.5	2	8.7	12	11.3
08	Whole Sale			12	15.0			12	11.3
09	Warehouses			10	12.5			10	9.4
10	Car Repair			20	25.0	3	13.1	23	21.7
11	Services			5	6.2	2	8.7	7	6.6
	Total	3	100.0	80	100.0	23	100.0	106	100.0

4.1 North Mergong Industrial Area

Sixteen representative factories were visited, and the results are shown in Table D-7.

Table D-7 Industrial Wastewaters Generated from Various Industries in the North Mergong Industrial Area

Category No.	Kind of Industry or Product	No. Sample	Land Area (ha)	Wastewater Generated	
				(m^3/day)	(m^3/day/ha)
01	Foodstuffs	3	0.2398	5.2	21.7
03	Plastic and Rubber	3	1.0536	62.1	58.9
04	Metal Works	2	0.1392	2.9	20.8
05	Electrical Works	1	0.2880	3.6	12.5
07	Others	1	0.0723	4.4	60.9
10	Car Repair	6	0.6742	16.4	24.3
Total		16	—	—	—

The area to be developed in the future in the North Mergong Industrial area is assumed to be shared by the various kinds of industries in the same rates now being occupied by the various categorical industries in Table D-6, thus amount of wastewater generated by each categorical industry is estimated as shown in Table D-8.

Data, in Table D-7, not covered by the industries categorized in Table D-6 such category as No. 02, 07, 08, 09 and 11 are supplemented by the data obtained by the Butterworth Sewerage Master Planning and field survey by this project.

Table D-8 Wastewater Quantities Generated from Net Unit Land of Various Industies

Category No.	Prorate Area (%)	Land Area (ha)	Wastewater	
			(m^3/day)	(m^3/day/ha)
01	8.8	10.3	223.5	21.7
02				
03	5.0	5.9	347.5	58.9
04	7.5	8.8	183.0	20.8
05	5.0	5.9	73.8	12.5
06	2.5	2.9	14.8	5.1 (*1)
07	12.5	14.6	889.1	60.9
08	15.0	17.6	160.2	9.1 (*2)
09	12.5	14.6	132.9	9.1 (*2)
10	25.0	29.2	709.6	24.3
11	6.2	7.2	65.5	9.1 (*2)
Total	100.0	117.0	2,799.9	(Av) 23.9 (*3)

Note: (1) (*1) assumed by the data in the Butterworth Sewerage Master Report by NSC.

(2) (*2) 9.1 m^3/day/ha is used assuming that per ha workers of 394 and per capita water consumption of 23 litres, used in the case of institutional area.

(3) (*3) net area

It should be noted that net industrial land in the Mergong Industrial area is assumed to be 117 ha excluding the areas occupied by road, open space, etc. out of gross area of 146 ha. Therefore, industrial wastewater generated from unit gross area is estimated to be 19.2 m^3/day/ha (=2,799.9 ÷ 146, refer to Table D-8).

By the same approach applied for estimating wastewater quantities generated from various industries in the North Mergong Industrial area, wastewater qualities are also estimated as resulted in Table D-9, thus being 58 mg/l for BOD and 94 mg/l for SS.

Table D-9 Wastewater Qualities Generated from Various Industries

Category No.	Wastewater (m^3/d)	BOD		SS	
		Concentration (mg/l)	Waste Load (kg/d)	Concentration (mg/l)	Waste Load (kg/d)
01	223.5	150 (*1)	33.525	150 (*1)	33.525
03	347.5	30 (*1)	10.425	50 (*1)	17.375
04	183.0	30 (*1)	5.490	50 (*1)	9.150
05	73.8	30 (*1)	2.214	50 (*1)	3.690
06	14.8	70 (*2)	1.036	130 (*2)	1.924
07	889.1	70 (*2)	62.237	130 (*2)	115.583
08	160.2	70 (*2)	11.214	130 (*2)	20.826
09	132.9	70 (*2)	9.303	130 (*2)	17.277
10	709.6	30 (*1)	21.288	50 (*1)	35.480
11	65.5	70 (*2)	4.585	130 (*2)	8.515
Total	2,799.9	(Av) 58	162.317	(Av) 94	263.345

Note: (1) (*1) obtainted from current survey.

(2) (*2) applied from previous data obtained in the Butterworth Sewerage Study by NSC, 1978.

4.2 South Mergong Industrial Area

Four large scale industries have been underconstruction in the South Mergong Industrial area. Their land areas and estimated future water consumptions and as shown in Table D-10.

Table D-10 Data Obtained for Existing Four Industries

Name of Factory	Land Area (ha)	Worker (Person)	Water Consumption (m^3/day)	Remarks
Dunlop Malaysia Industries, BHD	8.96	520	454.6 (1980) 909.2 (future)	Tire production, and recovery
Peninsular Paper Mills, SDN, BHD	2.82	8	79 (*1)	Paper (toilet)
Kedah Stramit Industries SDN, BHD	5.28	104	0.25	Partition of shielding board made of rice straw
Slaughter House	4.18	-	112 (*2)	Cow the processed: 14,000 heads/yr and Sheep to be processed: 60,000 heads/yr
Total	21.24		1,100.45	

Note : (*1) From Industrial Statistic in Japan, 1977

(*2) By NSC data in Japan

Wastewater quantity generated from the remaining future development area in the South Mergong Industrial area is assumed by applying the same basic wastewater rate (19.2 m^3/day/ha of gross area and 33.9 [≒1,459÷43] m^3/day/ha of net area) used for the North Mergong Industrial area thus total wastewater generation in the South Mergong Industrial area is estimated to be 1,459 m^3/day [=1,100.45+(15.0x23.9)].

Wastewater quality generated in the South Mergong Industrial area is estimated in Table D-11.

Table D-11 Estimated Wastewater Quality Generated in the South Mergong Industrial Area

Name of Factory or Industry	Wastewater (m^3/d)	B O D		S S	
		Concentration (mg/l)	Waste Load (kg/d)	Concentration (mg/l)	Waste Load (kg/d)
Dunlop Malaysia Industries, BHD	909.2	10 (*2)	9.09	50	45.46
Peninsular Paper Mills, SDN, BHD	79.0	100 (*2)	7.90	300	23.70
Kedah Stramit Industries SDN, BHD	0.25	10 (*2)	0.00	100	0.03
Slaughter House	112.0	3,294	368.9 (*1)	2,544	284.9 (*1)
S. Mergong Ind. Area (excluding above four industries)	358.55	58	20.78	94	33.70
Total	1,459.0	(Av) 279 ≑ 280	406.67	(Av) 266 ≑ 270	387.79

Note: (1) (*1) Wastewater quantity and quality generated from the factory by slaughtering cows and sheep are estimated by the following criteria and based on the designed processing capacity of 46.7 heads for cow, 20 heads for sheep per day.

Animal Name	Wastewater (m^3/head)	Waste Load (kg)	
		BOD	SS
Cow	2.1	7.3	5.8
Sheep	0.7	1.4	0.7

(2) (*2) standard data applied in Japan.

4.3 Kuala Kedah Industrial Area

Data were collected from the three existing fishery industiries in the Kuala Kedah Industrial area as shown in Table D-12.

Table D-12 Data Obtained from the Existing Three Fishery Industries

Kind of Industry	Land Area (ha)	Wastewater (m^3/day)	(m^3/day/ha*)
Fish processing	0.6075	55	90.5
Fish meal	0.4050	68	167.9
Fish powder	0.5400	50	92.6
Total	1.5525	173	111.4

Note: * net area

The wastewater quality in the drainage channel, wherein the wastewaters generated from the above three factories have been discharging, is taken at 10:25 p.m. on 25th of June, 1979 and analysed as shown in Table D-13.

Table D-13 Wastewater Quality of the Existing Three Fishery Industries

BOD (mg/l)	SS (mg/l)
2,350	324

5. Schools

Four typical schools were selected for estimating per capita water consumption rate, based on the JKR's metre reading record of these schools for the past one year as shown in Table D-14 and Figure D-1.

Table D-14 Data Obtained from Typical Schools

Name of School	No. of Students (Person)	Water Consumed (l/day)	(l/cap./day)
Kompleks II, Alor Malai	763	7,355	9.6
Vokesyenal Alor Setar	545	15,138	27.8
Darulaman	1,162	4,260	3.7
Publik Alor Setar	210	1,905	9.1
Total	2,757	28,658	10.4

Considering seasonal variation of water consumption rate, per capita water consumption rate is assumed to be 11.5 litres per day.

Number of students for the year 2000 are estimated to be 91,790 as shown in Table D-15 based on the present number of students of 40,260. The total 2000-year students are estimated by assuming that number of students will be increased in proportion to the increase of population till 2000 in the Study Area.

Table D-15 Estimated Student Numbers in the Study Area

Sewerage Sub-zone	Ref. No. (Refer to Fig. D-2)	Name of School	No. of Student in	
			1979	2000
A-1	M-3	SMK Kompleks II, Alor Malai	763	1,570
	M-11	SMJK Sultanah Asma II	910	1,870
	M-16	SM Vokesyenal, Alor Setar	545	1,120
	M-17	SMJK Darulaman	1,162	2,390
	R-18	SRK Haji Mohd, Shariff	771	1,580
	R-22	SRJK(C) Pumpong	288	590
	R-34	SRJK(T) Public, Alor Setar	210	430
	M-2	SMK Dato Syed Omar	1,523	3,130
		New schools in the future plan	-	2,000
		Sub-total	6,172	14,680
A-2	M-12	SM Tunku Abdul Malik	1,543	3,170
	R-1	SK Sri Amar di Raja	536	1,100
		New Schools in the future plan	-	1,000
		Sub-total	2,079	5,270
B-1	C	Sekolah Menengah Keat Hwa	600	1,370
	M-5	SMJK St. Nicholas Convent	978	2,010
	R-2	SK Kanchut	376	770
	R-15	SRK Tunku Abdul Halim	1,413	2,900
	R-16	SRK St. Nicholas Convent	1,427	2,930
	R-25	SRJK(C) Keat Hwa (H)	1,706	3,500
	R-26	SRJK(C) Keat Hwa (K)	1,673	3,430
	R-27	SRJK(C) Keat Hwa (S)	1,424	2,920
	M-9	SMJK St. Michael	792	1,630
	R-19	SRK St. Michael	245	500
	M-8	SMJK Kolej Sutan Abdul Hamid	1,747	3,590
	R-17	SRK Iskandar	1,743	3,580
	R-10	SK Tunku Raudzoh, Derga	976	2,000
		Sub-total	15,100	31,130

Sewerage Sub-zone	Ref. No. (Refer to Fig. D-2)	Name of School	No. of Student in	
			1979	2000
B-2	M-7	SMJK Sultanah Asma	1,550	3,180
	R-20	SRK Sultanah Asma	1,413	2,900
	R-23	SRJK(C) Kee Chee, Derga	297	610
		New Schools in the future plan	-	1,000
		Sub-total	3,260	7,690
B-3	M-1	SMK Sultanah Bahiyah	1,165	2,390
C-2	M-10	SMJK Tunku Abdul Rahman	1,534	3,150
	R-3	SK Mergong	569	1,170
	R-24	SRJK(C) Long Chuan, Mergong	398	820
		New Schools in the future plan	-	1,000
		Sub-total	2,501	6,133
D-1	A	Maktab Mahmud	815	1,670
	B	Maktab Mahmud Puteri	915	1,880
	R-6	SK Seberang Perak (P)	219	450
	R-7	SK Seberang Perak (L)	164	340
	R-12	SK Sungai Korok Baru	279	570
	R-13	SK Sungai Korok Lama	239	490
	R-31	SRJK(C) Sin Min, Sungai Korok	843	1,730
	R-32	SRJK(C) Peng Min, Simpang Kuala	866	1,780
		New Schools in the future plan	-	2,000
		Sub-total	4,340	10,908
D-2	M-6	SMJK Keat Hwa	2,492	5,110
	M-15	SM Teknik, Alor Setar	1,157	2,380
		New Schools in the future plan	-	1,000
		Sub-total	3,649	8,490
E-1	R-8	SK Seberang Nyoya	1,355	2,780
	R-28	SRJK(C) Pei Shin, Kuala Kedah	639	1,310
		New Schools in the future plan	-	1,000
		Sub-total	1,994	5,090
		Total	40,260	91,790

6. Extraneous Water

Although the sewerage system is intented to receive wastewater only, a certain amount of extraneous water is expected through incomplete pipe joints, cracks on sewers, and openings on manholes, etc., thus some infiltration allowance is necessary in designing sewer capacities. Since existing system is not available for estimating extraneous water within the Study Area, the allowances is assumed to be 0.045 m^3/day per metre of sewer length, based on the data of a similar city, Butterworth/Bukit Mertajam.

Typical areas selected include three places in residential, one place in commercial and industrial area as shown in Figure D-3, to estimate average sewer length in unit of area.

Thus infiltration rates by land use is resulted as shown in Table D-16.

Table D-16 Infiltration Allowances by Land Use

Land Use	Pipe Length* (m/ha)	Allowance (m^3/day/ha)
Residential	151~163	6.3
Commercial	118	4.5
Industrial	111	4.5

Note: * Refer to Figure D-3.

7. Wastewater Quantities and Qualities Generated from Sewerage Zones and Sub-Zones in 1979 and 2000

Wastewater quantities generated from Sewerage Zones and Sub-Zones are calculated for the years 1979 and 2000 as shown in Tables D-17-1 and D-18-1, based on the relevant design values set out in Section 3 (Population Distribution in Sewerage Zones and Sub-Zones) and Section 4 (Wastewater Quantities and Qualities) in Chapter 5 of the main report and their relevant Appendices C and D.

Similarly, waste loads (BOD, SS) generated from Sewerage Zones and Sub-Zones are calculated for 1979 and 2000 as shown in Tables D-17-2, D-17-3, D-18-2 and D-18-3.

Table D-17-1 <u>Wastewater Generated from Sewerage Sub-Zones (1979)</u>

Source of Wastewater / Sewerage Sub-Zones	Residential Area	Commercial Area	Institutional Area	School	Others	Industrial Area N.Mergong	Industrial Area S.Mergong	Industrial Area K.Kedah	Extraneous Water	Total (m^3/d)
	m^3/cap 0.17	m^3/cap 0.34	m^3/cap 0.023	m^3/cap 0.0115	m^3	m^3/ha 19.2	m^3/ha 33.9	m^3/ha 86.6	m^3/ha 4.5, 6.3	
A-1	15,100	-	-	6,172	-	-	-	-	385.0	
	2,567	-	-	71	418	-	-	-	2,426.0	5,482
A-2	3,700	-	-	2,079	-	-	-	-	437.0	
	629	-	-	24	-	-	-	-	2,753.0	3,406
Sub-total	18,800	-	-	8,251	-	-	-	-	822.0	
	3,196	-	-	95	418	-	-	-	5,179.0	8,888
B-1	23,800	19,800	3,000	15,100	-	-	-	-	343.0+116.0	
	4,046	6,732	690	174	8	-	-	-	2,683.0	14,333
B-2	11,400	-	-	3,260	-	-	-	-	410.0	
	1,938	-	-	37	-	-	-	-	2,583.0	4,558
B-3	1,300	-	-	1,165	-	-	-	-	102.0	
	221	-	-	13	-	-	-	-	643.0	877
Sub-total	36,500	19,800	3,000	19,525	-	-	-	-	971.0	
	6,205	6,732	690	224	8	-	-	-	5,909.0	19,768
C-1	6,000	-	-	-	-	60.0	-	-	67.9+119.1	
	1,020	-	-	-	-	1,152	-	-	964.0	3,136
C-2	2,900	-	-	2,501	-	-	-	-	357.1+69.9	
	493	-	-	29	-	-	-	-	2,564.0	3,086
Sub-total	8,900	-	-	5,501	-	60.0	-	-	614.0	
	1,513	-	-	29	-	1,152	-	-	3,528.0	6,222
D-1	28,900	6,100	-	4,340	-	-	-	-	34.8+40.0	
	4,913	2,074	-	50	-	-	-	-	2,372.0	9,409
D-2	7,700	-	-	3,649	-	-	-	-	270.0	
	1,309	-	-	42	-	-	-	-	1,701.0	3,052
Sub-total	36,600	6,100	-	7,989	-	-	-	-	658.0	
	6,222	2,074	-	92	-	-	-	-	4,073.0	12,461
E	6,700	2,400	-	1,994	-	-	-	2.0	89.0+36.0	
	1,139	816	-	23	-	-	-	173	723.0	2,874
Sub-total	6,700	2,400	-	1,994	-	-	-	2.0	125.0	
	1,139	816	-	23	-	-	-	173	723.0	2,874
T O T A L	107,500	28,300	3,000	40,260	-	60.0	-	2.0	2809.0+381.0	
	18,275	9,622	690	463	426	1,152	-	173	19,412.0	50,213

Note: Figures in upper rows in sewerage Sub-Zones (15,100, 6,172 and 385 in corresponding residential, school and extraneous water column in case of Sewerage Sub-Zone A-1) refer to persons or ha, and similarly figures in lower rows (2,567, 71, 418, 2426 and 5482 in corresponding wastewater sources of residential, school, others extraneous water and total column in case of the same Sub-Zone) refer to m^3/day.

Table D-17-2 <u>Wastewater Loads (BOD) Generated from Sewerage Sub-Zones (1979)</u>

Sewerage Sub-Zones \ Source of Wastewater	Residential	Commercial Area	Institutional Area	School	Others	Industrial Area N.Mergong	Industrial Area S.Mergong	Industrial Area K.Kedah	Total	Av. Concentration(mg/l)
	mg/l 200	mg/l 200	mg/l 200	mg/l 200	mg/l 200	mg/l 60	mg/l	mg/l 2000		
A-1	2,567.0	-	-	71.0	418.0	-	-	-	5,482.0	
	513.4	-	-	14.2	83.6	-	-	-	611.2	111
A-2	629.0	-	-	24.0	-	-	-	-	3,406.0	
	125.8	-	-	4.8	-	-	-	-	130.6	38
Sub-total	3,196.0	-	-	95.0	418.0	-	-	-	8,888.0	
	639.2	-	-	19.0	83.6	-	-	-	741.8	83
B-1	4,046.0	6,732.0	690.0	174.0	8.0	-	-	-	14,333.0	
	809.2	1,346.4	138.0	34.8	1.6	-	-	-	2,330.0	163
B-2	1,938.0	-	-	37.0	-	-	-	-	4,558.0	
	387.6	-	-	7.4	-	-	-	-	395.0	87
B-3	221.0	-	-	13.0	-	-	-	-	877.0	
	44.2	-	-	2.6	-	-	-	-	46.8	53
Sub-total	6,205.0	6,732.0	690.0	224.0	8.0	-	-	-	19,768.0	
	1,241.0	1,346.4	138.0	44.8	1.6	-	-	-	2,771.8	140
C-1	1,020.0	-	-	-	-	1,152.0	-	-	3,136.0	
	204.0	-	-	-	-	69.1	-	-	273.1	87
C-2	493.0	-	-	29.0	-	-	-	-	3,086.0	
	98.6	-	-	5.8	-	-	-	-	104.4	34
Sub-total	1,513.0	-	-	29.0	-	1,152.0	-	-	6,222.0	
	302.6	-	-	5.8	-	69.1	-	-	377.5	61
D-1	4,913.0	2,074.0	-	50.0	-	-	-	-	9,409.0	
	982.6	414.8	-	10.0	-	-	-	-	1,407.4	150
D-2	1,309.0	-	-	42.0	-	-	-	-	3,052.0	
	261.8	-	-	8.4	-	-	-	-	270.2	89
Sub-total	6,222.0	2,074.0	-	92.0	-	-	-	-	12,461.0	
	1,244.4	414.8	-	18.4	-	-	-	-	1,677.6	135
E	1,139.0	816.0	-	23.0	-	-	-	173.0	2,874.0	
	227.8	163.2	-	4.6	-	-	-	346.0	741.6	258
Sub-total	1,139.0	816.0	-	23.0	-	-	-	173.0	2,874.0	
	227.8	163.2	-	4.6	-	-	-	346.0	741.6	258
T O T A L	18,275.0	9,622.0	690.0	463.0	426.0	1,152.0	-	173.0	50,213.0	
	3,655.0	1,924.4	138.0	92.6	85.2	69.1	-	346.0	6,310.3	126

Note: Figures in upper rows in sewerage Sub-Zones (2,567, 71, 418 and 5,485 in corresponding residential, school, others and total column in case of Sewerage Sub-Zone A-1) refer to m^3/day, and similarly figures in lower rows (513.4, 14.2, 83.6 and 611.2 in corresponding residential, school, others and total column in case of the same Sub-Zone) refer to Kg/day.

Table D-17-3 Wastewater Loads (SS) Generated from Sewerage Sub-Zone (1979)

Source of Wastewater / Sewerage Sub-Zones	Residential Area	Commercial Area	Institutional Area	School	Others	Industrial Area N.Mergong	Industrial Area S.Mergong	Industrial Area K.Kedah	Total	Av. Concentration (mg/l)
	mg/l 200	mg/l 200	mg/l 200	mg/l 200	mg/l 200	mg/l 100	mg/l	mg/l 500		
A-1	2,567.0	-	-	71.0	418.0	-	-	-	5,482.0	111
	513.4	-	-	14.2	83.6	-	-	-	611.2	
A-2	629.0	-	-	24.0	-	-	-	-	3,406.0	38
	125.8	-	-	4.8	-	-	-	-	130.6	
Sub-total	3,196.0	-	-	95.0	418.0	-	-	-	8,888.0	83
	639.2	-	-	19.0	83.6	-	-	-	741.8	
B-1	4,046.0	6,732.0	690.0	174.0	8.0	-	-	-	14,333.0	163
	809.2	1,346.4	138.0	34.8	1.6	-	-	-	2,330.0	
B-2	1,938.0	-	-	37.0	-	-	-	-	4,558.0	87
	387.6	-	-	7.4	-	-	-	-	395.0	
B-3	221.0	-	-	13.0	-	-	-	-	877.0	53
	44.2	-	-	2.6	-	-	-	-	46.8	
Sub-total	6,205.0	6,732.0	690.0	224.0	8.0	-	-	-	19,768.0	140
	1,241.0	1,346.4	138.0	44.8	1.6	-	-	-	2,771.8	
C-1	1,020.0	-	-	-	-	1,152.0	-	-	3,136.0	102
	204.0	-	-	-	-	115.2	-	-	319.2	
C-2	493.0	-	-	29.0	-	-	-	-	3,086.0	34
	98.6	-	-	5.8	-	-	-	-	104.4	
Sub-total	1,513.0	-	-	29.0	-	1,152.0	-	-	6,222.0	68
	302.6	-	-	5.8	-	115.2	-	-	423.6	
D-1	4,913.0	2,074.0	-	50.0	-	-	-	-	9,409.0	150
	982.6	414.8	-	10.0	-	-	-	-	1,407.4	
D-2	1,309.0	-	-	42.0	-	-	-	-	3,052.0	89
	261.8	-	-	8.4	-	-	-	-	270.2	
Sub-total	6,222.0	2,074.0	-	92.0	-	-	-	-	12,461.0	135
	1,244.4	414.8	-	18.4	-	-	-	-	1,677.6	
E	1,139.0	816.0	-	23.0	-	-	-	173.0	2,874.0	168
	227.8	163.2	-	4.6	-	-	-	86.5	482.1	
Sub-total	1,139.0	816.0	-	23.0	-	-	-	173.0	2,874.0	168
	227.8	163.2	-	4.6	-	-	-	86.5	482.1	
T O T A L	18,275	9,622	690.0	463.0	426.0	1,152.0	-	173.0	50,213.0	121
	3,655.9	1,924.4	138.0	92.6	85.2	115.2	-	86.5	6,096.9	

Note: Figures in upper rows in sewerage Sub-Zones (2,567, 71, 418 and 5,485 residential, school, others and total column in case of Sewerage Sub-Zone A-1) refer to m^3/day, and similarly figures in lower rows (513.4, 14.2, 83.6 and 611.2 in corresponding residential, school, others and total column in case of the same Sub-Zone) refer to Kg/day.

Table D-18-1 Wastewater Generated from Sewerage Sub-Zones (2000)

Source of Wastewater / Sewerage Sub-Zones	Residential Area	Commercial Area	Institutional Area	School	Others	Industrial Area N.Mergong	Industrial Area S.Mergong	Industrial Area K.Kedah	Extraneous Water	Total (m^3/d)
	m3/cap 0.23	m^3/cap 0.46	m^3/cap 0.023	m^3/cap 0.0115	m^3	m^3/ha 19.2	m^3/ha 33.9	m^3/ha 86.6	m^3/ha 4.5, 6.3	
A-1	29,700	-	-	14,680	-	-	-	-	385.0	
	6,831	-	-	169	598	-	-	-	2,426.0	10,024
A-2	38,000	-	-	5,270	-	-	-	-	437.0	
	8,740	-	-	61	-	-	-	-	2,753.0	11,554
Sub-total	67,700	-	-	19,950	-	-	-	-	822.0	
	15,571	-	-	230	598	-	-	-	5,179.0	21,578
B-1	31,000	23,200	12,000	31,130	-	-	-	-	343.0+116.0	
	7,130	10,672	276	358	12	-	-	-	2,683.0	21,131
B-2	40,700	-	-	7,690	-	-	-	-	410.0	
	9,361	-	-	88	-	-	-	-	2,583.0	12,032
B-3	11,100	-	-	2,390	-	-	-	-	102.0	
	2,553	-	-	27	-	-	-	-	643.0	3,223
Sub-total	82,800	23,200	12,000	41,210	-	-	-	-	971.0	
	19,044	10,672	276	473	12	-	-	-	5,909.0	36,386
C-1	9,600	-	-	-	-	119.1	-	-	67.9+119.1	
	2,208	-	-	-	-	2,287.0	-	-	964.0	5,459
C-2	31,000	-	-	6,140	-	26.9	43.0	-	357.1+69.9	
	7,130	-	-	71	-	516.0	1,458.0	-	2,564.0	11,739
Sub-total	40,600	-	-	6,140	-	146.0	43.0	-	614.0	
	9,338	-	-	71	-	2,803.0	1,458.0	-	3,528.0	17,198
D-1	38,500	8,000	-	9,910	-	-	-	-	348.0+40.0	
	8,855	3,680	-	114	-	-	-	-	2,372.0	15,021
D-2	30,000	-	-	9,490	-	-	-	-	270.0	
	6,900	-	-	109	-	-	-	-	1,701.0	8,710
Sub-total	68,500	8,000	-	19,400	-	-	-	-	658.0	
	15,755	3,680	-	223	-	-	-	-	4,073.0	23,731
E	9,300	3,600	-	5,090	-	-	-	18.0	89.0+36.0	
	2,139	1,656	-	59	-	-	-	1,559.0	723.0	6,136
Sub-total	9,300	3,600	-	5,090	-	-	-	18.0	125.0	
	2,139	1,656	-	59	-	-	-	1,559.0	723.0	6,136
T O T A L	268,900	34,800	12,000	91,790	-	146.0	43.0	18.0	3,190.0	
	61,847	16,008	276	1,056	610	2,803.0	1,458.0	1,559.0	19,412.0	105,029

Note: Figures in upper rows in sewerage Sub-Zones (29,700, 14,680 and 385 in corresponding residential, school and extraneous water column in case of Sewerage Sub-Zone A-1), refer to persons or ha, and similarly figures in lower rows (6,831, 169, 598, 2,426 and 10,024 in corresponding residential, school, others extraneous water and total column in case of the same Sub-Zone) refer to m^3/day.

Table D-18-2 Wastewater Loads (BOD) Generated from Sewerage Sub-Zones (2000)

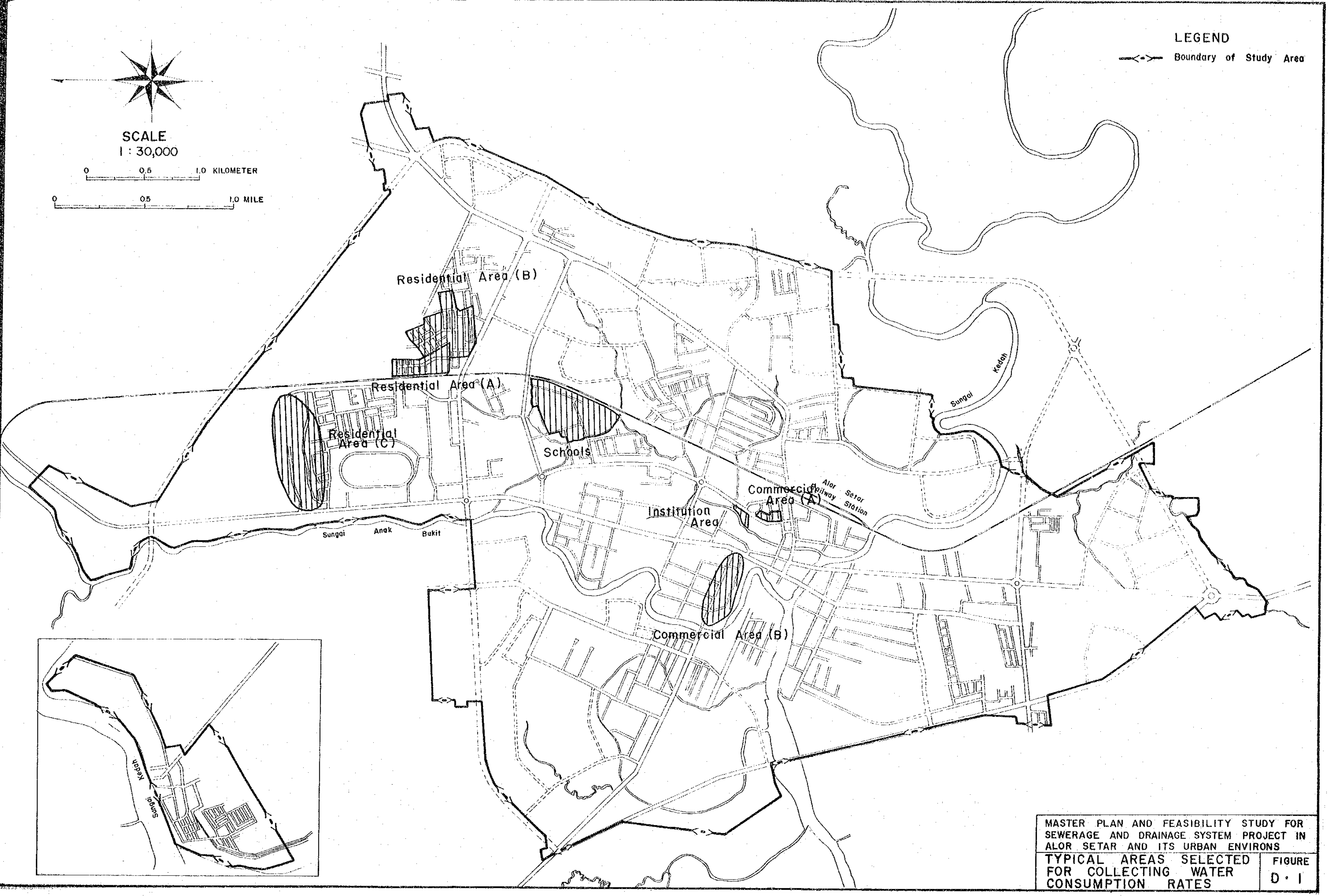
Source of Wastewater / Sewerage Sub-Zones	Residential Area	Commercial Area	Institutional Area	School	Others	Industrial Area			Total	Av. Concentration (mg/l)
						N.Mergong	S.Mergong	K.Kedah		
	mg/l 200	mg/l 200	mg/l 200	mg/l 200	mg/l 200	mg/l 60	mg/l 280	mg/l 2000		
A-1	6,831.0	-	-	169.0	598.0	-	-	-	10,024.0	152
	1,366.2	-	-	33.8	119.6	-	-	-	1,519.6	
A-2	8,740.0	-	-	61.0	-	-	-	-	11,554.0	152
	1,748.0	-	-	12.2	-	-	-	-	1,760.2	
Sub-total	15,571.0	-	-	230.0	598.0	-	-	-	21,578.0	152
	3,114.2	-	-	46.0	119.6	-	-	-	3,279.8	
B-1	7,130.0	10,672.0	276.0	358.0	12.0	-	-	-	21,131.0	175
	1,426.0	2,134.4	55.2	71.6	2.4	-	-	-	3,689.6	
B-2	9,361.0	-	-	88.0	-	-	-	-	12,032.0	157
	1,872.2	-	-	17.6	-	-	-	-	1,889.8	
B-3	2,553.0	-	-	27.0	-	-	-	-	3,223.0	160
	510.6	-	-	5.4	-	-	-	-	516.0	
Sub-total	19,044.0	10,672.0	276.0	473.0	12.0	-	-	-	36,386.0	168
	3,808.8	2,134.4	55.2	94.6	2.4	-	-	-	6,095.4	
C-1	2,208.0	-	-	-	-	2,287.0	-	-	5,459.0	106
	441.6	-	-	-	-	137.2	-	-	578.8	
C-2	7,130.0	-	-	71.0	-	516.0	1,458.0	-	11,739.0	160
	1,426.0	-	-	14.2	-	31.0	408.2	-	1,879.4	
Sub-total	9,338.0	-	-	71.0	-	2,803.0	1,458.0	-	17,198.0	143
	1,867.6	-	-	14.2	-	168.2	408.2	-	2,458.2	
D-1	8,855.0	3,680.0	-	114.0	-	-	-	-	15,021.0	168
	1,771.0	736.0	-	22.8	-	-	-	-	2,529.8	
D-2	6,900.0	-	-	109.0	-	-	-	-	8,710.0	161
	1,380.0	-	-	21.8	-	-	-	-	1,401.8	
Sub-total	15,755.0	3,680.0	-	223.0	-	-	-	-	23,731.0	166
	3,151.0	736.0	-	44.6	-	-	-	-	3,931.6	
E	2,139.0	1,656.0	-	59.0	-	-	-	1,559.0	6,136.0	634
	427.8	331.2	-	11.8	-	-	-	3,118.0	3,888.8	
Sub-total	2,139.0	1,656.0	-	59.0	-	-	-	1,559.0	6,136.0	634
	427.8	331.2	-	11.8	-	-	-	3,118.0	3,888.8	
T O T A L	61,847.0	16,008.0	276.0	1,056.0	610.0	2,803.0	1,458.0	1,559.0	105,029.0	187
	12,369.4	3,201.6	55.2	211.2	122.0	168.2	408.2	3,118.0	19,653.8	

Note: Figures in upper rows in sewerage sub-zones (6,831, 169, 598 and 10,024 in corresponding residential, school, others and toal column in case of Sewerage Sub-Zone A-1) refer to m^3/day, and similarly figures in lower rows (1,366.2, 33.8, 119.6 and 1,519.6 in corresponding residential, shool, others and total column in case of the same Sub-Zone) refer to Kg/day.

Table D-18-3 Wastewater Loads (SS) Generated from Sewerage Sub-Zone (2000)

Source of Wastewater / Sewerage Sub-Zones	Residential Area	Commercial Area	Institutional Area	School	Others	Industrial Area N.Mergong	Industrial Area S.Mergong	Industrial Area K.Kedah	Total	Av. Concentration (mg/l)
	mg/l 200	mg/l 200	mg/l 200	mg/l 200	mg/l 200	mg/l 100	mg/l 270	mg/l 500		
A-1	6,831.0	-	-	169.0	598.0	-	-	-	10,024.0	
	1,366.2	-	-	33.8	119.6	-	-	-	1,519.6	152
A-2	8,740.0	-	-	61.0	-	-	-	-	11,554.0	
	1,748.0	-	-	12.2	-	-	-	-	1,760.2	152
Sub-total	15,571.0	-	-	230.0	598.0	-	-	-	21,578.0	
	3,114.2	-	-	46.0	119.6	-	-	-	3,279.8	152
B-1	7,130.0	10,672.0	276.0	358.0	12.0	-	-	-	21,131.0	
	1,426.0	2,134.4	55.2	71.6	2.4	-	-	-	3,689.6	175
B-2	9,361.0	-	-	88.0	-	-	-	-	12,032.0	
	1,872.2	-	-	17.6	-	-	-	-	1,889.8	157
B-3	2,553.0	-	-	27.0	-	-	-	-	3,223.0	
	510.6	-	-	5.4	-	-	-	-	516.0	160
Sub-total	19,044.0	10,672.0	276.0	473.0	12.0	-	-	-	36,386.0	
	3,808.8	2,134.4	55.2	94.6	2.4	-	-	-	6,095.4	168
C-1	2,208.0	-	-	-	-	2,287.0	-	-	5,459.0	
	441.6	-	-	-	-	228.7	-	-	670.3	123
C-2	7,130.0	-	-	71.0	-	516.0	1,458.0	-	11,739.0	
	1,426.0	-	-	14.2	-	51.6	393.7	-	1,885.5	161
Sub-total	9,338.0	-	-	71.0	-	2,803.0	1,458.0	-	17,198.0	
	1,867.6	-	-	14.2	-	280.3	393.7	-	2,555.8	149
D-1	8,855.0	3,680.0	-	114.0	-	-	-	-	15,021.0	
	1,771.0	736.0	-	22.8	-	-	-	-	2,529.8	168
D-2	6,900.0	-	-	109.0	-	-	-	-	8,710.0	
	1,380.0	-	-	21.8	-	-	-	-	1,401.8	161
Sub-total	15,755.0	368.0	-	223.0	-	-	-	-	23,731.0	
	3,151.0	736.0	-	44.6	-	-	-	-	3,931.6	166
E	2,139.0	1,656.0	-	59.0	-	-	-	1,559.0	6,136.0	
	427.8	331.2	-	11.8	-	-	-	779.5	1,550.3	253
Sub-total	2,139.0	1,656.0	-	59.0	-	-	-	1,559.0	6,136.0	
	427.8	331.2	-	11.8	-	-	-	779.0	1,550.3	253
TOTAL	61,847.0	16,008.0	276.0	1,056.0	610.0	2,803.0	1,458.0	1,559.0	105,029.0	
	12,369.4	3,201.6	55.2	211.2	122.0	280.3	393.7	779.5	17,412.9	166

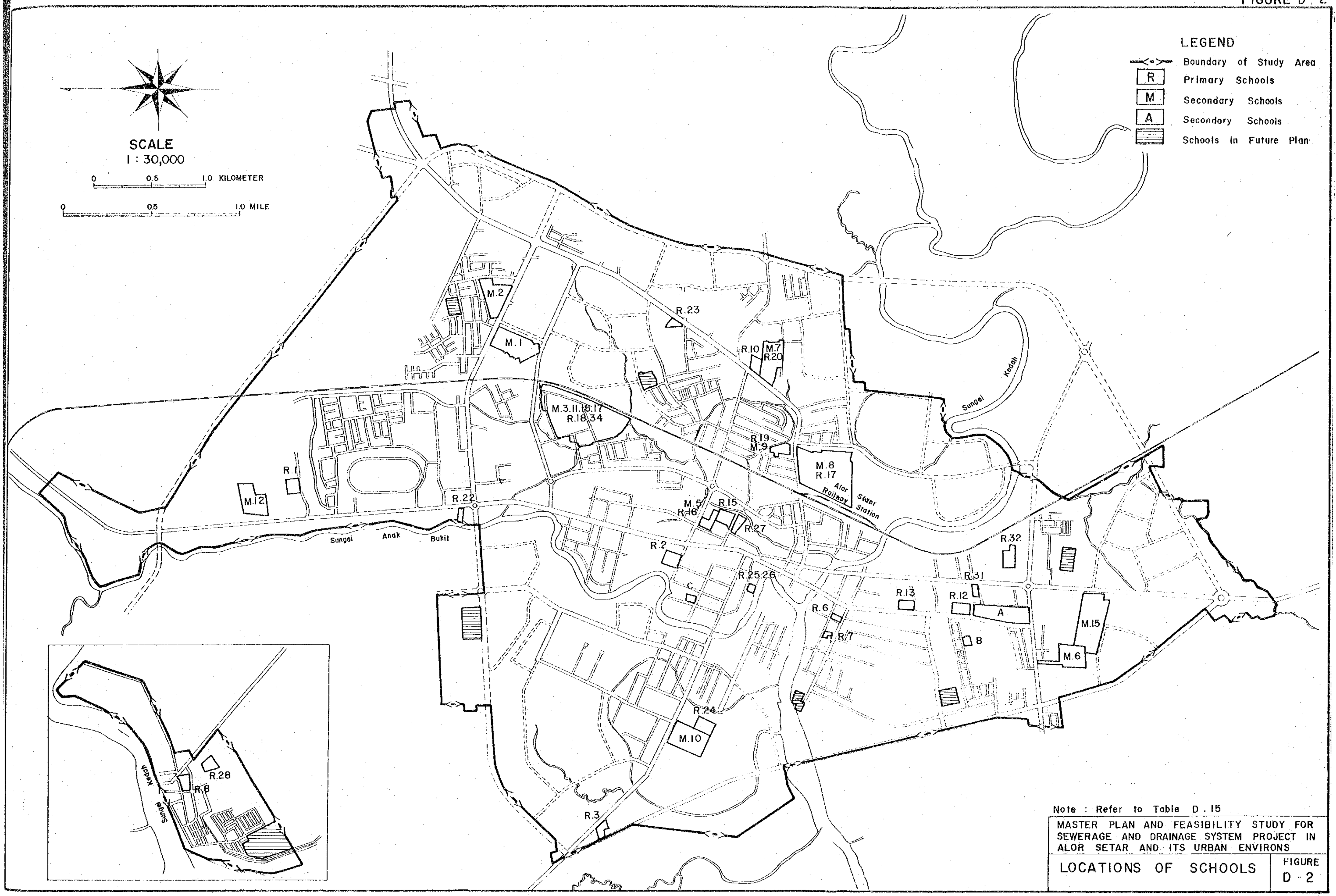
Note: Figures in upper rows in sewerage Sub-Zones (6,831.0, 169.0, 598 and 10,024.0 in corresponding, residential, school, others and total column in case of Sewerage Sub-Zone A-1) refer to m^3/day, and similarly figures in lower rows (1,366.2, 33.8, 119.6 and 1,519.6 in corresponding residential, school, others and total column in case of the same Sub-Zone) refer to Kg/day.



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

TYPICAL AREAS SELECTED FOR COLLECTING WATER CONSUMPTION RATES

FIGURE D · I

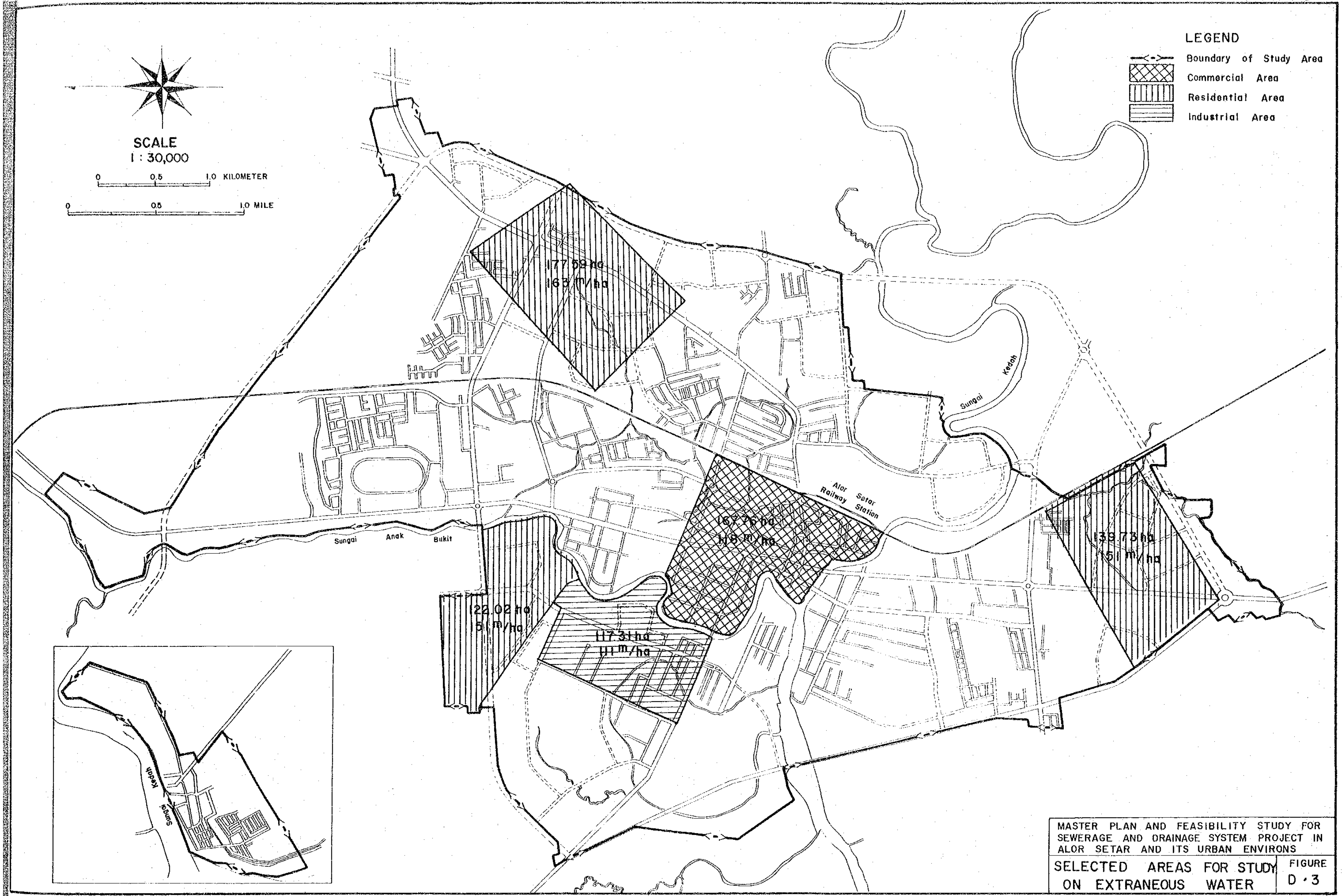


Note : Refer to Table D. 15

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

LOCATIONS OF SCHOOLS

FIGURE D - 2


LEGEND
Boundary of Study Area
Commercial Area
Residential Area
Industrial Area
SCALE
1 : 30,000
0 0.5 1.0 KILOMETER
0 0.5 1.0 MILE
177.59 ha
163 m/ha
122.02 ha
51 m/ha
117.31 ha
111 m/ha
139.73 ha
151 m/ha
Alor Setar Railway Station
Sungai Anak Bukit
Sungai Kedah
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS
SELECTED AREAS FOR STUDY ON EXTRANEOUS WATER
FIGURE D・3

APPENDIX E

ALTERNATIVE SEWERAGE SYSTEM CONSIDERED

1. Conveyance Network

Initially, for several reasons as described in Chapter 5 of Sewerage Master Plan Report, the entire Study Area was divided into five sewerage zones. Then, several alternative cases of conveyance networks are studies, considering topographical and economic aspects both for present and future conditions.

The conveyance networks are established in each sewerage zone independently to avoid a high initial investment by constructing small conveyance system to collect sewage from limited area, and to be flexible for future development programme.

2. Sewage Treatment and Disposal System

2.1 General

Sewage treatment facility improves raw wastewater into an allowable final effluent. It is, therefore, fundamental first to estimate the characteristics of the raw wastewater and the required degree of the effluent or the required treatment, before proceeding to the design of treatment facilities.

In the design of treatment facilities of the Study Area, it is necessary to determine the most desirable treatment system among the various methods, to meet the required degree of effluent as set-out in Section 5, Chapter 5 of main report by economical analysis.

This section deals briefly with alternative methods of treatment system such as stabilization pond, aerated lagoon and oxidation ditch, and recommendation is made for the desirable treatment methods from the both the technical and economical viewpoints.

2.2 Alternative Methods of Treatment

2.2.1 Stabilization Pond

Stabilization pond has been successfully used in many countries, which is sometimes referred to "oxidation pond" or "lagoon".

They are recognized as a means of sewage treatment and have considerable advantages particularly as regards to the overall costs and the removal of faecal bacteria.

They are the most economical method of sewage treatment in hot climates where sufficient land is available in reasonable cost and where the temperature is most favourable for their operation.

The stabilization pond is classified into three types, namely, aerobic, faclutative and anaerobic pond. Among them, since aerobic type requires large land and anaerobic type emits bad odour, facultative pond with maturation pond will be the most appropriate type in the Study Area as described below;

> Facultative pond is the system in which the upper layers of the pond are aerobic and the bottom layers are either devoid of dissolved oxygen or are anaerobic. At present most of the existing waste stabilization pond installations are of the facultative type.
>
> The facultative pond is oxygenated principally by the photosynthetic activity of algae under the influence of solar radiation, although in the larger ponds surface aeration by the wind action contributes significantly to the total oxygen budget.
>
> The dissolved oxygen concentration is greater during daylight period than at night. The measurement of oxidation-reduction potential will show the tendency towards either aerobic or anaerobic conditions.

For the facultative pond, temperature is of great importance because it affects the rate of biochemical degradation. The daily fluctuations, and yearly variations of temperature influence the biological, physical and chemical processes in the pond.

The practical design of a facultative pond depends on local conditions, but a number of useful and rational design procedures are available. The most important factors on stabilization pond design are areal load of BOD and depth of the pond. On the basis of the Butterworth sewage treatment facilities operation, 300 kg-BOD /day/ha (*1) of surface area and 1.5 m of pond depth is proposed for this study. This corresponds to 10 days of mean detention time.

The main purpose of maturation pond is to provide a high quality effluent which is used in a series with facultative pond for efficient reduction of the faecal bacteria. The principal factor for the design of the maturation pond is detention time. The detention time in the maturation pond, as well as the number of ponds, is determined primarily by the degree of bacterial reduction required. In design of maturation pond the reduction of faecal coliform in a pond has been found to follow first order kinetics. The appropriate equation is as follows.

(*1) Ref. "Master Plan for Sewerage and Drainage System Project, Butterworth/Bukit Mertajam Metropolitan Area", by NSC.

$$Ne = \frac{Ni}{1 + K_{b(t)}T}$$

$$K_{b(t)} = 2.6 \ (1.19)^{t-20}$$

where

Ne	:	effluent coliforms, cells/ml
Ni	:	influent coliforms, cells/ml
$K_{b(t)}$	:	die-off coefficient of coliforms at t°C, 1/day
T	:	detention time, days

From the above mentioned equation, the estimated number of effluent coliforms from facultative pond (Ne) is 4,500/ml, assuming

$Ni = 4 \times 10^5$/ml, $K_{b(27)} = 8.8 \ d^{-1}$, and T = 10 days.

This value (Ne = 4,500/ml) is unsatisfied on sanitary aspects, so that the facultative pond should be followed by a maturation pond (detention time is 3 days) for further reduction of coliforms.

That is

$$Ne = \frac{4 \times 10^5}{(1 + 8.8 \times 10) \ \ (1 + 8.8 \times 3)} = 164/ml$$

This can be satisfied for environmental protection from coliform contamination by treatment plant effluent.

2.2.2 Aerated Lagoon

The aerated lagoon is an activated sludge unit operated without sludge return. This is historically developed from stabilization pond.

Commonly, floating aerator for surface aeration is used to supply the necessary oxygen and for mixing lagoon contents.

In common with all activated sludge systems, aerated lagoon is not particularly effective in removing faecal coliforms and suspended solids. Since faecal coliform reduction of aerated lagoon is only 90-95 percent, maturation pond is necessary.

For the design of aerated lagoon in this study, the detention time is assumed as 4 days and the depth 3.0 m.

2.2.3 Oxidation Ditch

The oxidation ditch is a modification of the activated sludge process, generally followed by sedimentation basin except for small size plant. The oxidation ditch is a long continuous channel usually oval in plan and 1.0 - 1.5 m deep. The ditch liquor is aerated by one or more brush or rotors placed across the channel.

At present, there are several oxidation ditches exist in the hot climate areas due to the fact that stabilization ponds are usually more favourable in case available land is limited. However, chlorination of the effluent is considered for removal of bacteria.

A design of oxidation ditch is purely empirical at the present time. According to the Mara report (*1), the depth is in the range of 1-2 m and the volume is dependent on the detention time which in turn is based on the sludge loading factor. This is the weight of BOD applied to the ditch liquor suspended solids per day.

(*1) "Sewage Treatment in Hot Climate", by Duncan Mara

Therefore, the sludge loading factor is given by the following equation;

$$r = \frac{Li}{St}$$

where

r = sludge loading factor, 1/d

Li = influent BOD, mg/l

S = ditch liquor suspended solids, mg/l

t = detention time, days

Then, ditch volume is estimated as follows.

$$V = \frac{LiQ}{Sr}$$

where

V = ditch volume, cu m

Q = flow rate, cu m/day

The design values of this study are taken as $r = 0.1\ d^{-1}$, $S = 4{,}000$ mg/l, $t = 0.5$ days, and depth is assumed at 1.5 m.

2.3 Comparison of Alternative Treatment and Disposal Systems

For the purpose of cost comparison of alternative treatment and disposal systems among the (1) stabilization pond, (2) aerated lagoon and (3) oxidation ditch, firstly each type of treatment facilities is designed for varying daily average flow rates of wastewater for 5,000, 10,000, 30,000 and 50,000 m^3 respectively.

The wastewater quality of each treatment is estimated with the influent BOD of 200 mg/l and that the expected BOD removal of 75 percent of influent BOD.

The all types of treatment are analyzed as to costs accruing to alternatives considered. Each type of treatment and disposal methods is described below and illustrated in Figure E-1, E-2, E-3 and E-4.

1) Stabilization pond process shall consists of facultative and maturation pond in series.

2) Aerated lagoon process shall consist of aerated lagoon and maturation pond in series.

3) Oxidation ditch process shall consist of oxidation ditch, sedimentation basin, and sludge drying bed.

The capital cost for each alternative sewage treatment plant is estimated for the varying flow rates of 5,000 m^3, 10,000 m^3, 30,000 m^3 and 50,000 m^3 (daily average flow) by developing cost functions for the purpose of Master Planning, annual operation and maintenance costs are also estimated as discussed in Appendix G.

Table E-1 shows the estimated costs for construction, operation and maintenance, and land acquisition for each alternative treatment process. All costs are at 1979 price level but no consideration is given as to cost escalation for the purpose of cost comparison among the alternatives.

For comparison purpose, all costs are then expressed on an annual basis, using the following weighted average useful lives of facilities.

(a) pond, basin 30 years
(b) pump, aerator 7 years

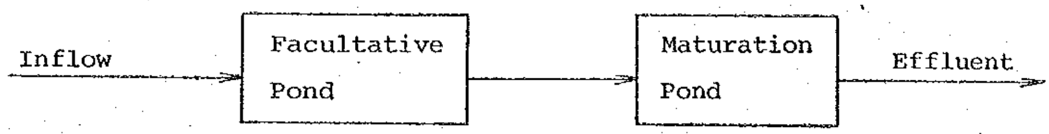
Overall useful life is estimated on the basis of the useful composite lives of facilities, 30 years for civil works and 7 years for machinery and other equipment. It is assumed that the fund is available at 10 percent interest rate and that annual depreciation payments into the sinking fund would grow the same rate.

Depreciated capital costs of the alternative processes are summarized in Table E-2, annual costs incurred by the interest in Table E-3 and total annual costs for the alternatives in Table E-4.

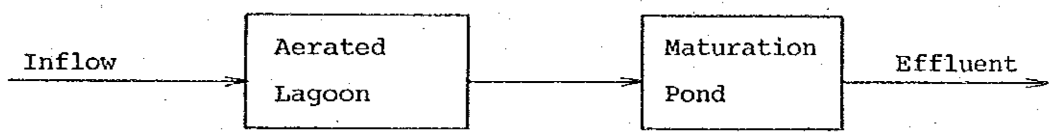
The results of cost analysis indicate that alternative (I) (stabilization pond process) is the most economical method when treatment capacity is less than 30,000 m^3/day, while (II) (aerated lagoon process) is when treatment capacity exceeds 30,000 m^3/day.

FIGURE E-1 Flow sheet

(1) Stabilization pond process



(2) Aerated lagoon process



(3) Oxidation ditch process

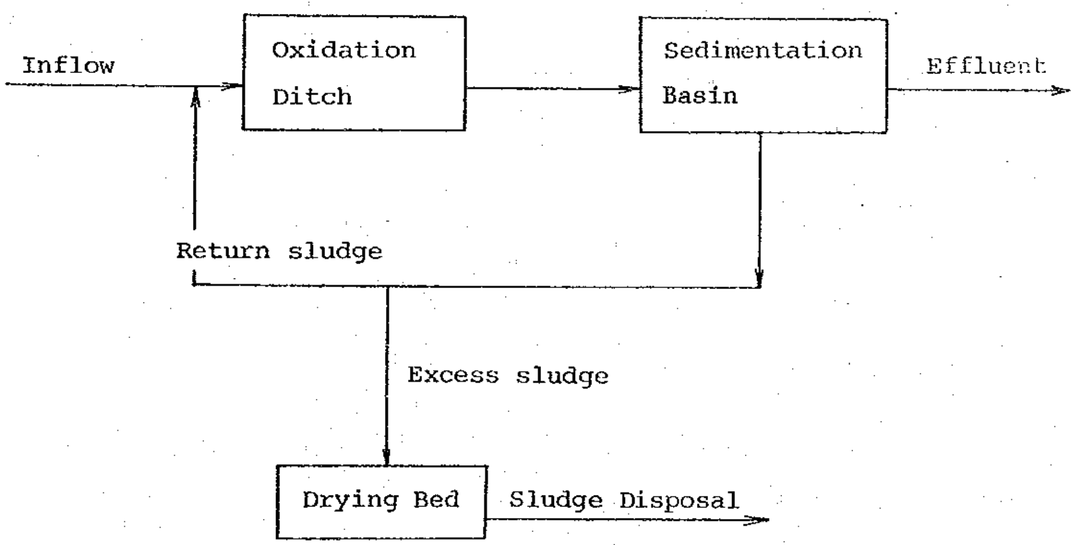


Table E-1 Cost Incurred by Alternative Treatment Processes

(1979 price level)

Alternative	Flow Rate (m^3/day)			
	5,000	10,000	30,000	50,000
1) Construction Costs (M$1,000)				
Alt. 1				
Stabilization Pond Process	705	1,062	3,722	5,881
Alt. II				
Aerated Lagoon Process	852	1,579	3,629	5,672
Alt. III				
Oxidation Ditch Process	1,229	2,348	6,367	10,738
2) O & M Cost (M$1,000/year)				
Alt. I				
Stabilization Pond Process	21.65	25.59	54.01	77.06
Alt. II				
Aerated Lagoon Process	57.13	98.77	252.69	359.48
Alt. III				
Oxidation Ditch Process	109.98	203.42	561.18	918.30
3) Land Acquisition Cost (M$1,000)				
Alt. I	171.31	319.92	891.13	1,512.65
Alt. II	122.03	227.04	545.93	736.85
Alt. III	30.96	43.86	121.26	188.34

Note: Land acquisition costs are estimated by applying the average land value of M$ 25,800 per ha for the proposed locations of entire treatment facilities.

Table E-2 Annual Depreciation Costs for Alternative Treatment Process

(M$1,000)

Alternative	Flow Rate (m^3/day)			
	5,000	10,000	30,000	50,000
Alt. I				
Stabilization Pond Process	4.29	6.46	22.63	35.76
Alt. II				
Aerated Lagoon Process	9.63	17.84	41.01	55.73
Alt. III				
Oxidation Ditch Process	34.19	65.32	177.13	298.73

Note: Calculated by sinking fund method applying 10% annual interest rate.

Table E-3 Annual Cost Incurred by Interest

(M$1,000)

Alternative	Flow Rate (m3/day)			
	5,000	10,000	30,000	50,000
Alt. I	509.93	804.14	2,684.38	4,302.37
Alt. II	566.79	1,050.93	2,429.40	3,729.32
Alt. III	733.18	1,391.82	3,775.52	6,358.04

Note: based on construction costs and land acquisition cost for alternative treatment processes. It is assumed that each half of the treatment facilities is constructed in the first phase and the remainder half in the second phase. The land acquisition and construction is completed in the first year of each phase (of 5 years).

Table E-4 Total Annual Cost for Treatment System by Alternatives

(M$1,000)

Alternative	5,000	10,000	30,000	50,000
Alt. I Stabilization Pond Process	535.87*	836.19	2,761.02	4,415.19
Alt. II Aerated Lagoon Process	633.55	1,167.54	2,723.10	4,144.53
Alt. III Oxidation Ditch Process	877.35	1,660.56	4,513.83	7,575.07

Note: for example, *535.87 = 21.65 (Table E-1) + 4.29 (Table E-2) + 509.93 (Table E-3)

3. Alternative Site Plans for Treatment Facilities

There are considerable number of alternative site plans available as to number of treatment facilities to be located in the Study Area.

In case of one treatment facility for the entire Study Area, which is one extreme case, the following merits and demerits can be expected;

(1) easy operation and maintenance

(2) overall construction cost will be high because of long trunk sewers to be connected to the one treatment facility from all over the area

(3) large number of intermittent pumping stations can be needed

(4) acquisition of such a large land will be very difficult

(5) influence to the water quality of the receiving watercourse by discharging a large amount of effluent from one place

The following considerations are given selecting candidate locations for treatment facilities;

(1) convenient place to collect sewage generated in sewerage zones in a minimum cost

(2) watercourses receiving the treated waters should be running near-by

(3) overall sewer length should be short

(4) number of pumping stations should be small

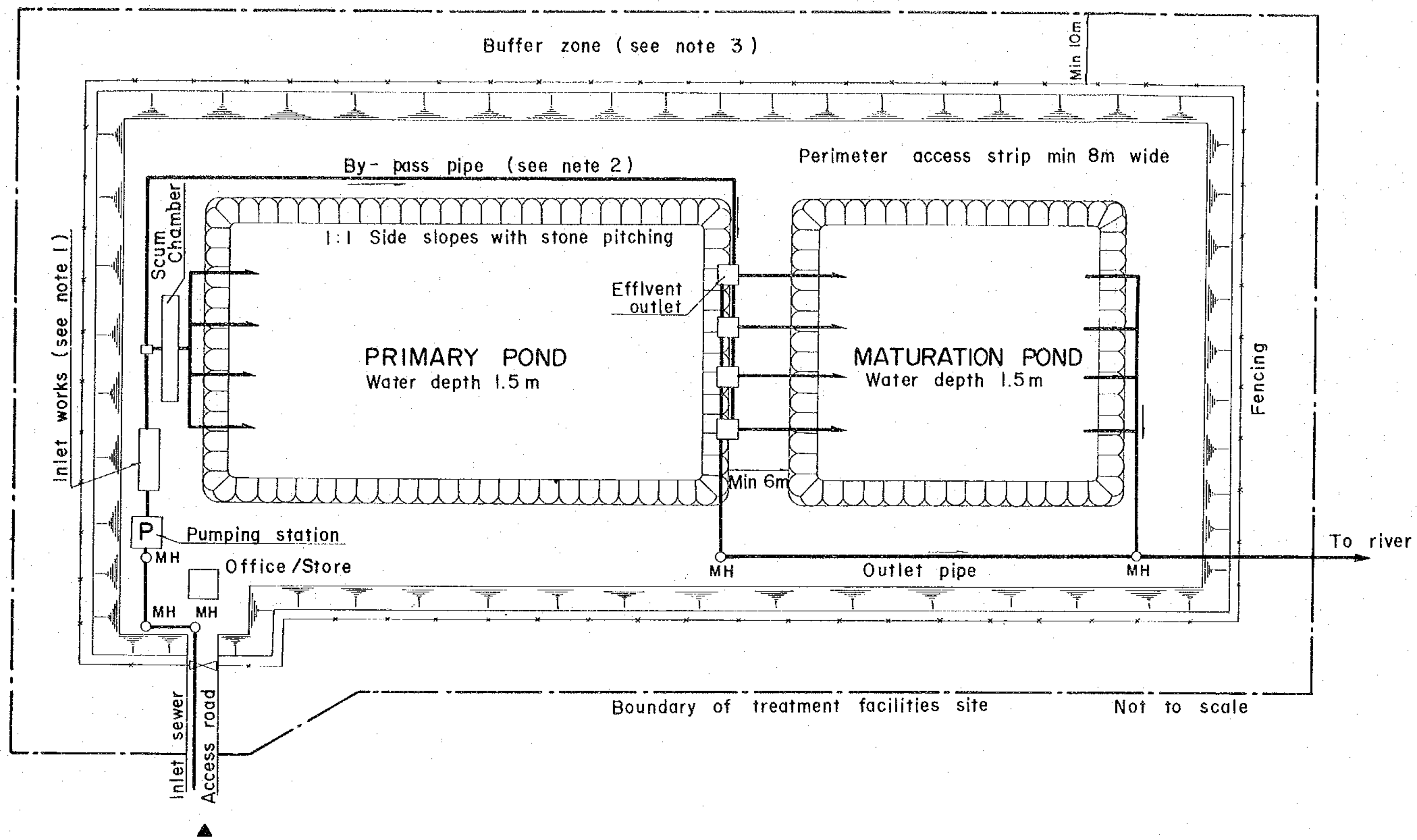
(5) availability of lands

Taking into account of the various items noted above, an alternative site plan for treatment facilities, which is considered the best in terms of engineering aspects are shown in Figure E-5.

This plan consists of 10 sewerage zones with treatment facility in each zone.

Due mainly because of previous commitment of the lands for other facilities, the sewerage layout plan (Figure E-5) was modified as shown in Figure E-6 based on the suggestion given by STCP, MADA, and MPKS.

The modified treatment sites plan (Figure E-6) was further commented by the State Government as finally proposed in Figure 5.2 of Section 6.1 in Chapter 5 in the main report.



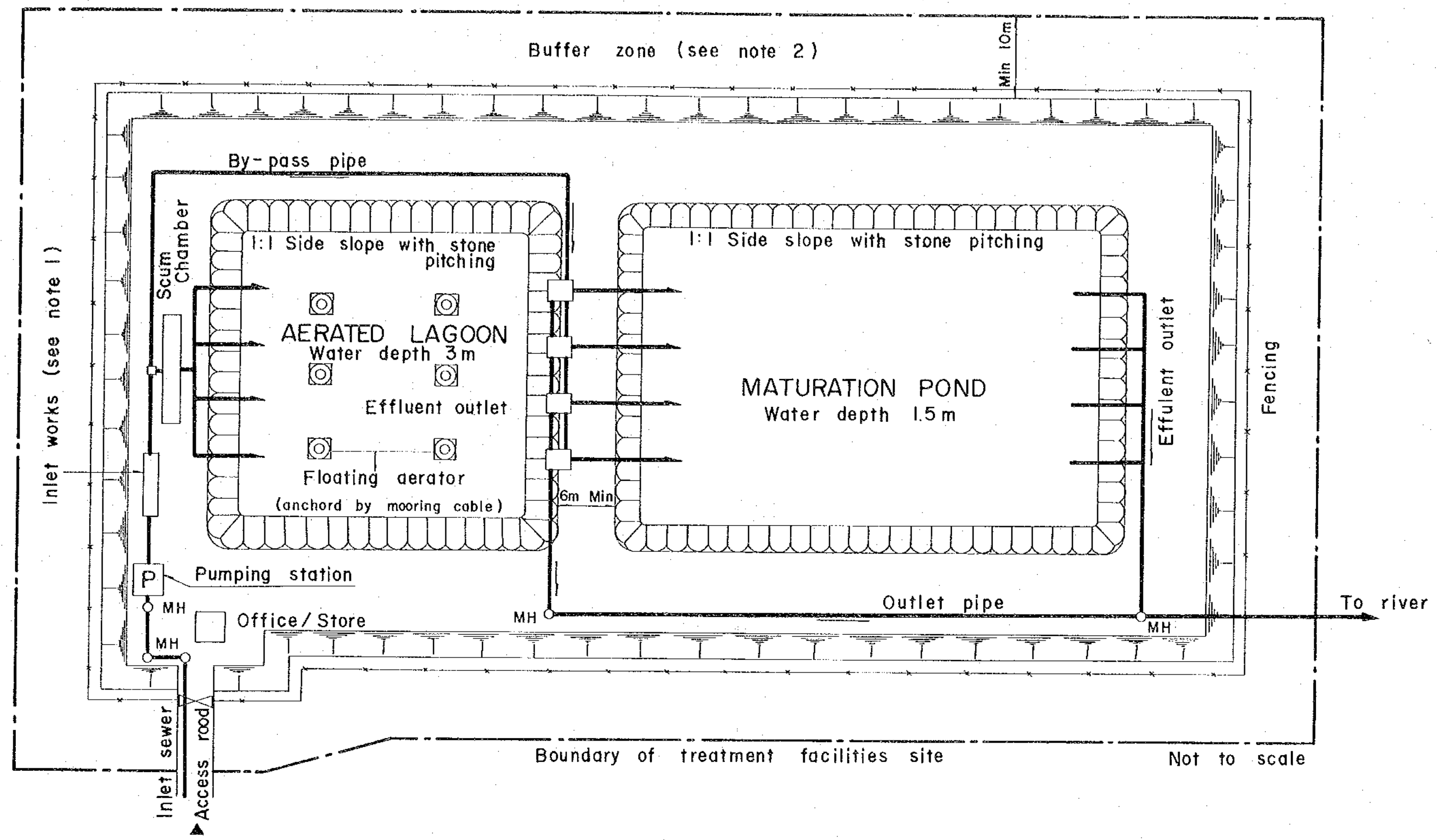
Notes

(1) Inlet works
- Flume
- Flow recorder & recorder house

(2) By-pass pipe can be used for purpose of cleaning out primary pond and alternative operation of ponds in parallel.

(3) Buffer zone is not required if either existing river or road reserve is equal to or greater than 10m width

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
TYPICAL LAYOUT OF STABILIZATION POND PROCESS	FIGURE E・2

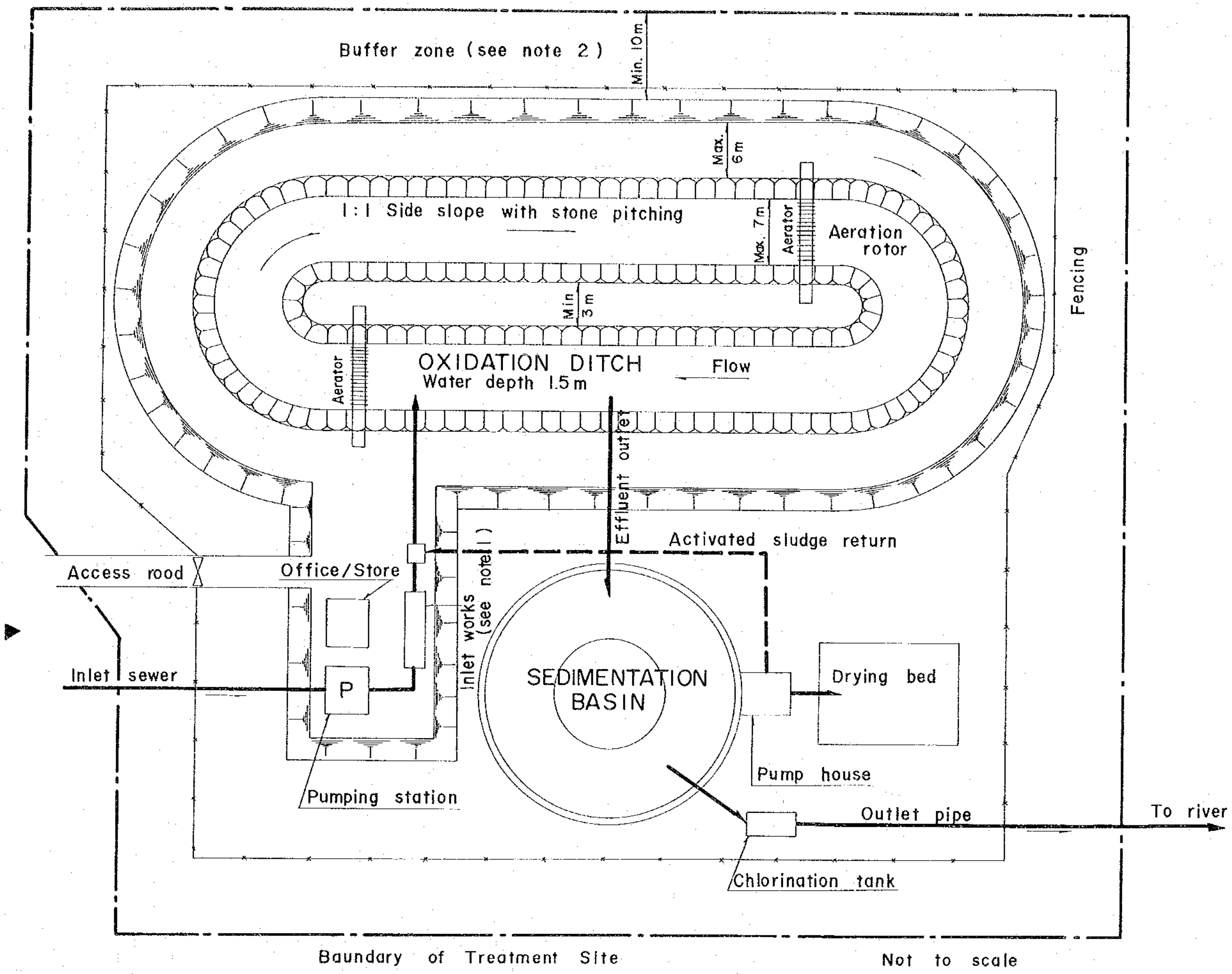


Notes

(1) Inlet works
- Flume
- Flow recorder & recorder house

(2) Buffer zone is not required if either existing river or road reserve is equal to or greater than 10m width

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
TYPICAL LAYOUT OF AERATED RAGOON PROCESS	FIGURE E・3



Notes

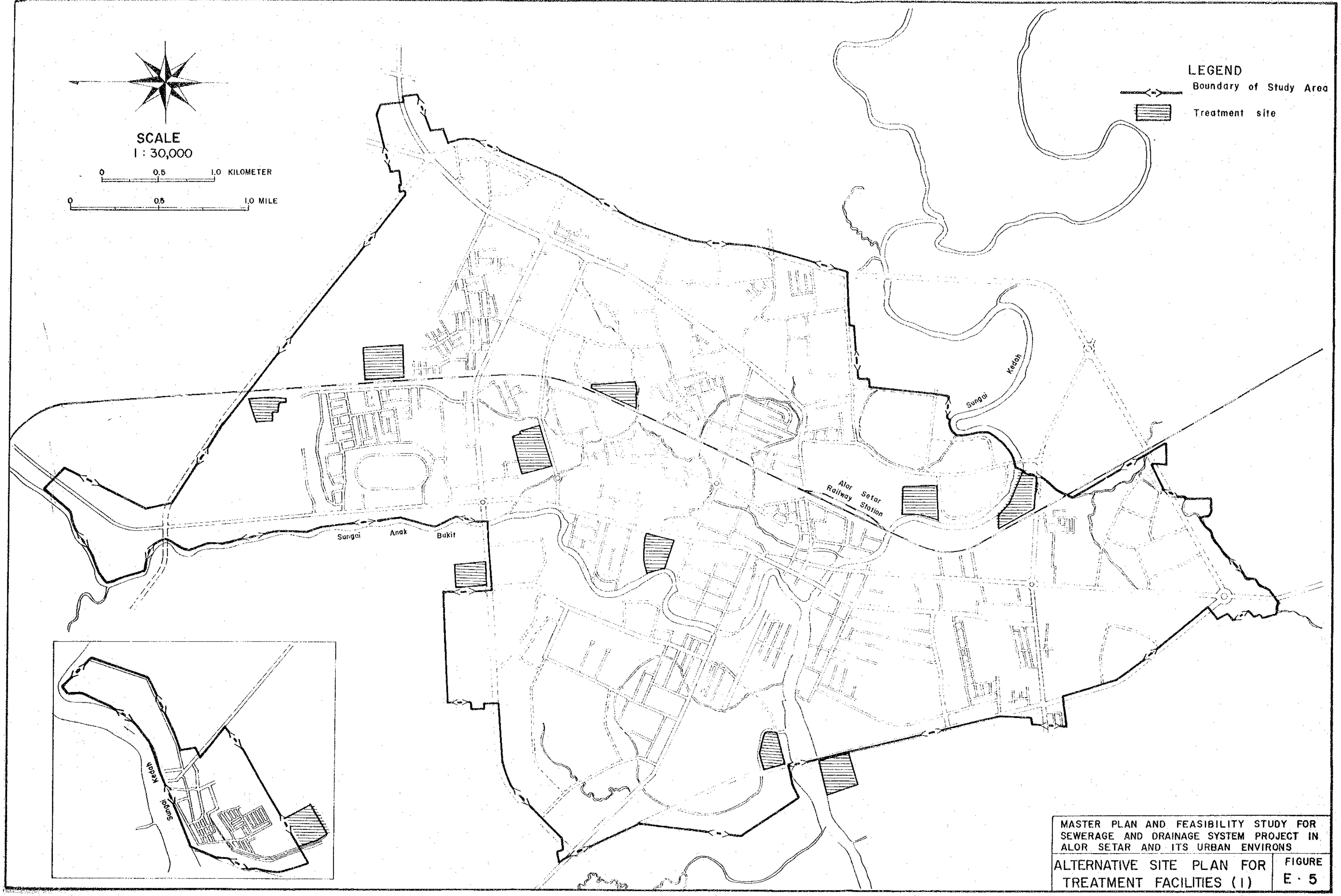
(1) Inlet works
- Grit channel
- Flume
- Flow recorder & recorder house

(2) Buffer zone is not required if either existing river or road reserve is equal to or greater than 10m width

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

TYPICAL LAYOUT OF OXIDATION DITCH PROCESS

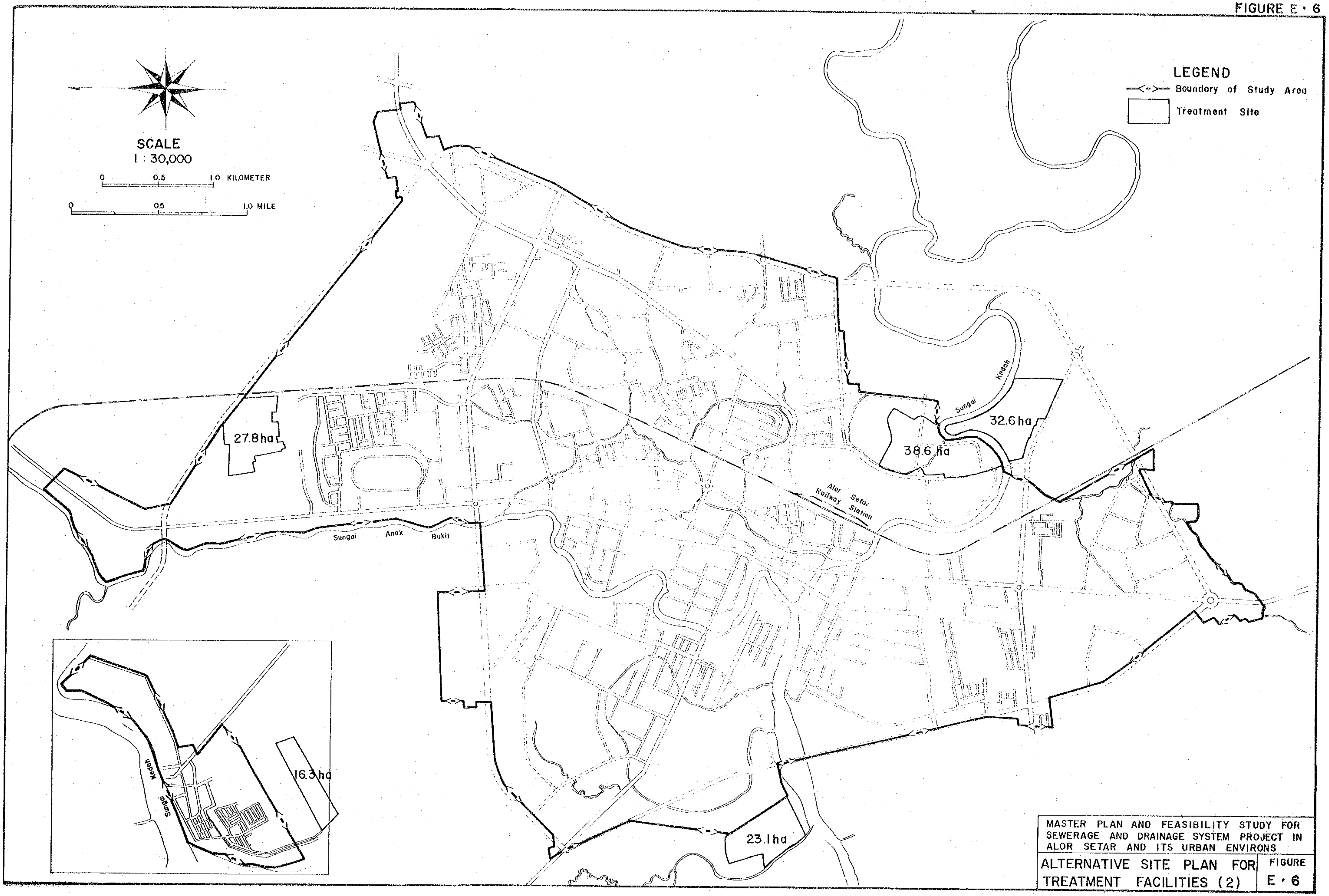
FIGURE E・4



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

ALTERNATIVE SITE PLAN FOR TREATMENT FACILITIES (I)

FIGURE E - 5



MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS

ALTERNATIVE SITE PLAN FOR TREATMENT FACILITIES (2)

FIGURE E・6

APPENDIX F

LAND REQUIREMENTS FOR SEWERAGE FACILITIES

1. General

Most of sewers are laid on the public roads, therefore, no land acquisition is required. However, a large land is needed for construction of each treatment facility and pumping station.

2. Pumping Stations

In developing equation for land required, three different pumping stations with capacities of 0.1 m^3/sec, 0.4 m^3/sec and 0.8 m^3/sec are designed and obtained as resulted in Table F-1.

Table F-1 Required Land for Pumping Stations

Peak flow, m^3/sec	0.1	0.4	0.8
Area, m^2	220	295	530

The relationship between peak flow and site area is illustrated in Figure F-1. The equation can be expressed as;

$$Sp = 450.7\ Q_p + 153.0$$

where Sp : Site area, m^2

Qp : Peak flow, m^3/sec

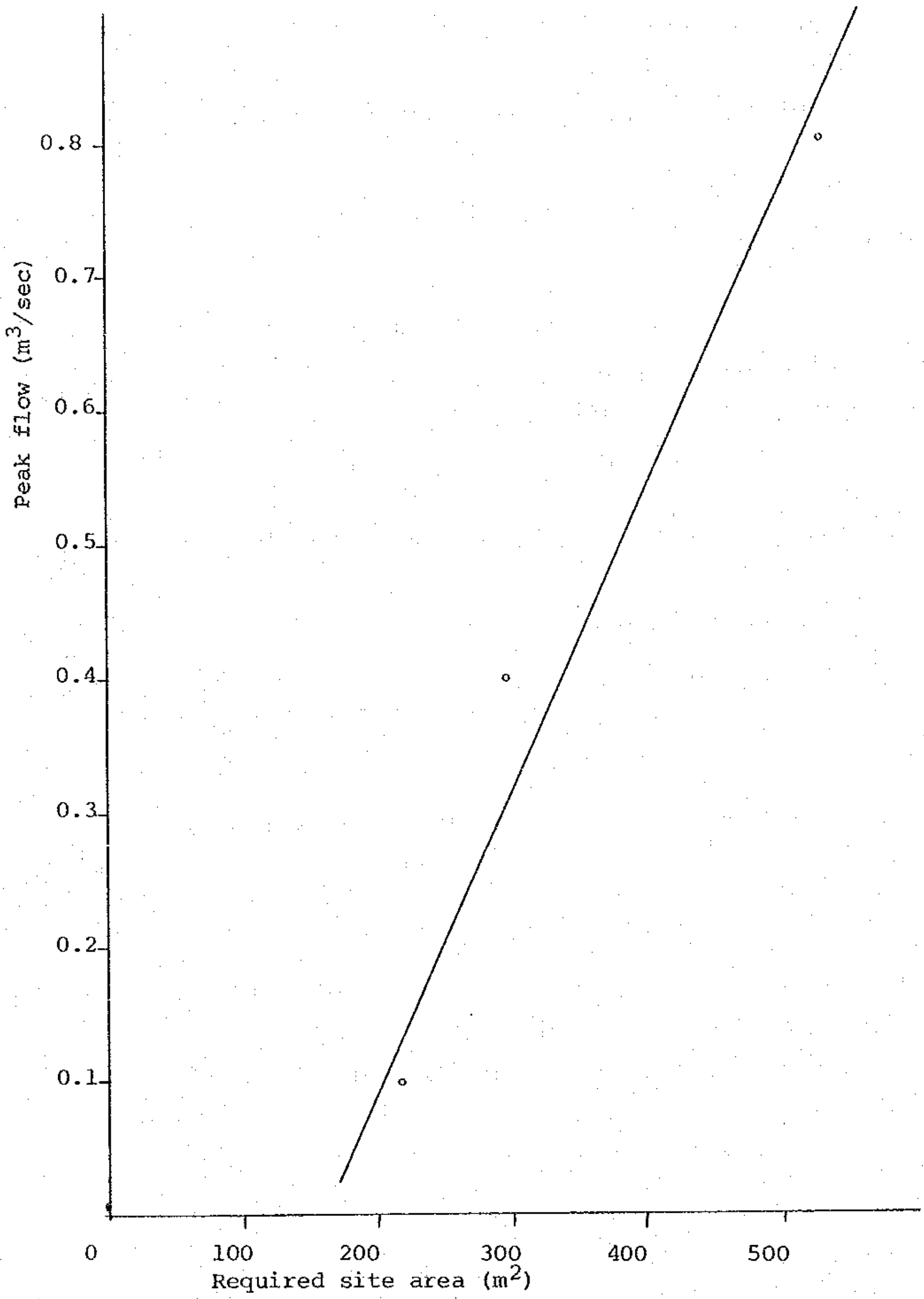


Figure F-1 Required site area for pumping station

3. Treatment Facilities

On the basis of layout plan of four different capacities, namely 5,000 m^3/day, 10,000 m^3/day, 30,000 m^3/day, and 50,000 m^3/day for the three different treatment processes, land required by each treatment process is obtained as shown in Table F-2 and Figure F-2.

Table F-2 Required Land for Treatment Facilities by Process

(ha)

Treatment Process \ Daily Average Flow (m^3/day)	5,000	10,000	30,000	50,000
Stabilization Pond	6.64	12.40	34.54	58.63
Aerated Lagoon	4.73	8.80	21.16	28.56
Oxidation Ditch	1.20	1.70	4.70	7.30

From this table, equations are developed as follows;

(a) Stabilization pond process

$$S = 0.0021\ Q^{0.942}$$

(b) Aerated lagoon process

$$S = 0.0060\ Q^{0.787}$$

(c) Oxidation ditch process

$$S = 0.0011\ Q^{0.807}$$

Where S : Required land, ha

Q : Daily average flow, m^3/day

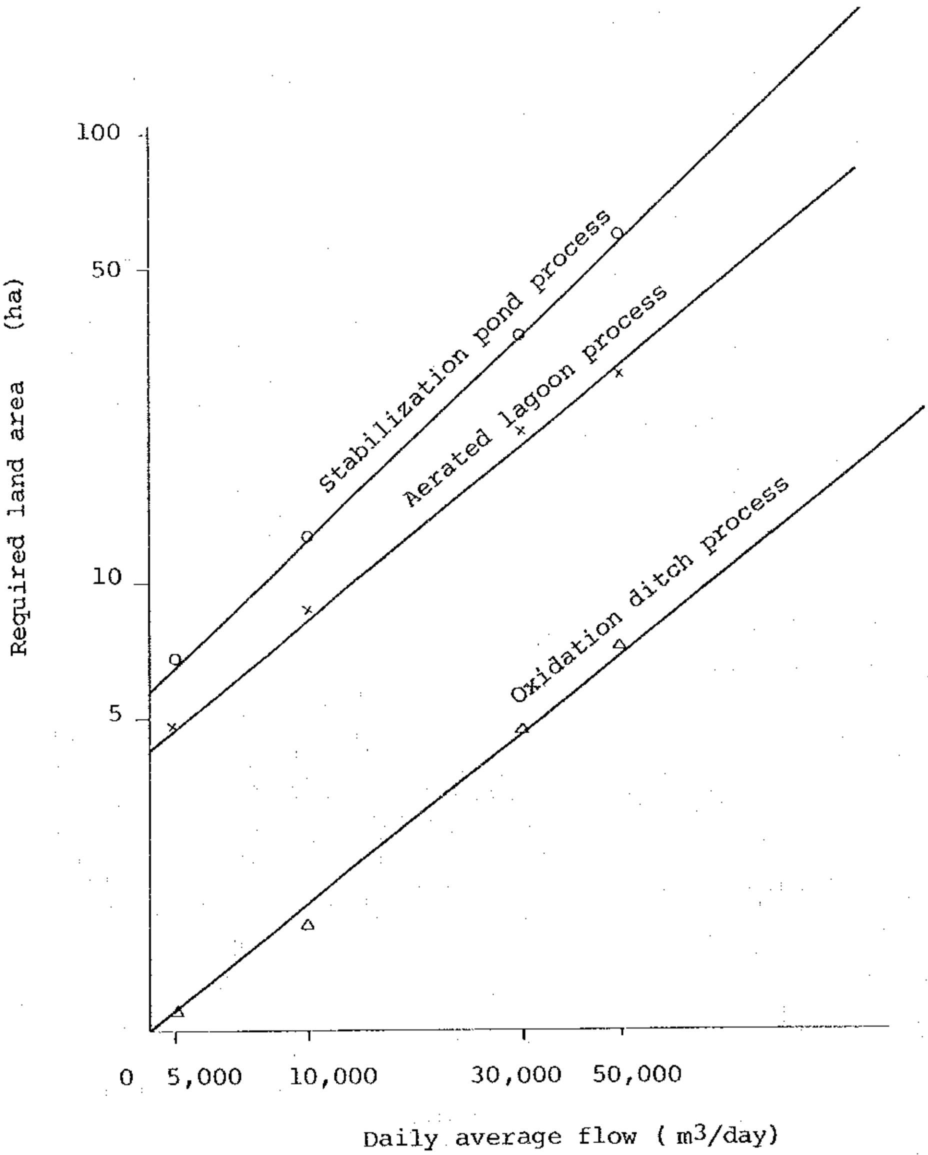


Figure F-2 Required land for treatment facilities

APPENDIX G

METHOD FOR CONSTRUCTION AND OPERATION AND MAINTENANCE COST ESTIMATES

1. Cost Estimating Procedures for Sewers

1.1 General

In the master planning of sewerage system, first of all alternatives of trunk sewer routes should be considered and evaluated in order to establish the most desirable plan. Cost comparison of these alternatives is made by applying estimated sewer laying costs in this appendix for various sizes and depths on the basis of 1979 price level.

1.2 Construction Costs

Construction costs of the master plan implementation will be defined as the sum of all expenditures required to bring the implementation plan to completion. These expenditures are divided into direct items and indirect items. The direct items include excavation of trenches, laying and construction of sewers, and all the related construction works including indirect items. In this study, preliminary designs have first been made to obtain quantities and then these have been multiplied by appropriate unit prices to obtain the total costs of project components. For the indirect items, 20 percent was added to the direct items based on the experience.

1.2.1 Basic Costs

In estimating the construction costs of the facilities, unit costs for domestic items such as labour, materials, power, equipment and transportation, and items imported such as materials and equipment, were collected through agencies concerned and checked by the survey team staff.

Labourers required for the sewerage constructions will include a wide range of occupational categories, from common labourers to skilled operators for heavy equipment. The current (1979) applicable labour costs for various types of labour in Kedah State are from M$ 11 to 24 per day as given in Table G-1.

Table G-1 Labour Costs

Type of Labourer	M$/day
Common worker	11
Skilled worker	20
Carpenter	20
Stone masonry	20
Plumber	20
Foreman	24

Data source: JKR

Generally, for construction of structures, including pumping stations and treatment facilities, most of the materials required are available, except mechanical equipment which will be imported internationally.

Reinforcing bars, timber, sand and gravel for concrete products, vitrified clay pipes (from 150 - 300 mm), and centrifugally-cast-reinforced concrete pipes (less than 1,800 mm in diameter) are available in Malaysia. The unit prices of these basic materials are given in the Tables G-2, 3, and 4.

Information of unit land prices in the various locations in the Study Area is obtained from both the State Land Office and Valuation Office. The unit prices from the former agency are used for land assessment as shown in Table G-5-1 and Figure G-1, and ones from the latter agency are prevailing market prices as shown in Table G-5-2 and Figure G-1.

Therefore, the market unit prices are used for estimating land acquisition costs of treatment and pumping station sites in the Study Area. However, since the unit market prices obtained are not covering entire Study Area, unit land prices in these areas are estimated by adjusting the available unit prices from the State Land Office referring to the known unit prices of the various areas by the both agencies.

Table G-2 Price of Basic Materials - (1)

Item	Unit	Price (M$)
Cement	ton	157.50
Sand	m^3	6.60
Crushed stone	m^3	22.00
Steel bar	ton	1,250.00
Timber	m^3	15.00
Vitrified clay pipe		
ø150	m	20.00
ø225	m	38.53
ø300	m	72.90

Data source: (1) JKR of Kedah State and ED of Penang State

(2) Unit costs obtained from ED were adjusted to suit in Kedah State.

Table G-3 Price of Basic Materials - (2)

Item	Unit	Price (M$)	Remarks
Centrifugally-cast-re-inforced concrete pipe (mm in dia.)			Including high alumina cement mortar lining and rubber ring
ø150	m	23.80	
ø225	m	33.60	
ø300	m	40.70	
ø375	m	56.60	
ø450	m	68.00	
ø525	m	80.50	
ø600	m	89.90	
ø675	m	112.80	
ø750	m	124.30	
ø900	m	163.00	
ø1,050	m	205.60	
ø1,200	m	226.40	
ø1,350	m	287.60	
ø1,500	m	331.20	
ø1,800	m	433.10	

Data source: Hume Industry at Butterworth

Table G-4 Unit Costs for Construction (including labour and materials)

Item	Description	Unit	Cost (M$)
Concrete	mix. 1:2:4	m^3	156.90
"	mix. 1:3:6	"	124.20
Reinforced concrete		"	313.70
Mortar works	mix. 1:2	"	186.50
	mix 1:3	"	182.10
Excavation	open cut	"	2.30
"	trench (depth 0-1.5m)	"	4.70
"	" (" 1.5-3.0m)	"	8.60
"	" (" 3.0-4.5m)	"	11.50
"	" (" 4.5-6.0m)	"	15.10
"	" (" 6.0-7.5m)	"	18.90
"	" (" 7.5m -)	"	22.50
Backfilling and compaction		"	3.00
Form works		m^2	8.20
Dewatering		day	24.00
Restoration of paving		m^2	17.10
Masonry works		m^3	71.00
Turfing		m^2	1.60
Sheeting by timber	(depth 1.0-2.0m)	m	7.12
"	(" 2.0-3.0m)	m	9.83
"	(" 3.0-4.0m)	m	17.46
"	(" 4.0-5.0m)	m	23.37
Steel sheet-pile works	(" 5.0-6.0m)	m	175.00
"	(" 6.0-7.0m)	m	218.00
"	(" 7.0-8.0m)	m	242.00
"	(" 8.0m-)	m	258.00

Data source: JKR of Kedah State, ED of Penang State, and local contractors

Table G-5-1 Unit Land Price in the Study Area (1)

Ref. No. (Refer to Fig. G-1)	Category	Land Value
1	(a)	$ 4860/ha
	(b)	$ 32.3/m^2
	(c)	$ 43.1/m^2
2	(a)	$ 4860/ha
	(b)	$ 32.3/m^2
	(c)	$ 43.1/m^2
3	(a)	$ 5260/ha
	(b)	$ 32.3/m^2
	(c)	$ 53.8/m^2
4	(a)	$ 6070/ha
	(b)	$ 37.7/m^2
	(c)	$ 64.6/m^2
5	(a)	$ 7280/ha
	(b)	$ 43.1/m^2
	(c)	$ 86.1/m^2
6	(a)	$ 7280/ha
	(b)	$ 43.1/m^2
	(c)	$ 86.1/m^2
7	(b)	$ 53.8/m^2
	(c)	$107.6/m^2
8	(a)	$ 8090/ha
	(b)	$ 43.1/m^2
	(c)	$ 86.1/m^2
9	(a)	$ 8900/ha
	(b)	$ 32.3/m^2
	(c)	$ 75.3/m^2
10	(a)	$ 8900/ha
	(b)	$ 43.1/m2
	(c)	$ 86.1/m^2
11	(b)	$ 53.8/m^2
	(c)	$161.5/m^2
12	(a)	$ 8900/ha
	(b)	$ 32.3/m^2
	(c)	$107.6/m^2
13	(a)	$ 8900/ha
	(b)	$ 43.1/m^2
	(c)	$129.2/m^2
14	(a)	$ 8090/ha
	(b)	$ 32.3/m^2
	(c)	$107.6/m^2
15	(b)	$129.2/ha
	(c)	$215.3/m^2
16	(b)	$150.7/m^2
	(c)	$269.1/m^2
17	(b)	$129.2/m^2
	(c)	$215.3/m^2
18	(b)	$161.5/m^2
	(c)	$322.9/m^2
19	(b)	$161.5/m^2
	(c)	$322.9/m^2
20	(a)	$10120/ha
	(b)	$107.6/m^2
	(c)	$215.3/m^2
21	(b)	$161.5/m^2
	(c)	$430.6/m^2
22	(b)	$129.2/m^2
	(c)	$215.3/m^2
23	(a)	$ 6070/ha
	(b)	$ 21.5/m^2
	(c)	$ 43.1/m^2
24	(a)	$ 5670/ha
	(b)	$ 21.5/m^2
	(c)	$ 53.8/m^2
25	(a)	$ 8090/ha
	(b)	$ 21.5/m^2
26	(a)	$ 8090/ha
	(b)	$ 21.5/m^2
27	(a)	$ 7280/ha
28	(a)	$10120/ha
	(b)	$ 43.1/m^2
	(c)	$ 86.1/m^2
29	(a)	$ 8900/ha
	(b)	$ 32.3/m^2
	(c)	$ 75.3/m^2
30	(a)	$ 9710/ha
	(b)	$ 32.3/m^2
	(c)	$ 86.1/m^2
31	(a)	$ 9710/ha
	(b)	$ 32.3/m^2
	(c)	$ 86.1/m^2
32	(a)	$ 7280/ha
	(b)	$ 21.5/m^2

Note: The land value in each block is classified into four categories as referred above, such as (a) paddy area, (b) residencial area, (c) commercial area, and (d) industrial area.

-continued -

Ref. No (Refer to Fig.G-1)	Category	Land Value
33	(a)	$ 8090/ha
	(b)	$\$32.3/m^2$
	(c)	$\$107.6/m^2$
34	(a)	$10120/ha
	(b)	$\$43.1/m^2$
	(c)	$\$150.7/m^2$
35	(a)	$ 8090/ha
36	(b)	$\$64.6/m^2$
	(c)	$\$193.8/m^2$
37	(b)	$\$64.6/m^2$
	(c)	$\$215.3/m^2$
38	(b)	$\$64.6/m^2$
	(c)	$\$215.3/m^2$
39	(b)	$\$43.1/m^2$
	(c)	$\$193.8/m^2$
40	(b)	$\$43.1/m^2$
	(c)	$\$161.5/m^2$
41	(a)	$10120/ha
	(b)	$\$43.1/m^2$
	(c)	$\$161.5/m^2$
42	(b)	$\$43.1/m^2$
	(c)	$\$129.2/m^2$
43	(a)	$10120/ha
	(b)	$\$43.1/m^2$
	(c)	$\$86.1/m^2$
44	(b)	$\$107.6/m^2$
	(c)	$\$215.3/m^2$
45	(b)	$\$64.6/m^2$
	(c)	$\$161.5/m^2$
46	(a)	$ 8093/ha
	(b)	$\$21.5/m^2$
47	(a)	$ 7280/ha
	(b)	$\$21.5/m^2$
48	(a)	$ 6070/ha
49	(a)	$ 4860/ha
50	(a)	$ 4860/ha
51	(a)	$ 7280/ha
	(b)	$\$21.5/m^2$
52	(a)	$ 4860/ha
53	(a)	$ 8090/ha
	(b)	$\$32.3/m^2$
	(c)	$\$86.1/m^2$
54	(a)	$ 6070/ha
55	(a)	$ 5460/ha
56	(a)	$ 5460/ha
57	(a)	$ 6070/ha
	(b)	$\$21.5/m^2$
58	(a)	$ 7280/ha
59	(a)	$ 8093/ha
	(b)	$\$43.1/m^2$
	(c)	$\$215.3/m^2$
60	(b)	$ 4650/ha
	(c)	$\$215.3/m^2$
61	(b)	$\$53.8/m^2$
	(c)	$\$236.8/m^2$
62	(a)	$10120/ha
	(b)	$\$53.8/m^2$
63	(a)	$ 8090/ha
	(b)	$\$43.1/m^2$
64	(a)	$ 9710/ha
	(b)	$\$32.2/m^2$
	(c)	$\$107.6/m^2$
65	(b)	$\$64.6/m^2$
	(c)	$\$269.1/m^2$
66	(b)	$\$53.8/m^2$
	(c)	$\$161.5/m^2$
67	(b)	$\$53.8/m^2$
	(c)	$\$215.3/m^2$
68	(a)	$10120/ha
	(b)	$\$43.1/m^2$
	(c)	$\$215.3/m^2$
69	(a)	$10120/ha
	(b)	$\$32.3/m^2$
	(c)	$\$86.1/m^2$
70	(a)	$ 8090/ha
71	(a)	$ 4050/ha
72	(a)	$ 4050/ha

Note: The land value in each block is classified into four categories as referred above, such as (a) paddy area, (b) residencial area, (c) commercial area, and (d) industrial area.

- continued-

Ref. No. (Refer to Fig. G-1)	Category	Land Value
73	(a)	$\$\ 5670/ha$
74	(a)	$\$\ 8090/ha$
75	(a)	$\$\ 8902/ha$
	(b)	$\$\ 32.3/m^2$
76	(a)	$\$10120/ha$
	(b)	$\$\ 43.1/m^2$
	(c)	$\$107.6/m^2$
77	(b)	$\$\ 75.3/m^2$
	(c)	$\$129.2/m^2$
	(d)	$\$161.5/m^2$
78	(b)	$\$107.6/m^2$
	(c)	$\$161.5/m^2$
79	(b)	$\$\ 43.1/m^2$
	(c)	$\$129.2/m^2$
80	(a)	$\$10120/ha$
	(b)	$\$\ 43.1/m^2$
	(c)	$\$129.2/m^2$
81	(b)	$\$\ 53.8/m^2$
	(c)	$\$161.5/m^2$
	(d)	$\$215.3/m^2$
82	(b)	$\$\ 86.1/m^2$
	(c)	$\$161.5/m^2$
	(d)	$\$215.3/m^2$
83	(b)	$\$\ 32.3/m^2$
	(c)	$\$107.6/m^2$
84	(b)	$\$\ 53.8/m^2$
	(c)	$\$129.2/m^2$
85	(b)	$\$\ 43.1/m^2$
	(c)	$\$107.6/m^2$
86	(a)	$\$\ 8900/ha$
	(b)	$\$\ 32.3/m^2$
87	(a)	$\$\ 8900/ha$
	(b)	$\$\ 32.3/m^2$
88	(b)	$\$\ 43.1/m^2$
	(c)	$\$107.6/m^2$
	(d)	$\$161.5/m^2$
89	(a)	$\$10120/ha$
	(b)	$\$\ 43.1/m^2$
	(c)	$\$161.5/m^2$
90	(a)	$\$\ 8090/ha$
	(b)	$\$\ 32.3/m^2$
	(c)	$\$107.6/m^2$
91	(c)	$\$\ 64.6/m^2$
92	(a)	$\$\ 6070/ha$
	(b)	$\$\ 21.5/m^2$
	(c)	$\$\ 43.1/m^2$
93	(b)	$\$\ 21.5/m^2$
	(c)	$\$\ 43.1/m^2$
	(d)	$\$\ 64.6/m^2$
94	(a)	$\$\ 4860/ha$
	(b)	$\$\ 21.5/m^2$
95	(a)	$\$\ 3640/ha$
96	(a)	$\$\ 3640/ha$

Note: The land value in each block is classified into four categories as referred above, such as (a) paddy area, (b) residencial area, (c) commercial area, and (d) industrial area.

Table G-5-2 Unit Land Prices in the Study Area (2)

Ref. No. (Refer to Fig. G-1)	Category	Land Value
10	(c)	\$ 108 - 183/m^2
11	(c)	\$ 108 - 183/m^2
12	(b)	\$ 75 /m^2
13	(b)	\$ 75 /m^2
14	(b)	\$ 75 /m^2
17	(b)	\$ 75 /m^2
20	(c)	\$ 172 /m^2
23	(a)	\$ 19,114 - 20,852 (20,000)/ha
33	(b)	\$ 97 - 140/m^2
36	(b) (c)	\$ 97 - 140/m^2 \$ 754 /m^2
37	(b)	\$ 86 - 118/m^2
38	(b)	\$ 86 - 118/m^2
40	(b) (c)	\$ 86 - 108/m^2 \$ 431 - 484/m^2
41	(b)	\$ 86 - 108/m^2
44	(b)	\$ 86 - 118/m^2
45	(b)	\$ 32 - 43/m^2
46	(b)	\$ 32 - 43/m^2
47	(a) (b)	\$ 34,753 (35,000)/ha \$ 32 - 43/m^2
48	(a)	\$ 34,753 (35,000)/ha
50	(a)	\$ 20,852 - 34,753 (28,000)/ha
71	(a)	\$ 22,590 - 41,704 (32,000)/ha
96	(a)	\$ 17,377 - 27,803 (23,000)/ha

Note: The land value in each block is classified into four categories as referred above, such as (a) paddy areas, (b) residencial area, (c) commercial area, and (d) industrial area.

1.2.2 Construction Costs for Sewers

Prior to the estimation of the construction costs, a study on methods of construction and selection of suitable construction materials is made taking various factors into account, including the ability of local contractors and availability of local materials.

In general, all sewers shall be laid under existing or planned road except that the conditions allow the pipe laying inside private house plot. Excavation shall generally be made by trench method with different sheetings depending upon soil conditions and depth to be excavated. In the majority of locations, the soil will be primarily soft clay and sand, and the high ground water table will be encountered.

In those areas of primarily silty soil, tight sheeting and bracing will be required with a depth of 2.0 meteres or deeper.

Construction costs for sewers were estimated for the sewerage system, taking into account the known or estimated costs of excavation, sheeting, dewatering, bedding, pipe supplying and laying, concrete placing, form works, reinforcing, restoration of paving and contractor's profit and overhead.

Construction costs of sewer by size and depth are summarized in Table G-6, and manhole in Table G-7.

Table G-6 Construction Costs of Sewers

(M$/m of pipe length, at 1979 price level)

Pipe Dia. mm	Depth of Excavation (m) 2.0	3.0	4.0	5.0	6.0	7.0	8.0
225	148	176	202	453	562	-	-
300	197	225	251	451	610	-	-
375	169	197	224	474	587	611	-
450	200	230	257	509	620	650	-
525	224	250	283	537	653	681	810
600	254	288	318	580	693	735	875
675	308	345	378	645	762	811	957
750	334	372	405	675	792	845	995
900	413	455	491	769	891	955	1,119
1,050	496	543	582	868	994	1,068	1,246
1,200	555	608	650	942	1,072	1,157	1,346
1,350	662	717	761	1,060	1,193	1,286	1,484
1,500	755	815	862	1,169	1,305	1,402	1,620

Table G-7 Construction Costs of Manholes

(M$/Unit at 1979 price level)

(1) Internal Size(mm)	Depth (m) 3.0	4.0	5.0	6.0	7.0	8.0
1,200 (2)	1,864	2,164	2,503	2,778	3,071	3,346
1,500 (3)	2,102	2,548	2,800	3,074	3,368	3,642
1,800 (4)		3,162	3,416	3,689	3,984	4,257

Note: (1) Internal sizes of manholes are decided by those of sewers connected to the manholes.

(2) Sewers less than 900 mm shall be connected.

(3) Sewers between 900 and 1200 mm shall be connected.

(4) Sewers between 1200 and 1500 mm shall be connected.

2. Cost Function for Pumping Stations

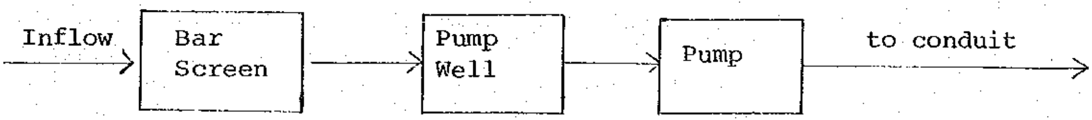
2.1 General

Pumping stations are required at most of the treatment facility sites and at other locations where sewers become unreasonable depth if pump is not installed.

Cost function curves are prepared covering the all ranges of peak flows and of the depths of inflowing conduits which vary according to sites.

In developing cost functions for pumping stations, cost estimates are made for three cases of different capacities (0.1 m^3/sec, 0.4 m^3/sec, 0.8 m^3/sec) and additional three different cases of inflowing depths of conduits (6m, 8m, and 10m).

Flow sheet for the stations is given as follows ;



Cost estimates for mechanical and electrical equipment installation are made on the basis of quotations obtained from various manufacturers in Japan, including allowance for freight, insurances, customs duties, transportation and installation.

Cost estimates for civil works were made based on preliminary drawings.

Construction cost for each case includes civil works (including architectural works), pipings, mechanical and electrical equipment, and other appurtenances plus overhead cost, which is 20 percent of total cost, as summarized in Table G-8.

Table G-8 Construction Costs of Pumping Stations by Varying Pump Capacities

(1979 price M$ 1,000)

Depth of Inlet Sewer	Capacity (m^3/sec)	Civil works	Machinery & Electricity	Total
6 m	0.1	192	85	277
	0.4	299	380	679
	0.8	526	588	1,114
8 m	0.1	225	92	317
	0.4	366	414	780
	0.8	647	631	1,278
10 m	0.1	279	110	389
	0.4	447	453	900
	0.8	795	665	1,460

2.2 Cost Function

As illustrated in Figure G-2, the cost function of pumping stations can be expressed in a linear form as ;

$$Cp = aQ + b$$

where Cp : Construction cost, M$1,000
Q : Peak flow rate, m^3/sec
a.b: Constants

The constants, "a" and "b", are obtained by the least square solution for three different depthes, and these cost functions can be expressed as :

$$Cp = 1189.9\ Q + 174.4 \quad (H = 6.0m)$$
$$Cp = 1365.9\ Q + 199.8 \quad (H = 8.0m)$$
$$Cp = 1523.0\ Q + 256.4 \quad (H = 10.0m)$$

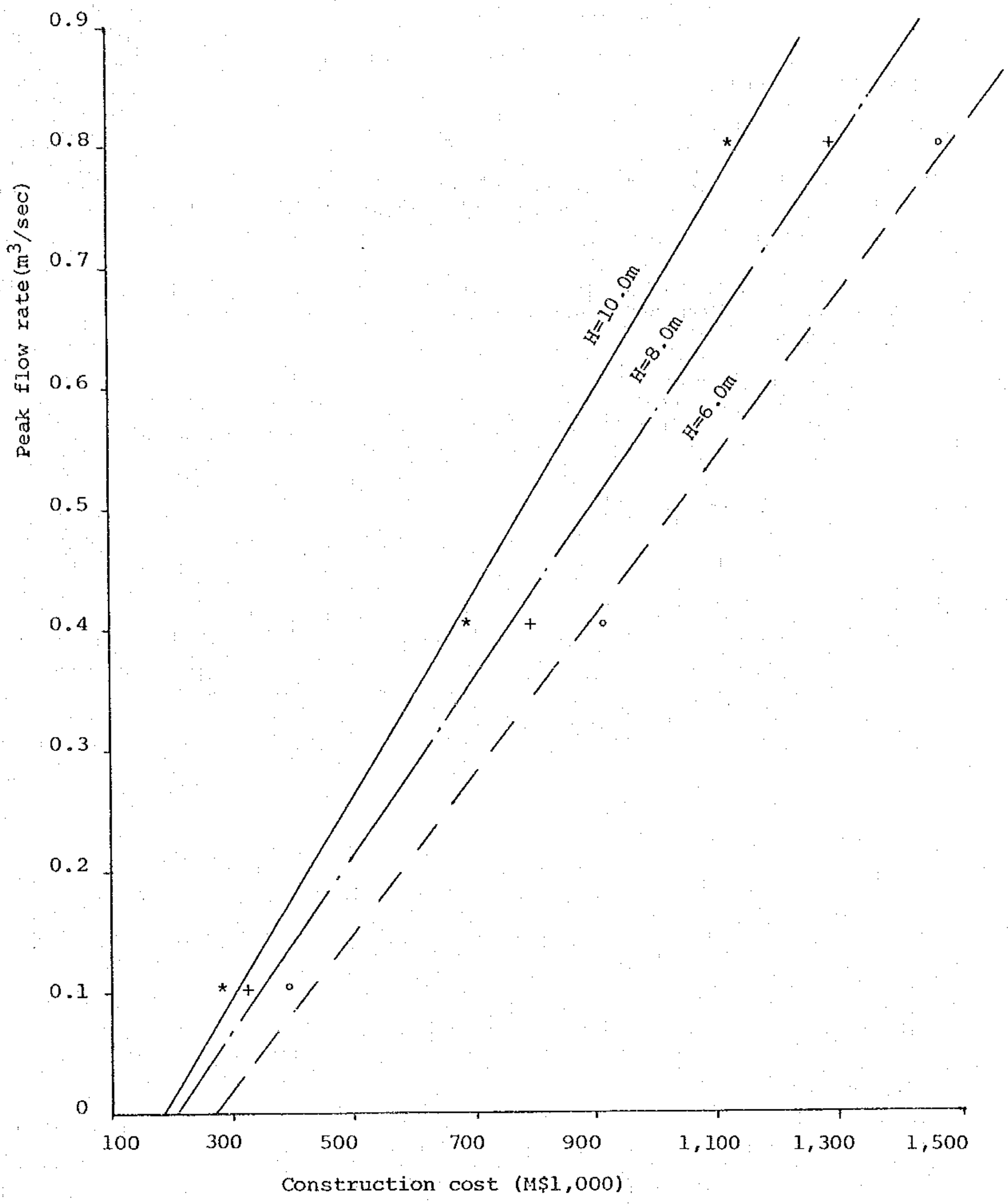


Figure G-2 Construction cost for pmping station

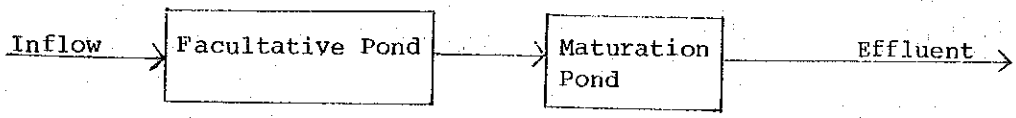
3. Cost Function for Treatment Facilities

3.1 General

A relation is found between varying treatment capacities and the resulting construction costs in a form of function for each three conceivable treatment processes applicable in the Study Area, namely stabilization pond, aerated lagoon and oxidation ditch. These costs were estimated by designing the facilities for the three different treatment processes by varying treatment capacities of 5,000, 10,000, 30,000 and 50,000 m^3/day.

3.2 Stabilization Pond Process

The flow sheet of the stabilization pond process is given as follows ;



Based on the design criteria in Section 5. 3 , Chapter 5, and reasonable design conditions and drawings are prepared for estimating construction cost.

(i) stabilization ponds have 1.5 metres liquid depth with stone-piched embankment of 1 to 1 side slope ;

(ii) for ease of operation, maintenance and control, the maximum surface area of pond is limited to 3 ha with a length to width ratio of about 1 to 1.5 or 2 ;

(iii) the ponds are lined with a 0.3 metre layer of impervious clay material ;

(iv) the top width of embankment has 6 meters to permit access of maintenance vehicles ;

(v) the pond area is enclosed with a suitable fence to preclude livestock and discourage trespassing ;

(vi) treatment facility site is surrounded by a minimum of 10 meters wide strip of land

Figure E-2 in Appendix E shows conceptual layout plan for stabilization pond.

The construction costs of civil works are estimated on the basis of material costs and unit costs at 1979 price levels.

Table G-9 shows estimated construction costs including 20 percent overhead.

Table G-9 Construction Costs for Stabilization Pond Process with Varying Treatment Capacities

(M$1,000)

Item \ Capacity m^3/day	5,000	10,000	30,000	50,000
Civil Works & Building	705	1,062	3,722	5,881
Machinery & Electricity	-	-	-	-
Total	705	1,062	3,722	5,881

As illustrated in Figure G-3, the cost function for stabilization pond process can be expressed in a linear form as :

$$C_s = AQ + b$$

where

Cs : Construction cost, M$ 1,000
Q : Capacity, m^3/day
a.b : Constants

The values of "a" and "b" are obtained by the least square solution as 0.1173 and -38.99 respectively.
Hence, the cost function can be expressed as :

$$C_s = 0.1173Q - 38.99 \qquad (Q > 500\ m^3/day)$$

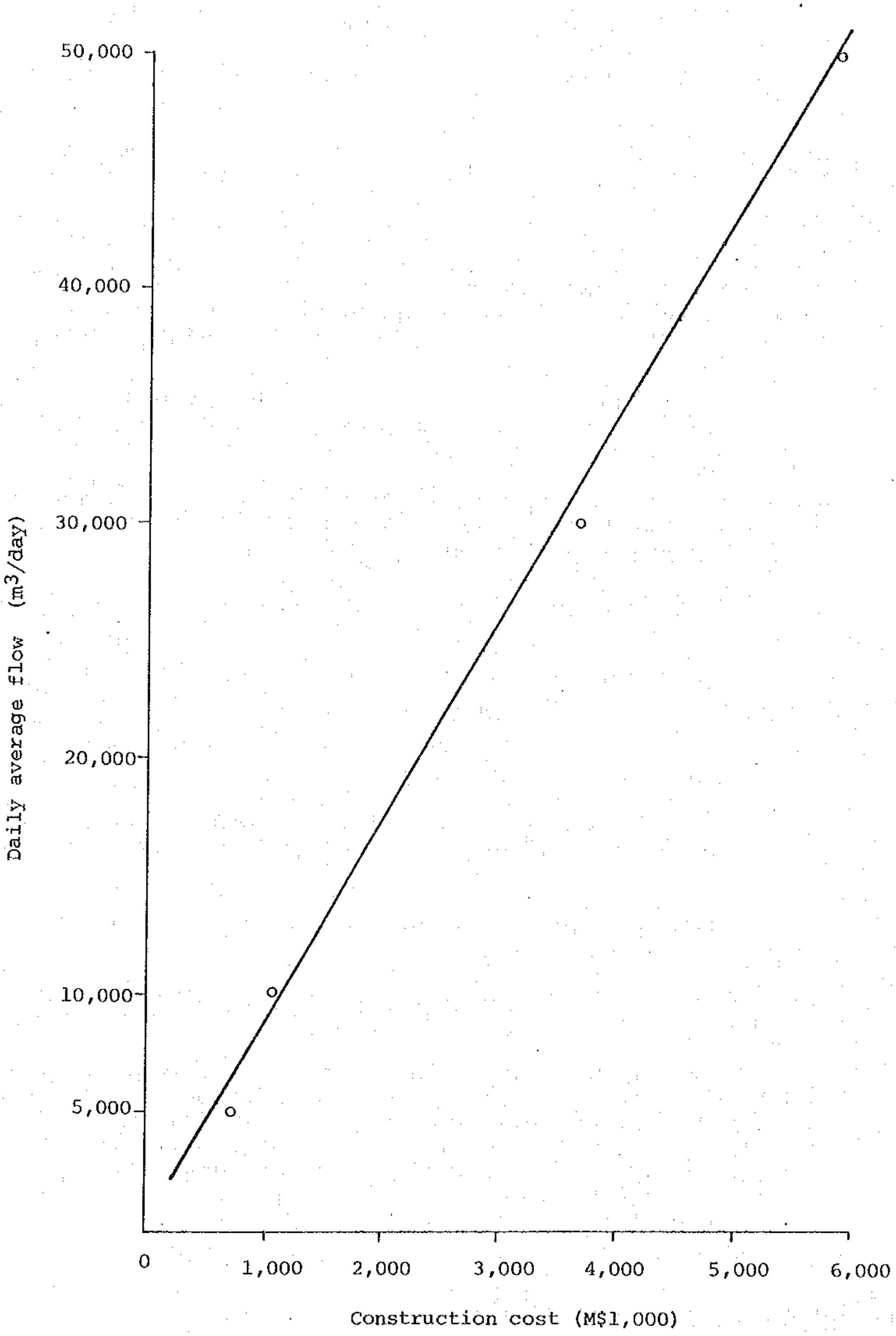
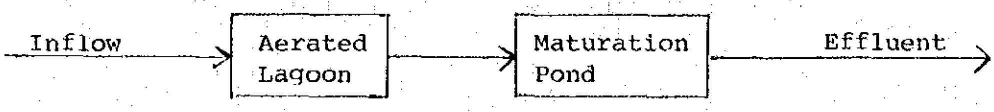


Figure G-3 Construction cost for stabilization pond process

3.3 Aerated Lagoon Process

Flow sheet of the aerated lagoon process is given as follows:



Based on the design criteria in Section 5, Chapter 5, and reasonable design conditions as described hereunder, preliminary design and drawings are prepared for estimating construction cost.

(i) aerated lagoons have 3 meters liquid depth with 1 to 1 side slope, 0.3 metre thickness with stone pitched surface to protect against the scouring effects by surface aerators ;

(ii) for ease of operation, maintenance and control, the maximum surface area of pond is limited to 3 ha with a length to breadth ratio of about 1 to 1.5 or 2 ;

(iii) ponds are lined with a 0.3 metre layer of impervious clay material ;

(iv) top width of embankment has 6 metres to permit access of maintenance vehicles ;

(v) pond area is enclosed with a suitable fence to preclude livestock and discourage trespassing ;

(vi) treatment facility site is surrounded by a minimum of 10 metres wide strip of land ;

A conceptual layout plan for aerated lagoon is given in Figure E-3, Appendix E.

Table G-10 shows estimated construction costs including 20 percent overhead cost.

The construction costs of civil works include for ponds, inlet and outlet works, manholes, drain of the site, fencing, turfing, and site roads and embankments. The installation costs of machinery and electricity equipment are estimated on the basis of quotations of manufacturs in Japan, and allowances are made for the costs of freight, insurance customs duties, transports to site and installation.

Table G-10 Construction Cost for Aerated Logoon Process with Varying Treatment Capacities

Item \ Capacity (m^3/day)	5,000	10,000	30,000	50,000
Civil works & Building	605	1,086	2,590	3,584
Machinery & Electricity	247	493	1,039	1,348
Total	852	1,579	3,629	4,932

As illustrated in Figure G-4, the cost function for aerated lagoon process can be expressed in a linear form as :

$$C_A = a\,Q + b$$

where

C_A : Construction cost, M$1,000
Q : Capacity, m^3/day
a,b : Constants

The values of "a" and "b" are obtained by the least square solution as 0.0902 and 605.4 respectively.
Hence, the cost function can be expressed as :

$$C_A = 0.0902\,Q + 605.4$$

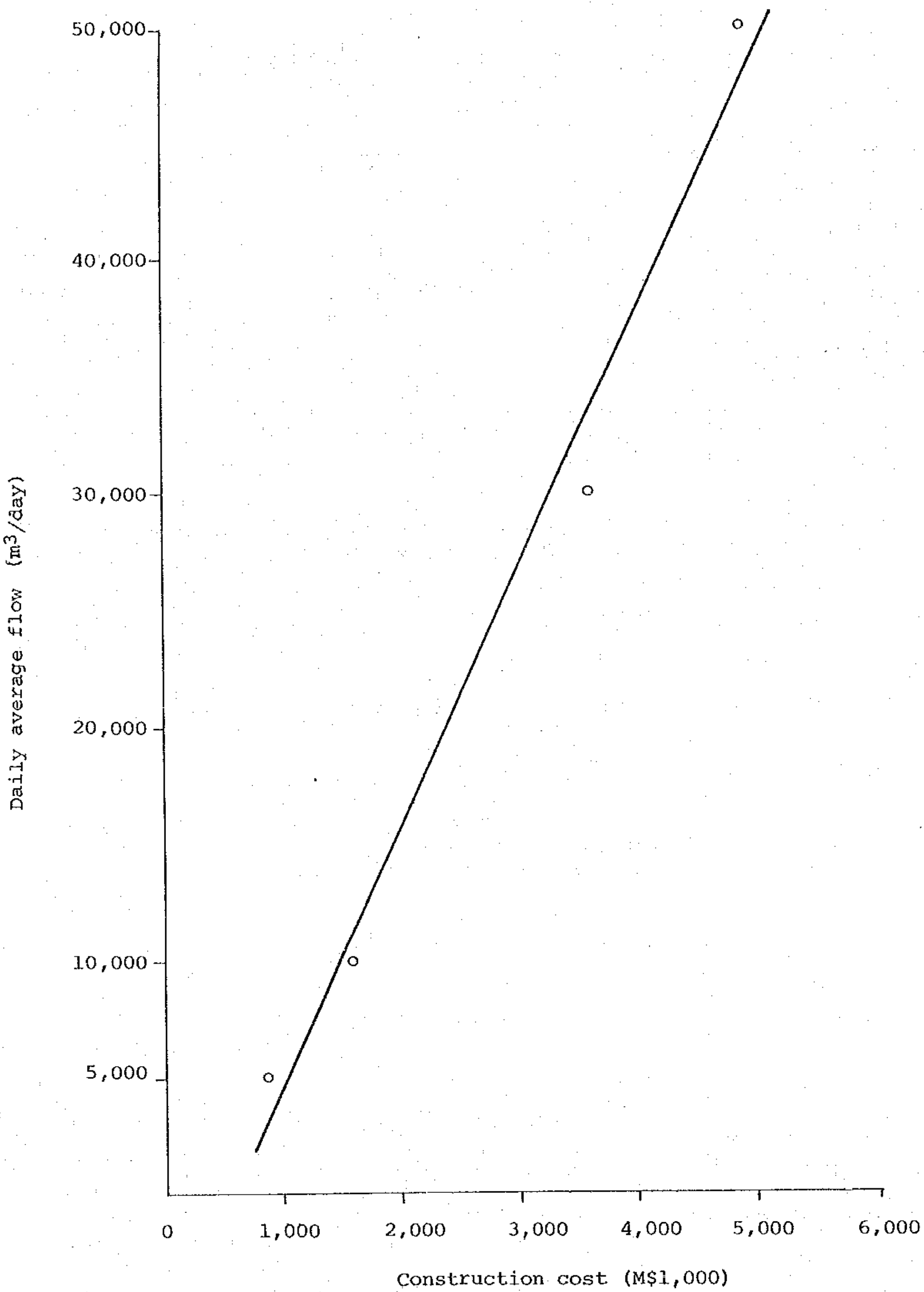
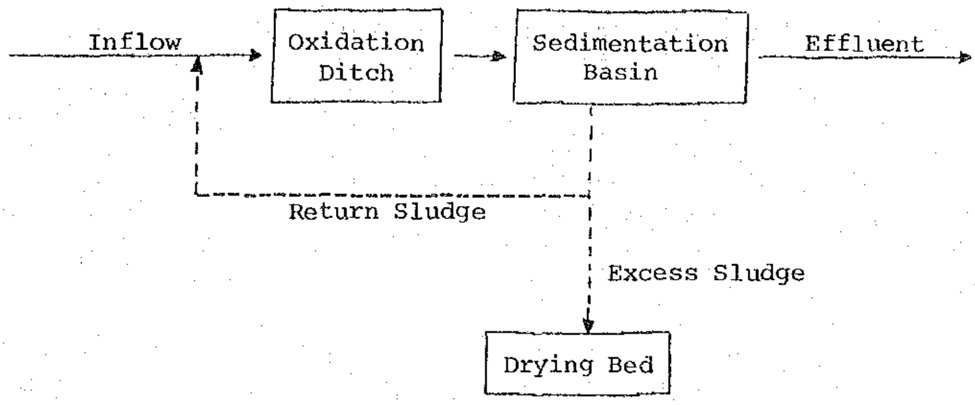


Figure G-4 Construction cost for aerated lagoon process

3.4 Oxidation Ditch Process

Flow sheet of the oxidation ditch process is given as follows;



Based on the design criteria in Section 5, Chapter 5, and reasonable design conditions as described hereunder, preliminary design and drawings were worked out for estimating construction cost.

(i) Oxidation ditches have 1.5 metre liquid depth with 1 to 1 side slope, 0.3 metre thickness with stone pitch to protect against the scouring effects by mechanical brush aerators;

(ii) For ease of operation, maintenance and control, the maximum total length of ditch is limited to 300 metres and the maximum width of ditch 7 metres;

(iii) Ditch is lined with a 0.3 metre layer of impervious clay material;

(iv) Top width of embankment has 6 metres;

(v) Shape of sedimentation basin is circular type and its maximum diameter is 20 metres;

(vi) Ditch area is enclosed with a suitable fence to preclude livestock and discourage trespassing;

(vii) Treatment facility site is surrounded by a minimum of 10 metres wide strip of land.

A conceptual layout plan for oxidation ditch is given in Figure E-4, Appendix E.

Table G-11 shows estimated construction costs including 20 percent overhead cost.

The construction costs of civil works include for oxidation ditch, sedimentation cell, inlet and outlet works, manholes, drain of the site, sedimentation basin, chlorination tank, drying bed, fencing, turfing, and site roads. The installation costs of machinery and electricity equipment are estimated on the basis of quotations from manufactures in Japan, and allowances are made for the costs of freight, insurance, customs duties, transports to site and installation.

Table G-11 Construction Cost for Oxidation Ditch Process with Varying Treatment Capacities

Capacity (m^3/day) / Item	5,000	10,000	30,000	50,000
Civil Works	505	984	2,442	4,066
Machinery & Electricity	724	1,364	3,925	6,672
Total	1,229	2,348	6,367	10,738

As illustrated in Figure G-5, the cost function for aerated lagoon process can be expressed in a linear form as;

$$C_A = aQ + b$$

where C_A : Construction cost, M$1,000
Q : Capacity, m^3/day
a.b: Constants

The values of "a" and "b" are obtained by the least square solution as 0.2099 and 184.9 respectively.

Hence, the cost function can be expressed as;

$$C_A = 0.2099Q + 184.9$$

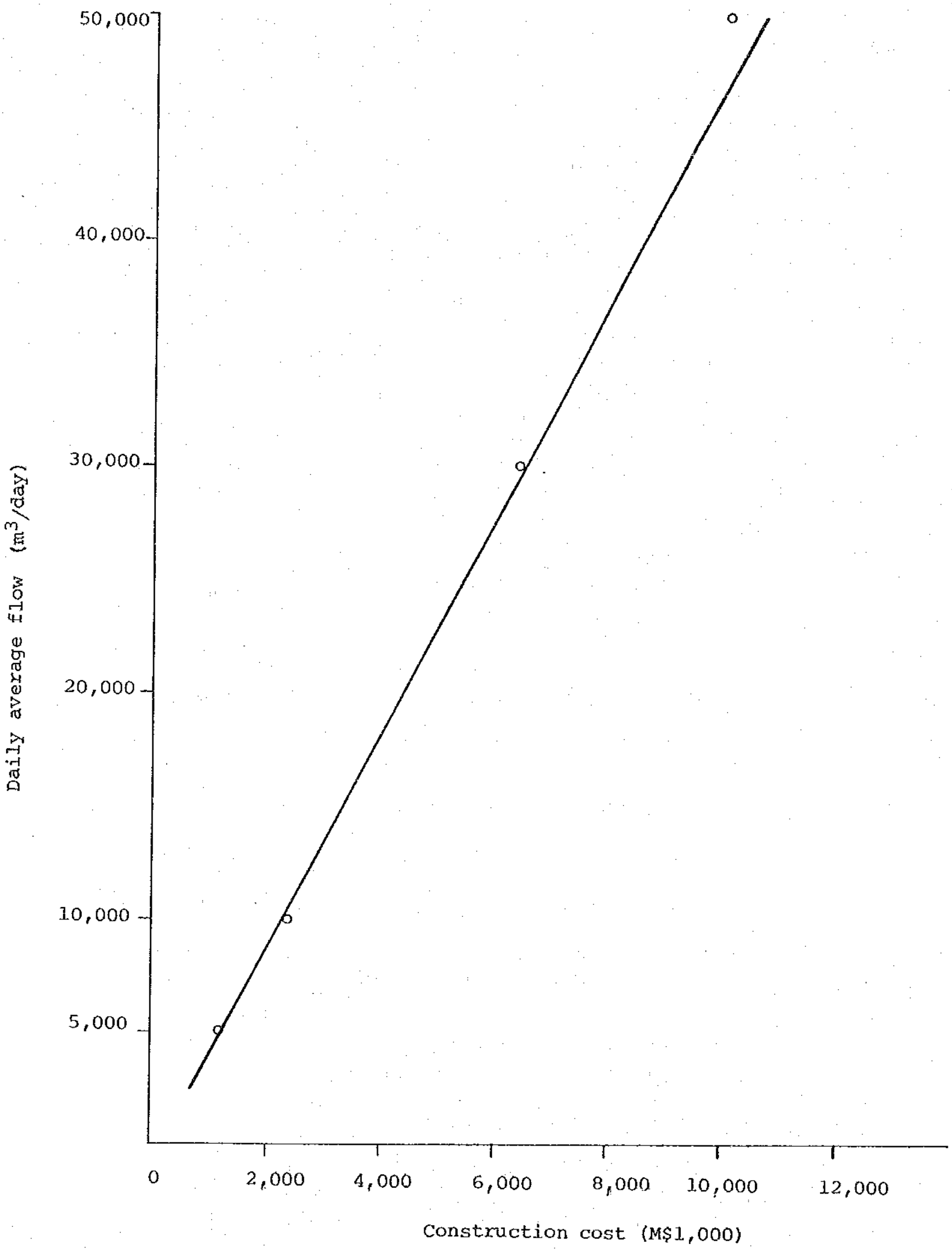


Figure G-5 Construction cost for oxidation ditch process

4. Operation and Maintenance Costs

4.1 General

Generally, comprehensive sewerage system consists of sewers, pumping stations, and treatment facilities. In order to maintain these facilities considerable expenditures are required, including salaries for operators and labours, electricity, chemicals for laboratory testing, purchase of cleaning equipment, overhauling costs, machine oil, repairing cost, etc.

Cost function for sewer maintenance, operation and maintenance of pumping stations and treatment facilities are developed respectively as below.

4.2 Sewers

Maintenance costs for sewers are estimated based on the following assumptions;

(a) Frequency of cleaning of public sewers (trunk sewer and branch & lateral sewer) is once in every four years.

(b) Frequency of cleaning of house connections is once in every ten years.

(c) Ability to clean by one crew for public sewers is 200 m/day.

(d) Useful life of the cleaning equipment is 10 years.

(e) Crew member for public sewers is 6 persons.

(f) Crew member for house connections is 3 persons.

(g) Costs for spare parts, repairing, overhauling of equipment are five percent per annum of equipment cost.

(h) Annual rehabilitation cost of sewers is 0.5 percent of construction cost.

(i) Working days and hours

Working days are 250 days/year
Working hours are 6 hours/day

(j) Labour cost is M$11/day.

(k) Price of power driven bucket machine to clean sewers is M$112,000/set.

4.3 Pumping Stations

In developing the cost function, the following assumptions are made;

(a) Daily average number of operator is 0.5 person per station,

(b) Electricity is assumed at M¢8/kWh, and average salary of operator is assumed at M$20/day,

(c) Cost of repairs and overhauling of part are estimated at one percent of capital costs of civil works and two percent of mechanical and electrical works.

The operation and maintenance costs by pump capacity are then estimated as shown in Table G-12 and Figure G-6.

Table G-12 Annual Operation and Maintenance Costs for Pumping Station by Capacity

(M$ 1,000)

Item \ Capacity (m^3/sec)	0.1	0.4	0.8
. Salary	3.7	3.7	3.7
. Electricity	10.5 (1)	44.2 (2)	103.7 (3)
. Repairs & part	3.9	11.8	18.7
Total	18.1	59.7	126.1

Note: (1) 7.5 kW/No. x 2 Nos. x 8,760 h x 0.08 M$/kWh = M$10,512

(2) 21.0 kW/No. x 3 Nos. x 8,760 h x 0.08 M$/kWh = M$44,150

(3) 37.0 kW/No. x 4 Nos. x 8,760 h x 0.08 M$/kWh = M$103,718

As illustrated in Figure G-6, the cost function of pumping stations can be expressed in a linear form as;

$$C_{MP} = aQ + b$$

where C_{MP} : Annual operation and maintenance cost, M$1,000

Q : Peak flow rate, m^3/sec

a,b : Constants

The constants, "a" and "b" are obtained by the least square solution, and the cost function can finally be expressed as;

$$C_{MP} = 154.92\ Q + 0.74$$

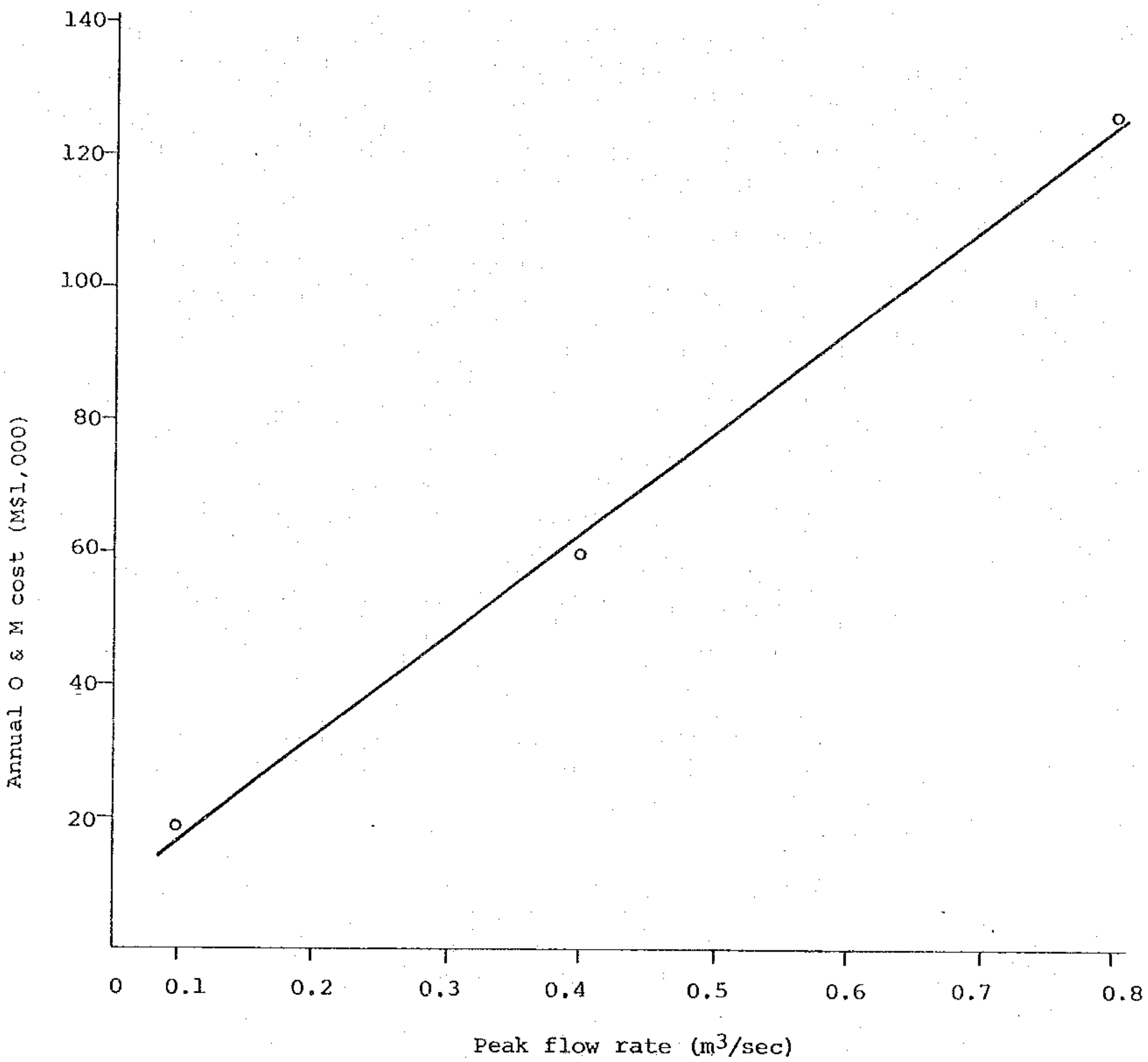


Figure G-6 Annual operation and maintenance cost for pumping station