2.2.4 Excreta Disposal System

The existing excreta disposal system in the Study Area is represented by two systems, namely septic tank and bucket system. Most of the population in the new housing development areas use flush toilets with individual or communal septic tank and most of the population in the build-up areas are served by mixture of individual septic tanks and bucket systems, while rural population use bucket system dominantly.

Table J-4 shows estimated number of houses served either by bucket system or by various kinds of latrines (such as pit privy, over-river latrine, etc.) according to data in Section 8 in Chapter 3 with additional assumptions based on the field investigations. Assessment as to present excreta disposal situation is made considering the availability of bucket system and latrines which should be higher in priority to be replaced into sewerage system than septic tanks exist.

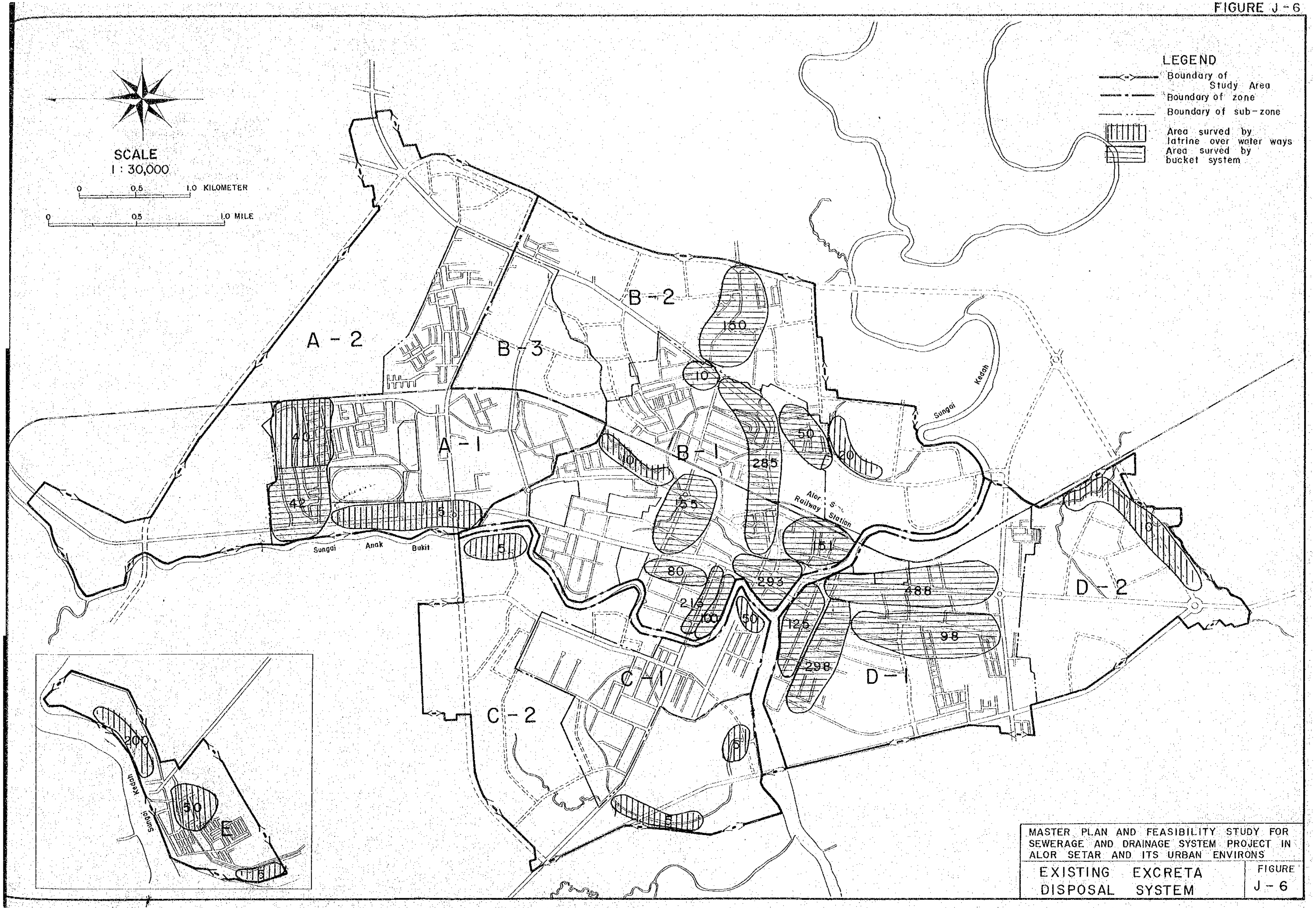
For the purpose of rating, a maximum of 100 points is assigned to sewerage sub-zones wherein more than 10 percent of households provided either bucket system or latrines, that is, the remaining 90 percent of households were provided with septic tanks, while a minimum of 0 point to sub-zones wherein less than five percent of households provided either bucket system or latrines as shown below:

Assigned Point	Households Served by Bucket System or Latrine (%)
100	10
50	5 - 10
0	0 - 5

Each sewerage sub-zone is evaluated as shown in Table J-4 and Figure J-6. B-1 comes top in priority as to excreta disposal aspect gaining 16.2 points, followed by D-1 and E.

Table J-4 Evaluated Points for Existing Excreta Disposal System by Sewerage Sub-Zone

Sub-Zone	Number of Houses	Bucket System including over-river latrine System		Evaluated Points
		Number	Ratio (%)	
A - 1	2,748	42	1.5	0
A - 2	667	45	6.7	50
B - 1	8,296	1,347	16.2	100
B - 2	2,074	170	8.2	50
B - 3	226	0	0	0
C - 1	1,423	50	3.5	0
C - 2	527	15	2.8	0
D - 1	6,368	1,009	15.8	100
D - 2	1,398	10	0.7	0
E	1,656	255	15.4	100
Total	25,383	2,938		



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

EXISTING EXCRETA DISPOSAL SYSTEM

FIGURE J - 6

2.2.5 Flooding Condition

As shown in Figure J-7, flooding occurs in the Study Area except in zone C. However, sewerage zones (or sub-zones) heavily affected by flooding are limited into three, namely B-1, D-1 and E. More than 20 percent of area in sub-zone B-1 and zone E is liable to flooding and more than 14 percent of area in sub-zone D-1.

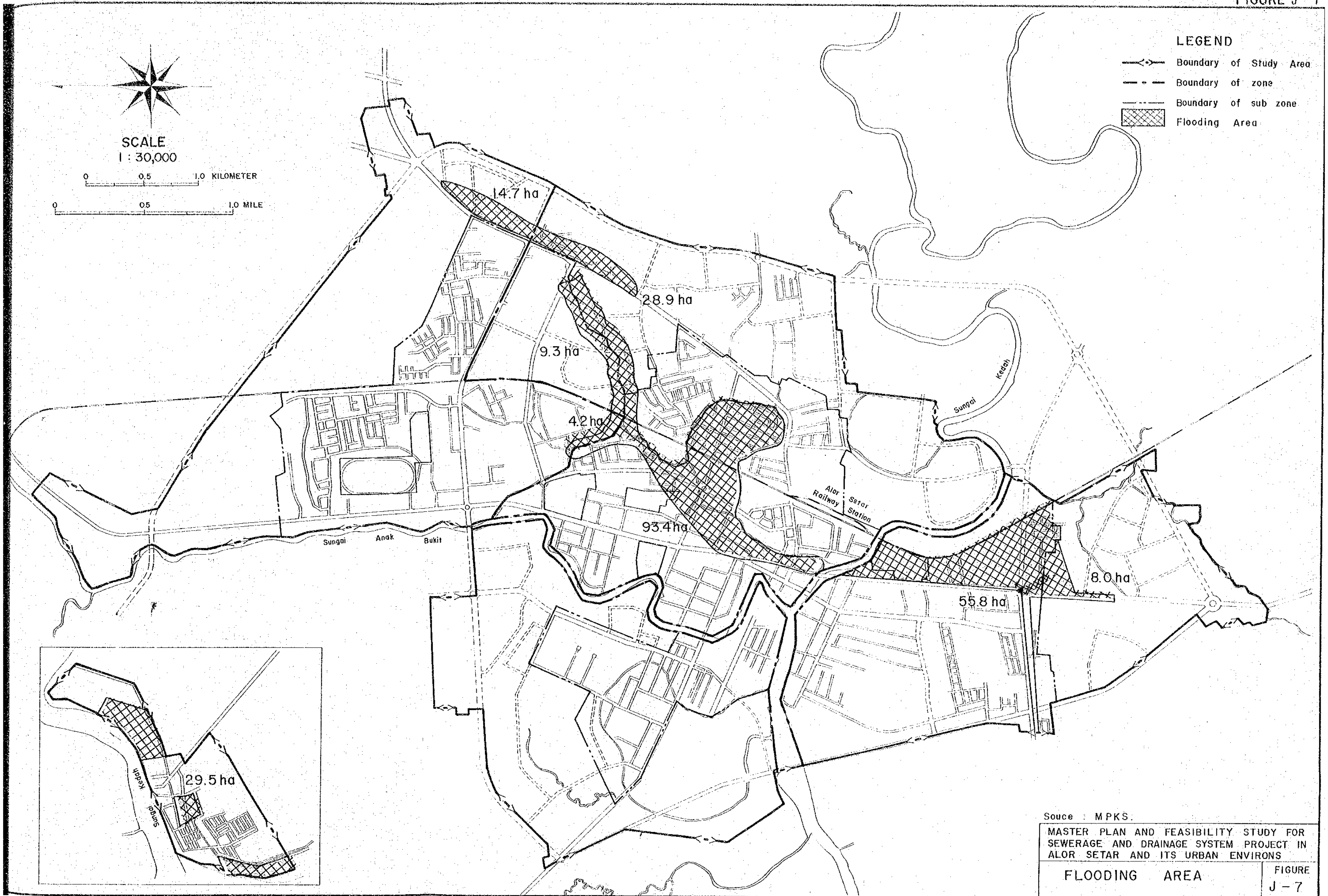
An assessment point for rating is given according to the extent of flooding in sewerage sub-zones as follows;

Assigned Point	Percentage Area Flooded
50	above 20
25	10 - 20
0	0 - 10

All sewerage sub-zones are evaluated based on the assessment points given in above table as resulted in Table J-5.

Tabel J-5 Evaluated Points in terms of Flooding

Sub - Zone	Area (ha)	Flooded Area (ha)	Ratio (%)	Evaluated Points
A - 1	385	4.2	1.1	0
A - 2	437	14.7	3.4	0
B - 1	459	93.4	20.3	50
B - 2	410	28.9	7.0	0
B - 3	102	9.3	9.1	0
C - 1	187	-	-	0
C - 2	427	-	-	0
D - 1	388	55.8	14.4	25
D - 2	270	8.0	3.0	0
E	125	29.5	23.6	50
Total	3,190	243.8		



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

FLOODING AREA	FIGURE J-7

2.2.6 Incidence of Water Borne Diseases

For the purpose of rating on incidence of water borne diseases, cholera cases are taken as the indicator.

Cholera patients recorded are listed below on the basis of Mukim (administrative unit) in Alor Setar Areas, including the Study Area ;

Mukim	Cholera Patient
Hutan Kampong	11
Anak Kukit	9
Alor Merah	2
Alor Malai	11
Kota Setar	19
Pumpong	7
Mergong	9
Pengkalan Kundor	25
Kuala Kedah	13
Total :	106

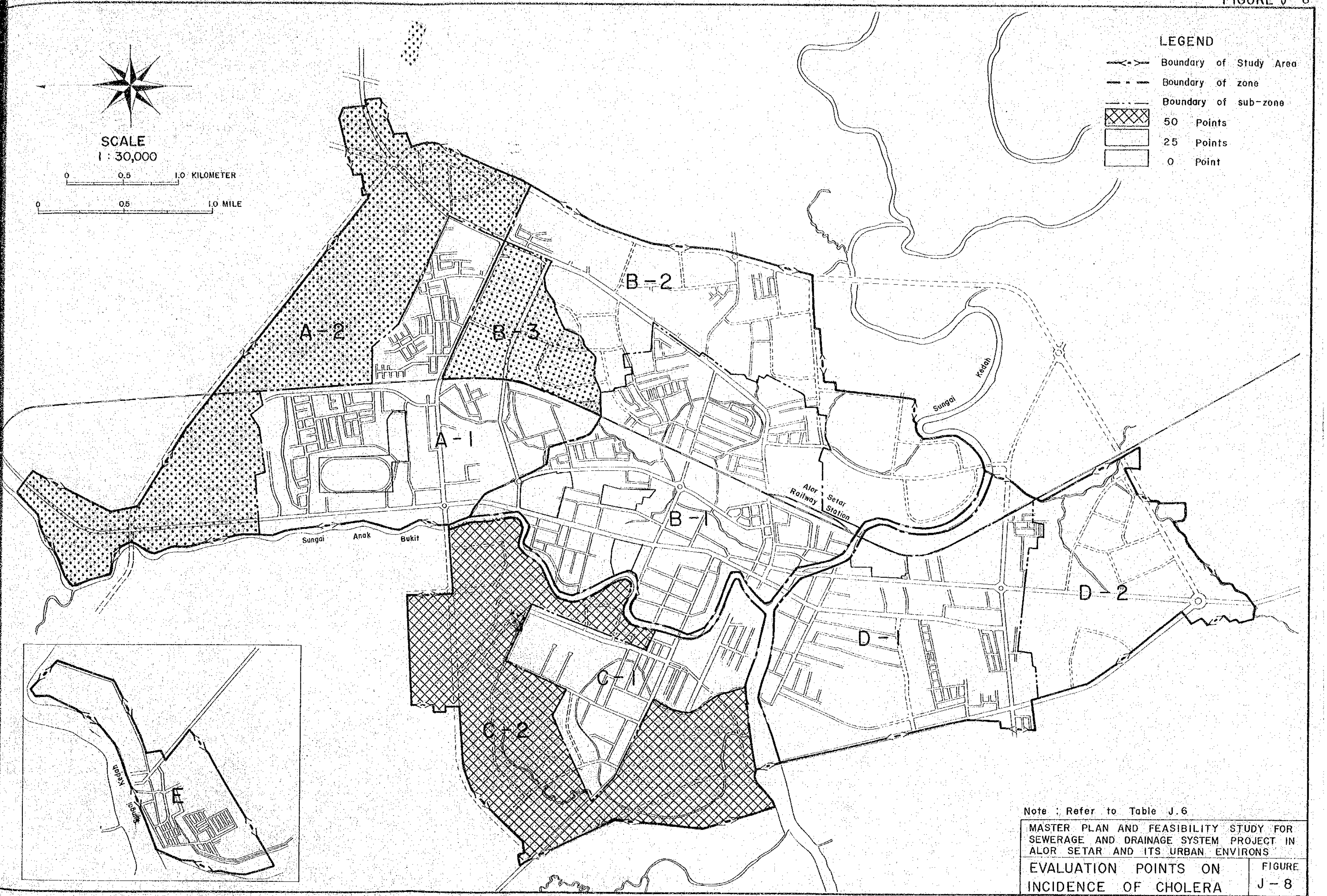
A maximum of 50 points are assigned and each of sewerage sub-zones are evaluated according to the level of incidence set out as follows :

Assessment Point	No. of Cholera Patient
50	More than 2
25	1 - 2
0	0 - 1

The result of the assessment for each of sewerage sub-zones are shown in Table J-6 and Figure J-8.

Table J-6 Evaluated Points for Distribution of Cholera Cases by Sewerage Sub-Zone

Sub-Zone	Population at 1979 (Persons)	Number of Cholera Patients	Ratio (Person/1,000 Perns)	Evaluated Points
A - 1	15,112	2	0.13	0
A - 2	3,666	5	1.36	25
B - 1	45,629	9	0.20	0
B - 2	11,407	10	0.88	0
B - 3	1,243	2	1.61	25
C - 1	7,827	1	0.13	0
C - 2	2,897	6	2.07	50
D - 1	35,025	3	0.09	0
D - 2	7,689	3	0.39	0
E	9,105	4	0.44	0
Total	139,600	45		


LEGEND
Boundary of Study Area
Boundary of zone
Boundary of sub-zone
50 Points
25 Points
0 Point
SCALE
1 : 30,000
0 0.5 1.0 KILOMETER
0 0.5 1.0 MILE
A-2
B-3
B-2
A-1
B-1
Sungai Anak Bukit
Alor Setar Railway Station
Sungai Kedah
C-1
C-2
D-1
D-2
E
Note : Refer to Table J.6
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS
EVALUATION POINTS ON INCIDENCE OF CHOLERA
FIGURE J-8

2.2.7 Overall Evaluated Points by Sewerage Sub-Zone

All assessment points for six major items are listed in Table J-7 and Figure J-9 according to sewerage sub-zones.

Table J-7 Overall Evaluated Points by Sub-Zone

Sub-Zone	Population Density	Urbanization	Waste Loading	Existing Excreta Disposal System	Flooded Area	Distribution of Water Borne Disease	Total
A - 1	90	150	100	0	0	0	340
A - 2	30	50	50	50	0	25	205
B - 1	300	200	300	100	50	0	950
B - 2	90	50	50	50	0	0	240
B - 3	90	100	50	0	0	25	265
C - 1	180	200	0	0	0	0	380
C - 2	0	50	50	0	0	50	150
D - 1	270	200	200	100	25	0	795
D - 2	150	100	50	0	0	0	300
E	180	100	300	100	50	0	730

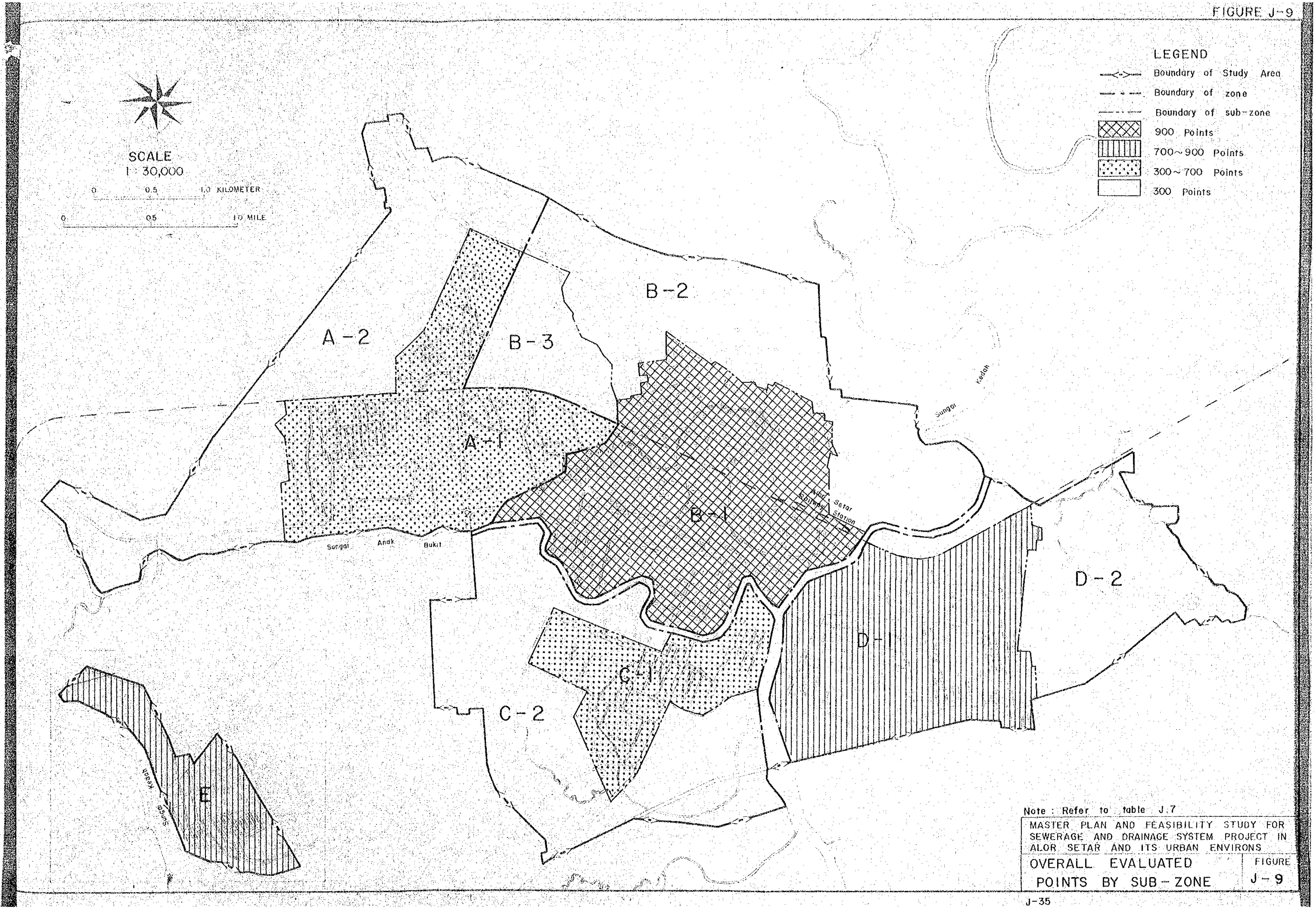


FIGURE J-9
LEGEND
Boundary of Study Area
Boundary of zone
Boundary of sub-zone
900 Points
700~900 Points
300~700 Points
300 Points
SCALE
1 : 30,000
0 0.5 1.0 KILOMETER
0 0.5 1.0 MILE
A-2
A-1
B-3
B-2
B-1
C-1
C-2
D-1
D-2
E
Sungai Anak Bukit
Sungai Kedah
Alor Setar Railway Station
Note : Refer to table J.7
MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN ALOR SETAR AND ITS URBAN ENVIRONS
OVERALL EVALUATED POINTS BY SUB-ZONE
FIGURE J-9

APPENDIX K

COMPUTATION FOR TRUNK SEWER DESIGN

Separate sewerage system proposed collects and conveys all wastewaters from residential, commercial and industrial areas to waste stabilization ponds provided at the terminal of the system.

The design sewage flows are calculated for the conditions in the year 2000, including extraneous flows such as groundwater infillration.

Sewer capacity has been determined using the design criteria as discussed in Section 5, Chapter 5, Sewerage Master Plan Report.

Hydraulic computations are shown in Table K-1 for the trunk sewers in every sewerage zone as shown in Figure 5-3 of the main report, applying the conveniently provided hydraulic computation chart in Table K-2 on the basis of Manning's Formula.

Table K-1

COMPUTATION FOR DESIGN OF TRUNK SEWERS

Zone A (1)

Line No.	Sewer Length (m)	Area		Population	Peak Flow			Peak Flow Total (m3/s)	Proposed Sewer								Remarks
		Increment (ha)	Total (ha)		Domestic (m3/s)	Industrial (m3/s)	Extraneous (m3/s)		Dia. (mm)	Slope of Sewer (%)	Full Velocity (m/sec)	Capacity (m3/s)	Sewer Invert Elevation Upper End (m)	Sewer Invert Elevation Lower End (m)	Elevation Ground Surface Upper End (m)	Elevation Ground Surface Lower End (m)	
1	630	40.66		3,486	0.039		0.003	0.042	300	2.2	0.65	0.047	0.787	-0.977	2.62	2.50	
2	690	16.57	57.23	4,905	0.052		0.004	0.056	375	2.2	0.75	0.086	-1.052	-2.570	2.50	3.11	
		to 5															
3	520	18.13		1,554	0.019		0.001	0.020	225	2.8	0.61	0.025	0.386	-2.436	2.14	3.06	
4	720	47.97	66.10	5,667	0.059		0.005	0.064	375	2.2	0.75	0.086	-2.586	-4.170	3.06	3.11	
5	200	2.16	125.49	10,759	0.102		0.009	0.111	450	1.8	0.77	0.126	-4.245	-4.605	3.11	3.05	
	to P, pumping station																
6	1220	21.54		1,847	0.023		0.002	0.025	225	2.8	0.61	0.025	0.646	-2.770	2.40	3.27	
P_2		0.00	21.54					0.024									
7	620	48.87	70.41	6,036	0.062		0.005	0.067	375	2.2	0.75	0.086	1.357	-0.007	3.27	3.64	
8	250	19.82	90.23	7,736	0.077		0.007	0.084	375	2.2	0.75	0.086	-0.007	-1.375	3.64	3.05	
P_1	0	28.07		20,901	0.180		0.018	0.198									
9	630	0.00		20,901	0.180		0.018	0.198	600	1.3	0.79	0.231	0.900	0.081	3.05	2.22	
10	570	28.07		23,307	0.198		0.020	0.218	600	1.3	0.79	0.231	0.066	-0.675	2.22	2.34	
		to 13															
11	640	41.80		3,584	0.040		0.003	0.043	300	2.2	0.65	0.047	0.407	-1.387	2.24	2.44	
12	980	46.02	87.82	7,529	0.075		0.006	0.081	375	2.2	0.75	0.086	-1.460	-3.616	2.44	2.34	
13	280	25.32	385.00	33,007	0.267		0.028	0.295	675	1.2	0.82	0.303	-3.916	-4.252	2.34	1.83	
14	720	27.10	412.10	35,379	0.283		0.030	0.313	750	1.1	0.85	0.385	-4.327	-5.119	1.83	1.73	
		to 28															
15	200	22.31		1,952	0.024		0.002	0.026	300	2.2	0.65	0.047	0.567	0.007	2.40	2.40	
16	1090	40.65	62.96	5,510	0.058		0.005	0.063	375	2.2	0.75	0.086	-0.068	-2.466	2.40	2.14	
17	550	42.64	105.60	9,241	0.090		0.008	0.098	450	1.8	0.77	0.126	-2.541	-3.531	2.14	2.25	
P_3	0	68.70	174.30	15,253	0.138		0.013	0.151									
18	830	0	174.30	15,253	0.138		0.013	0.151	375		1.34	0.153			2.25	2.68	force main
19	730	64.56	238.86	20,903	0.180		0.017	0.197	600	1.3	0.79	0.231	0.526	-0.423	2.68	1.73	
		to 28															
20	500	16.59		1,452	0.018		0.001	0.019	225	2.8	0.61	0.025	0.996	-0.404	2.75	2.75	
21	630	38.80	55.39	4,847	0.052		0.004	0.056	375	2.2	0.75	0.086	-0.554	-1.940	2.75	2.44	

Table K-1

Zone A (2) (continue)

COMPUTATION FOR DESIGN OF TRUNK SEWERS

Line No.	Sewer Length (m)	Area: Increment (ha)	Area: Total (ha)	Population	Peak Flow: Domestic (m3/s)	Peak Flow: Industrial (m3/s)	Peak Flow: Extraneous (m3/s)	Peak Flow Total (m3/s)	Proposed Sewer: Dia. (mm)	Slope of Sewer (‰)	Full Velocity (m/sec)	Capacity (m3/s)	Sewer Invert Elevation: Upper End (m)	Sewer Invert Elevation: Lower End (m)	Elevation Ground Surface: Upper End (m)	Elevation Ground Surface: Lower End (m)	Remarks
22	710	14.44	69.83	6,111	0.063		0.005	0.068	375	2.2	0.75	0.086	-1.940	-3.502	2.44	2.40	
		to P4															
23	530	23.05			0.023		0.002	0.025	300	2.2	0.65	0.047	0.407	-1.077	2.44	2.40	
24	700	42.99	66.04	5,779	0.060		0.005	0.065	375	2.2	0.75	0.086	-1.152	-2.692	2.40	2.40	
P4				11,890	0.111		0.010	0.121									
25	300		135.87	11,890	0.111		0.010	0.121	375		1.52	0.174			2.40	2.44	force main
26	400	28.83	164.70	14,413	0.131		0.012	0.143	525	1.5	0.78	0.174	0.365	-0.235	2.44	2.40	
27	600	6.34	171.04	14,968	0.135		0.013	0.148	525	1.5	0.78	0.174	-0.235	-1.935	2.40	1.73	
28	30	0.00	822.00	71,250	0.516		0.060	0.576	900	1.0	0.91	0.598	-5.269	-5.299	1.73	1.73	
		to treatment facilities															

Table K-1

<u>Zone B (1)</u> (continue)

COMPUTATION FOR DESIGN OF TRUNK SEWERS

Line No.	Sewer Length (m)	Area		Population	Peak Flow			Peak Flow Total	Proposed Sewer								Remarks
		Increment (ha)	Total (ha)		Domestic (m3/s)	Industrial (m3/s)	Extraneous (m3/s)	(m3/s)	Dia. (mm)	Slope of Sewer (%)	Full Velocity (m/sec)	Capacity (m3/s)	Sewer Invert Elevation Upper End (m)	Sewer Invert Elevation Lower End (m)	Elevation Ground Surface Upper End (m)	Elevation Ground Surface Lower End (m)	
1	500	11.65		2,023	0.024		0.001	0.025	225	2.8	0.61	0.025	1.086	-0.314	2.84	2.30	
2	310	17.87	29.52	5,125	0.054		0.002	0.056	375	2.2	0.75	0.086	-0.464	-1.146	2.30	2.28	
3	760	58.07	87.59	15,207	0.137		0.006	0.143	525	1.5	0.78	0.174	-1.296	-2.640	2.28	2.27	
		to 5															
4	1270	69.46		12,059	0.088		0.005	0.093	450	2.2	0.85	0.139	1.715	-1.079	3.71	2.27	
5	570	16.57	173.62	30,143	0.247		0.012	0.259	675	1.2	0.82	0.303	-2.790	-3.474	2.27	2.00	
		to 8															
6	610	19.61		3,405	0.038		0.001	0.039	300	2.2	0.65	0.047	1.360	-0.348	3.19	2.61	
7	860	44.85	64.46	11,192	0.106		0.004	0.110	450	1.8	0.77	0.126	-0.498	-2.046	2.61	2.00	
8	340	30.29	268.37	46,594	0.358		0.018	0.376	750	1.1	0.85	0.385	-3.549	-3.923	2.00	1.95	
P_1			268.37	46,594				0.376									
9	560	0.00	268.37	46,594	0.358		0.018	0.376	750	1.1	0.85	0.385	-3.923	-1.006	1.95	2.01	
		to 11															
10	450	30.77		5,342	0.053		0.002	0.055	375	2.2	0.75	0.086	0.467	-0.523	2.38	2.01	
11	370	0.95	300.09	52,102	0.394		0.020	0.414	900	1.0	0.91	0.598	-1.156	-1.526	2.01	2.03	
		to 14															
12	700	32.80		5,695	0.059		0.002	0.061	375	2.2	0.75	0.086	-0.133	-2.093	1.78	1.53	
13	350	9.68	42.48	7,375	0.074		0.003	0.077	375	2.2	0.75	0.086	-2.093	-2.863	1.53	2.03	
14	1100	50.14	392.71	66,995	0.489		0.027	0.516	900	1.0	0.91	0.598	-3.388	-4.488	2.03	1.40	
	to P4	pumping station															
15	1060	49.57		5,027	0.053		0.004	0.057	375	2.2	0.75	0.086	1.387	-0.945	3.30	2.98	
		to 19															
16	1060	26.51		2,689	0.031		0.002	0.033	300	2.2	0.65	0.047	0.567	-2.401	2.40	2.40	
		to 18															
17	870	30.57		3,100	0.035		0.002	0.037	300	2.2	0.65	0.047	0.697	-1.739	2.53	2.40	
18	520	11.36	68.44	6,941	0.070		0.005	0.075	375	2.2	0.75	0.086	-2.476	-3.620	2.40	2.98	
19	70	0.79	118.80	12,048	0.112		0.009	0.121	450	1.8	0.77	0.126	-3,695	-3.821	2.98	3.00	
	to P_3	pumping station															
20	950	31.53		3,483	0.039		0.002	0.041	300	2.2	0.65	0.047	1.827	-0.833	3.36	2.14	

Table K-1

Zone B (2) (continue)

COMPUTATION FOR DESIGN OF TRUNK SEWERS

Line No.	Sewer Length (m)	Area		Population	Peak Flow			Peak Flow Total (m3/s)	Proposed Sewer								Remarks
		Increment (ha)	Total (ha)		Domestic (m3/s)	Industrial (m3/s)	Extraneous (m3/s)		Dia. (mm)	Slope of Sewer (%)	Full Velocity (m/sec)	Capacity (m3/s)	Sewer Invert Elevation Upper End (m)	Sewer Invert Elevation Lower End (m)	Elevation Ground Surface Upper End (m)	Elevation Ground Surface Lower End (m)	
21	1190	70.47	102.00	11,268	0.106		0.007	0.113	450	1.8	0.77	0.126	-0.983	-3.125	2.14	2.40	
P2			102.00	11,268				0.113									
22	1010	27.23	129.23	14,029	0.128		0.009	0.137	525	1.5	0.78	0.174	0.625	-0.890	2.40	3.00	
P3		10.85	258.88	27,178	0.226		0.019	0.245									
23	330		258.83	27,178				0.245	450		1.52	0.294			3.00	3.03	force main
24	620	51.67	310.55	36,149	0.288		0.022	0.310	750	1.1	0.85	0.385	0.717	0.035	3.03	2.29	
		to 26															
25	1040	88.02		8,927	0.087		0.009	0.096	450	2.2	0.85	0.139	0.535	-1.753	2.53	2.29	
26	1170	31.06	429.63	50,469	0.384		0.031	0.415	900	1.0	0.91	0.598	-2.203	-3.373	2.29	1.40	
P4		55.77	485.4	123,120	0.824		0.062	0.886									
27	830	0.00	485.4	123,120				0.886	1050	1.0	1.01	0.899	-1.242	-2.722	1.40	2.40	
		to 30															
28	820	61.99		6,287	0.064		0.005	0.069	375	2.2	0.75	0.086	0.487	-1.809	2.40	2.04	
29	660	30.90	92.89	9,421	0.091		0.007	0.098	450	1.8	0.77	0.126	-2.059	-3.247	2.04	2.40	
30	890	0.00	971.00	132,541	0.878		0.068	0.946	1200	1.0	1.10	1.286	-3.997	-4.887	2.40	1.53	
P5																	
		to treatment facilities															

Table K-1

Zone - C (continue)

COMPUTATION FOR DESIGN OF TRUNK SEWERS

Line No.	Sewer Length (m)	Area		Popu- lation	Peak Flow			Peak Flow Total	Proposed Sewer								Remarks
		Increment (ha)	Total (ha)		Domes- tic (m3/s)	Indus- trial (m3/s)	Extra- neous (m3/s)	(m3/s)	Dia. (mm)	Slope of Sewer (%)	Full Velo- city (m/sec)	Capa- city (m3/s)	Sewer Invert Elevation Upper End (m)	Sewer Invert Elevation Lower End (m)	Elevation Ground Surface Upper End (m)	Elevation Ground Surface Lower End (m)	
1	850.00	58.05		4,255	0.046	0	0.004	0.050	375	2.2	0.75	0.086	0.487	-1.893	2.40	2.40	
2	750.00	68.23	126.28	9,257	0.090	0	0.009	0.099	450	1.8	0.77	0.126	-1.968	-3.318	2.40	2.82	
P_1		0.00	126.28	9,257	0.090	0	0.009	0.099									
3	1,340.00	72.53	198.81	13,646	0.125	0.057	0.013	0.195	600	1.3	0.79	0.231	0.966	-0.776	2.82	2.20	
		to P_3 Pumping Station															
4	720.00	28.92		1,477	0.019	0.023	0.002	0.044	300	2.2	0.65	0.047	-0.003	-2.019	1.83	0.84	
5	600.00	25.41	54.33	2,774	0.032	0.043	0.003	0.078	375	2.2	0.75	0.086	-2.094	-3.414	0.84	2.19	
		to 10															
6	570.00	44.88		3,290	0.037	0	0.003	0.040	375	2.2	0.75	0.086	-0.083	-1.679	1.83	2.40	
7	1,170,00	80.20	125.08	9,169	0.089	0	0.009	0.098	450	1.8	0.77	0.126	-1.754	-2.106	2.40	2.40	
P_2	0.00	19.40	144.48	10,591	0.101	0	0.010	0.111									
8	570.00	0.00	144.48	10,591	0.101	0	0.010	0.111	375		1.52	0.174			2.40	2.40	force main
9	670.00	37.91	182.40	12,938	0.119	0.008	0.013	0.140	525	1.5	0.78	0.174	0.635	-0.370	2.71	2.19	
10	270.00	18.31	255.03	16,793	0.149	0.051	0.017	0.217	600	1.3	0.79	0.231	-3.639	-3.990	2.19	1.68	
11	320.00	2.95	257.98	16,943	0.151	0.053	0.017	0.221	675	1.2	0.82	0.303	-4.065	-4.449	1.68	2.20	
P_3	0.00	15.36	472.15	31,375	0.255	0.114	0.031	0.400									
12	350.00	0.00	472.15	31,375	0.255	0.114	0.031	0.400	900	1.0	0.91	0.598	-0.278	-0.628	2.20	1.92	
		to 14															
13	900.00	33.86		1,729	0.021	0	0.002	0.023	300	2.2	0.65	0.047	-0.303	-2.823	1.53	1.92	
14	190.00	7.65	513.66	33,494	0.270	0.114	0.034	0.418	900	1.0	0.91	0.598	-3.423	-3.613	1.92	1.81	
15	730.00	30.28	543.94	35,713	0.270	0.114	0.036	0.420	900	1.0	0.91	0.598	-3.613	-4.343	1.81	3.71	
		to P_4 Pumping Station															
16	800.00	30.12		2,208	0.026	0.017	0.002	0.045	300	2.2	0.65	0.047	0.737	-1.503	2.57	2.12	
17	470.00	39.94	70.06	5,136	0.054	0.034	0.005	0.093	450	1.8	0.77	0.126	-1.653	-2.499	2.12	3.71	
P_4	0.00	0.00	614.00	40,849	0.3200	0.148	0.041	0.509									
18	350.00	0.00	614.00	40,849	0.3200	0.148	0.041	0.509	675		1.50	0.553			3.71	1.51	force main
		to Treatment facilities															

Table K-1

COMPUTATION FOR DESIGN OF TRUNK SEWERS

Zone - D (continue)

Line No.	Sewer Length (m)	Area		Population	Peak Flow			Peak Flow Total (m3/s)	Proposed Sewer								Remarks
		Increment (ha)	Total (ha)		Domestic (m3/s)	Industrial (m3/s)	Extraneous (m3/s)		Dia. (mm)	Slope of Sewer (%)	Full Velocity (m/sec)	Capacity (m3/s)	Sewer Invert Elevation Upper End (m)	Sewer Invert Elevation Lower End (m)	Elevation Ground Surface Upper End (m)	Elevation Ground Surface Lower End (m)	
1	930	61.72		8,751	0.085		0.004	0.089	450	2.4	0.89	0.146	-0.775	-3.007	1.22	2.12	
2	730	18.42	80.14	11,363	0.107		0.006	0.113	450	1.8	0.77	0.126	-3.007	-4.321	2.12	2.13	
		to 5															
3	930	68.27		9,680	0.093		0.005	0.098	450	2.8	0.96	0.157	-0.456	-3.069	1.53	1.53	
4	730	46.24	114.51	16,237	0.146		0.008	0.154	525	1.5	0.78	0.174	-3.144	-4.239	1.53	2.13	
5	80	1.39	196.04	27,797	0.230		0.014	0.244	675	1.2	0.82	0.303	-4.546	-4.642	2.13	2.04	
		to P_1															
6	1130	45.72		6,483	0.066		0.003	0.069	375	2.2	0.75	0.086	0.817	-2.347	2.73	2.04	
P_1		0.00	241.76	34,279	0.275		0.017	0.292									
7	400	0.00	241.76	34,279				0.292	450		1.52	0.249			2.04	2.36	force main
8	830	104.45	346.21	49,089	0.375		0.025	0.400	900	1.1	0.91	0.598	-0.118	-1.861	2.36	3.04	
9	700	41.79	388.00	55,015	0.413		0.028	0.441	900	1.1	0.91	0.598	-1.861	-2.631	3.04	1.53	
		to 11															
10	1340	19.19		2,162	0.026		0.001	0.027	300	2.2	0.65	0.047	-0.303	-4,055	1.53	1.53	
11	280	7.45	414.64	55,015	0.432		0.029	0.461	900	1.1	0.91	0.598	-4.655	-4.963	1.53	1.83	
P_2		0.00	414.64	55,015				0.461									
12	1480	0.00	414.64	55,015				0.461	600		1.63	0.476			1.83	1.83	force main
		to treatment facilities															
13	1050	55.72		6,279	0.064		0.004	0.068	375	2.2	0.75	0.086	0.487	-2.887	2.40	2.14	
14	1560	78.94	134.66	15,175	0.137		0.010	0.147	525	1.5	0.78	0.174	-3.037	-5.377	2.14	2.40	
		to P_3															
15	730	61.83		6,968	0.070		0.005	0.075	375	2.2	0.75	0.086	0.227	-1.817	2.14	2.40	
16	880	46.87	108.70	12,000	0.112		0.008	0.120	450	1.8	0.77	0.126	-1.892	-3.476	2.40	2.40	
P_3		0.00	243.36	27,424	0.227		0.018	0.245									
17	1500			27,424				0.245	450		1.52	0.249			2.40	1.83	force main
	to treatment facilities																

Table K-1

Zone - E (continue)

COMPUTATION FOR DESIGN OF TRUNK SEWERS

Line No.	Sewer Length (m)	Area Increment (ha)	Area Total (ha)	Population	Peak Flow Domestic (m3/s)	Peak Flow Industrial (m3/s)	Peak Flow Extraneous (m3/s)	Peak Flow Total (m3/s)	Proposed Sewer Dia. (mm)	Slope of Sewer (%)	Full Velocity (m/sec)	Capacity (m3/s)	Sewer Invert Elevation Upper End (m)	Sewer Invert Elevation Lower End (m)	Elevation Ground Surface Upper End (m)	Elevation Ground Surface Lower End (m)	Remarks
1	340.00	6.53		0	0	0.019	0.001	0.020	225	2.8	0.61	0.025	0.646	-0.306	2.40	2.40	
2	490.00	12.23	18.76	0	0	0.054	0.001	0.055	375	2.2	0.75	0.086	-0.456	-1.534	2.40	2.40	
3	700.00	16.88	35.64	2,668	0.031	0.054	0.002	0.087	450	1.8	0.77	0.126	-1.609	-2.869	2.40	1.90	
4	250.00	8.76	44.40	4,052	0.044	0.054	0.003	0.101	450	1.8	0.77	0.126	-2.869	-3.319	1.90	2.40	
		to 6															
5	700.00	18.98		3,000	0.034	0	0.001	0.035	300	2.2	0.65	0.047	0.237	-1.723	2.07	2.40	
6	450.00	9.02	72.40	8,478	0.083	0.054	0.005	0.142	525	1.5	0.78	0.174	-3.394	-4.069	2.40	2.40	
		to 9															
7	500.00	29.86		4,719	0.050	0	0.002	0.052	375	2.2	0.75	0.086	0.037	-1.363	1.95	2.40	
8	620.00	16.62	46.48	7,346	0.074	0	0.003	0.077	375	2.2	0.75	0.086	-1.363	-2.727	2.40	2.40	
9	330.00	6.12	125.00	16,791	0.149	0.054	0.008	0.211	600	1.3	0.79	0.231	-4.144	-4.573	2.40	2.40	
		to Treatment facilities															

Table K-2

Chart of Manning's Formula for Circular Pipes, N=0.013

Dia. of Sewer (m)	0.153 (150)*		0.229 (225)*		0.304 (300)*		0.381 (375)*		0.457 (450)*		0.534 (525)*		0.610 (600)*	
Sectional Area (m^2)	0.018		0.041		0.073		0.114		0.164		0.224		0.292	
Wetted Perimeter (m)	0.481		0.719		0.955		1.197		1.436		1.678		1.916	
Hydraulic Radius (m)	0.038		0.057		0.076		0.095		0.114		0.133		0.152	
Slope of Sewer (0/00)	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
14.0	1.033	0.019	1.352	0.056	1.633	0.119	1.898	0.216	2.143	0.352	2.377	0.532	2.598	0.759
13.0	0.996	0.018	1.303	0.054	1.574	0.114	1.829	0.209	2.065	0.339	2.291	0.513	2.503	0.732
12.0	0.957	0.018	1.252	0.052	1.512	0.110	1.757	0.200	1.984	0.325	2.201	0.493	2.405	0.703
11.0	0.916	0.017	1.198	0.049	1.448	0.105	1.683	0.192	1.900	0.312	2.107	0.472	2.303	0.673
10.0	0.873	0.016	1.143	0.047	1.380	0.100	1.604	0.183	1.811	0.297	2.009	0.450	2.196	0.642
9.0	0.828	0.015	1.084	0.045	1.309	0.095	1.522	0.174	1.718	0.282	1.906	0.427	2.083	0.609
8.5	0.805	0.015	1.053	0.043	1.272	0.092	1.479	0.169	1.670	0.274	1.852	0.415	2.024	0.592
8.0	0.781	0.014	1.022	0.042	1.234	0.090	1.435	0.164	1.620	0.266	1.797	0.402	1.964	0.574
7.5	0.756	0.014	0.990	0.041	1.195	0.087	1.389	0.158	1.569	0.257	1.740	0.390	1.902	0.556
7.0	0.731	0.013	0.956	0.039	1.155	0.084	1.342	0.153	1.515	0.249	1.681	0.377	1.837	0.537
6.5	0.704	0.013	0.921	0.038	1.113	0.081	1.293	0.147	1.460	0.240	1.620	0.363	1.770	0.517
6.0	0.676	0.012	0.885	0.036	1.069	0.078	1.243	0.142	1.403	0.230	1.556	0.349	1.701	0.497
5.5	0.648	0.012	0.847	0.035	1.024	0.074	1.190	0.136	1.343	0.220	1.490	0.334	1.628	0.476
5.0	0.617	0.011	0.808	0.033	0.976	0.071	1.134	0.129	1.281	0.210	1.421	0.318	1.553	0.454
4.5	0.586	0.011	0.767	0.032	0.926	0.067	1.076	0.123	1.215	0.199	1.348	0.302	1.473	0.430
4.0	0.552	0.010	0.723	0.030	0.873	0.063	1.015	0.116	1.145	0.188	1.271	0.285	1.389	0.406
3.5	0.517	0.009	0.676	0.028	0.817	0.059	0.949	0.108	1.072	0.176	1.189	0.266	1.299	0.380
3.0	0.478	0.009	0.626	0.026	0.756	0.055	0.879	0.100	0.992	0.163	1.101	0.246	1.203	0.351
2.8	0.462	0.008	0.605	0.025	0.730	0.053	0.849	0.097	0.958	0.157	1.063	0.238	1.162	0.340
2.6	0.445	0.008	0.583	0.024	0.704	0.051	0.818	0.093	0.924	0.151	1.025	0.229	1.120	0.327
2.5	0.437	0.008	0.571	0.024	0.690	0.050	0.802	0.091	0.906	0.149	1.005	0.225	1.098	0.321
2.4	0.428	0.008	0.560	0.023	0.676	0.049	0.786	0.090	0.887	0.146	0.984	0.220	1.076	0.314
2.2	0.410	0.008	0.536	0.022	0.647	0.047	0.753	0.086	0.850	0.139	0.942	0.211	1.030	0.301
2.0	0.391	0.007	0.511	0.021	0.617	0.045	0.717	0.082	0.810	0.133	0.899	0.201	0.982	0.287
1.9	0.381	0.007	0.498	0.021	0.602	0.044	0.699	0.080	0.789	0.129	0.876	0.196	0.957	0.280

Note: V: Full Velocity (m/s)
Q: Full Capacity (m^3/s)

- continue -

Table K-2 (continue)

Dia. of Sewer (m)	0.153 (150)*		0.229 (225)*		0.304 (300)*		0.381 (375)*		0.457 (450)*		0.534 (525)*		0.610 (600)*	
Sectional Area (m^2)	0.018		0.041		0.073		0.114		0.164		0.224		0.292	
Wetted Perimeter (m)	0.481		0.719		0.955		1.197		1.436		1.678		1.916	
Hydraulic Radius (m)	0.038		0.057		0.076		0.095		0.114		0.133		0.152	
Slope of Sewer (0/00)	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
1.8	0.370	0.007	0.485	0.020	0.586	0.043	0.681	0.078	0.768	0.126	0.852	0.191	0.932	0.272
1.7	0.360	0.007	0.471	0.019	0.569	0.041	0.661	0.075	0.747	0.122	0.828	0.186	0.905	0.265
1.6	0.349	0.006	0.457	0.019	0.552	0.040	0.642	0.073	0.724	0.119	0.804	0.180	0.878	0.257
1.5	0.338	0.006	0.443	0.018	0.535	0.039	0.621	0.071	0.701	0.115	0.778	0.174	0.850	0.249
1.4	0.327	0.006	0.428	0.018	0.516	0.037	0.600	0.068	0.678	0.111	0.752	0.168	0.822	0.240
1.3	0.315	0.006	0.412	0.017	0.498	0.036	0.578	0.066	0.653	0.107	0.724	0.162	0.792	0.231
1.2	0.303	0.006	0.396	0.016	0.478	0.035	0.556	0.063	0.627	0.103	0.699	0.156	0.761	0.222
1.1	0.290	0.005	0.379	0.016	0.458	0.033	0.532	0.061	0.601	0.099	0.666	0.149	0.728	0.213
1.0	0.276	0.005	0.361	0.015	0.436	0.032	0.507	0.058	0.573	0.094	0.635	0.142	0.694	0.203
0.9	0.262	0.005	0.343	0.014	0.414	0.030	0.481	0.055	0.543	0.089	0.603	0.135	0.659	0.193
0.8	0.247	0.005	0.323	0.013	0.390	0.028	0.454	0.052	0.512	0.084	0.568	0.127	0.621	0.181
0.7	0.231	0.004	0.302	0.012	0.365	0.027	0.424	0.048	0.479	0.079	0.532	0.119	0.581	0.170
0.6	9.214	0.004	0.280	0.012	0.338	0.025	0.393	0.045	0.444	0.073	0.492	0.110	0.538	0.157
0.5	0.195	0.004	0.256	0.011	0.309	0.022	0.359	0.041	0.405	0.066	0.449	0.101	0.491	0.143
0.4	0.175	0.003	0.229	0.009	0.276	0.020	0.321	0.037	0.362	0.059	0.402	0.090	0.439	0.128

Note: V: Full Velocity (m/s)
Q: Full Capacity (m^3/s)

- continue -

Table K-2 (continue)

Dia. of Sewer (m)	0.685 (675)*		0.762 (750)*		0.838 (825)*		0.915 (900)*		1.066 (1,050)*		1.219 (1,200)*		1.372 (1,850)*	
Sectional Area (m^2)	0.369		0.456		0.552		0.658		0.892		1.167		1.478	
Wetted Perimeter (m)	2.152		2.394		2.633		2.875		3.349		3.830		4.310	
Hydraulic Radius (m)	0.171		0.191		0.210		0.229		0.266		0.305		0.343	
Slope of Sewer (0/00)	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
14.0	2.807	1.034	3.013	1.374	3.211	1.771	3.404	2.239	3.769	3.364	4.122	4.810	4.460	6.593
13.0	2.705	0.997	2.904	1.324	3.094	1.706	3.280	2.157	3.632	3.242	3.972	4.635	4.298	6.354
12.0	2.599	0.958	2.790	1.272	2.972	1.639	3.152	2.072	3.490	3.114	3.816	4.454	4.129	6.104
11.0	2.488	0.917	2.671	1.218	2.846	1.570	3.018	1.984	3.341	2.982	3.654	4.264	3.953	5.844
10.0	2.372	0.874	2.547	1.161	2.713	1.497	2.877	1.892	3.186	2.843	3.484	4.066	3.769	5.572
9.0	2.250	0.829	2.416	1.102	2.574	1.420	2.730	1.795	3.022	2.697	3.305	3.857	3.576	5.287
8.5	2.187	0.806	2.348	1.071	2.502	1.380	2.653	1.744	2.937	2.621	3.212	3.748	3.475	5.138
8.0	2.122	0.782	2.278	1.039	2.427	1.339	2.573	1.692	2.849	2.543	3.116	3.636	3.371	4.984
7.5	2.054	0.757	2.206	1.006	2.350	1.296	2.492	1.638	2.759	2.462	3.017	3.521	3.264	4.826
7.0	1.985	0.731	2.131	0.972	2.270	1.252	2.407	1.583	2.665	2.379	2.915	3.401	3.154	4.662
6.5	1.912	0.705	2.053	0.936	2.188	1.207	2.320	1.525	2.568	2.292	2.809	3.278	3.039	4.493
6.0	1.837	0.677	1.973	0.900	2.102	1.159	2.229	1.465	2.468	2.202	2.698	3.149	2.920	4.316
5.5	1.759	0.648	1.889	0.861	2.012	1.110	2.134	1.403	2.362	2.108	2.583	3.015	2.795	4.133
5.0	1.677	0.618	1.801	0.821	1.919	1.058	2.034	1.338	2.253	2.010	2.463	2.875	2.665	3.940
4.5	1.591	0.586	1.708	0.779	1.820	1.004	1.930	1.269	2.137	1.907	2.337	2.727	2.528	3.738
4.0	1.500	0.553	1.611	0.735	1.716	0.946	1.820	1.197	2.015	1.798	2.203	2.571	2.384	3.524
3.5	1.403	0.517	1.507	0.687	1.605	0.885	1.702	1.119	1.885	1.682	2.061	2.405	2.230	3.297
3.0	1.299	0.479	1.395	0.636	1.486	0.820	1.576	1.036	1.745	1.557	1.908	2.227	2.064	3.052
2.8	1.255	0.463	1.348	0.615	1.436	0.792	1.522	1.001	1.686	1.504	1.843	2.151	1.994	2.949
2.6	1.210	0.446	1.299	0.592	1.384	0.763	1.467	0.965	1.624	1.450	1.776	2.073	1.922	2.841
2.5	1.186	0.437	1.273	0.581	1.357	0.748	1.439	0.946	1.593	1.422	1.742	2.033	1.885	2.786
2.4	1.162	0.428	1.248	0.569	1.329	0.733	1.410	0.927	1.561	1.393	1.707	1.992	1.847	2.730
2.2	1.113	0.410	1.195	0.545	0.273	0.702	0.350	0.887	1.494	1.334	1.634	1.907	1.768	2.614
2.0	1.061	0.391	1.139	0.519	1.213	0.669	1.287	0.846	1.425	1.271	1.558	1.818	1.686	2.492
1.9	1.034	0.381	1.110	0.506	1.183	0.652	1.254	0.825	1.389	1.239	1.518	1.772	1.643	2.429

Note: V: Full Velocity (m/s)
Q: Full Capacity (m^3/s)

- continue -

Table K-2 (continue)

Dia. of Sewer (m)	0.685 (675)*		0.762 (750)*		0.838 (825)*		0.915 (900)*		1.066 (1,050)*		1.219 (1,200)*		1.372 (1,850)*	
Sectional Area (m^2)	0.369		0.456		0.552		0.658		0.892		1.167		1.478	
Wetted Perimeter (m)	2.152		2.394		2.633		2.875		3.349		3.830		4.310	
Hydraulic Radius (m)	0.171		0.191		0.210		0.229		0.266		0.305		0.343	
Slope of Sewer (0/00)	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
1.8	1.006	0.371	1.080	0.493	1.151	0.635	1.221	0.803	1.352	1.206	1.478	1.725	1.599	2.364
1.7	0.978	0.360	1.050	0.479	1.119	0.617	1.186	0.780	1.313	1.172	1.436	1.676	1.554	2.298
1.6	0.949	0.350	1.019	0.465	1.085	0.599	1.151	0.757	1.274	1.137	1.393	1.626	1.508	2.229
1.5	0.919	0.339	0.986	0.450	1.051	0.580	1.114	0.733	1.234	1.101	1.349	1.575	1.460	2.158
1.4	0.888	0.327	0.953	0.435	1.015	0.560	1.077	0.708	1.192	1.064	1.303	1.521	1.410	2.085
1.3	0.855	0.315	0.918	0.419	0.978	0.540	1.037	0.682	1.149	1.025	1.256	1.466	1.359	2.009
1.2	0.822	0.303	0.882	0.402	0.940	0.518	0.997	0.655	1.104	0.985	1.207	1.408	1.306	1.930
1.1	0.787	0.290	0.845	0.385	0.900	0.496	0.954	0.627	1.057	0.943	1.155	1.348	1.250	1.848
1.0	0.750	0.276	0.805	0.367	0.858	0.473	0.910	0.598	1.007	0.899	1.102	1.286	1.192	1.762
0.9	0.712	0.262	0.764	0.348	0.814	0.449	0.863	0.568	0.956	0.853	1.045	1.220	1.131	1.672
0.8	0.671	0.247	0.720	0.328	0.767	0.423	0.814	0.535	0.901	0.804	0.985	1.150	1.066	1.576
0.7	0.628	0.231	0.674	0.307	0.718	0.396	0.761	0.501	0.843	0.752	0.922	1.076	0.997	1.474
0.6	0.581	0.214	0.624	0.284	0.665	0.367	0.705	0.463	0.780	0.696	0.853	0.996	0.923	1.365
0.5	0.530	0.195	0.569	0.260	0.607	0.335	0.643	0.423	0.712	0.636	0.779	0.909	0.843	1.246
0.4	0.474	0.175	0.509	0.232	0.543	0.299	0.575	0.378	0.637	0.569	0.697	0.813	0.754	1.114

Note: V: Full Velocity (m/s)
Q: Full Capacity (m^3/s)

APPENDIX L

ANALYSIS FOR WATER POLLUTION CONTROL

1. General

Alor Setar town has been developed in the tributary area of Sg. Kedah and Sg. Anak Bukit. Wastewaters from the town including domestic, commercial and industrial wastes, flow into these two rivers through existing drains, contributing to the pollution of the rivers at present. Water pollution of the rivers is increasing with the expansion of the town. Thus it is evident that river's pollution will be further advanced in the future unless adequate pollution control measure is taken.

Appendix L, therefore, study the effect of sewerage system to control water pollution of the two major rivers towards the future in contrast with the case without the system.

The two rivers had been tidal rivers before the barrage was constructed at the point of a little downstream from confluente point of the two rivers. After construction of the tidal barrage, qualities and quantities of the rivers are greatly influenced by gate operation.

The gate operation is largely affected by season. In rainy season, the gates are opened at least once a day, and especially in monsoon season, a whole day. In dry season, however, the gates are opened only once a few days, or for navigation of boats through the barrage.

2. Cross Sections, Mass Balance and Water Pollution Forecast of Rivers

2.1 Cross Sectional Area of Rivers

Cross sectional areas of the rivers vary with locations and flow valumes. For easiness estimating quantities and qualities of the rivers, the cross sectional areas of rivers are simplifed as follows:

a. Slope of River-bed

Average slope of river-bed is assumed as 0.0084% for both the Sg. Kedah and the Sg. Anak Bukit based on the data obtained from MPKS.

b. Cross section

The two rivers in the Study Area are divided into three zones as shown in Figure L-1, and simplified cross section of each zone is assumed as shown in Figure L-2.

Figure L-1 Schematic Plan of Rivers

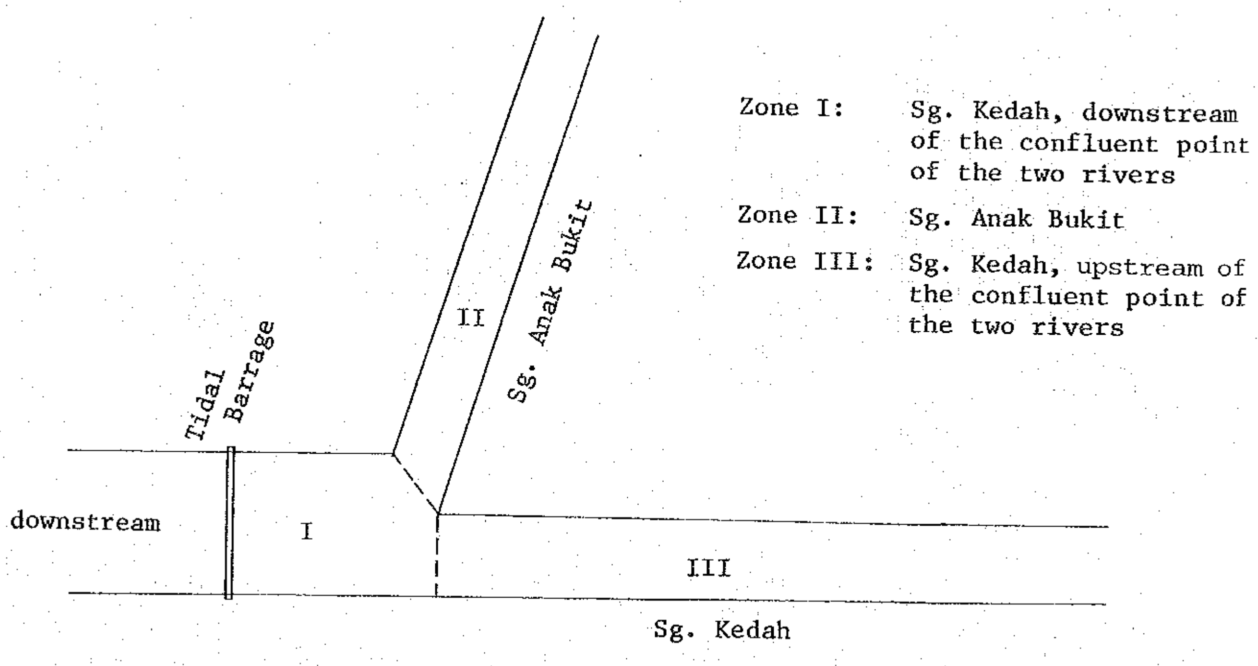
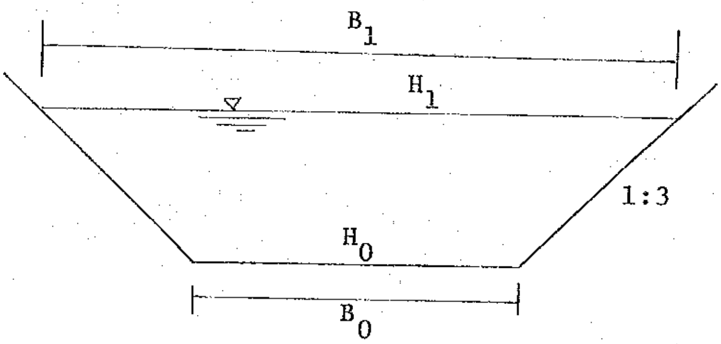


Figure L-2 Simplified cross section

I. Sg. Kedah (from the tidal barrage to the confluent point of the two rivers)



H_1: River stage (m)

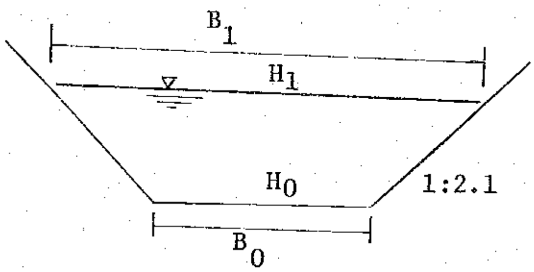
H_0: River-bed elevation (m)

B_1: Width of water surface (m)

B_0: Width of river-bed (m)

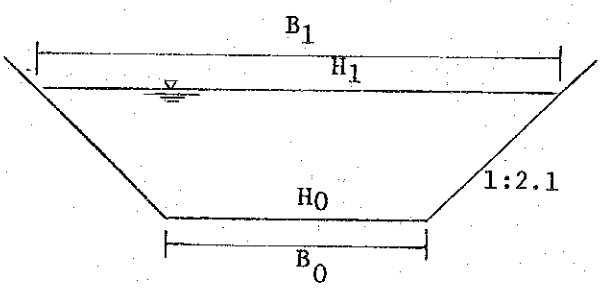
$$B_0 = (H_0 + 15.7) \times 6.0$$
$$B_1 = (H_1 + 15.7) \times 6.0$$

II. Sg. Anak Bukit



$$B_0 = (H_0 + 8.6) \times 4.2$$
$$B_1 = (H_1 + 8.6) \times 4.2$$

III. Sg. Kedah (upstream of the confluent point of the two rivers)



$$B_0 = (H_0 + 13.4) \times 4.2$$
$$B_1 = (H_1 + 13.4) \times 4.2$$

Based on the assumptions and formulas for B_0 and B_1 developed for each zone, water surface elevations, river bed elevations and widths of river-beds at key points of the zones are obtained as shown in Figure L-3.

Figure L-3 Elevations and Widths at Key Points Along the Rivers

Sg. Kedah		Distance from Tidal Barrage (km)	Sg. Anak Bukit	
Width of River-Bed (m)	Elevation of River-bed (+M)		Elevation of River-bed (+M)	Width of River-bed (m)
72.252	-3.658	0.00		
72.978 41.425	-3.537	1.44	-3.537	21.265
42.441	-3.295	4.32	-3.295	22.281
43.457	-3.053	7.20	-3.053	23.297
44.474	-2.811	10.08	-2.811	24.314

2.2 Mass Balance

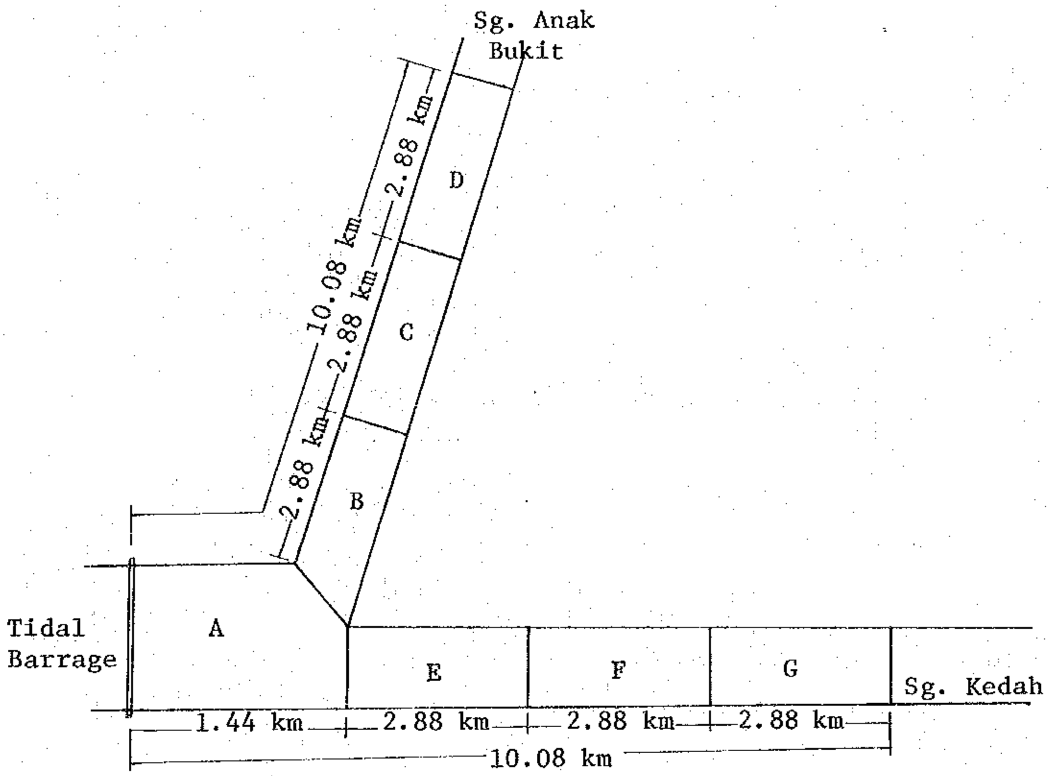
Mass balance is calculated based on the following assumptions;

(a) Study area of the rivers is confined from the tidal barrage to the point of the Study Area line or 10.08 km upstream for both rivers.

(b) River stage is constant regardless upstream or downstream because rivers can be considered as a isolated pond in dry season.

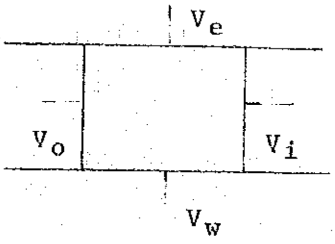
(c) The three zones of the rivers area further divided into 7 sub-zones as shown in Figure L-4, to calculate mass balance of each sub-zone.

Figure L-4 Rivers Divided into Seven Sub-zones



Mass balance in one differential area of a stream is shown in Figure L-5.

Figure L-5 Mass Balance Model



where

V_o : Outflow

V_i : Inflow

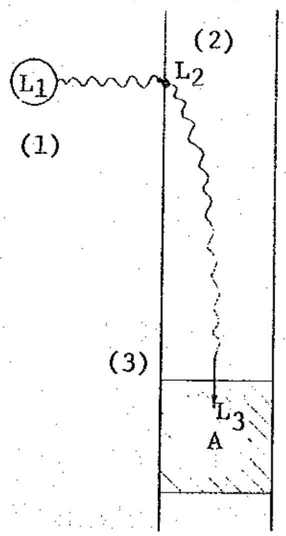
V_e : Loss by evapo-transpiration

V_w : Inflow of wastewater

2.3 Simulation Model for Waste Loads (BOD)

Waste organic load (L_1) originated at point (1) reaches the river (point (2)) reducing waste load to (L_2) on the way to point (2). Further, L_2 reduces to L_3 by the purification capacity of the river between point (2) and point (3).

Figure L - 6 Simulation Model



A: Sub-zone A

L_1: BOD load Produced (kg/day)

L_2; BOD load which reaches a main river (kg/day)

L_3: BOD load which arrives at sub-zone A (kg/day)

L_2/L_1: Coefficient of BOD reaching to a stream from source $(= \alpha)$

L_3/L_2: Coefficient of BOD reduction in a stream $(= \beta)$

Coefficient of BOD reducing in a stream (β) differs with microbic living environment, water velocity, flow time, etc. River condition in dry season, is almost similar to that of stabilization pond, thus β can be obtained by following equation (2-1).

$$\beta = \frac{L_3}{L_2} = \frac{1}{1 + k_t} \quad \text{.......... (2-1)}$$

where

t: Flow time from inlet point to the point under consideration (day)

k: Self-purification coefficient (1/day)

The value k = 0.23 (base e) is adopted at 20°C, and its variation with temperature is described by equation (2-2).

$$k(T) = k\,(20) \times \Theta^{T-20} \quad \text{....... (2-2)}$$

where

k(T): k value at T°C (1/day)

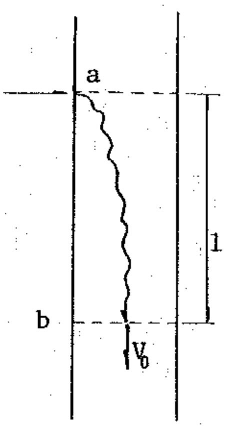
Θ : Arrhenius coefficient, 1.08 for stabilization pond

Assuming water temperature as 30°C, k value is calculated as follow;

$$k(30) = 0.23 \times 1.08^{10}$$

$$= 0.4965$$

Figure L-7 Flow Model



Flow time (t) is calculated by the following equation;

$$t = 1/\nu \quad \text{(day)} \quad \text{....... (2-3)}$$

where

1: distance between point a and point b (km)

ν: velocity (km/day)

$\nu = V_0/A_b$

V_0: Outflowing quantity from sub-zone under consideration

A_b: cross sectional area at point b

Charging point of wastewater from tributary area in each sub-zone is assumed as Figures L-8 and L-9 for two cases that sewerage system is not provided and is provided.

Figure L-8 Charging Points of Wastewater from Tributary Areas of Each Sub-zone through Existing Drains (In case sewerage system is not provided)

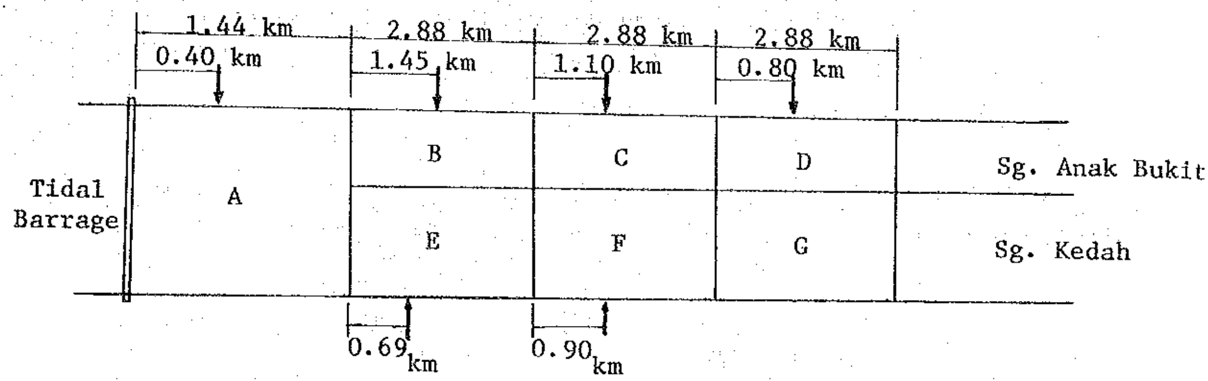
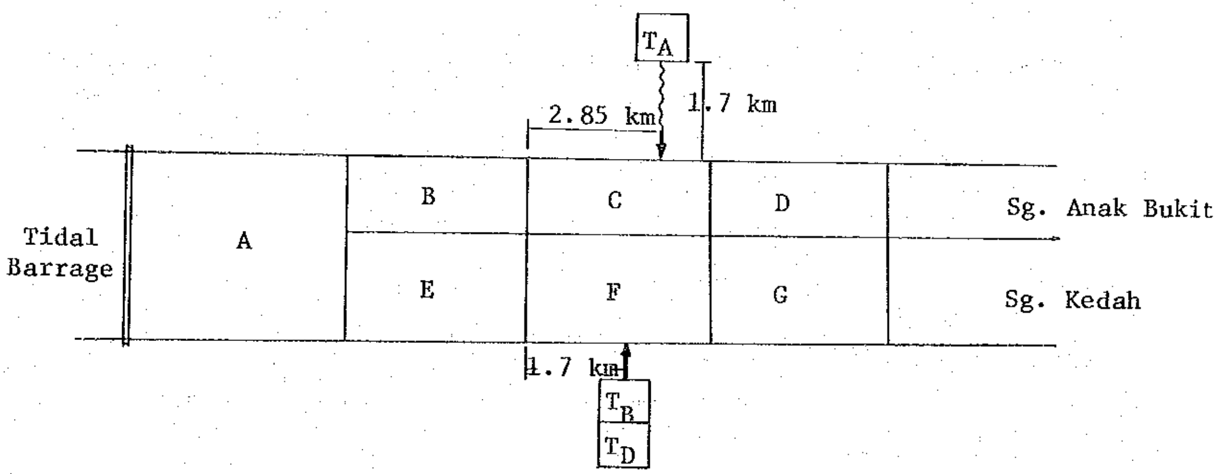


Figure L-9 Charging Points of Wastewater through Treatment Facilities (In case sewerage system is provided)



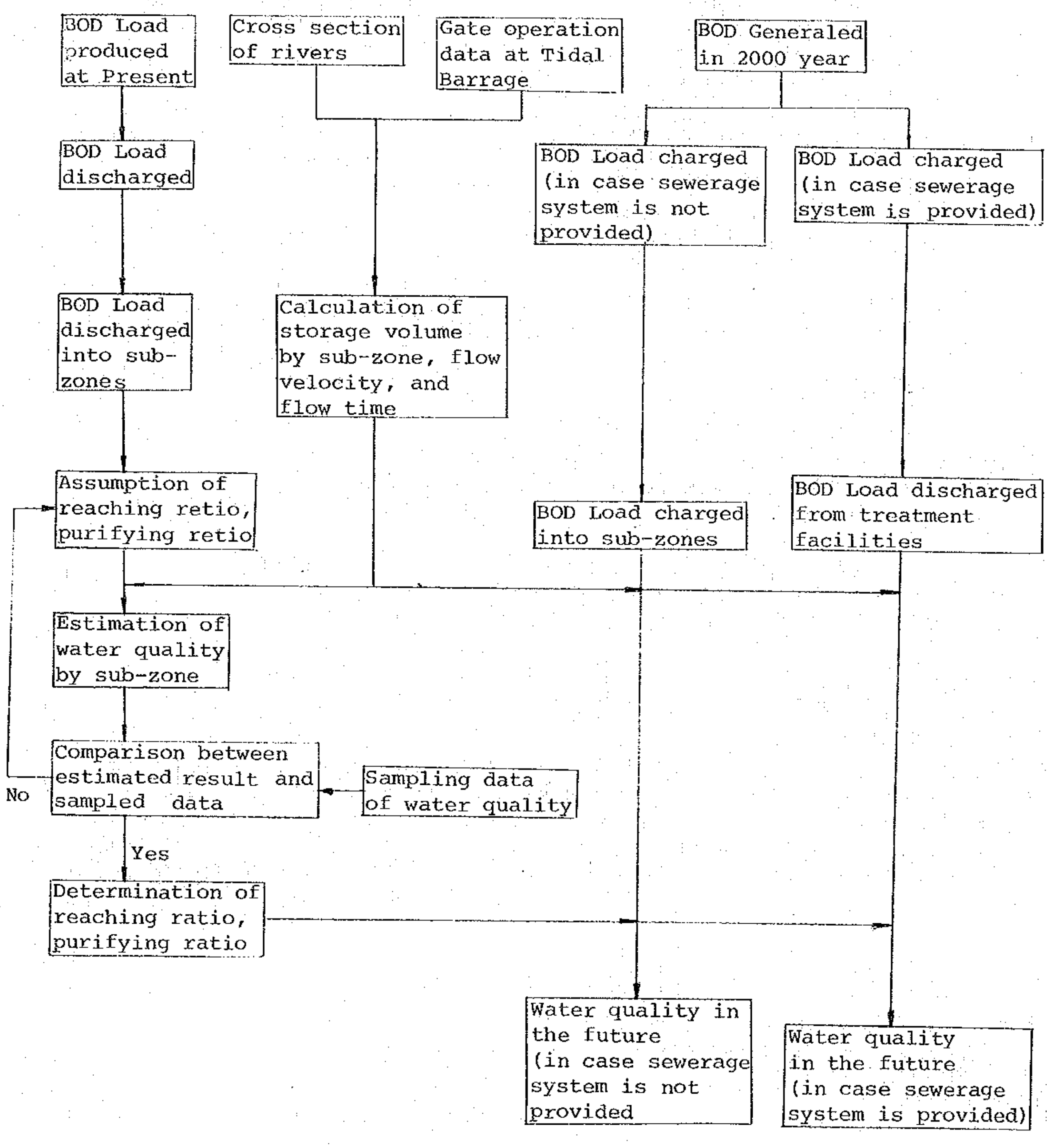
where

T: Treatment facilities

2.4 Flow Sheet for Waste Load Simulation Procedure

Simulation of waste load is carried out by the following procedure.

Figure L-10 Flow Sheet for Waste Load Simulation Procedure



3. BOD Load Charged to Sub-zones of the Rivers

3.1 Present BOD Load Generated and Discharged for Source

Present BOD Load generated and discharged from source as follows:

(1) to estimate present population according to tributary to each sub-zone of the rivers

(2) to estimate population and BOD Load with respect to night soil disposal systems.

a. BOD Load removed through septic tank is assumed to be 50 percent, thus BOD load discharged from source is calculated to be 6.5 g/capt.

b. BOD Load discharged through Buket system is assumed to be 0.

c. BOD Load discharged through latrine over waterways is assumed to be 13 g/capt.

(3) to estimate BOD Load generated by sullage water

3.2 Future BOD Load Generated and Discharged from Source

BOD Load generated and discharged from source in the future is estimated in the same manner as described in 3.1.

3.3 BOD Load Charged to Sub-zones of Rivers

BOD Loads charged to the sub-zones in the rivers are calculated assuming that in case no sewerage system is provided in the future all night soil generated in the Study Area is discharged through septic tank system, while in case sewerage system is provided, all sanitary wastes are discharged of 50 mg/l (BOD) from treatment facilities.

3.4 Present and Future Wastewater Quantity and Quality Generated and Charged Sub-zones of Rivers

Wastewater volumes and BOD Loads generated and charged to sub-zones of the rivers both at present and in the future are summarized in table L-1.

Table L-1 Wastewater volumes and BOD Loads Generated and Charged to Rivers

Sub-zone	Present		Future (2000)			
			In case No sewerage facility is provided		In case Sewerage Facility is provided	
	Waste-water Gene-rated 1,000 m^3/day	BOD Load Gene-rated kg/day	Waste-water charged 1,000 m^3/day	BOD Load charged kg/day	Effluent of Treatment Facility 1,000 m^3/day	BOD Load charged through Treatment Facilities kg/day
A	7.31	1,054.1	12.47	1,973.8	A 21.57	1,078.4
B	4.80	829.7	12.50	2,018.6		
C	3.40	629.7	19.68	3,384.7		
D	0.54	89.2	2.96	422.4		
E	10,40	1,901.4	24.97	4,295.9		
F	1.55	242.5	6.37	1,095.6	B 36.39 D 23,73	1,819.7 1,186.3
Total	28.00	4,746.6	78.45	13,191.0	81.69	4,084.4

4. Storage Volumes of Sub-zone in Rivers

Based on the simplified cross sections of the rivers in Figure L-2 and average slope of river bed of 0.0084%, storage volumes of the sub-zones in the two rivers are calculated by the derived formulas as follows:

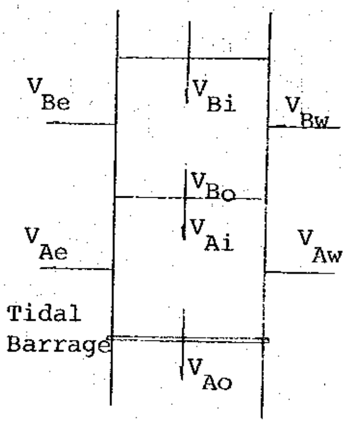
$$\left.\begin{aligned}
V_A &= 4.32\,H^2 + 135.70\,H + 432.44\\
V_B &= 6.05\,H^2 + 104.05\,H + 284.75\\
V_C &= 6.05\,H^2 + 104.05\,H + 269.25\\
V_D &= 6.05\,H^2 + 104.05\,H + 253.04\\
V_E &= 6.05\,H^2 + 162.14\,H + 483.11\\
V_F &= 6.05\,H^2 + 162.14\,H + 453.56\\
V_G &= 6.05\,H^2 + 162.14\,H + 423.31
\end{aligned}\right\}\quad (4-1)$$

$$\Sigma V = 40.62\,H^2 + 934.27\,H + 2599.46$$

H : River stage (m)

$V_A \sim V_G$: Storage capacity by sub-zone (1000 m^3)

5. Verocity in Sub-zones of Rivers



Velocity ν is calculated by the form,

$\nu = Vo/A$ (refer to Section 2.3) (5-1)

V_{AO} (outflowing quantity from sub-zone A) is calculated by estimating discharge through the tidal barrage.

Vno (outflowing quantity from n sub-zone) is culculated by the following equation;

$V_{n+1} = V_n - V_o + V_i - V_e + V_w$ ....(5-2)

Where

V_n : Storage Volume on nth day (m^3)

V_o : Outflowing volume (m^3)

V_i : inflowing volume (m^3)

V_e : Loss by evapo-transpiration (m^3)

5.1. Estimation of V_{AO}

In case the main gates of the tidal barrage are closed, outflowing volume from sub-zone A is assumed to be 3,000 m^3/day based on the opening time of the lock chamber for nevigation of boats. Similarly in case the main gates are opened, outflowing volume (V_{AO}) is calculated by the difference of settled water stages before and after the gates opening.

5,2, Estimation of V_{nw}

Inflowing wastewater to n sub-zone (V_{nW}) are obtained from Table (L-1).

5.3. Estimation of V_{ne}

Average evapo-transpiration rates in dry and rainy seasons are assumed to be 5.1mm/day and 3.3mm/day respectively, based on the record obtained from Meteorological Station, ALOR SETAR. Infiltration rate is disregarded in this study due to lack of data applicable.

5.4. Flow Velocities (ν_x) in Sub-zones of the Rivers

The records of the river stage and the gate operation are analyzed as follows:

(1) The gate opening period differs significantly between dry and rainy seasons

(2) The difference of the river stage before and after the gate opening ranges from 1.2m to 0.25m.

(3) Average gate opening frequency is once in 4.7 days in dry season, and once in 0.7 day in rainy season.

Based on the data mentioned above and applying the quation (4-1), outflowing quantities through tidal barrage are assumed as follows:

(a) Outflowing quantity by one gate operation 256,000 m^3/NO

(b) Outflowing quantity in case the gate are clossed: 3,000 m^3/day

Therefore, average outflowing quantity per day is obtained as follow :

(c) In dry season: 256,000/4.7 + 3,000=57,470 m^3/day

(d) In rainy season: 256,000/0.7 + 3,000= 368,710 m^3/day

The gate operation frequency has to be changed by the increase of wastewater by the year 2000 as indicated below to avoid flowing in low upstream areas.

(1) In case no sewerag system is provided: once per 3.21 days

(2) In case sewerage system is provided: once per 2.09 days

Mass balance and average flow velocity in each sub-zone of the rivers are summarized by case in Figure L-11 and Table L-2 respectively.

Table L-2 Estimated Average Velocity in Sub-zones of the Rivers

Unit Km/day

		A	B	C	D	E	F	G
Present	Dry season	0.145	0.151	0.144	0.141	0.150	0.137	0.144
	Rainy season	0.927	1.013	1.039	1.075	1.002	1.028	1.080
Future in dry season	In case no sewerage system is provided	0.208	0.246	0.213	0.149	0.192	0.148	0.144
	In case sewerage system is provided	0.315	0.277	0.292	0.139	0.389	0.411	0.144

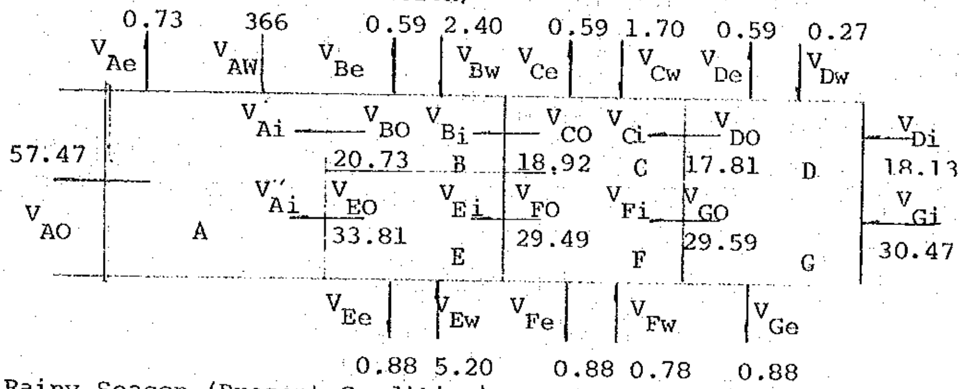
Note: (1) Average velocity ν_x is obtained by dividing outflowing volume V_o by average sectional area of each sub-zone.

(2) Average river stage adopted is assumed to be 1.0 m.

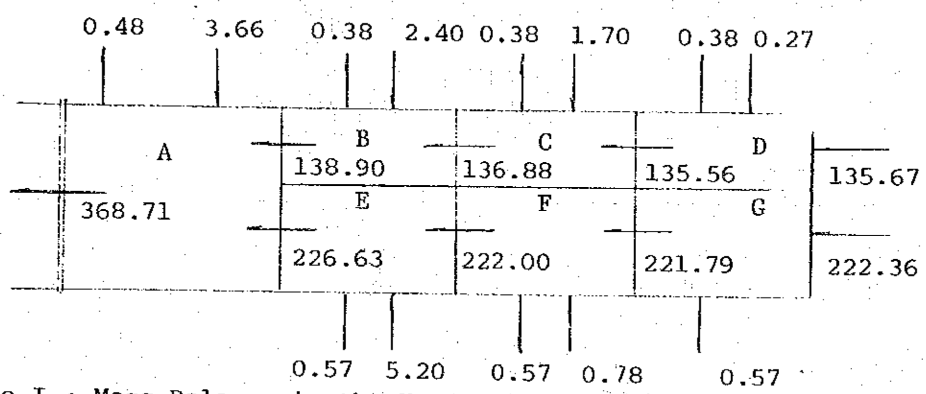
Figure L-11 Mass Balance by Case

Unit 1000 m^3/day

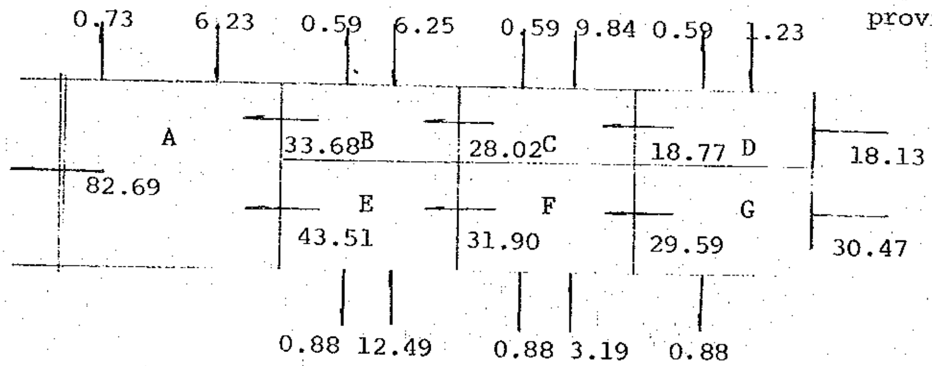
Dry season (Present Condition)



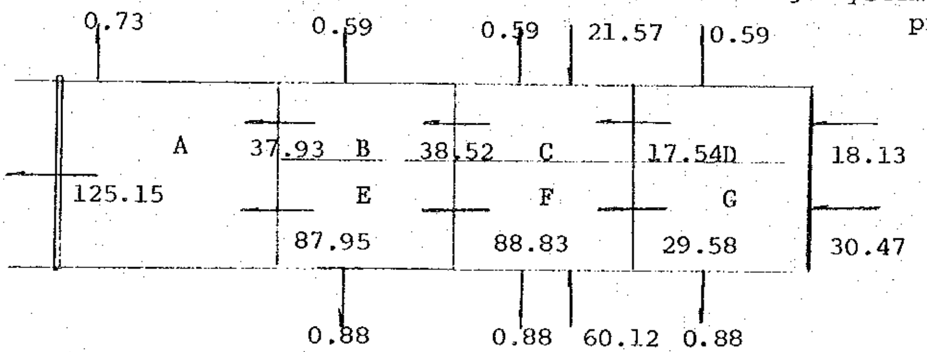
Rainy Season (Present Condition)



Case I : Mass Balance in the Year 2000 (In case no sewerage system is provided)



Case II; Mass Balance in the year 2000 (In case sewerage system is provided)



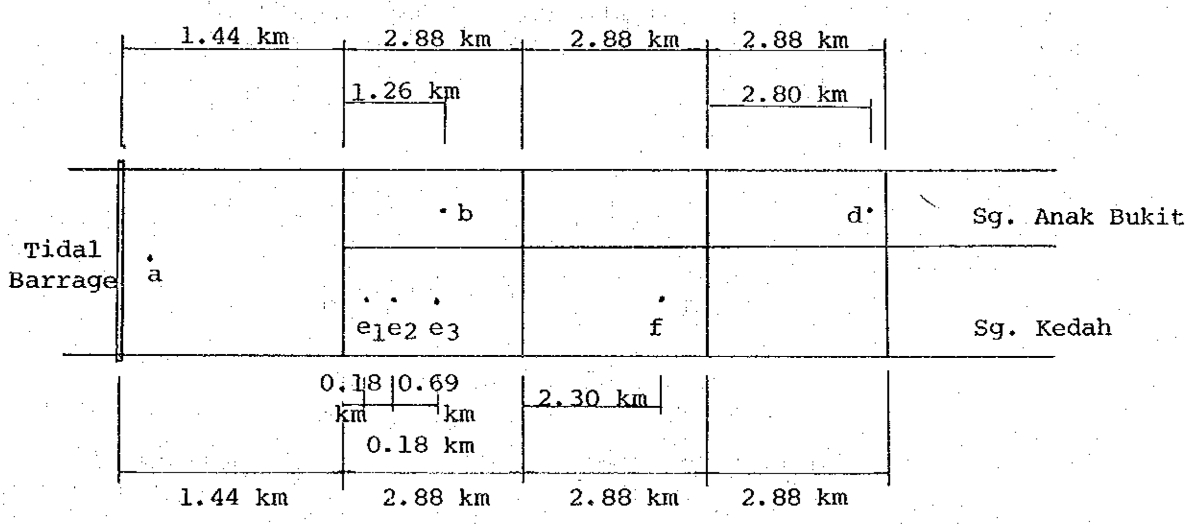
6. Water Quality Analysis for Present Conditions of the Rivers

Sampling data for BOD obtained by the survey is summarized in Table L-3. The locations of the sampling points are shown in Figure L-12.

Table L-3 Sampling Data

Paint Name	Dry Season	Rainy Season	BOD (mg/l) date ( )
a	14 (21/3)	3.8 (17/6)	
b	16 (21/3)	7.0 (17/6)	
d		3.4 (8/7)	
e1		3.6 (3/7)	
e2	17 (21/3)	2.1 (18/6)	
e3		2.3 (18/6)	
f		1.4 (18/6)	

Figure L-12 Locations of Sampling Points



For grasping the present condition of rivers, seven sampling data are obtained in the dry season, and three in the rainy season. then three points are selected as monitoring points for future reference. The monitoring points should be representative to view the degree of river pollution. The three points are point a (upstream at the tidal barrage), point b (confluent point of Sg. Anak Bukit and Jl. Putera)and point e_2 (confluent point of Sg. Kedah and Jl. Sungai Korok).

BOD load which reaches to L_3 from L_2 is calculated in Table L-4 by equations (2-1), (2-3), assuming four cases for α (i.e., 0.4, 0.5, 0.6 and 0.7)and using ν (in Table L-2), l (in Figur L-7), and L_1 (Table L-1) and V_o (in Figure L-10) values already estimated.

Table L-4 Water Quality (BOD) Surveyed and Estimated for Varying α at Monitoring Points.

		Dry Season			Rainy Season			
Point		a	b	e_2	a	b	e_1	e_2
Sampling	Data (BOD mg/l)	14	16	17	3.8	7.0	3.6	2.1
α	40 %	8.0	13.0	13.0	2.9	3.3	3.1	3.4
	50 %	9.6	15.7	15.7	3.6	4.1	3.9	4.2
	60 %	11.1	18.5	18.5	4.3	5.0	4.7	5.0
	70 %	12.7	21.2	21.2	5.1	5.8	5.4	5.9

[α ; Coefficient of BOD reaching to a stream from source]

It is noted that estimated BOD values of the points a,b,and e2 are closed to the analyzed BOD values of the points, in case α is in a range of 50 to 60%.

7. Estimated Water Qualities of the Monitoring Points in the Future

Water quality simulation at the monitoring points is carried out in two cases as follows; and the results are summarized in Table L-5 and L-6.

Case 1 : In case no sewerage system is provided by the year 2000.

Case 2 : In case sewerage system is provided by the year 2000.

Table L-5 Case 1.

(BOD mg/l)

Point		a	b	e_2
α	40 %	13.6	24.6	23.9
	50 %	16.6	30.4	29.5
	60 %	19.7	36.3	35.1
	70 %	22.8	42.1	40.7

Table L-6 Case 2.

Point	a	b	e_2
BOD (mg/l)	4.7	5.8	7.2

Based on the tables above, it is noted that;

(1) BOD of the rivers will be degraded from 1.5 to 2 times than present condition, in case no sewerage system is provided.

(2) BOD of the rivers will be reduced to 1/3 ~ 2/5 of the present condition in case sewerage system is provided.

8. Conclusion and Recommendation

In this study, simulation of water quality in the rivers is carried out for the year 2000. Assuming outflow volume V_o, self-purification coefficient k and coefficient of BOD reaching to streams from source α. The simulation results reveal that water quality will be greatly improved by provision of sewerage treatment facility.

However, it is noted that the study results stand on the broad assumption of the values. Therefore, it is suggested that in the future, the following data should be fully collected to obtain more dependable results;

(1) Wastewater quanity generated from each sub-zone.

(2) BOD load reaching to sub-zones of the rivers

(3) Collection of sampling data about water quality at the monitoring points.

The following data are used for this study;

(1) Operation record of Tidal Barrage in 1978 (MADA)

(2) River stage at the Tidal Barrage both up and down streams (MADA)

(3) Structural drawing of the Tidal Barrage (MADA)

(4) Plan figure, cross section and profile of Sg. Anak Bukit (MPKS)

(5) Drainage Master Plan Report for Alor Setar (DID)

1 Gate Opening Data of Tidal Barrage

	January		February		March		April	
	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)
1	2	2.30	0		0		0	
2	0		0		0		0	
3	0		0		0		0	
4	0		0		0		0	
5	0		0		0		1	0.40
6	0		0		0		0	
7	0		0		0		0	
8	0		0		0		0	
9	1	2.20	0		0		0	
10	0		0		0		0	
11	1	2.35	0		0		0	
12	0		0		0		0	
13	0		0		0		0	
14	0		0		0		0	
15	0		0		0		0	
16	2	4.15	0		0		0	
17	1	1.00	0		0		0	
18	1	2.00	0		0		0	
19	1	2.00	0		0		0	
20	2	3.00	0		0		0	
21	0		0		0		0	
22	2	2.00	0		0		0	
23	1	1.25	0		0		0	
24	0		0		0		0	
25	0		0		0		0	
26	0		0		0		0	
27	0		0		0		0	
28	0		0		0		0	
29	0				0		0	
30	0				0		1	2.10
31	1	2.00			0			
TOTAL		25.05		0.00		0.00		0.00

Gate Opening Data of Tidal Barrage

	May		June		July		August	
	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)
1	0		1	:55	2	11:50	2	11:15
2	1	:45	1	1:20	* 2	15:55	2	11:20
3	1	1:10	1	1:05	* 2	14:30	2	7:55
4	0		1	2:10	* 1	15:00	2	4:35
5	0		1	2:35	* 1	11:15	2	3:10
6	2	3:10	1	2:15	* 1	12:55	2	2:55
7	4	7:50	2	3:45	* 1	18:00	2	3:10
8	3	12:00	3	5:25	1	16:25	1	1:40
9	2	6:10	2	5:10	2	11:30	1	1:40
10	3	10:00	2	5:15	2	12:30	2	2:45
11	3	14:05	3	16:40	2	12:00	1	1:55
12	2	10:10	2	16:40	2	8:00	1	2:35
13	2	10:05	2	20:00	2	8:15	1	4:15
14	1	23:00	*	15:00	2	6:05	1	2:20
15	* 0	24:00	1	9:55	2	5:10	1	3:00
16	* 0	24:00	2	9:05	* 2	6:10	2	4:05
17	* 0	24:00	1	3:40	* 2	6:20	1	1:40
18	1	21:30	2	2:25	1	2:55	2	5:45
19	1	10:20	1	1:55	2	10:35	2	10:55
20	2	5:35	1	2:10	2	14:15	2	6:15
21	2	5:30	1	1:30	2	9:05	2	2:50
22	2	4:35	1	1:15	2	6:35	2	3:10
23	2	3:40	1	1:05	2	7:10	2	2:15
24	2	3:45	0		2	6:40	2	2:30
25	2	4:15	1	1:10	2	5:00	1	4:10
26	2	2:15	1	:45	2	6:15	1	1:05
27	2	2:35	1	1:35	2	8:15	1	:30
28	1	1:30	1	2:30	* 1	18:00	1	3:00
29	0		* 2	17:45	* 0	24:00	1	2:40
30	1	:55	2	12:35	* 0	24:00	1	1:05
31	1	4:30			* 1	18:05	2	17:10
TOTAL		240:20		167:35		352:00		123:35

Gate Opening Data of Tidal Barrage

	May		June		July		August	
	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)
1	0		1	:55	2	11:50	2	11:15
2	1	:45	1	1:20	* 2	15:55	2	11:20
3	1	1:10	1	1:05	* 2	14:30	2	7:55
4	0		1	2:10	* 1	15:00	2	4:35
5	0		1	2:35	* 1	11:15	2	3:10
6	2	3:10	1	2:15	* 1	12:55	2	2:55
7	4	7:50	2	3:45	* 1	18:00	2	3:10
8	3	12:00	3	5:25	1	16:25	1	1:40
9	2	6:10	2	5:10	2	11:30	1	1:40
10	3	10:00	2	5:15	2	12:30	2	2:45
11	3	14:05	3	16:40	2	12:00	1	1:55
12	2	10:10	2	16:40	2	8:00	1	2:35
13	2	10:05	2	20:00	2	8:15	1	4:15
14	1	23:00	*	15:00	2	6:05	1	2:20
15	* 0	24:00	1	9:55	2	5:10	1	3:00
16	* 0	24:00	2	9:05	* 2	6:10	2	4:05
17	* 0	24:00	1	3:40	* 2	6:20	1	1:40
18	1	21:30	2	2:25	1	2:55	2	5:45
19	1	10:20	1	1:55	2	10:35	2	10:55
20	2	5:35	1	2:10	2	14:15	2	6:15
21	2	5:30	1	1:30	2	9:05	2	2:50
22	2	4:35	1	1:15	2	6:35	2	3:10
23	2	3:40	1	1:05	2	7:10	2	2:15
24	2	3:45	0		2	6:40	2	2:30
25	2	4:15	1	1:10	2	5:00	1	4:10
26	2	2:15	1	:45	2	6:15	1	1:05
27	2	2:35	1	1:35	2	8:15	1	:30
28	1	1:30	1	2:30	* 1	18:00	1	3:00
29	0		* 2	17:45	* 0	24:00	1	2:40
30	1	:55	2	12:35	* 0	24:00	1	1:05
31	1	4:30			* 1	18:05	2	17:10
TOTAL		240:20		167:35		352:00		123:35

Gate Opening Data of Tidal Barrage

	September		October		November		December	
	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)	Frequency of Gate Opening	Duration Time (hour)
1	2	15:00	1	1:45	2	12:20	0	
2	3	8:40	1	1:10	2	8:00	0	
3	2	16:55	1	1:45	2	8:20	0	
4	2	6:35	2	3:30	2	10:00	1	2:40
5	2	9:25	2	2:25	2	16:20	1	1:00
6	2	15:30	1	2:00	* 1	21:00	1	3:15
7	* 2	19:40	2	5:20	* 0	24:00	* 1	7:00
8	* 1	20:30	2	3:55	* 0	24:00	* 1	18:30
9	* 0	24:00	2	6:40	* 0	24:00	1	10:00
10	* 0	24:00	2	4:45	* 3	16:25	1	4:30
11	* 0	24:00	* 2	10:35	1	12:00	1	:55
12	* 0	24:00	1	2:15	2	11:55	1	1:40
13	1	22:00	2	10:20	2	12:50	0	
14	2	11:40	2	13:50	2	13:25	1	2:00
15	2	15:50	2	13:50	2	16:40	1	2:35
16	2	6:20	2	8:15	2	17:00	1	1:55
17	2	5:30	3	10:40	2	14:50	1	2:10
18	2	5:05	2	14:20	2	18:00	0	
19	1	1:30	2	11:30	2	10:40	0	
20	2	3:50	2	8:25	2	17:45	0	
21	2	8:15	* 3	17:45	2	18:20	0	
22	2	8:00	2	20:10	1	19:00	0	
23	2	18:05	* 0	24:00	* 2	10:05	0	
24	* 2	17:20	* 0	24:00	* 1	14:25	0	
25	* 2	19:30	* 0	24:00	* 1	6:25	0	
26	* 2	17:30	* 0	24:00	0	4:00	0	
27	2	7:30	* 0	24:00	0		0	
28	1	4:00	0	20:20	1	1:40	0	
29	1	2:30	2	12:50	1	:55	0	
30	1	2:35	2	5:55	0		0	
31			2	6:00			0	
TOTAL		385:45		340:15		380:20		58:10

JICA