3. Alternative Site Plans for Treatment Facilities

There are considerable number of alternative plans available according to number of treatment facilities located in the Study Area and to their various candidate lands available and locations.

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 because of one treatment facility

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

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

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

(5) influence to the water quality of the receiving water course 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 zone in a minimum cost

(2) receiving water courses of treated waters should be running near-by

(3) overall sewer length should be short

(4) number of pumping stations should be small

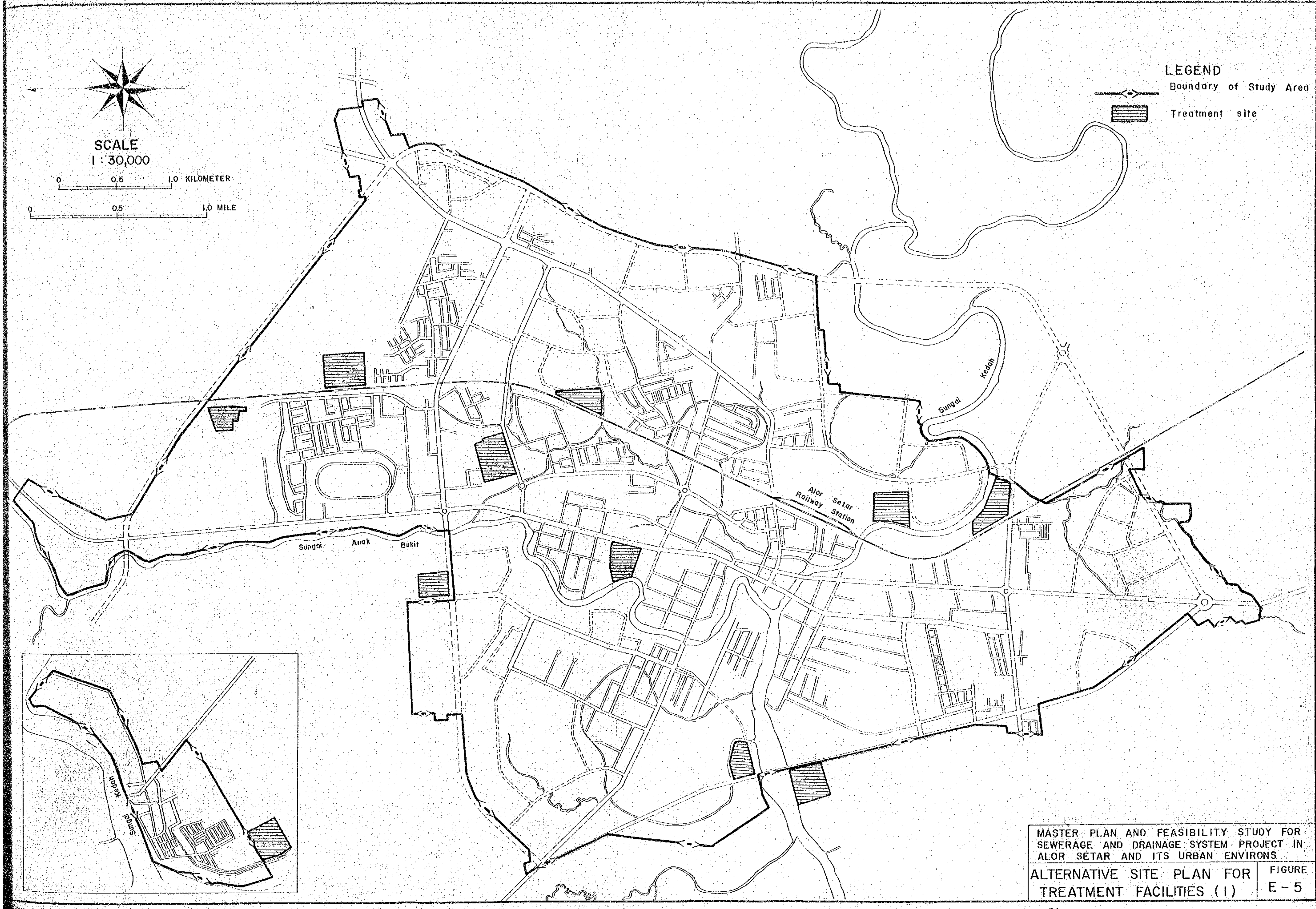
(5) availability of lands

Taking into account of the various items noted above, a alternative site plan for treatment facilities, which is considered the best in terms of engineering aspects, shown in Figure E-5, was made and brought to discussions with the agencies concerned.

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

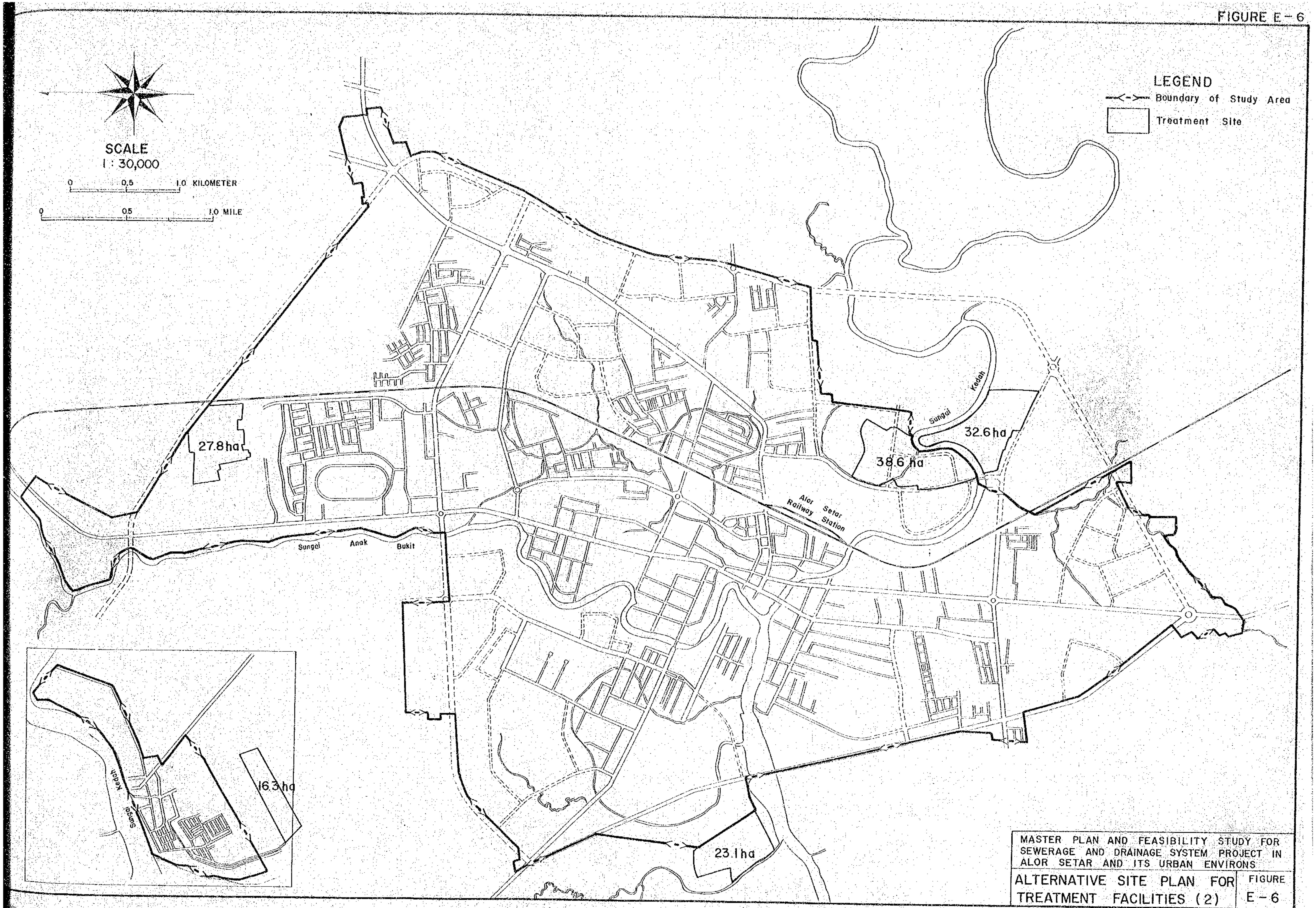
Due mainly because of previous commitment of the lands for treatment facilities, the sewerage layout plan (Figure E-5) was modified as shown in Figure E-6 based on the suggestion given by T.C.P., MADA, and MPKS.

The modified treatment sites plan (Figure E-6) was further commented by the State Government as finally proposed in Figure 5.2 of Section 7.2.1 in Chapter 5 in the main text.



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 area required, three each different stations with capacities of 0.1 m^3/sec, 0.4 m^3/sec and 0.8 m^3/sec were designed and obtained as resulted in Table F-1.

Table F-1 Required Site Areas 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;

$$S_p = 450.7\ Q_p + 153.0$$

where Sp : Site area, m^2
Qp : Peak flow, m^3/sec

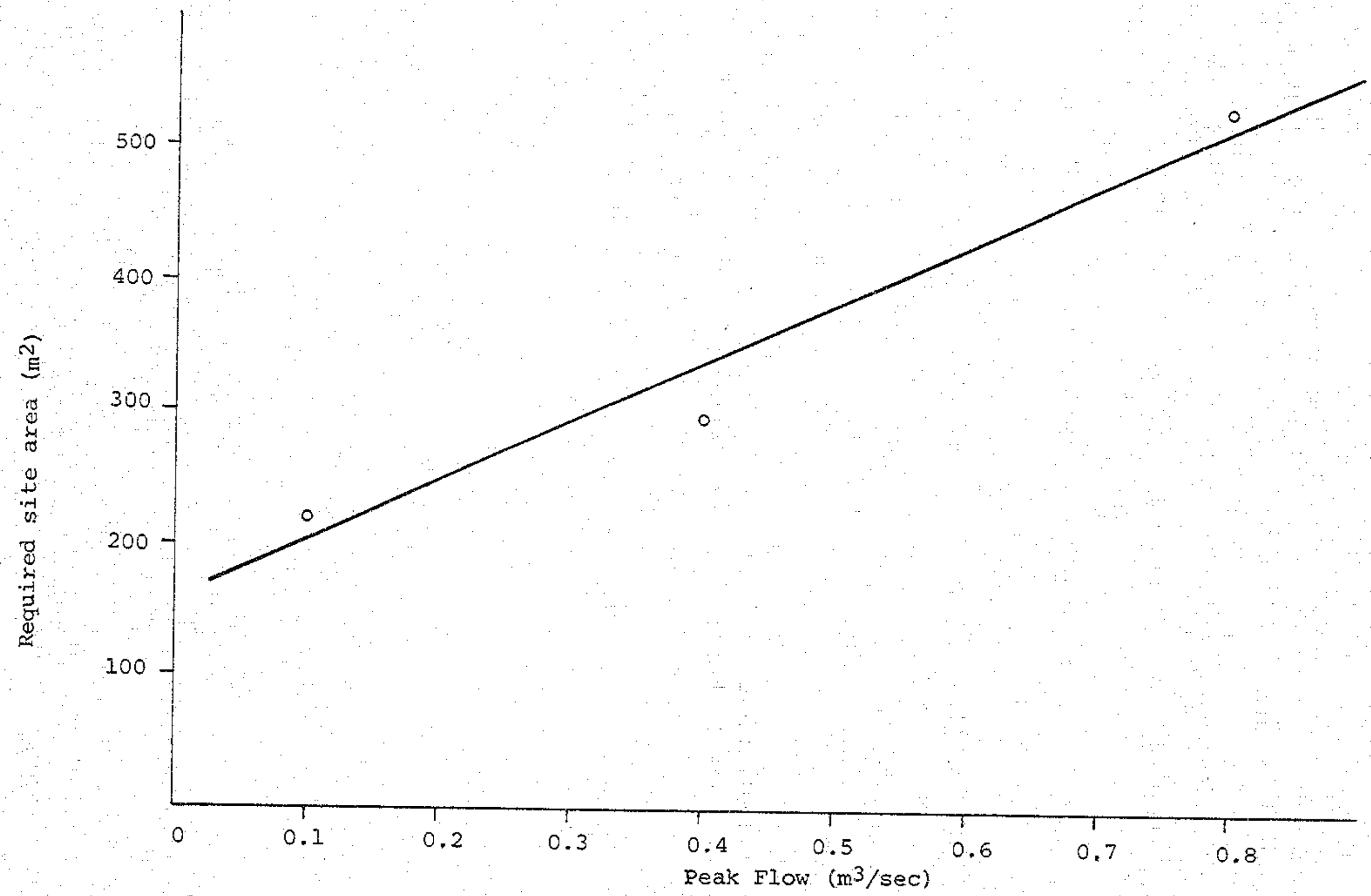


Figure F-1 Required site area for pumping station

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, site areas required are obtained as shown in Table F-2 and Figure F-2.

Table F-2 Required Site Areas 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 were 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 area, ha
Q : Daily average flow, m^3/day

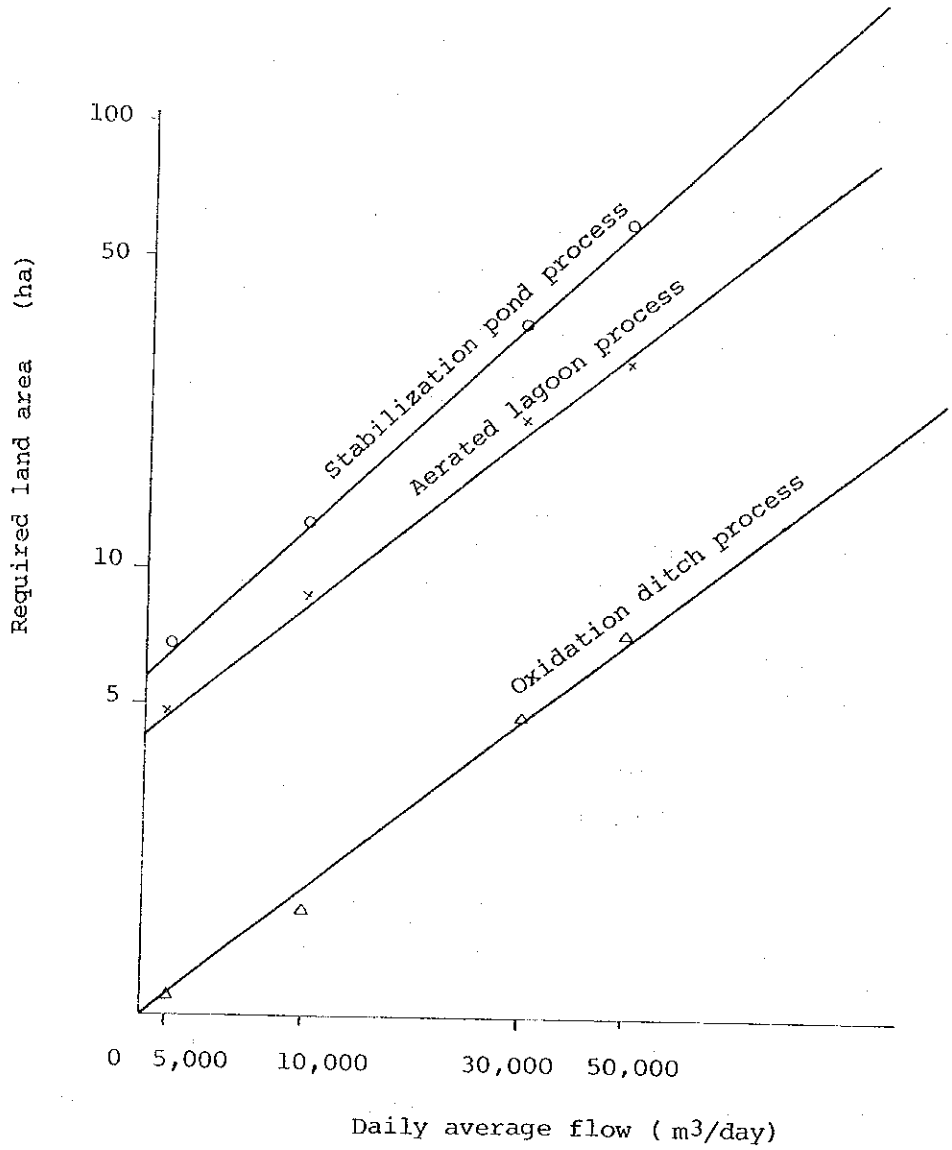


Figure F-2 Required site area for treatment facilities

APPENDIX G

METHOD FOR CONSTRUCTION AND RECURRENT 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 estimates of these alternatives are made by estimated sewer laying costs for various sizes and depths for conveyance system on the basis of 1979 price level in Kedah State.

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 and any other expenditures expected. 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.

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, and centrifugally-cast-reinforced concrete pipes (less than 1,800 mm in diameter) are available in Malaysia. The unit price of these basic materials are given in the Tables G-2, 3, and 4.

Land acquisition cost in 1979 price level in the Study Area is estimated on the basis of information obtained from State Land Office as shown in Table G-5, Figure G-1.

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-reinforced concrete pipe (mm in dia.)			With high alumina cement mortar linings 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
Steel sheet-pile works	(" 5.0-6.0m)	m	175.00
"	(" 6.0-7.0m)	m	242.00
"	(" 7.0-8.0m)	m	218.00
"	(" 8.0m -)	m	258.00

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

Table G-5 Land Value in the Study Area

Ref. No. (Refer to G-1)	Category	Land Value
1	(a)	$ 4860/ha
	(b)	$ 32.3/m²
	(c)	$ 43.1/m²
2	(a)	$ 4860/ha
	(b)	$ 32.3/m²
	(c)	$ 43.1/m²
3	(a)	$ 5260/ha
	(b)	$ 32.3/m²
	(c)	$ 53.8/m²
4	(a)	$ 6070/ha
	(b)	$ 37.7/m²
	(c)	$ 64.6/m²
5	(a)	$ 7280/ha
	(b)	$ 43.1/m²
	(c)	$ 86.1/m²
6	(a)	$ 7280/ha
	(b)	$ 43.1/m²
	(c)	$ 86.1/m²
7	(b)	$ 53.8/m²
	(c)	$ 107.6/m²
8	(a)	$ 8090/ha
	(b)	$ 43.1/m²
	(c)	$ 86.1/m²
9	(a)	$ 8900/ha
	(b)	$ 32.3/m²
	(c)	$ 75.3/m²
10	(a)	$ 8900/ha
	(b)	$ 43.1/m²
	(c)	$ 86.1/m²
11	(b)	$ 53.8/m²
	(c)	$ 161.5/m²
12	(a)	$ 8900/ha
	(b)	$ 32.3/m²
	(c)	$ 107.6/m²
13	(a)	$ 8900/ha
	(b)	$ 43.1/m²
	(c)	$ 129.2/m²
14	(a)	$ 8090/ha
	(b)	$ 32.3/m²
	(c)	$ 107.6/m²
15	(b)	$ 129.2/m²
	(c)	$ 215.3/m²
16	(b)	$ 150.7/m²
	(c)	$ 269.1/m²
17	(b)	$ 129.2/m²
	(c)	$ 215.3/m²
18	(b)	$ 161.5/m²
	(c)	$ 322.9/m²
19	(b)	$ 161.5/m²
	(c)	$ 322.9/m²
20	(a)	$ 10120/ha
	(b)	$ 107.6/m²
	(c)	$ 215.3/m²
21	(b)	$ 161.5/m²
	(c)	$ 430.6/m²
22	(b)	$ 129.2/m²
	(c)	$ 215.3/m²
23	(a)	$ 6070/ha
	(b)	$ 21.5/m²
	(c)	$ 43.1/m²
24	(a)	$ 5670/ha
	(b)	$ 21.5/m²
	(c)	$ 53.8/m²
25	(a)	$ 8090/ha
	(b)	$ 21.5/m²
26	(a)	$ 8090/ha
	(b)	$ 21.5/m²
27	(a)	$ 7280/ha
28	(a)	$ 10120/ha
	(b)	$ 43.1/m²
	(c)	$ 86.1/m²
29	(a)	$ 8900/ha
	(b)	$ 32.3/m²
	(c)	$ 75.3/m²
30	(a)	$ 9710/ha
	(b)	$ 32.3/m²
	(c)	$ 86.1/m²
31	(a)	$ 9710/ha
	(b)	$ 32.3/m²
	(c)	$ 86.1/m²
32	(a)	$ 7280/ha
	(b)	$ 21.5/m²
33	(a)	$ 8090/ha
	(b)	$ 32.3/m²
	(c)	$ 107.6/m²
34	(a)	$ 10120/ha
	(b)	$ 43.1/m²
	(c)	$ 150.7/m²
35	(a)	$ 8090/ha
36	(b)	$ 64.6/m²
	(c)	$ 193.8/m²
37	(b)	$ 64.6/m²
	(c)	$ 215.3/m²
38	(b)	$ 64.6/m²
	(c)	$ 215.3/m²
39	(b)	$ 43.1/m²
	(c)	$ 193.8/m²
40	(b)	$ 43.1/m²
	(c)	$ 161.5/m²
41	(a)	$ 10120/ha
	(b)	$ 43.1/m²
	(c)	$ 161.5/m²
42	(b)	$ 43.1/m²
	(c)	$ 129.2/m²
43	(a)	$ 10120/ha
	(b)	$ 43.1/m²
	(c)	$ 86.1/m²
44	(b)	$ 107.6/m²
	(c)	$ 215.3/m²

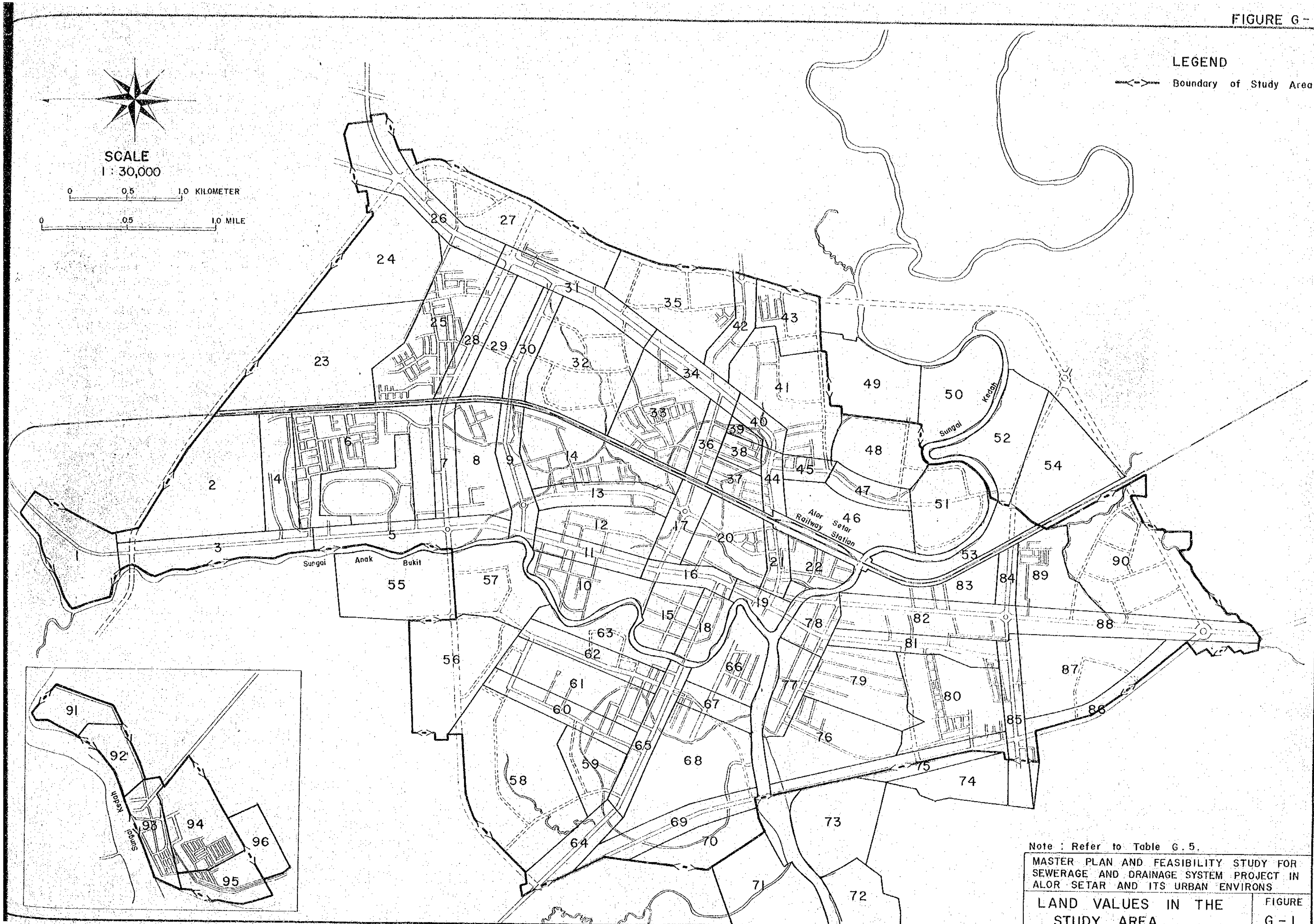
Note: The land value in each block is classified into four categories as referred above, such as (a) paddy area, (b) residencial area, (c) commercial area, and (d) industrial area.

- continued -

Ref. No. (Ref.to G-1)	Category	Land Value
45	(b)	$ 64.6 / m²
	(c)	$ 161.5 / m²
46	(a)	$ 8093/ ha
	(b)	$ 21.5 / m²
47	(a)	$ 7280/ ha
	(b)	$ 21.5 / m²
48	(a)	$ 6070/ha
49	(a)	$ 4860/ha
50	(a)	$ 4860/ha
51	(a)	$ 7280/ha
	(b)	$ 21.5 / m²
52	(a)	$ 4860/ha
53	(a)	$ 8090/ha
	(b)	$ 32.3 / m²
	(c)	$ 86.1 / m²
54	(a)	$ 6070/ha
55	(a)	$ 5460/ha
56	(a)	$ 5460/ha
57	(a)	$ 6070/ha
	(b)	$ 21.5 / m²
58	(a)	$ 7280/ha
59	(a)	$ 8093/ha
	(b)	$ 43.1 / m²
	(c)	$ 215.3 / m²
60	(b)	$ 4650/ ha
	(c)	$ 215.3 / m²
61	(b)	$ 53.8 / m²
	(c)	$ 236.8 / m²
62	(a)	$ 10120/ ha
	(b)	53.8 / m²
63	(a)	$ 8090/ha
	(b)	$ 43.1 / m²
64	(a)	$ 9710/ha
	(b)	$ 32.3 / m²
	(c)	$ 107.6 / m²
65	(b)	$ 64.6 / m²
	(c)	$ 269.1 / m²
66	(b)	$ 53.8 / m²
	(c)	$ 161.5 / m²
67	(b)	$ 53.8 / m²
	(c)	$ 215.3 / m²
68	(a)	$ 10120/ ha
	(b)	$ 43.1 / m²
	(c)	$ 215.3 / m²
69	(a)	$ 10120/ha
	(b)	$ 32.3 / m²
	(c)	$ 86.1 / m²
70	(a)	$ 8090/ha
71	(a)	$ 4050/ha
72	(a)	$ 4050/ha

Ref. No. (Ref.to G-1)	Category	Land Value
73	(a)	$ 5670/ha
74	(a)	$ 8090/ha
75	(a)	$ 8902/ha
	(b)	$ 32.3 / m²
76	(a)	$ 10120/ha
	(b)	$ 43.1 / m²
	(c)	$ 107.6 / m²
77	(b)	$ 75.3 / m²
	(c)	$ 129.2 / m²
	(d)	$ 161.5 / m²
78	(b)	$ 107.6 / m²
	(c)	$ 161.5 / m²
79	(b)	$ 43.1 / m²
	(c)	$ 129.2 / m²
80	(a)	$ 10120/ha
	(b)	$ 43.1 / m²
	(c)	$ 129.2 / m²
81	(b)	$ 53.8 / m²
	(c)	$ 161.5 / m²
	(d)	$ 215.3 / m²
82	(b)	$ 86.1 / m²
	(c)	$ 161.5 / m²
	(d)	$ 215.3 / m²
83	(b)	$ 32.3 / m²
	(c)	$ 107.6 / m²
84	(b)	$ 53.8 / m²
	(c)	$ 129.2 / m²
85	(b)	$ 43.1 / m²
	(c)	$ 107.6 / m²
86	(a)	$ 8900/ ha
	(b)	$ 32.3 / m²
87	(a)	$ 8900/ha
	(b)	$ 32.3 / m²
88	(b)	$ 43.1 / m²
	(c)	$ 107.6 / m²
	(d)	$ 161.5 / m²
89	(a)	$ 10120/ha
	(b)	$ 43.1 / m²
	(c)	$ 161.5 / m²
90	(a)	$ 8090/ha
	(b)	$ 32.3 / m²
	(c)	$ 107.6 / m²
91	(c)	$ 64.6 / m²
92	(a)	$ 6070/ha
	(b)	$ 21.5 / m²
	(c)	$ 43.1 / m²
93	(b)	$ 21.5 / m²
	(c)	$ 43.1 / m²
	(d)	$ 64.6 / m²
94	(a)	$ 4860/ha
	(b)	$ 21.5 / m²
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.



Note : Refer to Table G.5.

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

LAND VALUES IN THE STUDY AREA

FIGURE G - I

1.2.2 Construction Costs for Sewers

Prior to the estimation of the construction costs, studies on methods of construction and selection of suitable construction materials have been 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 planned road except that the conditions allow the pipe laying inside private house plot. Excavation shall generally be made by trench method with 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 that of sewers connected to the manholes.

(2) Less than 900mm of sewers connected.

(3) 900 - 1200mm of sewers connected.

(4) 1,200 - 1,500mm of sewers connected.

2. Cost Function for Pumping Stations

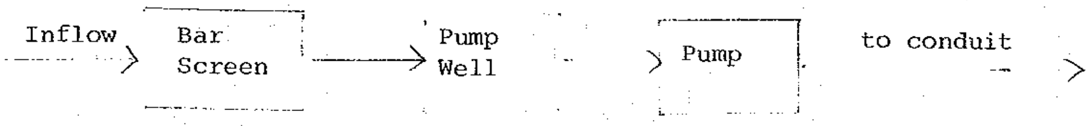
2.1 General

Pumping stations are required at most of the treatment facilities sites and at other locations where sewers should be laid at unreasonable depth if pump is not installed.

Cost function curves were 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 pamping stations, cost estimates were 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 were 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, 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-8-1 Construction Costs of Pumping Stations of 6m Depth with Varying Pump Capacities

(1979 prices M$1,000)

Capacity (m^3/sec)	Civil works & Building	Machinery & Electricity	Total
0.1	192	85	277
0.4	299	380	679
0.8	526	588	1,114

Table G-8-2 Construction Costs of Pumping Stations of 8m Depth with Varying Pump Capacities

(1979 Prices M$1,000)

Capacity (m^3/sec)	Civil works & Building	Machinery & Electricity	Total
0.1	225	92	317
0.4	366	414	780
0.8	647	631	1,278

Table G-8-3 Construction Costs of Pumping Stations of 10m Depth with Varying Pump Capacities

(1979 Prices M$1,000)

Capacity (m^3/sec)	Civil works & Building	Machinery & Electricity	Total
0.1	279	110	389
0.4	447	453	900
0.8	795	665	1,460

2.2 Cost Functions

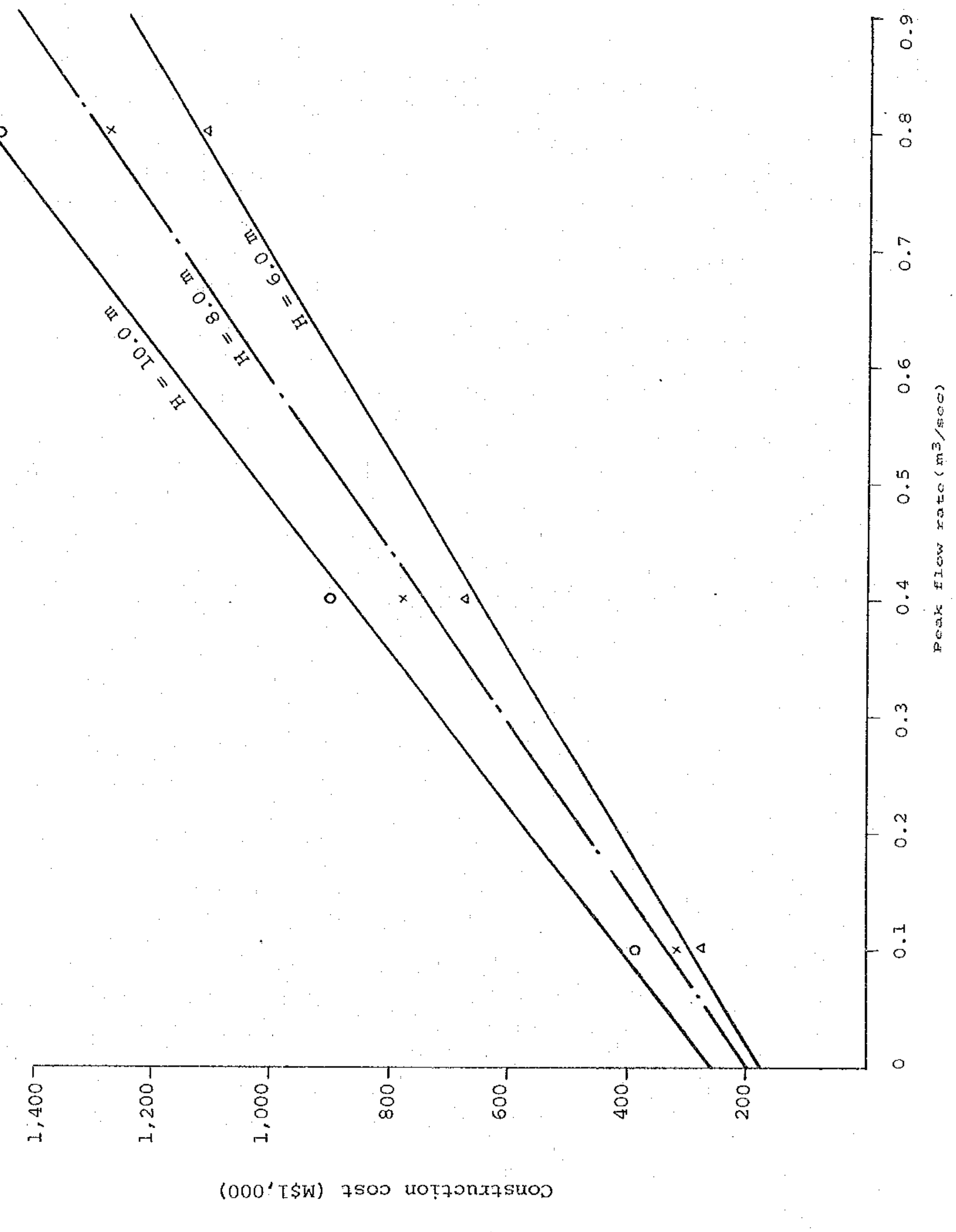
As illustrated in Figure G-2, the cost function of pumping stations can be expressed in a linear form such as ;

$$Cp = aQ + b$$

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 :

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



Construction cost (M$1,000)
1,400
1,200
1,000
800
600
400
200
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Peak flow rate (m3/sec)
H = 10.0 m
H = 8.0 m
H = 6.0 m

3. Cost Functions for Treatment Faclities

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 the 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 ;

Inflow → Facultative Pond → Maturation Pond → Effluent →

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

(i) stabilization ponds have 1.5 metres liquid depth with one to one side slope, stone-pitched ;

(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) 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 were estimated on the basis of material costs and unit costs for construction 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 :

$$Cs = AQ + b$$

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 :

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

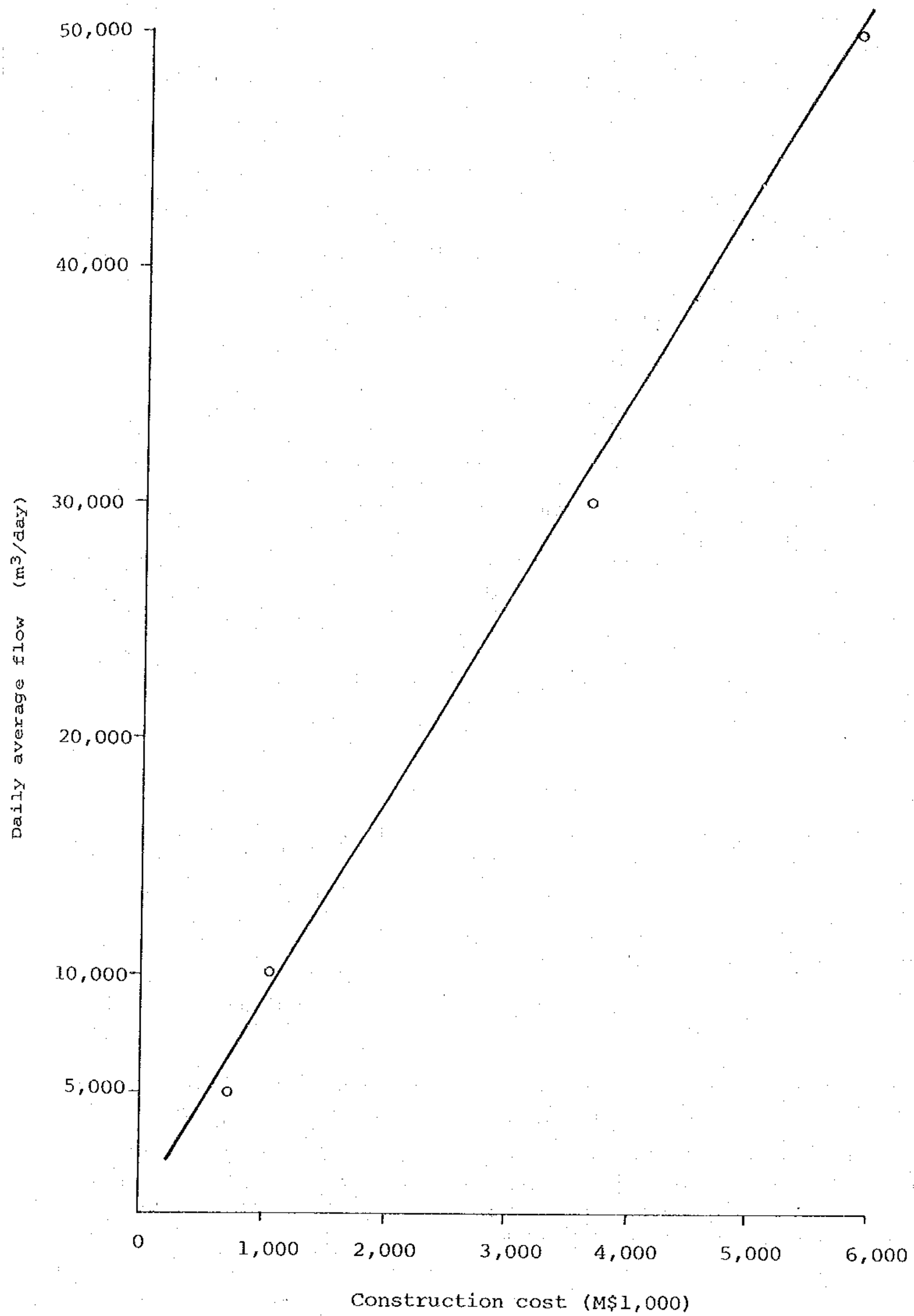
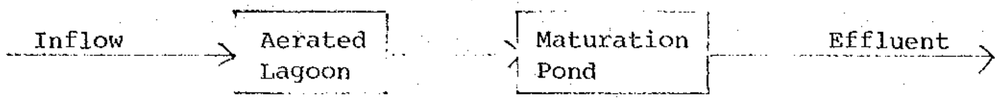


Figure G-3 Construction cost for stabilization pond process

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 were worked out for estimating construction cost.

(i) aerated lagoons have 3 meters liquid depth with 1 to 1 side slope, 0.3 metre stone pitched thickness 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 ;

An 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, sedimentation cell, inlet and outlet works, manholes, drain of the site, fencing, turfing, and site roads and embankments. The installation costs of machinery and electricity equipment were estimated on the basis of quotations of manufacturs in Japan, and allowances were 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 :

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

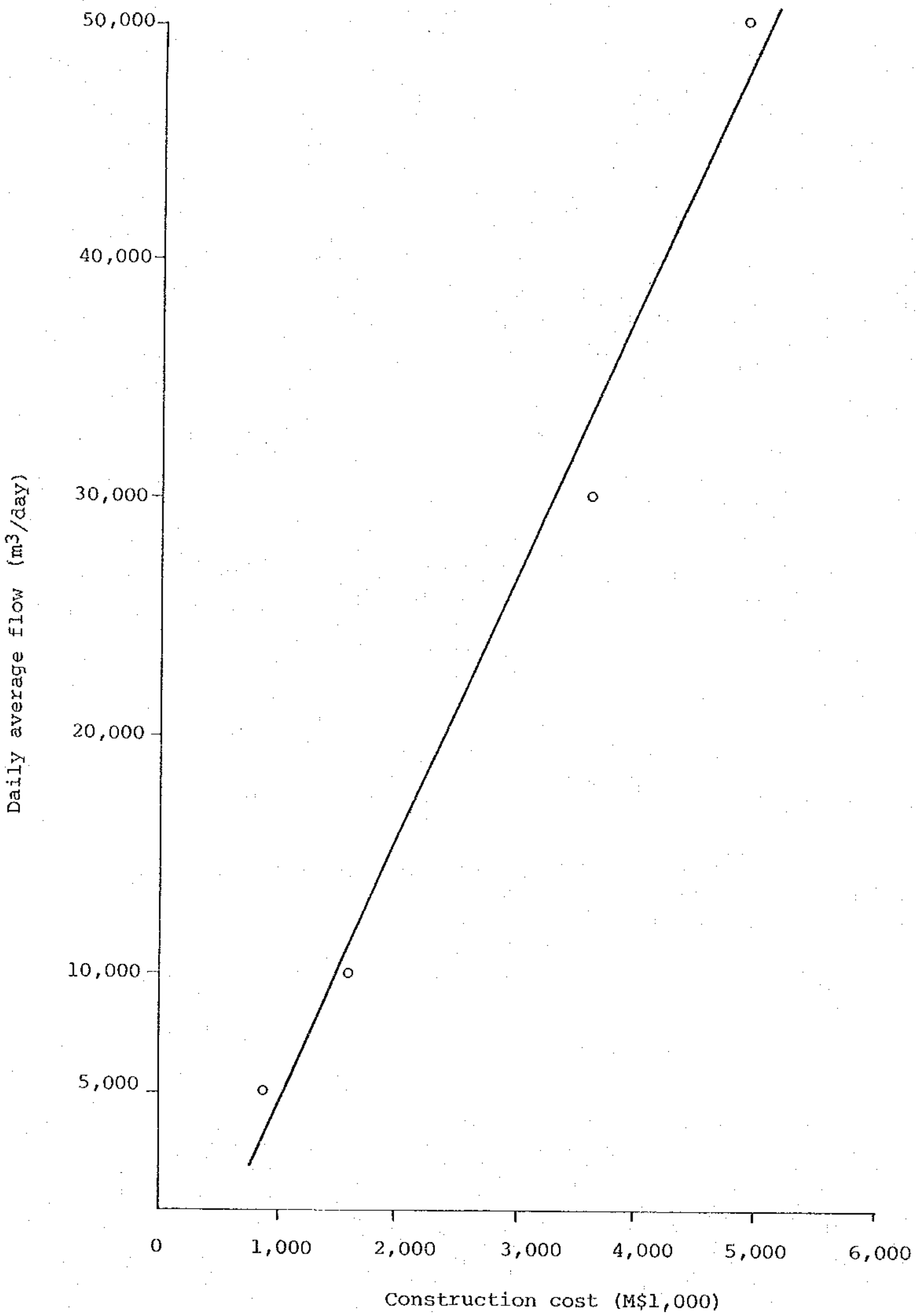
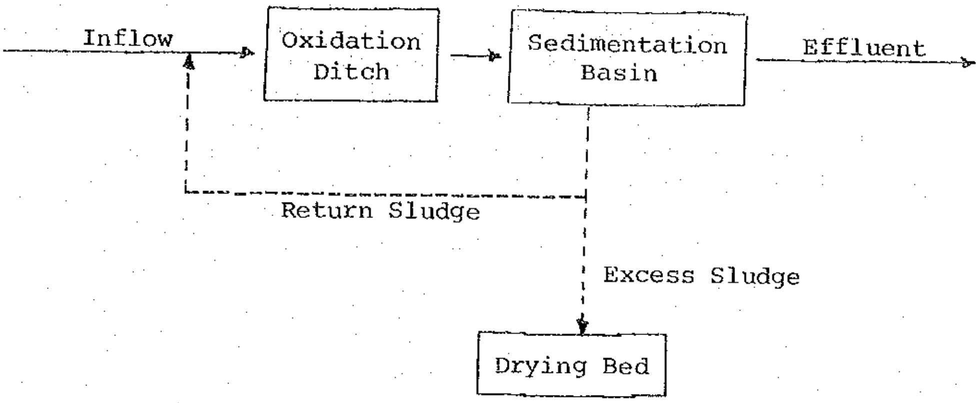


Figure G-4 Construction cost for aerated lagoon process

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 stone pitched thickness 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 3 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 were estimated on the basis of quotations from manufactures in Japan, and allowances were 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;

$$C_{AO} = 0.2099Q + 184.9$$

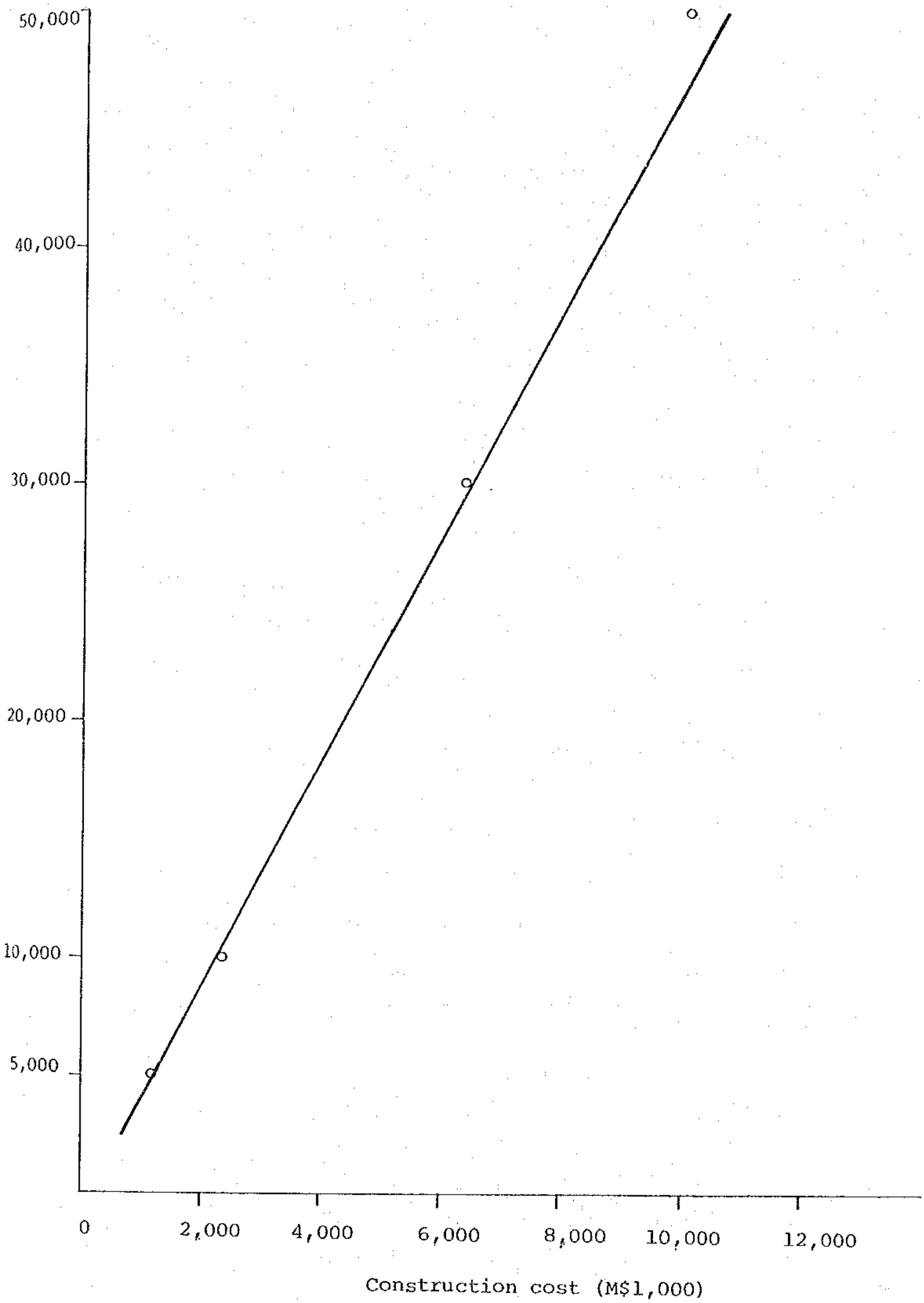


Figure G-5 Construction cost for oxidation ditch process

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, chemical, purchase of cleaning equipment, replacement 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 were estimated based on the following assumptions;

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

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

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

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

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

(f) Team 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 300 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, followings are assumed in advance;

(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 replacement of part are estimated at 1 percent of capital cost of civil works and 2 percent of mechanical and electrical works.

The operation and maintenance costs by capacity were 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

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 & Replacement of 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 such 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 these cost functions can be expressed as;

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

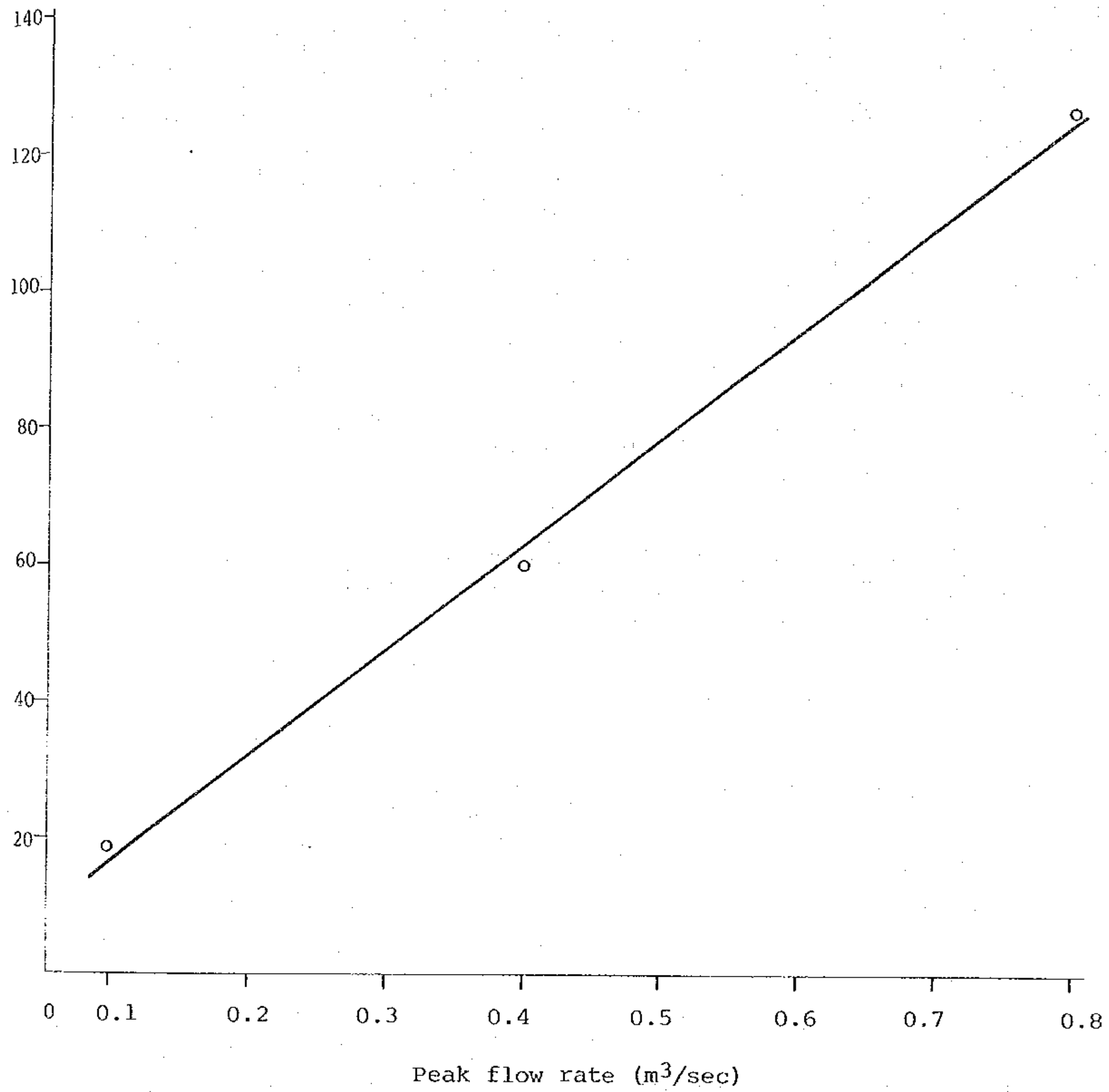


Figure G-6 Annual operation and maintenance cost for pumping station

4.4 Treatment Facilities

Cost functions for three different treatment processes, namely statilization pond, aerated lagoon, and oxidation ditch, are developed.

In developing the cost functions for treatment facilities followings are assumed:

(a) Daily average number of operator is 2 (two) persons for 5,000 m^3/day plant and 2.5 persons for 50,000 m^3/day plant for stabilization pond and aerated lagoon processes,

For oxidation ditch process 4 (four) persons for 5,000 m^3/day plant and 8 (eight) persons for 50,000 m^3/day plant are required,

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

(c) Repairs and replacement of parts are estimated at one percent of capital cost of civil works and two percent of machanical and electrical works.

The operation and maintenance costs by capacity and treatment process were then estimated as shown in Table G-13 and Figures G-7, G-8 and G-9.

Table G-13 Annual Operation and Maintenance Costs for Treatment Facilities by Capacity and Treatment Process

(M$1,000)

Item \ Capacity (m^3/day)	5,000	10,000	30,000	50,000
(a) Stabilization Pond				
. Salary	14.60	14.97	16.79	18.25
. Electricity, etc.	-	-	-	-
. Repairs & Replacement of Parts	7.05	10.62	37.22	58.81
Total	21.65	25.59	54.01	77.06
(b) Aerated Lagoon				
. Salary	14.60	14.97	16.79	18.25
. Electricity, etc.	31.54	63.07	189.22	278.43
. Repairs & Replacement of Parts	10.99	20.73	46.68	62.80
Total	57.13	98.77	252.69	359.48
(c) Oxidation Ditch				
. Salary	29.20	43.80	51.10	58.40
. Electricity, etc.	61.25	122.50	407.16	685.80
. Repairs & Replacement of Parts	19.53	37.12	102.92	174.10
Total	109.98	203.42	561.18	918.30

On the basis of these figures in Table G-13, cost for annual operation and maintenance of treatment plants were obtained as follows;

(i) For stabilization pond process

$$C_{MS} = 1.263 \times 10^{-3} Q + 14.55$$

(ii) For aerated lagoon process

$$C_{MA} = 6.768 \times 10^{-3} Q + 31.29$$

(iii) For oxidation ditch

$$C_{MO} = 1.793 \times 10^{-2} Q + 22.29$$

where C_{MS}, C_{MA}, C_{MO} : Annual operation and maintenance costs, M$1,000/year

Q : Daily average flow, m^3/day

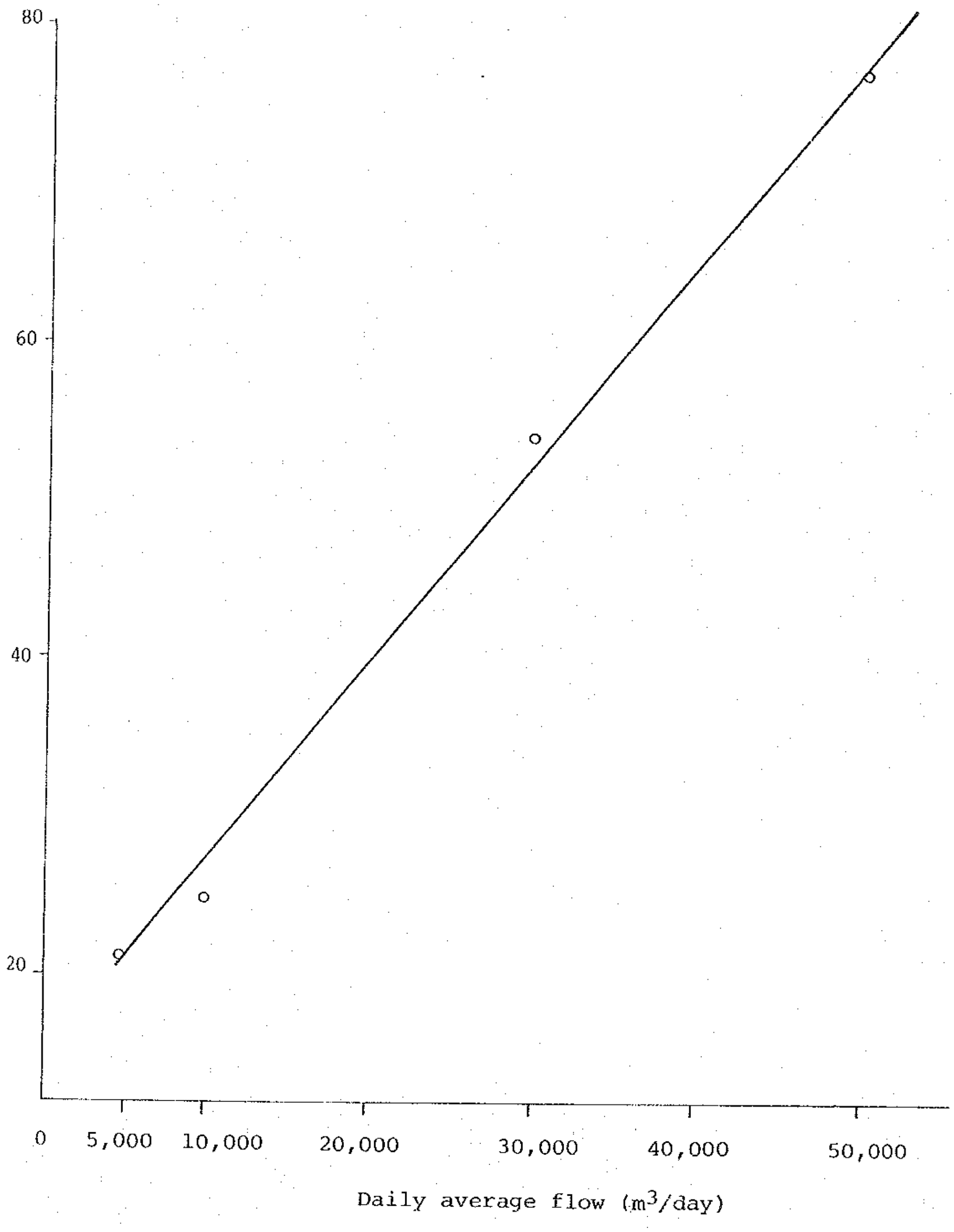


Figure G-7 Annual operation and maintenance cost for stabilization pond

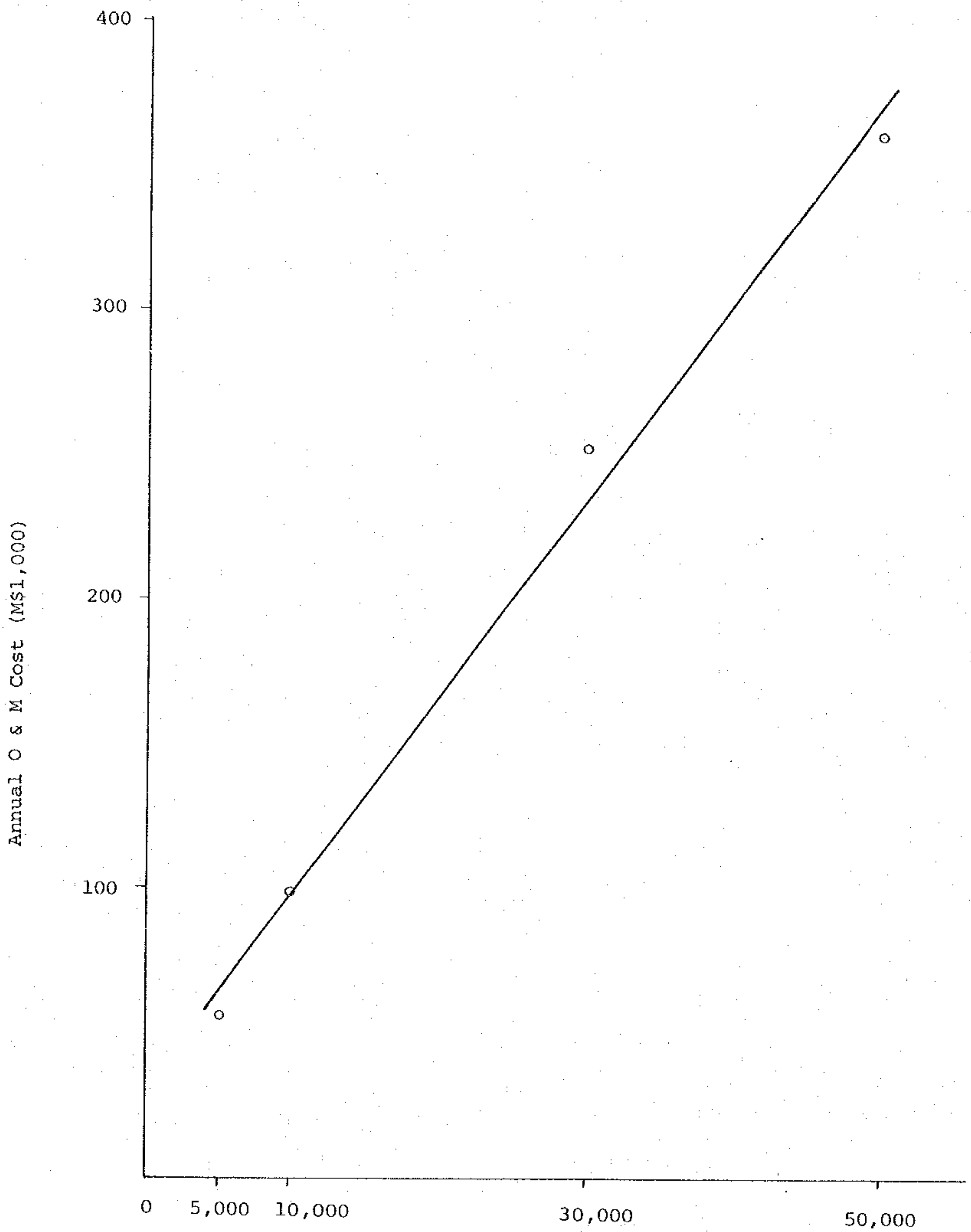


Figure G-8 Annual operation and maintenance cost for aerated lagoon

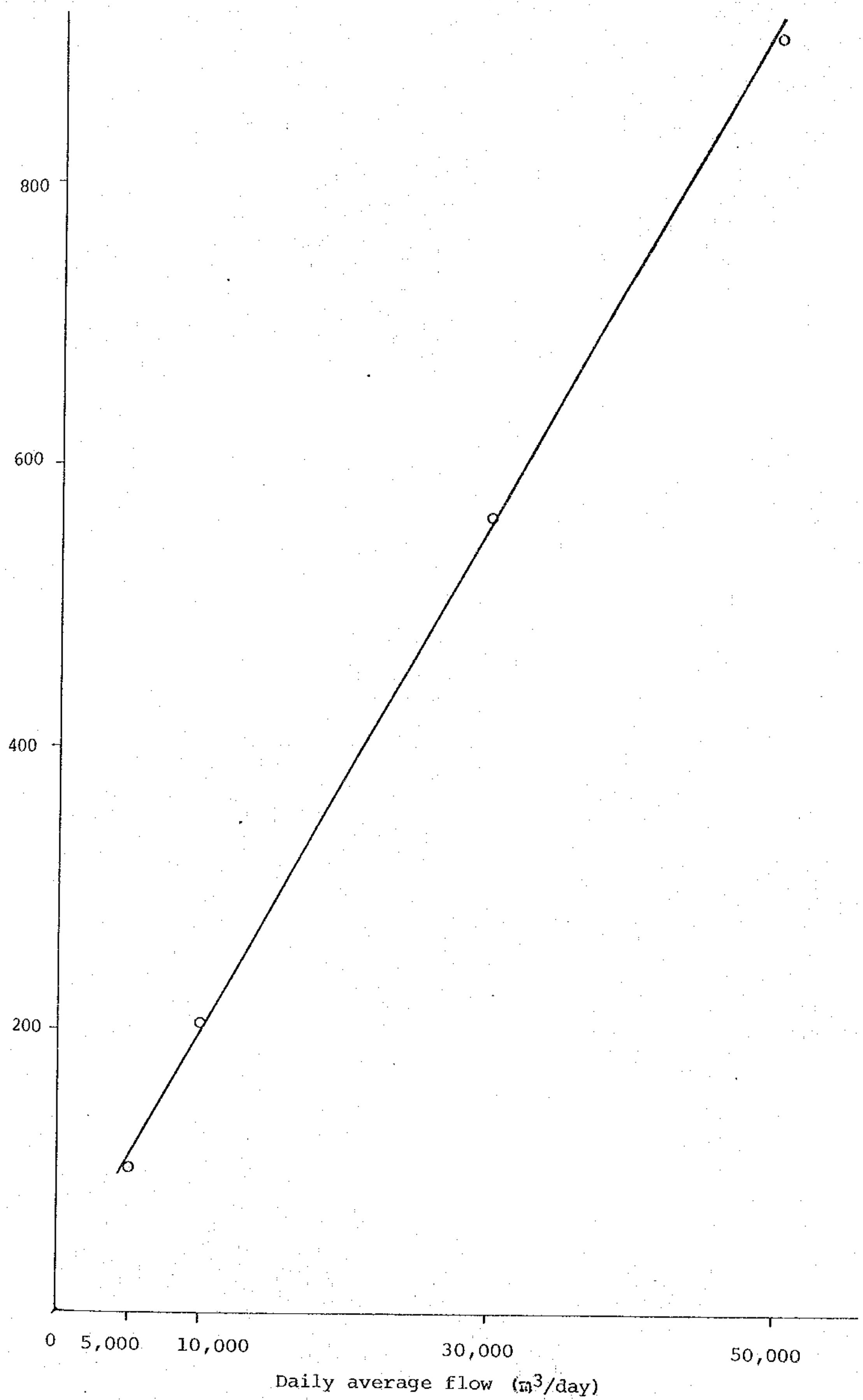


Figure G-9 Annual operation and maintenance cost for oxidation ditch process

APPENDIX H

ESTIMATION OF CONSTRUCTION COST FOR BRANCH AND LATERAL SEWERS

1. Unit Construction Cost Estimates for Branch and Lateral Sewers

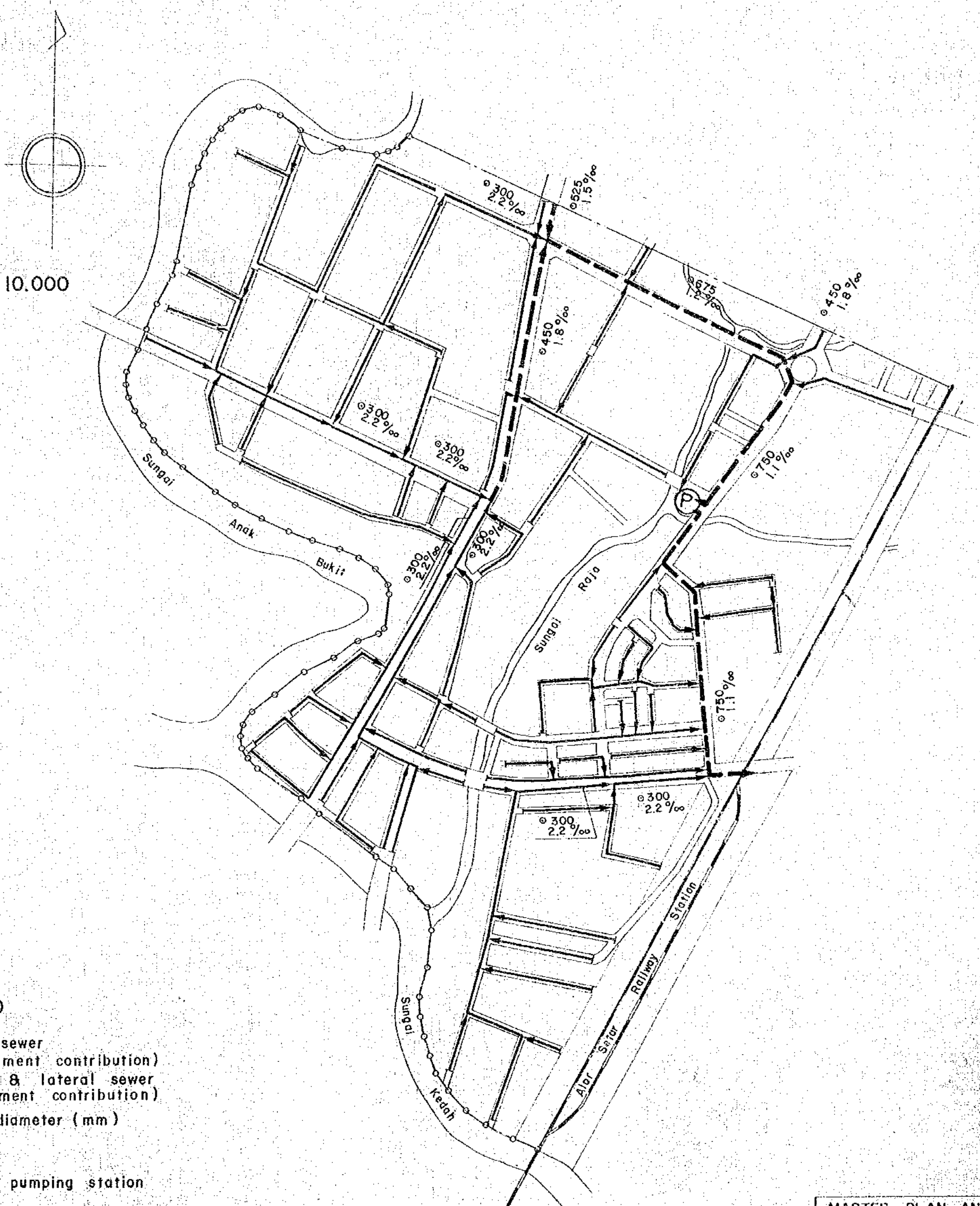
As described in Section 10.2 in Chapter 5 of Sewerage Master Plan Report, all public sewers (consisting of trunk and branch/lateral sewers) in the "urbanized and/or urbanizing area" and trunk sewers in the future development areas will be provided by the Government. However, branch and lateral sewers in the future development areas will be mainly provided by developers.

The construction costs for the trunk sewers, which are described in Section 7 Chapter 5 in Main Report, are estimated by utilizing the method discussed in Section 1, Appendix G, while the construction costs of branch/lateral sewers in "urbanized and/or urbanizing areas" and "the future development areas" are estimated by applying the basic unit costs derived by the reasonable preliminary engineering design of sewer networks upon the areas representing typical conditions of the two areas as shown in Figure H-1 and Figure H-2 respectively.

Based on Figure H-1, entire sewer lengths for branch and lateral sewers are measured in varying sizes in a typical urbanized/urbanizing area as shown in Table H-1 with additional major items for further construction cost estimates as follow.

Table H-1 Unit Construction Cost for Branch/Lateral Sewers in Urbanized and/or Urbanizing Area

Total area ... (1)	167.8 ha
Area of open space, mosque etc. .... (2)	24.6 ha
(1) - (2)	143.2 ha
Sewers	225-300 mm dia. Total length: 15,760 m
Sewer length per ha	110 m/ha
Total construction cost for sewer	M$3,672,080
Construction cost per ha	M$25,643/ha



LEGEND

- Trunk sewer (Government contribution)
- Branch & lateral sewer (Government contribution)
- ⊖300 Sewer diameter (mm)
- 2.2 ‰ Slope
- (P) Sewage pumping station

Note : Unless otherwise shown, all pipes are 225 mm in diameter

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
SEWER LAYOUT PLAN IN TYPICAL URBANIGED AND/OR URBANIZING AREA	FIGURE H - I

It should be noted that the branch/lateral sewers in public areas (such as schools, mosques, open spaces, etc.) as well as housing development areas completed/planned are excluded from the sewer lengths measured and unit construction cost estimates in Table H-1.

Table H-2 shows the component areas of sewerage zones as to (1) urbanized and/or urbanizing area, (2) future development area, and public areas and housing development areas completed/planned.

Table H-2 Component Areas in Sewerage Sub-zones

Name of Sub-zone	Total Area (ha)	(1) Urbanized and/or Urbanizing Area (ha)	(2) Future Development Area (ha)	(3) Public Areas & Housing Development Areas Completed/Planned				
				School (ha)	Mosque (ha)	Open Space (ha)	Housing Estates (ha)	Sub-total (ha)
A - 1	385	251	51	36.9	8.8	28.7	8.6	83.0
A - 2	437	99	331	7.0	0	0	0	7.0
B - 1	459	358.1	10	34.5	12.9	25.7	17.8	90.9
B - 2	410	113.1	281.8	5.7	8.2	0	1.2	15.1
B - 3	102	49.9	43	8.1	1.0	0	0	9.1
C - 1	187	160.7	26	0	0	0	0.3	0.3
C - 2	427	90.1	321	15.9	0	0	0	15.9
D - 1	388	324.3	26	19.3	2.1	9.6	6.7	37.7
D - 2	270	95.6	154	20.4	0	0	0	20.4
E	125	60.1	52.4	11.2	0	0	1.3	12.5
Total	3,190	1,601.9	1,296.2	159	33	64	35.9	291.9

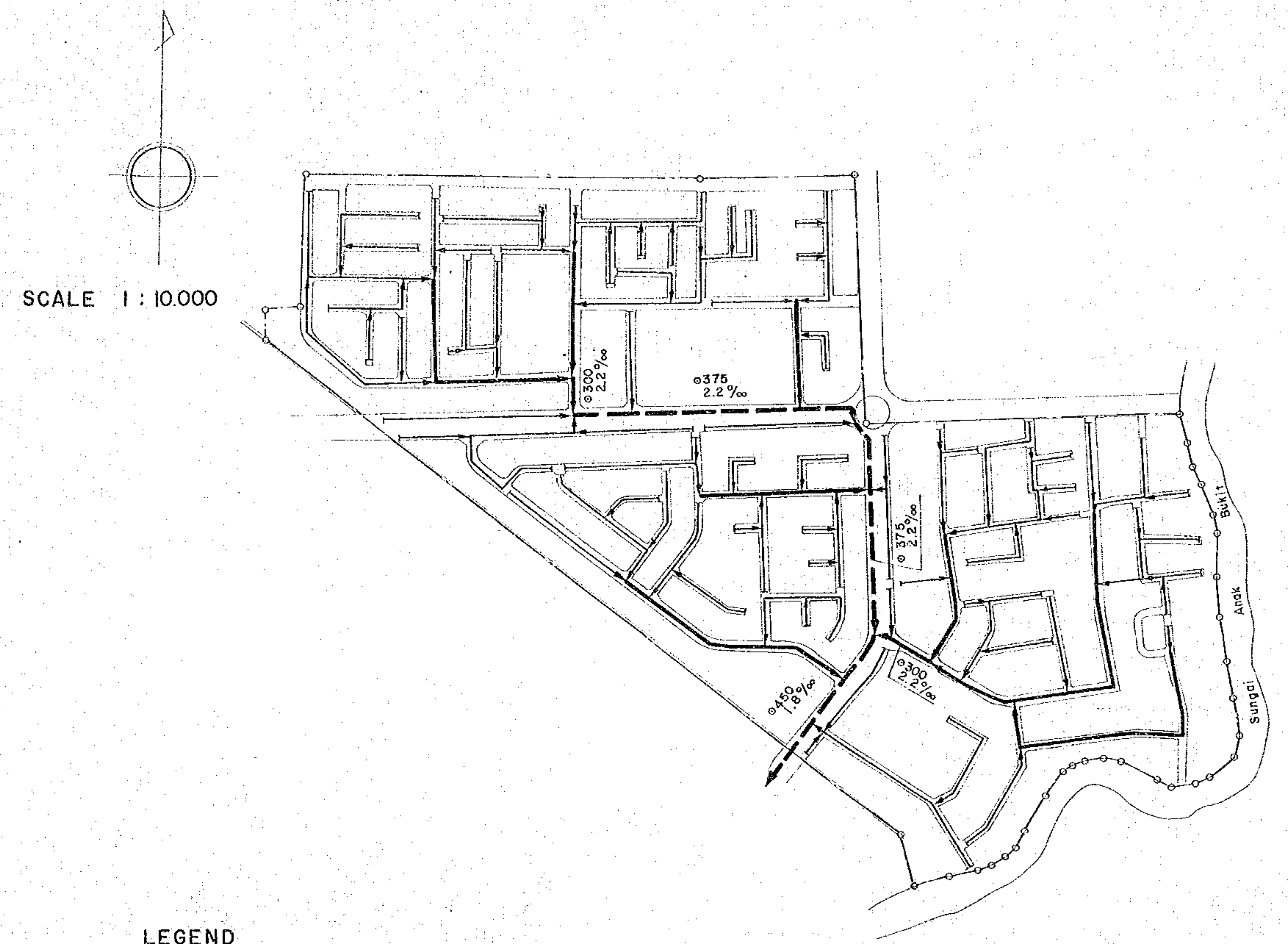
Note: (1) and (2) do not include public areas as well as new housing estates.

Similarly, based on Figure H-2, entire sewer lengths for branch and lateral sewers are measured in varying sizes in a typical existing housing development area as shown in Table H-3 with additional major items for further construction cost estimates as follow.

Table H-3 Unit Construction Cost for Branch/Lateral Sewers in Future Development Area

Total Area ... (1)		122.0 ha
Area of Open Space, School, Mosque, etc. ... (2)		15.9 ha
(1) - (2)		106.1 ha
Government Portion	Sewer Facilities	225-300 mm dia. Length: 3,225 m
	Sewer Length per ha	30 m/ha
	Construction Cost	M$1,035,225
	Construction Cost per ha	M$9,757/ha
Private Portion	Sewer Facilities	225 mm dia. Length: 13,475 m
	Sewer length per ha	127 m/ha
	Construction Cost	M$2,681,525
	Construction Cost per ha	M$25,273/ha

It should be noted that the construction cost for the branch sewers (shown in thick lines), connecting the branch/ lateral sewers (shown in thin lines) serving sectional areas to the trunk lines in Figure H-2, will be contributed by the Government, and the remaining cost for branch/lateral sewers are considered to be raised from direct beneficiaries. Here, these sectional areas with a range of 5 to 10 ha are assumed to be developed by developers based on a survey data obtained.



LEGEND

- Trunk sewer
- Branch & lateral sewer (Government contribution)
- Branch & lateral sewer (Private contribution)
- ⊙300 Sewer diameter (mm)
- 2.2 ‰ Slope

Note : Unless otherwise shown, all pipes are 225 mm in diameter.

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS	
SEWER LAYOUT PLAN IN TYPICAL HOUSING DEVELOPMENT AREA	FIGURE H-2

2. Proposed Financial Sources Construction Branch and Lateral Sewers in the Study Area

Table H-4 summarizes estimated total lengths of branch/ lateral sewers in both "urbanized/urbanizing areas" "future development areas" for each sewerage zone. Further, the same table provides construction costs to be contributed from the Government and Private sources.

Table H-4 Proposed Financial Sources Constructing Branch/ Lateral Sewers in the Study Area

(M$1,000 at 1979 Prive Level)

Name of Sewerage Sub-zone	Government Contribution			Private Contribution		
	Dia. (mm)	Length (mm)	Construction Cost	Dia. (mm)	Length (mm)	Construction Cost
A - 1	225-300	29,140	6,933	225	6,480	1,288
A - 2	225-300	20,820	5,768	225	42,040	8,365
B - 1	225-300	39,691	9,279	225	1,270	252
B - 2	225-300	20,900	2,863	225	35,790	7,121
B - 3	225-300	6,780	1,699	225	5,460	1,086
C - 1	225-300	18,460	4,374	225	3,300	657
C - 2	225-300	19,540	5,442	225	40,770	8,112
D - 1	225-300	36,450	8,569	225	3,300	657
D - 2	225-300	15,140	3,954	225	19,560	3,892
E	225-300	8,180	2,052	225	6,650	1,324
Total		215,100	50,933		164,620	33,754

APPENDIX I

SULFIDE CONTROL METHODS

1. Introduction

Hydrogen sulfide and other undesirable gases associated with the operation of sanitary sewers are produced in an anaerobic environment. Therefore, the key to their control is keeping the wastewater aerobic. It has been observed that the rate of hydrogen sulfide buildup is closely related to sludge accumulation in the sewer. In other words, a well-designed, self-cleansing sewers should have little trouble from hydrogen sulfide.

Hence, the following three methods are brought up for sulfide control.

a. Keep sufficient flow velocity to prevent sulfide buildup without special sulfide corrosion protection measures.

b. Use anti-sulfide corrosion pipe or lining pipe without special velocity control where sulfide buildup is expected.

c. Inject air to keep sewage aerobic without special considerations on flow velocity and pipe material.

2. Sulfide Controlling Velocities

The equation relating flow velocities to marginal EBOD (effective BOD) is:

$$\text{Marginal EBOD} = 787\ V^{3/4}\ b/P$$

where

$$\text{EBOD} = \text{BOD}_5 \times 1.07^{(T-20)},$$

T : temperature, °C
V : flow velocity, m/sec
b/P: surface width/wetted perimeter, dimention less

The BOD concentration of the sewage for the year 2000 has been estimated at 200 mg/l. Therefore, the equivalent EBOD for the year 2000, at a temperature of 27°C, will be

$$200 \times 1.07^{27-20} = 321\ \text{mg/l}$$

Sulfide control velocity curve for the year 2000 condition was then developed, as shown in Figure I-1.

If peaking factor is expresses as:

$$P.F. = \frac{5}{P^{1/7}}$$

Where P: Population (1,000 persons)

and population is estimated at 4,800 persons, the P.F. will be 4.0 That is, the daily average flow will be one fourth of peak flow in such areas which has population of 4,800. Because, for sanitary sewer, full pipe capacity of the design peak flow rate is provided, the pipe diameter for this population will be 300 mm. (Per capita sewage flow is estimated at 230 l/cap/day). This is the upper limit of VCP market size. The minimum design flow velocity should be determined at least on the basis of the daily average flow velocity of above pipe size. Hence, the minimum design flow velocity is determined at 75 cm/sec.

The Figure indicates that if the minimum design flow velocity is decided at 75 cm/sec, the sulfide generation will be controlled from 0.25 to 0.70 of peak design flow rate. The problem of sulfide control is much more severe during the initial year of service of sewer pipeline when flows are considerably less than future design flows. However, as shown in Figure I-1, it is impossible to keep the sulfide control velocity to meet all flow variations.

3. Anti-Corrosion Pipe

VCP, RCP, ACP, and Pitch Fibre Pipe are available in Malaysia. Among them VCP is the best pipe against sulfide corrosion. However, the available VCP market size is up to 300 mm in diameter, and larger sewers will be of concrete-bonded pipes, either centrifugally cast or cast in place, which are likely subject to sulfide attack.

Coatings and linings of acid-resistant materials, such as vinyl and epoxy resins, PVC sheet, and high alumina cement mortar, will be effective for protecting concrete pipes against the acid attack.

4. Air Injection to Sewer

This method is useful only in the force main.

5. Conclusions

In view of the above considerations especially for future operation and maintenance problems of the sewerage system, it is concluded that all sanitary sewers shall be so designed and constructed to give mean velocity, when flowing full or half-full, of not less than 60 cm/sec for VCP, and for RCP or any cement-bonded pipe the minimum design flow velocity should be 75 cm/sec, and suitable lining or coating pipes should be used.

Pomeroy-Davy Formula
for Marginal Effective BOD
Marginal EBOD = 787 $V^{4/3}$ b/P

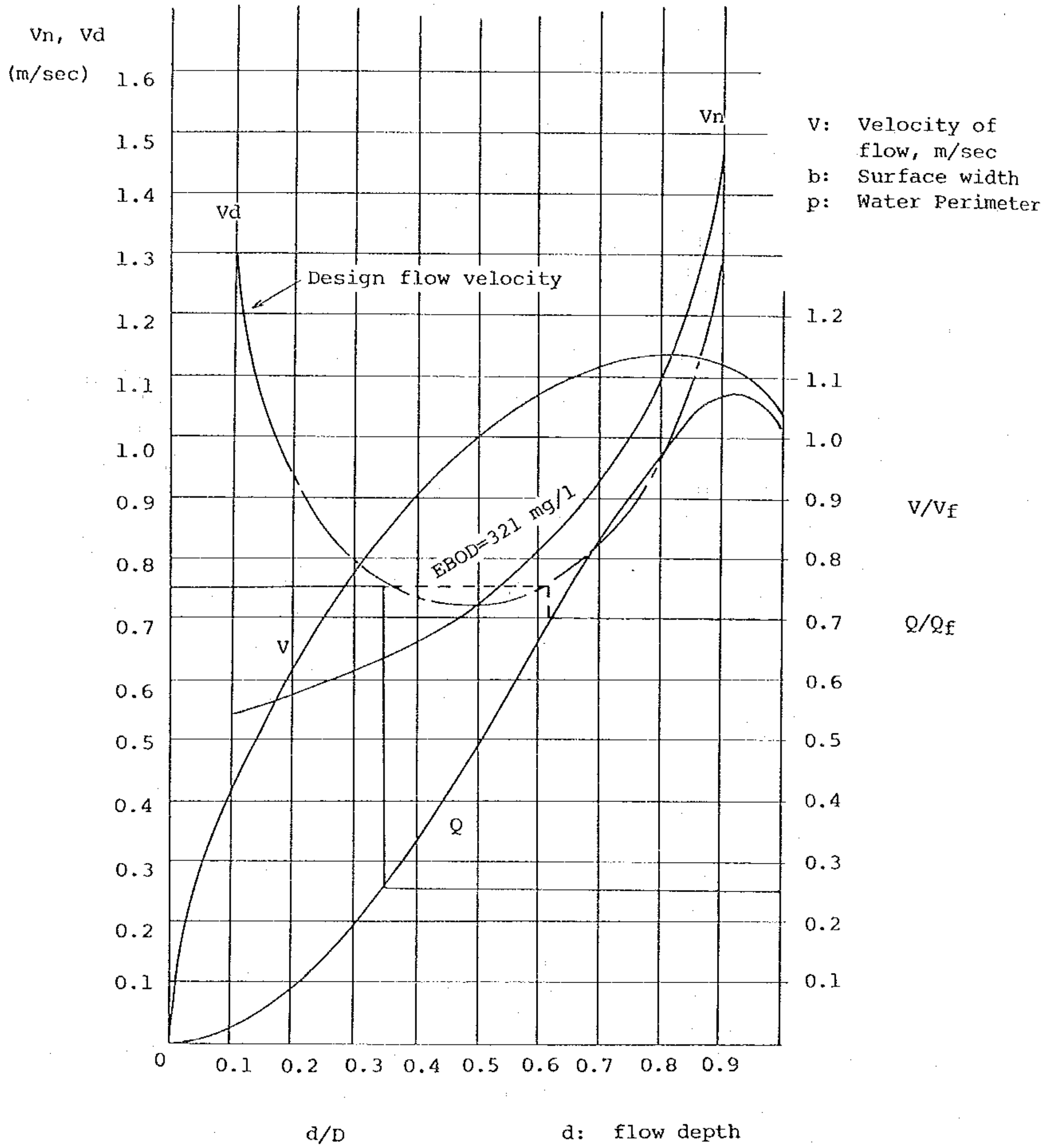


FIGURE I-1 Sulfide control velocity curve

APPENDIX J

STAGING CONSIDERATIONS

1. Introduction

The provision of a complete sewerage system for entire study Area with its large and expanding population, is a task of tremendous magnitude.

Therefore, it is necessary to build the required facilities in stages, according to the urgency of need and benefits to be derived. Staged construction will spread capital expenditure over an extended period of years, as well as saving interest on borrowed capital and reducing initial costs.

A study has, therefore, been made to determine the priority of work and the desirable stages of the sewerage sub-zones, taking into account the various important elements which affect sanitary conditions in the Study Area, applying a reasonable rating procedure.

2. Rating of Sanitary Conditions

2.1 Basic Consideration for Rating

The elements considered in the priority of sewerage sub-zones for implementation of sewerage construction up to the year 2000 include the following six items, each of which has impacts on environmental sanitation in the Study Area.

1) Population density

2) Development condition

3) Waste load generation aspect

4) Excreta disposal system

5) Flooding condition

6) Incidence of water borne diseases

Note: An evaluation item "availability of water supply" is not considered for this particular situation because the Study Area is almost uniformly served by the water supply system.

The above-mentioned six elements are assigned by the different evaluation points to reflect their relative importance to the sanitation, and each of the ten sewerage sub-zones, is evaluated carefully and graded according to the rating for each element for the purpose of establishing sewerage priority for implementation.

It is however noted that re-evaluation of these sewerage sub-zones should be made at the beginning of each stage reflecting urbanization of these areas, especially in the future development area.

2.2 Application of Rating System

For the purpose of rating system, a total of 1,000 points is assigned to each of the six major elements, according to order of importance, as described below.

(1) One of the most important factors is the number of persons

who will be benefited by the system. It is, therefore, particularly significant to provide sewerage facilities in high population density area, in order to gain the maximum benefit to the maximum population with the minimum expenditures thus making the benefit-cost ratio higher. Hence, highest point is assigned for the population density.

(2) Development Condition:

Development condition of the Study Area differs largely according to areas and land uses. The greater portion of the future development area lying periphery of the Study Area remains to be paddy field yet, thus unabling to provide sewerage system for the time being and in the immediate future.

(3) Waste load generation aspect:

Three hundred points is assigned to the extent of waste load generation. The waste load generated from the housing, commercial and industrial areas are generally discharged into drains and rivers without any treatment except septic tanks. It is, therefore, necessary to quantify the waste load in each of the sewerage zones to determine the urgency of the need of sewerage facilities.

(4) Excreta disposal system:

Since there is no sanitary sewerage system in the Study Area, except a few local systems, most of the excreta produced in the area is disposed of either septic tank, bucket pit privy or directly to waterways, causing water pollution at many places in the Area. The existing excreta disposal system is, therefore, analyzed as to the present excreta disposal.

(5) Flooding Condition:

Although the Government has undertaken improvement works for the existing rivers and drains, flooding has occurred frequently and caused substantial damage in the built-up areas. Sanitary conditions in these areas have been significantly deteriorated, which can only be improved by the provision of the sewerage system.

(6) Incidence of water-borne diseases:

Incidence of water-borne diseases, has also effected to sanitation conditions, but this is less critical than the above five elements, these giving the lowest points of 50.

In view of these factors, the six elements, all of which affect sanitary conditions, are given points arbitarily for the years 1979 and 2000 according to their importance for the rating.

The rating points are shown as followings:

		Point assigned
a)	Population density	300
b)	Development condition	200
c)	Waste load generated	300
d)	Excreta disposal system	100
e)	Floading condition	50
f)	Incidence of water-borne diseases	50
	Total	1000

Further applications on these factors are discussed in the following section.

2.2.1 Population Density

Population densities, both present and future, by sewerage sub-zones, range approximately from 6.8 to 125.1 persons per hectare, as presented in Table J-1 and Figures J-1 and-2. For purpose of rating, 150 points are given to both present and future population densities respectively:

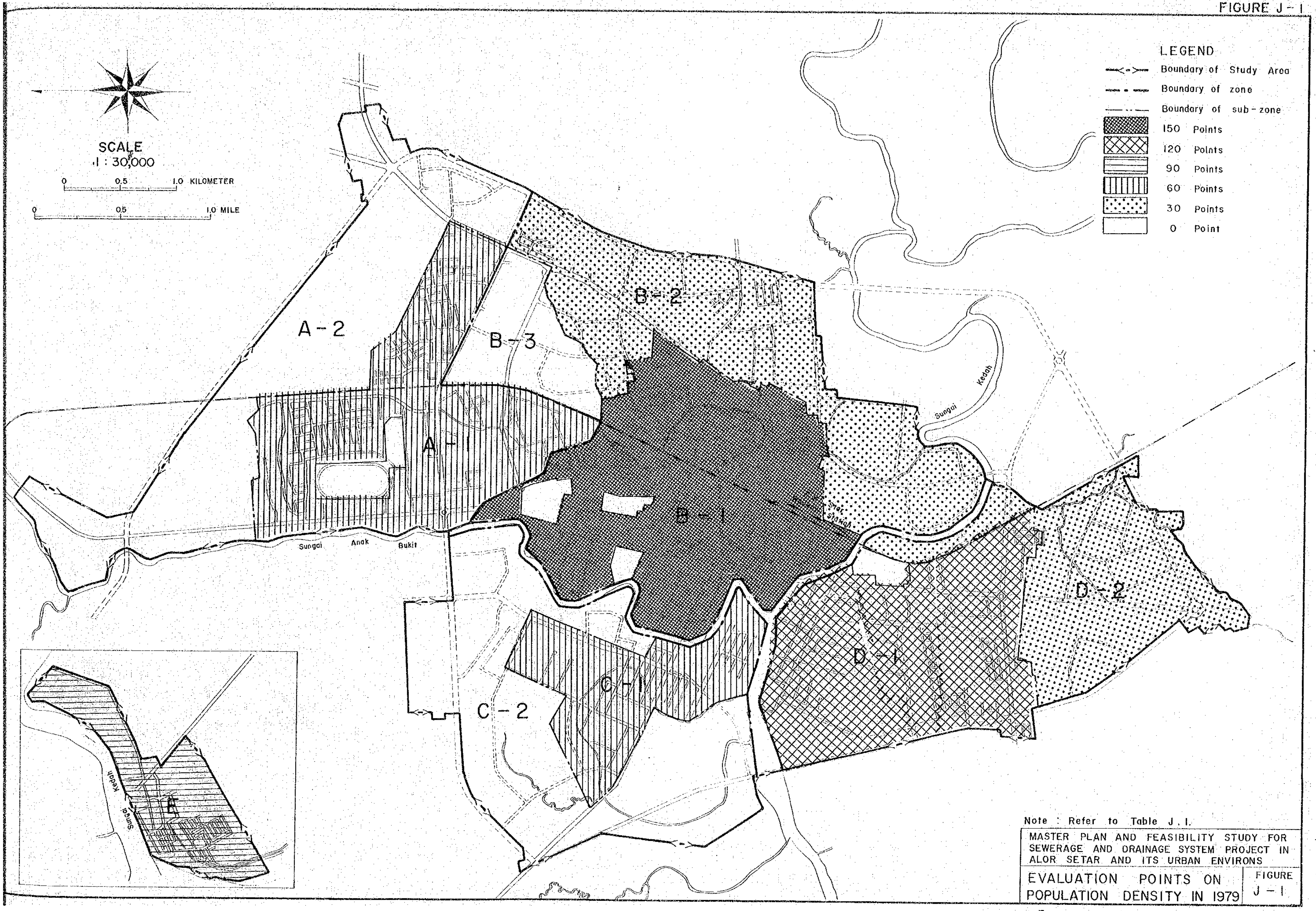
Assigned Point	Present Population Density (Persons/ha)	Future Pppulation Density (Persons/ha)
150	100 or more	120 or more
120	80 - 100	110 - 120
90	60 - 80	100 - 110
60	40 - 60	90 - 100
30	20 - 40	80 - 90
0	0 - 20	70 - 80

As shown in Table J-1, sub-zone B-1 gains 300 points, followed by sub-zone D-1 and Sub-zone C-1.

Table J-1 Evaluated Points for Population Density by Sewerage Sub-Zone

Sewerage Sub-Zone	Area * (ha)	1979		2000		Evaluated Points		
		Population (Persons)	Population Density (Persons/ha)	Population (Persons)	Population Density (Persons/ha)	1979	2000	Total
A - 1	356.3	15.112	42.4	29,674	83.3	60	30	90
A - 2	437.0	3,666	8.4	37,980	86.9	0	30	30
B - 1	433.3	45,629	105.3	54,210	125.1	150	150	300
B - 2	410.0	11,407	27.8	40,738	99.4	30	60	90
B - 3	102.0	1,243	12.2	11,148	109.3	0	90	90
C - 1	187.0	7,827	41.9	21,458	114.7	60	120	180
C - 2	427.0	2,897	6.8	33,684	48.9	0	0	0
D - 1	378.4	35,025	92.6	46,520	122.9	120	150	270
D - 2	270.0	7,689	28.5	29,952	110.9	30	120	150
E	125.0	9,105	72.8	12,936	103.5	90	90	180
Total	3,126.0	139,600	44.7	318,300	101.8			

Note:
* These figures do not include rivers, railways, parks and open spaces, etc.

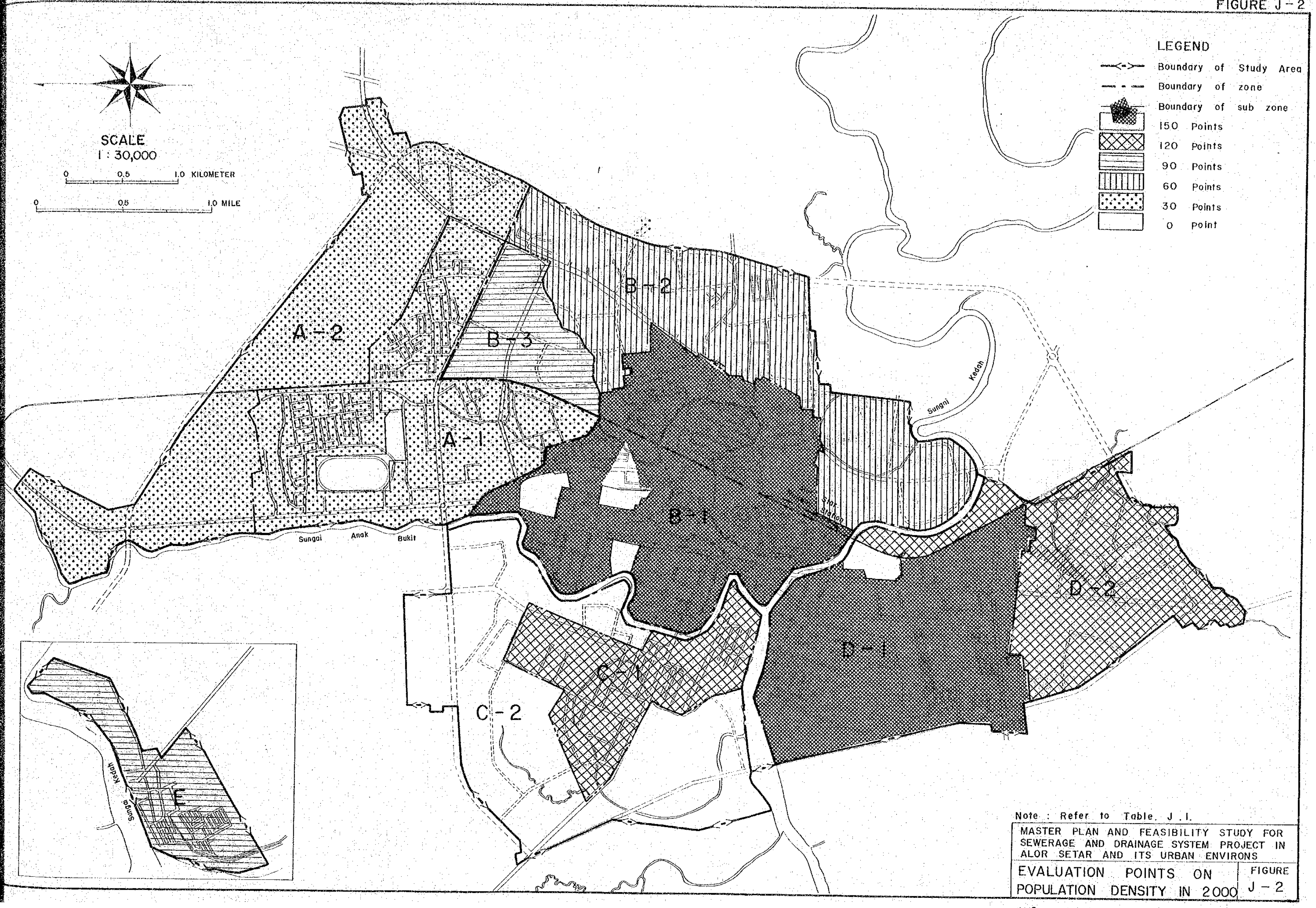


Note : Refer to Table J.1.

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

EVALUATION POINTS ON POPULATION DENSITY IN 1979

FIGURE J-1



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

EVALUATION POINTS ON POPULATION DENSITY IN 2000

FIGURE J - 2

2.2.2 Development Condition

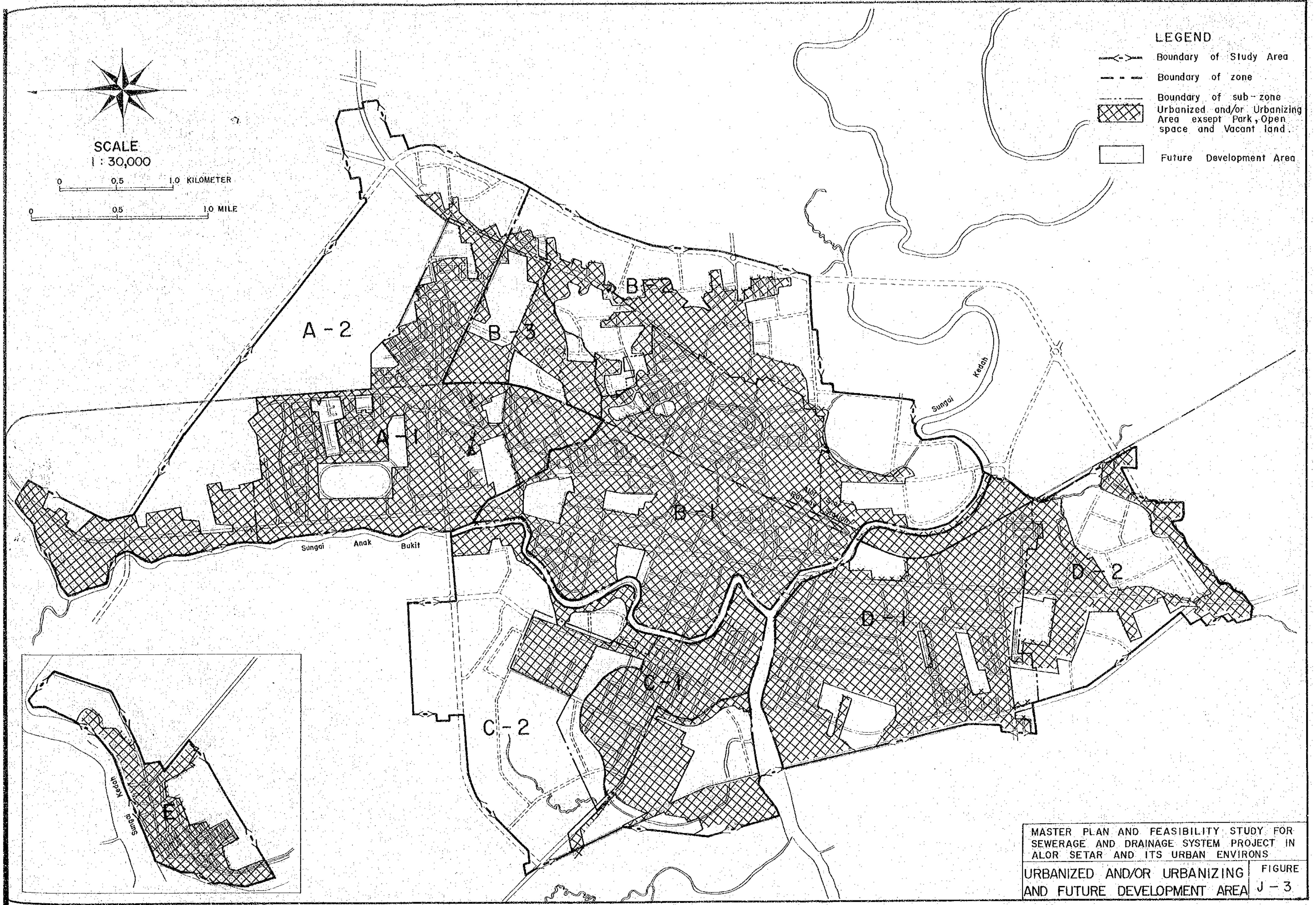
Evaluation is made for each sub-zone in terms of estimated percentage of estimated urbanization or industrialization for the coming two to three years as shown in Table J-2. Since the Study Area is assumed to be urbanized by 2000, evaluation for the year 2000 is not made.

Assigned Point	Percentage of Urbanization and Industrialization
200	80
150	60 - 80
100	40 - 60
50	20 - 40
0	0 - 20

Table J-2 Evaluated Points for Development by Sewerage Sub-Zone

Sewerage Sub-Zone	Area			Evaluated Points
	Total Area * (ha)	Developed and Developing Area (ha)	Ratio (%)	
A - 1	385	305	79	150
A - 2	437	106	24	50
B - 1	459	423	92	200
B - 2	410	127	31	50
B - 3	102	59	58	100
C - 1	187	161	86	200
C - 2	427	102	24	50
D - 1	388	352	91	200
D - 2	270	116	43	100
E	125	64	51	100
Total	3,190	1,815	57	

Note: * These figures do not include areas of rivers and railways.


LEGEND
Boundary of Study Area
Boundary of zone
Boundary of sub-zone
Urbanized and/or Urbanizing Area exsept Park, Open space and Vacant land.
Future Development Area
SCALE
1 : 30,000
0 0.5 1.0 KILOMETER
0 0.5 1.0 MILE
A-2
A-1
B-3
B-2
B-1
C-1
C-2
D-1
D-2
E
Sungai Anak Bukit
Sungai Kedah
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS
URBANIZED AND/OR URBANIZING AND FUTURE DEVELOPMENT AREA
FIGURE J - 3

2.2.3 Waste Load Generated

According to the investigation carried out in the Study Area, streams are generally polluted by the deposit of organic matters and industrial wastes, hence it is necessary to control the waste load discharging into waterways. For the purpose of rating, waste load originating in each sewerage sub-zone is estimated at per ha waste load generation basis both for 1979 (present) and 2000. Evaluated points are shown in Table J-3 and Figures J-4 and J-5.

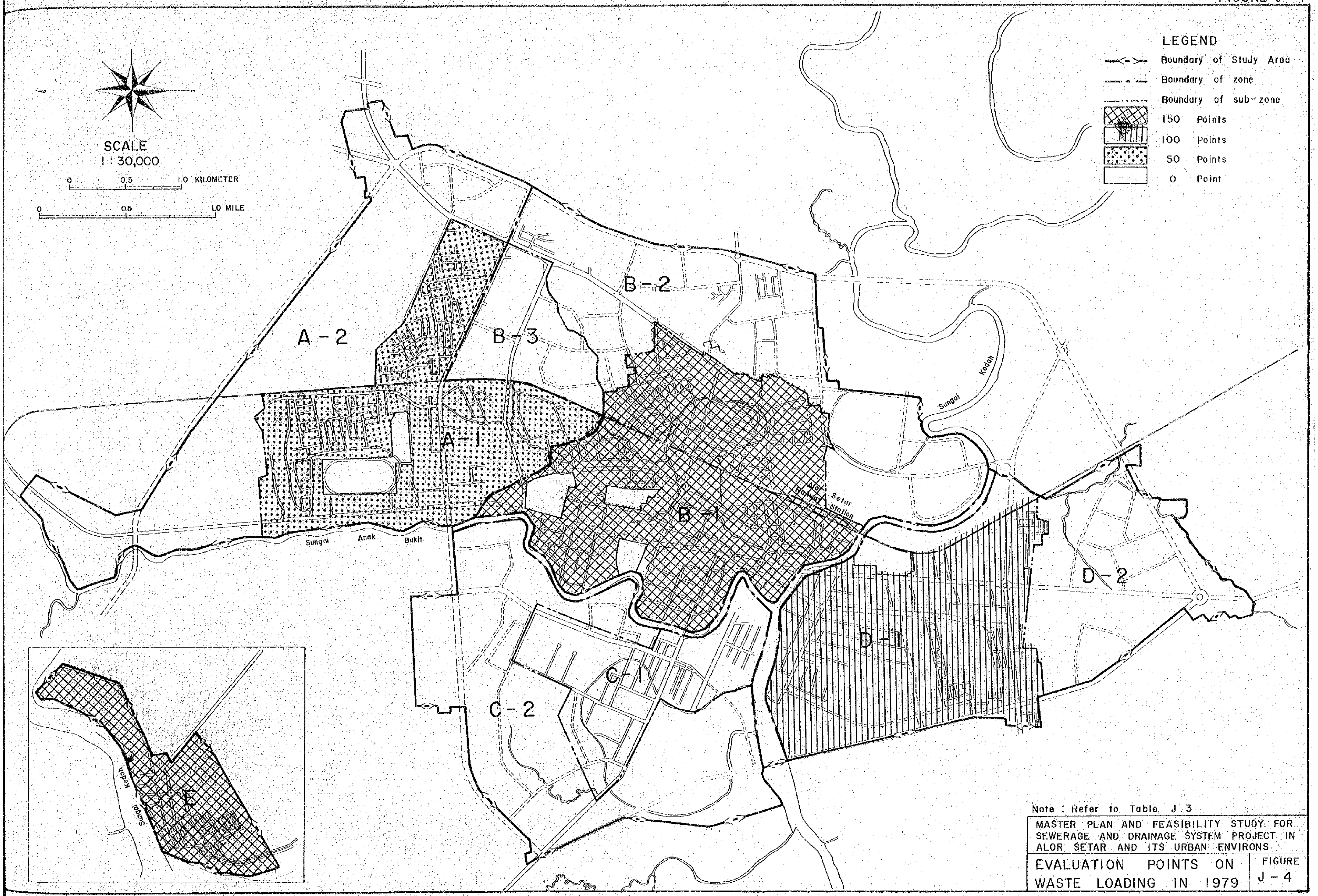
In this rating, a maximum of 300 points is assigned, 150 points each for 1979 and 2000 waste load generation rates of 6-8 kgBOD/d/ha and 8 or more kgBOD/d/ha respectively, and a minimum of 0 point in case 0-2 kgBOD/d/ha and 2-4 kgBOD/d/ha for 1979 and 2000 respectively as shown below:

Assigned Point	Waste Load Generated in 1979 (kg BOD/d/ha)	Waste Load Generated in 2000 (kg BOD/d/ha)
150	6 - 8	8 or more
100	4 - 6	6 - 8
50	2 - 4	4 - 6
0	0 - 2	2 - 4

Table J-3 Evaluated Points for Waste Load Generated by Sewerage Sub-Zone

Sewerage Sub-Zone	Area * (ha)	1979		2000		Evaluated Points		
		Waste Load (kg BOD/day)	Waste Load per ha (kg BOD/d/ha)	Waste Load (kg BOD/day)	Waste Load per ha (kg BOD/d/ha)	1979	2000	Total
A - 1	356.3	617.6	1.7	1,518.4	4.3	50	50	100
A - 2	437.0	130.6	0.3	1,759.2	4.0	0	50	50
B - 1	433.3	2,523.7	5.8	3,665.8	8.5	150	150	300
B - 2	410.0	409.7	1.0	1,912.8	4.7	0	50	50
B - 3	102.0	45.2	0.4	518.2	5.1	0	50	50
C - 1	187.0	254.1	1.4	585.6	3.1	0	0	0
C - 2	427.0	105.3	0.2	1,881.2	4.4	0	50	50
D - 1	378.4	1,444.6	3.8	2,530.8	6.7	100	100	200
D - 2	270.0	272.5	1.0	1,399.6	5.2	0	50	50
E	125.0	752.6	6.0	3,890.4	31.1	150	150	300
Total	3,126.0	6,324.6		19,662.0				

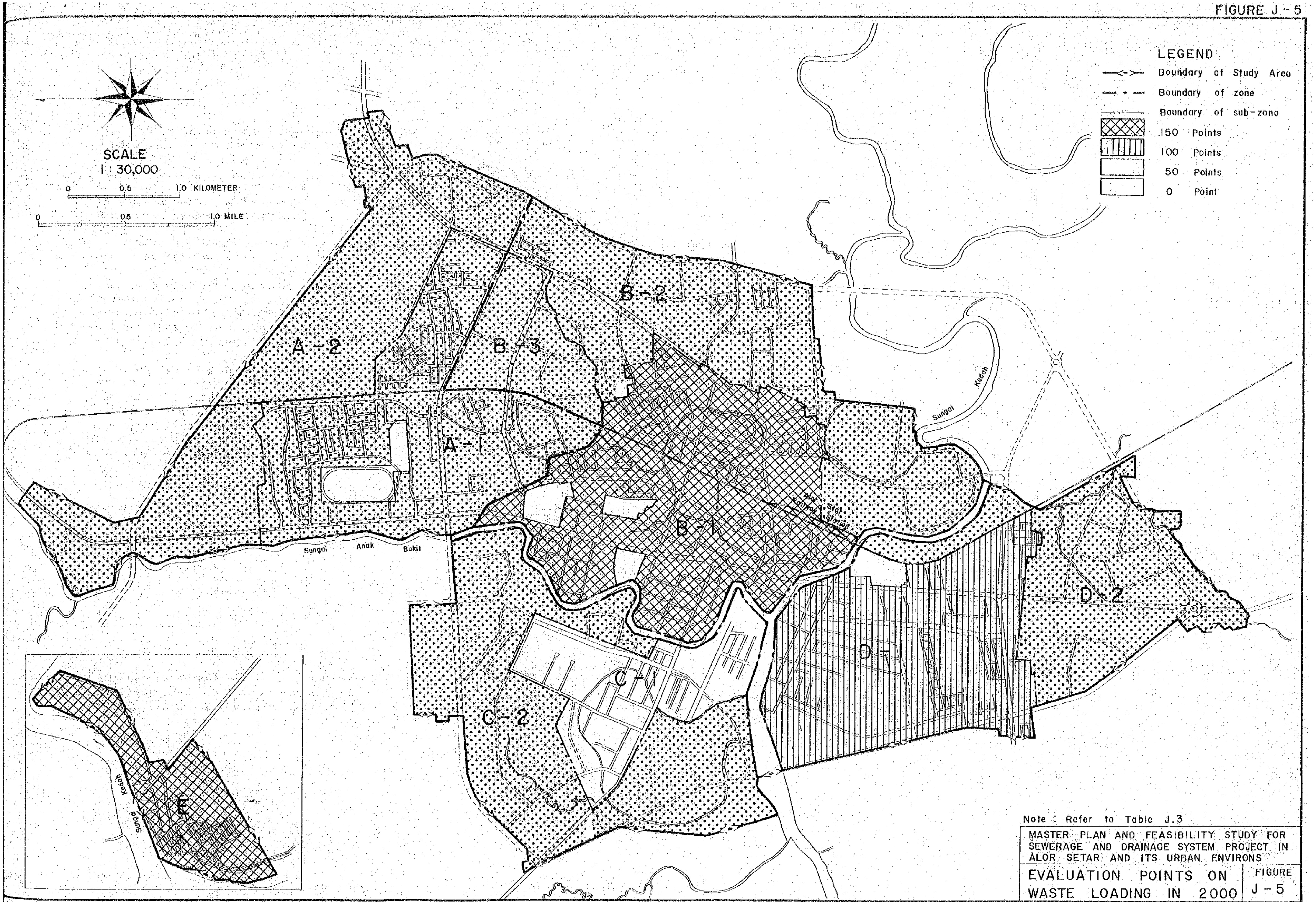
Note: * These figures do not include areas of rivers, railways, parks and open spaces, etc.



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

EVALUATION POINTS ON WASTE LOADING IN 1979

FIGURE J-4



Note : Refer to Table J.3

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

EVALUATION POINTS ON WASTE LOADING IN 2000

FIGURE J - 5