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MALAYSIA

MASTER PLAN AND FEASIBILITY STUDY FOR SEWERAGE AND DRAINAGE SYSTEM PROJECT IN KELANG, PORT KELANG AND ITS ENVIRONS

VOLUME IV SEWERAGE

APPENDICES

NOVEMBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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This Master Plan and Feasibility Study consists of eight volumes:

I	Sewerage Summary Report
II	Sewerage Master Plan
III	Sewerage Feasibility Study
IV	Sewerage Appendices
V	Drainage Summary Report
VI	Drainage Master Plan
VII	Drainage Feasibility Study
VIII	Drainage Appendices

Appendices for Sewerage Master Plan and Feasibility Study

APPENDIX A

POPULATION PROJECTION AND LAND USE

APPENDIX A. POPULATION PROJECTION AND LAND USE

A.1. Population Projection

a) Projection Using Annual Growth Rate

Annual growth rates for the past 33 years from 1947 to 1957, 1957-70, and 1970-80 are calculated as 3.6 percent, 3.5 percent and 3.7 percent respectively. Using the most recent annual growgh rate of 3.7 percent, population in 1990 and 2000 are forecasted as 410,000 and 590,000 respectively.

Table A.1. Population Projection Using Annual Growth Rates of the Kelang District

Projected Annual Growth Rate

Year	Annual Growth Rate (%)
1947 - 1957	3.6 *1)
1957 - 1970	3.5 *1)
1970 - 1980	3.7 *1)
1980 - 1990	3.7 *2)
1990 - 2000	3.7 *2)

Estimated Population

Year	Population
1990	410,000
2000	590,000

Source: *1) Population Census
*2) Projected growth rates

b) Projection Using Regression Curve

The most suitable regression curve which fits past figures is worked out using the least square method. Formula of its regression curve is as follows:

$$P = 17{,}194\ e^{0.03505(x - 1900)}$$

P : Population

e : Exponential

x : Year

From this formula, population in 1990 and 2000 are calculated as 400,000 and 570,000 respectively.

Table A.2. Population Projection Using Regression Curve: Logarithmic Function

$y = a.e^{bx}$

y : Population

x : Year

e : Exponent

a,b: Variables

$y = 17{,}194\ e^{0.03505x}$

r : 0.9999

Population 1947-80

Year	Population
1947	89,000
1957	127,000
1970	198,433
1980	284,941

Estimated Population

Year	Population
1990	400,000
2000	570,000

c) Projection Using Ratio to Population of West Malaysia

Proportional ratio of the Kelang District population to that of West Malaysia in 1947, '57, '70 and 1980 are calculated as 1.8 percent, 2.0 percent, 2.3 percent and 2.6 percent respectively. From extrapolation of these figures, future ratio of 2.8 percent in 1990 and of 3.1 percent in 2000 are obtained.

On the other hand, population growth rate in West Malaysia from 1970 to 1980 was 2.4 percent and that of from 1980 to 1985 was estimated as 2.4 percent in the Fourth Malaysia Plan. Using the same growth rate of 2.4 percent up to the year 2000, the population of West Malaysia is estimated as 14,100,000 and 17,900,000 in 1990 and 2000 respectively.

Based on proportional rates and population in West Malaysia, the Kelang District population is estimated to be 400,000 in 1990 and 560,000 in 2000.

Table A.3. Population Projection Using Ratio to Population of West Malaysia

Estimated Population of Peninsular Malaysia

Year	Annual Growth Rate (%)	Population
1970		8,819,928
1980	2.4 *1)	11,138,227
1985	2.4 *2)	12,540,000
1990	2.4 *3)	14,100,000
2000	2.4 *3)	17,900,000

Source: *1) Population Census
*2) Fourth Malaysia Plan
*3) Projected rates

Estimated Population

Year	Population
1990	400,000
2000	560,000

Kelang District Population Ratios Against Peninsular Malaysia

Year	Ratio (%)
1947	1.8
1957	2.0
1970	2.3
1980	2.6
1990	2.8*
2000	3.1*

Source: An extrapolation of past figures.

d) Projection Using Ratio to Population of Selangor State

The same procedure described in the previous paragraph c) can be adopted to project future District population against the population of Selangor State.

Proportional ratio of the Kelang District population to that of Selangor State in 1947, '57, '70 and 1980 are calculated as 12.5 percent, 12.6 percent, 12.2 percent and 11.8 percent. From extrapolation of these figures, future ratio of 11.7 percent in 1990 and of 11.5 percent in 2000 are obtained.

The population of Selangor State in 1980 was 2,405,316, and annual growth rate from 1970 to 1980 was 4.0 percent. From extrapolation of the past growth rate in Selangor State, growth rates of 3.9 percent from 1980 to 1990 and of 3.8 percent from 1990 to 2000 are obtained.

Consequently, the Kelang District population in 1990 and 2000 are estimated as 410,000 and 590,000.

Table A.4. Population Projection Using Ratio to Population of Selangor State

Estimated Population of Selangor and Wilayah Persekutuan

Year	Annual Growth Rate (%)	Population
1970		1,630,366
	4.0 *1)	
1980		2,405,316
	3.9 *2)	
1990		3,530,000
	3.8 *2)	
2000		5,120,000

Source: *1) Population Census

*2) Projected rates

Estimated Population

Year	Population
1990	410,000
2000	590,000

Kelang District Population Ratios Against Selangor and Wilayah Persekutuan

Year	Ratio (%)
1947	12.5
1957	12.6
1970	12.2
1980	11.8
1990	11.7*
2000	11.5*

Source: An extrapolation of past figures.

A.2. Total Employment in 2000

The total employment in 2000 is estimated by the projected future population and the estimated participation rate.

Table A.5. Total Employment in 2000

Year	Participation Rate (%)	Total Employment	
		Kelang District	Study Area
1980	33.0 *1)	94,000	65,000
1990	36.0 *1)	148,000	119,000
2000	39.0 *1)	226,000	195,000

Source: *1) From paragraph A.1.

A.3. Projection of Sectoral Employment

1) Agriculture

The agricultural employment will be reduced steadily due to the urbanization. The annual growth rate of Selangor from 1957 to 1970 is assumed to be minus 0.7 percent.

Table A.6. Agricultural Employment

Year	Annual Growth Rate (%)	Estimated Agricultural Employment
1970		13,361 *1)
1980	-0.7 *2	12,500
1990	-0.7 *2)	11,500
2000	-0.7 *2)	11,000

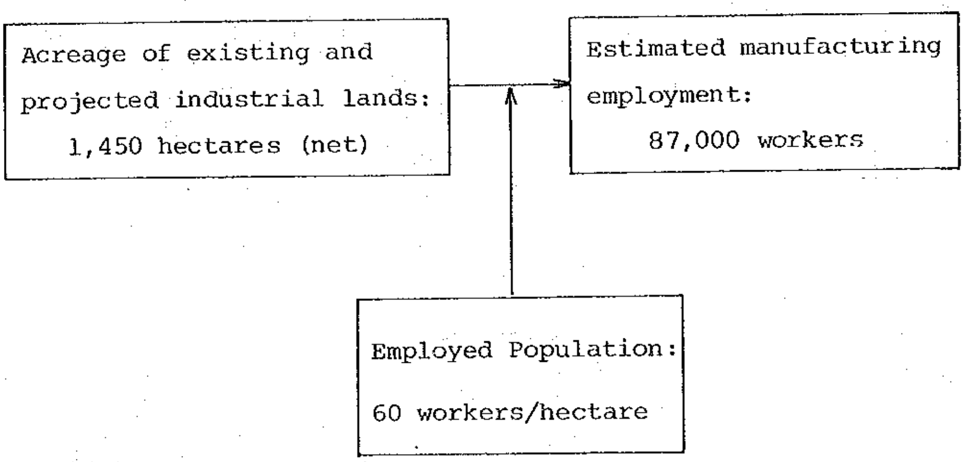
Source: *1) Population Census 1970

*2) Projected annual growth rates

2) Manufacturing

The employment in the manufacturing sector is estimated from the acreage of the projected industrial lands elaborated by PKNS.

Table A.7. Estimation of Manufacturing Employment



Source: Interim Development Control Planning Study

3) Transport

The following estimated employed population for the transport sector has taken into account the development in North Port and New Port.

Table A.8. Transport Employment

Year	Port Employment	Others	Transport Employment
1970	6,457 *1)	3,339 *1)	9,796
1990	23,904 *2)	6,899 *4)	30,803
2000	32,617 *3)	9,759 *4)	42,376

Notes: *1) Estimated on the assumption that the ratio of employed population is the same as that of Selangor State.

*2) North Port had not been constructed in 1970 but it is expected to be completed in 1990.

$$\frac{\text{Length of quay (North Port 3,902 m)}}{\text{Length of quay (South Port 1,054 m)}} \times 6{,}457 = 23{,}904$$

*3) Taking account of the New Port in Pulau Lumut, the Team estimates the workers in 2000 A.D. by extrapolation of past figures: 6,457 workers in 1970, 23,904 workers in 1990.

*4) Estimated future population.

4) Others

This categorys comprised of 'construction', 'electricity, gas and water', 'wholesale and retail trade' and 'services' is estimated to be proportional to the future population.

Table A.9. Employment in Other Sectors

Projected Supportable Population

Year	Supportable Population
1970	1 worker: 9.3 *1) persons
1980	1 worker: 8.6 *2) persons
1990	1 worker: 7.9 *2) persons
2000	1 worker: 7.2 *2) persons

Employment of Others

Sector	Employment
Construction	7,438
Electricity	3,185
Wholesale and Retail	29,917
Services	40,015
Total	80,555 *1)

Population in 2000
580,000 persons

Source: *1) Population Census 1970

*2) The decrease of supportable population in the Kelang District is according to the decrease of Selangor from 1957 to 1970.

Note: This figure is divided to the each sector in proportion to the ratios of 1970 Population Census.

A.4. Sectoral Employment in 2000

The total employment of 220,757 should be adjusted by the control total i.e. 226,000.

Table A.10. Sectoral Employment in 2000

Kelang District
1) - 4) Total

Sector	Employment
Agriculture	10,790
Mining	36
Manufacturing	87,000
Construction	7,438
Electricity	3,185
Transport	42,376
Wholesale & Retail	29,917
Services	40,015
Total	220,757

Control Total

226,000 (from paragraph 2.2)

Kelang District

Sector	Employment
Agriculture	11,000
Mining	0
Manufacturing	89,000
Construction	8,000
Electricity	3,000
Transport	43,000
Wholesale & Retail	31,000
Services	41,000
Total	226,000

Control Total

195,000

Project Area

Sector	Employment
Agriculture	1,000 *1)
Mining	0
Manufacturing	81,000 *2)
Construction	7,000 *2)
Electricity	3,000 *2)
Transport	38,000 *2)
Wholesale & Retail	28,000 *2)
Services	37,000 *2)
Total	195,000

Notes: *1) To begin with, the team distributes the 'Agricultural Workers' to the Study Area by the ratio of farm lands.
11,000 x 8,000 acres/114,000 acres = 1,000

*2) In the next step, the team distributes the 'Remains' to the Study Area in proportion to the employment of Kelang District under the 'Control Total'.

Table A.13. Commercial Area

Commercial Employment in 2000	85,000 workers
Employment Density	300 workers/hectare
Required Commercial Area	280 hectares
(Existing Commercial Area)	(90 hectares)
Additional Requirement 1980 - 2000	190 hectares

Note: Existing employment density: 400 workers/hectare

Table A.14. Institutional Area

Population in 2000	500,000 persons
Existing Institutional Area per person	12 m^2/person
Required Institutional Area	600 hectares
(Existing Institutional Area)	(230 hectares)
Additional Requirement 1980 - 2000	370 hectares

A.5. Land Use

Table A.11. Residential Area

Population in 2000 A.D.	500,000 persons
Average Gross Residential Population Density	100 persons/hectare
Required Residential Area	5,000 hectares
(Existing Residential Area)	(1,600 hectares)
Additional Requirement 1980 - 2000	3,400 hectares

Note: Existing average gross population density: 120 persons/hectare

Table A.12 Industrial Area

Manufacturing Employment in 2000	81,000 workers
Average Gross Employment Density	40 workers/hectare
Required Industrial Area	2,000 hectares
Existing Industrial Area	700 hectares
Projected Industrial Area	1,400 hectares
Additional Requirement 1980 - 2000	0

Note: Net employment density: 60 workers/hectare

APPENDIX B

INVESTIGATION OF THE WATER QUALITY IN RIVERS AND DRAINS

APPENDIX B. INVESTIGATION OF THE WATER QUALITY IN RIVERS AND DRAINS

B.1. Investigation of the Kelang River Water Quality

As a preliminary step, a study of the Kelang River water quality was made from 1978 to 1980 data obtained from the Division of Environment (DOE), as shown in Table B.1. It shows that the Kelang River seems to receive a large amount of SS from all parts of the Kelang River basin, while BOD concentrations are comparatively low. However, these figures are considered to be affected by salinity, since the Kelang River throughout the Project Area is affected by tidal influence. Under the influence of sea water, BOD is not considered to be an appropriate index of organic pollution. Thus, COD concentration was used as the index of organic pollution, with results indicating high organic pollution of the Kelang River. However, the polluted condition of the Kelang River is considered to be due as much to pollutants from the upper reaches of the river outside the Project Area in the vicinity of Kuala Lumpur as to those from Kelang and Port Kelang.

Investigation of the Kelang River water quality was made both at low tide and at high tide on April 15th by the Study Team. At the same time, water samples at depths of 0.3 m, 2.0 m, 4.0 m, 6.0 m and 8.0 m below the water surface were analyzed. The results of the investigation are shown in Table B.2 and also in Fig. B.1 and Fig B.2.

Table B.1. Sanitary Chemical Analysis of the Kelang River Water Quality

Conditions and Constituents / Distance from River Mouth / Year	1980			1979			1978		
	2.25 km	18.19 km	23.18 km	2.25 km	18.19 km	23.18 km	2.25 km	18.19 km	23.18 km
Temperature (in-Situ) (°C)	31	30	29.4	-	-	-	-	-	-
Color (Hazen)	10	14	12	11	16	19	72	74	91
Turbidity (FTU)	422.9	958	478	-	-	-	-	-	-
Conductivity (umhos/cm) (in-Situ/Lab)	28,611	2,157	351	12,431	4,136	1,161	24,983	930	4,121
Salinity (in-Situ) (%)	16.5	6.5	0	-	-	-	-	-	-
pH (in-Situ)	6.57	6.85	6.78	-	-	-	-	-	-
pH (Lab)	7.30	7.00	6.90	7.5	7.0	6.9	7.9	5.8	6.9
BOD_5 at 20°C (mg/ℓ)	2.6	6.6	4.0	1.1	3.2	3.0	2.4	2.6	2.1
COD (mg/ℓ)	172.1	53.3	95.0	48.4	125.0	123.5	430.5	731.3	41.6
Albuminoid-Nitrogen (mg/ℓ)	-	-	-	-	-	-	-	-	-
Ammoninoid-Nitrogen (mg/ℓ)	1.3	2.44	19.98	5.01	2.06	1.84	1.16	2.1	467.8
Nitrate-Nitrogen (mg/ℓ)	0.27	0.34	0.27	0.66	0.08	0.55	1.82	1.23	1.56
Total Nitrogen (mg/ℓ)	3.40	6.3	5.4	-	-	-	-	-	-
Chloride (mg/ℓ)	7,989	247.3	17.0	9,021	2,078.6	552.9	8,083	2,187	2,287
Fluoride (mg/ℓ)	0.70	0.02	0.28	0.81	0.46	11.44	0.8	0.58	0.56
Cyanide (mg/ℓ)	0	0	0	0	-	0	0	0	0
Sulphate (mg/ℓ)	1,238	55.8	18.3	-	-	-	-	-	-
Phosphate (mg/ℓ)	0.66	0.79	0.91	0.32	1.33	1.80	0.2	2.51	0.57
Hardness (mg/ℓ)	2,861	283	99	-	-	-	-	-	-

Table B.1. (Cont.)

Conditions and Constituents \ Distance from River Mouth \ Year		1980			1979			1978		
		2.25 km	18.19 km	23.18 km	2.25 km	18.19 km	23.18 km	2.25 km	18.19 km	23.18 km
Suspended Solids	(mg/ℓ)	974	2,296	1,175	449	1,723	2,273	1,554	1,753	838
Dissolved Solids	(mg/ℓ)	22,312	756	391	-	-	-	-	-	-
Total Solids	(mg/ℓ)	23,282	1,915	1,843	-	-	-	-	-	-
Oil and Grease	(mg/ℓ)	6	7	9	27	23	26	18	13	23
Phenol	(mg/ℓ)	0.05	0.05	0.06	-	-	-	-	-	-
Detergents (MBAS)	(mg/ℓ)	0.2	0.5	0.2	-	-	-	-	-	-
As	(mg/ℓ)	0.054	0.051	0.051	0.029	0.056	0.133	0.03	0.14	0.105
B	(mg/ℓ)	0.86	0.32	0.36	0.3	-	0.24	-	0.06	-
Ca	(mg/ℓ)	248	67.1	22	115.5	227.5	32.0	383.5	80.6	31.15
Cd	(mg/ℓ)	0.01	0.01	0.01	0.03	0.02	0	0	0	0
Cr (Total)	(mg/ℓ)	0.05	0.04	0.05	0.12	0.11	0.03	-	0	0
Cu	(mg/ℓ)	0.04	0.06	0.52	-	-	-	-	-	-
Fe	(mg/ℓ)	9.28	19.0	14.7	1.71	10.15	6.67	1.46	69.5	10.21
Pb	(mg/ℓ)	0.09	0.12	0.11	0.05	0.1	-	0.13	-	0.2
Mg	(mg/ℓ)	566	25.6	5.6	637	82.6	0.1	512.3	-	0.17
Mn	(mg/ℓ)	0.20	0.26	0.22	-	-	-	0.28	-	0.23
Hg	(mg/ℓ)	0.002	0.002	0.02	-	-	-	-	-	-
Ni	(mg/ℓ)	0.73	0.02	0.15	4,483	-		-	-	75
Na	(mg/ℓ)	-	48.3	17.5	-	1,003	280	6,342	-	-
Sn	(mg/ℓ)	-	0	0	-	-	-	-	-	-
Aℓ	(mg/ℓ)	0.2	1.03	0.98	-	-	-	-	-	-

Table B.2. Kelang River Water Quality Analysis at Low and High Tide

Sampling Point / Conditions and Constituents	Jabantan Kota Bridge (at low tide)						Jabantan Kota Bridge (at high tide)						
Depth from Water Level	0.3 m	2.0 m	4.0 m	6.0 m	8.0 m	9.0 m	0.3 m	2.0 m	4.0 m	6.0 m	8.0 m	10.0 m	12.0 m
Date	15 April						15 April						
Time	9:20	9:38	9:55	10:03	10:42	-	15:39	15:44	15:52	16:00	16:10	16:25	16:32
Rate of Effluent (m^3/day)													
Atmospheric Temperature (°C)	25.5	25.5	26.0	26.6	27.5	27.5	30.5	30.5	30.5	30.5	30.5	30.0	30.5
Water Temperature (°C)	27.6	27.1	26.5	27.0	26.7		28.4	28.5	28.1	28.1	28.4	28.2	28.2
pH	6.7	6.8	6.7	7.0	6.9		6.8	6.8	6.8	6.8	7.1	7.1	7.1
Transparency (cm)	1.5	1.3	1.1	1.0	1.0		3.0	4.0	5.0	3.5	1.5	0.8	0.9
Coliforms (c/mℓ)	2,550	2,550	2,550	2,400	2,400		2,550	2,550	2,550	2,400	2,400	2,400	2,550
Conductivity (μV/cm)	240	230	230	220	230		12,000	12,800	13,200	17,200	19,800	27,300	25,100
COD (mg/ℓ)		175.0			90			350			695		
DO (mg/ℓ)	1.4	1.8	1.6	2.3	1.7		2.5	2.0	2.6	2.6	2.2	1.9	2.5
NH_3-N (mg/ℓ)		1.73			2.26			1.89			3.05		
PO_4-P (mg/ℓ)		0.57			0.02			<0.01			0.16		
BOD (mg/ℓ)		55.0			35.0			140			170		
Remarks													

Fig.B.1. Relationship of Kelang River Water Quality to Sampling Depth at Low Tide

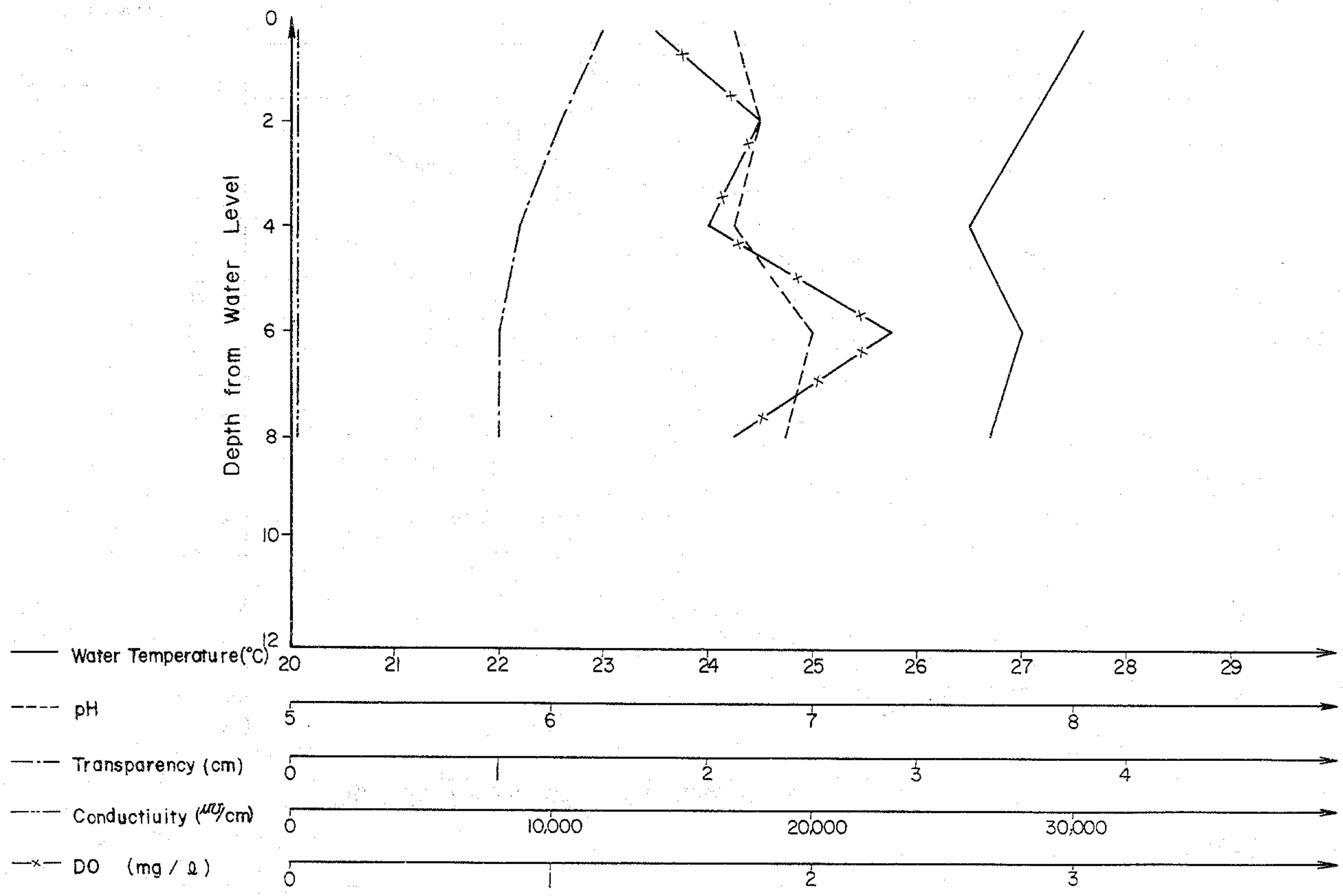
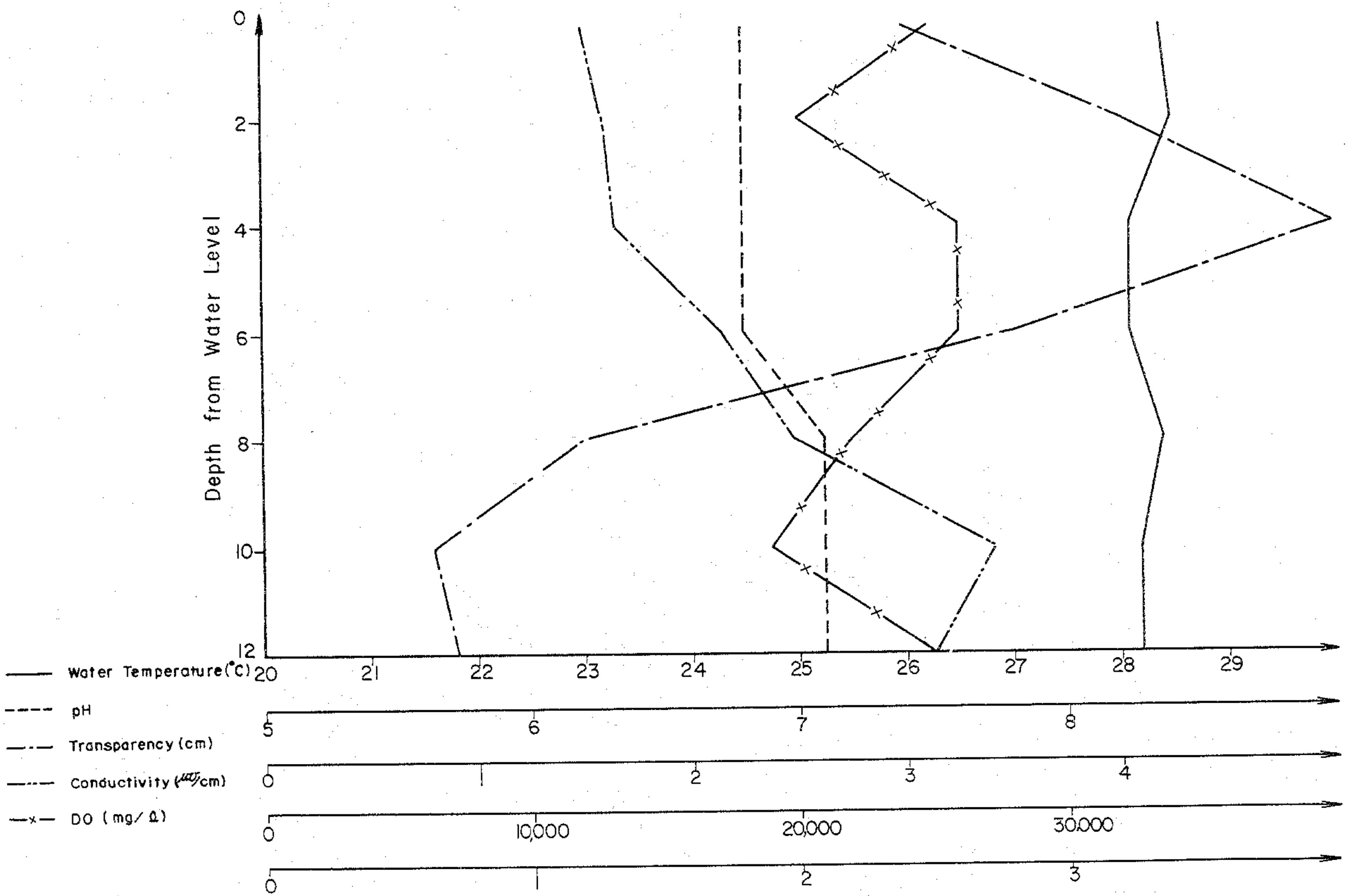


Fig. B.2. Relationship of Kelang River Water Quality to Sampling Depth at High Tide

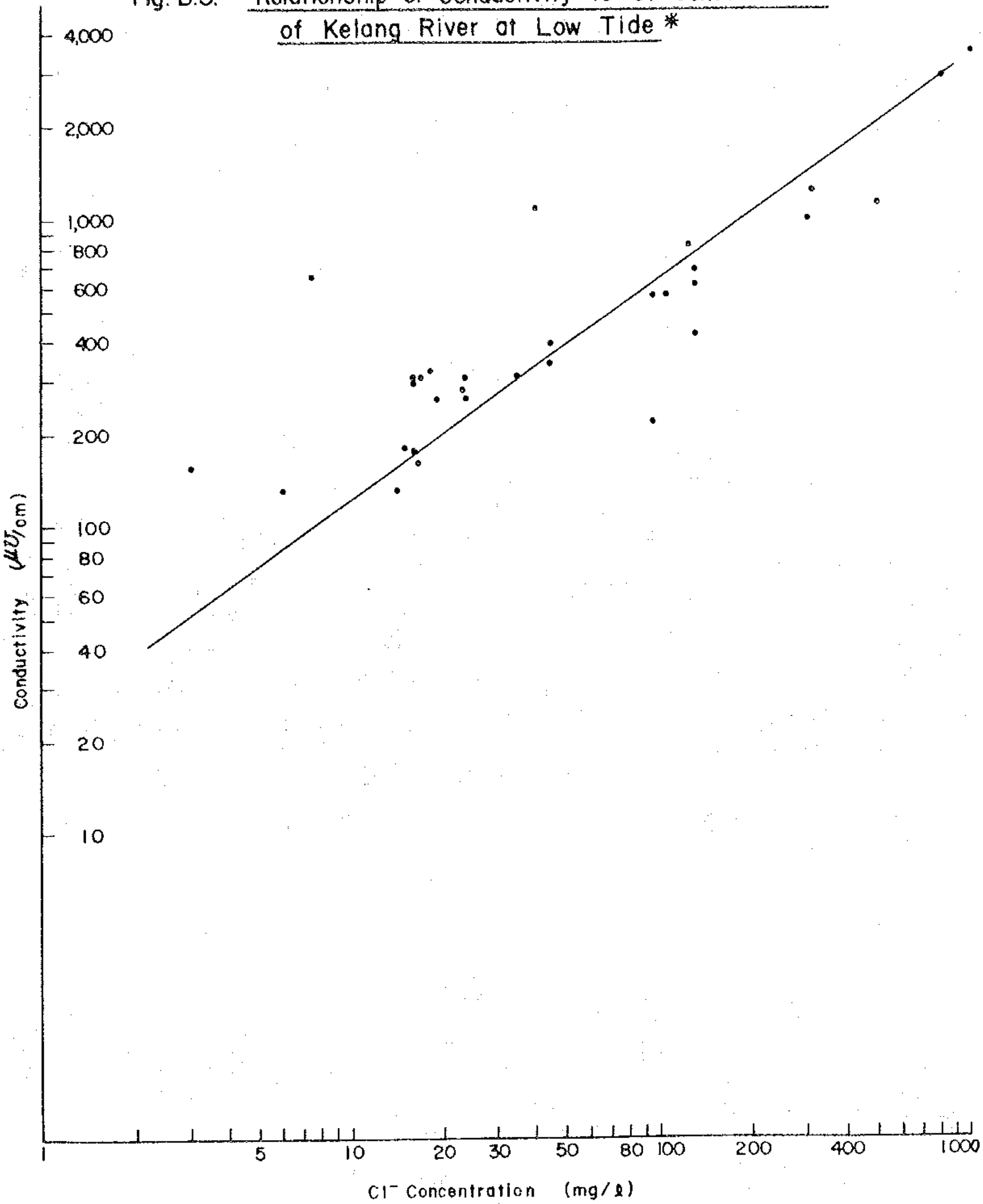


Field investigation was carried out in order to determine the difference in water quality between samples taken at low tide and at high tide, and also to determine the difference in quality according to varying depths from the water surface. The first thing noted was the great influence of the sea at high tide. Although the average conductivity at low tide is 230 μν/cm, it is 18,200 μν/cm on the average at high tide, which is eighty times higher than at low tide. In other words, the high tidal sea water has a purifying effect on the water quality. However, the difference in quality according to various depths from the water surface was not so distinct that a relationship could be observed.

The relationship between conductivity and concentration of Cl^- in Kelang River water quality is illustrated in Fig. B.3 and Fig. B.4. Fig. B.3 indicates the absence of influence by sea water and Fig. B.4 indicates the influence of sea water.

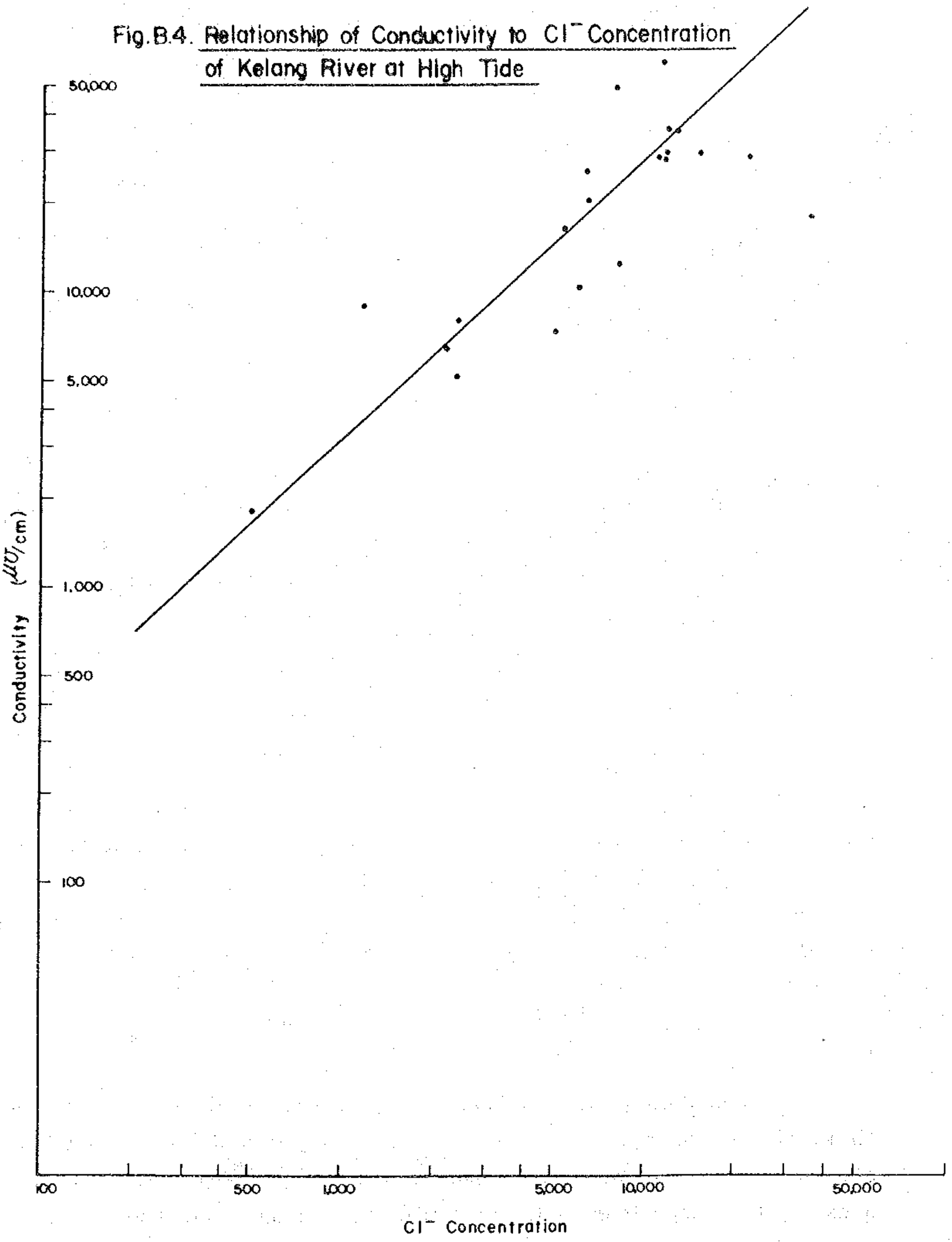
By comparing the data obtained in the field studies as illustrated in Fig. B.1 and Fig. B.2, the influence of sea water can be realized to some degree. A rough estimate of Cl^- concentration also can be obtained simply through conductivity measurement. For instance, since the average conductivity of various depths at low tide on April 15th was 230 μν/cm, it can therefore be said that the average Cl^- concentration was around 25 mg/ℓ. Similarly, it can be said that the average Cl^- concentration at high tide on that day ranged between 4,000 mg/ℓ and 9,400 mg/ℓ.

Fig. B.3. Relationship of Conductivity to Cl⁻ Concentration of Kelang River at Low Tide *



* Based on Kelang Municipality (1978 - 80) monthly water quality analysis data on samples taken at 0.3m below water level

Fig. B.4. Relationship of Conductivity to Cl^- Concentration of Kelang River at High Tide



Based on Kelang Municipality (1978-80) monthly water quality analysis data on samples taken at 0.3 m below water level

B.2. Water Quality Investigation of the Kelang River Tributaries and Main Drains

The Study Team investigated the water quality of the Kelang River tributaries and main drains from May 4th through May 11th in order to realize the existing condition of water pollution in the Project Area.

The sampling points of tributaries and main drains which numbered thirty, are located at Kelang, Port Kelang, Kapar and Meru. These thirty sampling points were classified according to location into five groups; namely, Port Kelang (P-1 - P-8), Kelang South (S-1 - S-8), Kelang North (N-1 - N-8), Kapar (K-1 - K-3) and Meru (M-1 - M-3).

The water quality analysis results are shown in Table B.3, Table B.4, Table B.5 and Table B.6, and the sampling points are shown in Fig. B.5.

The results of the investigation are summarized as follows:

1) pH

pH of P-8, N-8, S-8, K-1, M-2, M-3 indicate acidity. Of these six sampling points, only K-1 is affected by the heavy acid factory wastewater. Generally, water which flows through plantations seems to become acid. Thus, the acidity of the water is considered to be caused by acidic soil or acid fertilizer. However, the cause or causes of the acidity have yet to be confirmed.

2) Coliforms

Sampling points in Port Kelang are situated in the industrial area; thus, coliform numbers are not so large. Kapar and Meru consist mainly of open space; thus, coliform numbers are not so large either in these two areas. In comparison with Port Kelang, Kapar and Meru, the coliform numbers in Kelang are high, due to its large number of densely inhabited areas.

3) NH_3-N

Generally, ammonia nitrogen can be used as an indicator of organic pollution, especially that of human excreta. Therefore, it can be said that the results of NH_3-N analysis in Tables B.3 through B.6 reflect the existing land use.

4) BOD

High BOD concentrations at Port Kelang indicate a deteriorated condition of pollution in this area. The average BOD of the eight sampling points in Port Kelang is 141 mg/ℓ, while the average BOD in the other areas is 38 mg/ℓ.

However, this low average does not indicate the absence of water pollution in Kelang, Kapar and Meru; because BOD concentration of more than 10 mg/ℓ generally indicates existence of domestic and/or industrial wastes. Direct discharge from densely populated residential areas and untreated discharge from industrial areas into rivers and drains are considered to be the main causes of such water pollution. It is a situation requiring careful and urgent consideration.

Table B.3. Results of Water Quality Analysis of Main Rivers and Drains at Port Kelang

Conditions and Constituents	Sampling Point							
	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8
Date	7 May							
Time	10:35	11:00	11:20	11:40	12:00	12:30	12:50	13:00
Rate of Effluent (m^3/day)	-	-	-	-	-	-	-	-
Atmospheric Temperature (°C)	31.0	33.0	34.0	33.5	33.5	34.5	34.5	34.5
Water Temperature (°C)	28.8	29.0	29.2	29.5	29.8	30.2	29.8	29.5
pH	6.6	6.9	6.9	6.9	6.9	7.1	7.1	5.5
Transparency (cm)	5.0	9.0	10.0	20.0	7.0	11.0	14.0	13.0
Coliforms (c/mℓ)	1,800	0	900	2,100	1,500	6,600	1,200	1,200
Conductivity (μν/cm)	550	13,000	560	24,000	11,000	7,600	3,700	4,300
COD (mg/ℓ)	90.0	175.0	215.0	1,010.0	285.0	455.0	290.0	275.0
DO (mg/ℓ)	0.6	0.7	0.8	0.6	0.4	0.4	0.4	2.6
NH_3-N (mg/ℓ)	0.56	1.26	7.43	1.94	7.00	23.70	19.60	6.30
PO_4-P (mg/ℓ)	0.69	0.21	0.28	0.08	0.46	0.15	0.16	0.35
BOD (mg/ℓ)	35.0	65.0	80.0	390.0	130.0	180.0	135.0	110.0
Remarks								

Table B.4. Results of Water Quality Analysis of Main Rivers and Drains at Kelang South

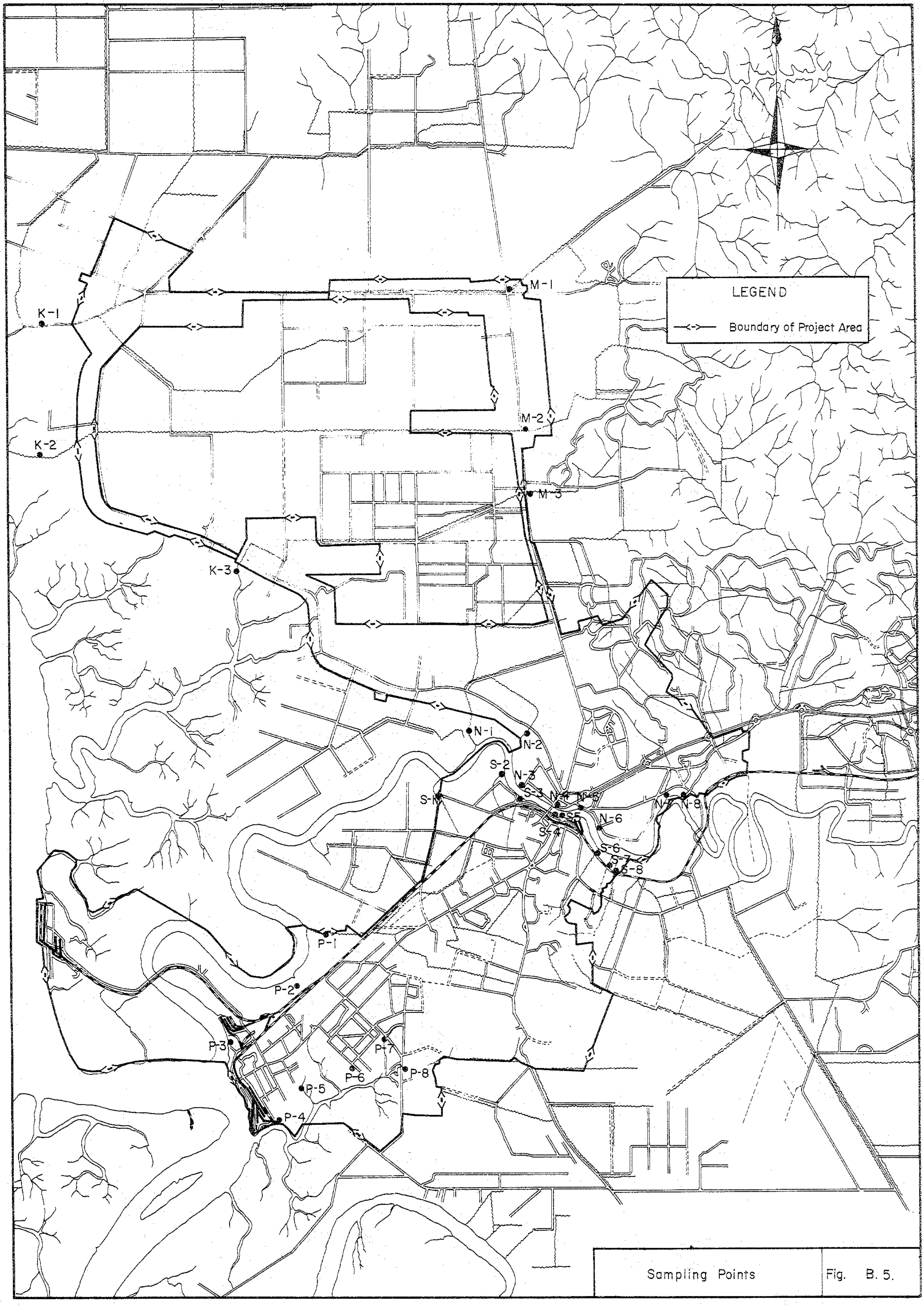
Conditions and Constituents	Sampling Point							
	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8
Date	5 May							
Time	9:00	9:30	9:45	9:55	10:05	10:20	10:35	10:45
Rate of Effluent (m^3/day)	-	-	-	-	-	-	-	-
Atmospheric Temperature (°C)	27.5	30.5	31.0	37.0	39.0	39.2	39.0	39.5
Water Temperature (°C)	27.5	27.9	28.3	29.0	28.2	29.0	28.1	28.5
pH	6.7	6.7	6.7	6.7	6.7	6.7	6.7	5.0
Transparency (cm)	2.5	2.0	9.0	8.0	4.2	10.0	11.0	7.5
Coliforms (c/mℓ)	60,000	120,000	120,000	120,000	150,000	15,000	30,000	15,000
Conductivity (μν/cm)	2,000	1,000	700	500	0...?	380	350	350
COD (mg/ℓ)	80.0	70.0	75.0	185.0	285.0	30.0	40.0	45.0
DO (mg/ℓ)	0.6	0.9	0.5	1.5	0.9	1.1	1.2	2.0
NH_3-N (mg/ℓ)	4.61	5.60	9.88	15.3	24.6	7.49	4.69	1.52
PO_4-P (mg/ℓ)	<0.01	0.18	<0.01	0.18	0.65	0.23	0.14	0.10
BOD (mg/ℓ)	33.0	24.0	30.3	68.0	95.0	18.0	13.0	20.0
Remarks								

Table B.5. Results of Water Quality Analysis of Main Rivers and Drains at Kelang North

Conditions and Constituents	Sampling Point							
	N-1	N-2	N-3	N-4	N-5	N-6	N-7	N-8
Date	4 May							
Time	9:25	9:10	9:45	10:05	10:10	10:35	11:15	10:55
Rate of Effluent (m^3/day)	-	-	-	-	-	-	-	-
Atmospheric Temperature (°C)	29.0	28.5	29.5	30.5	30.0	30.5	34.0	31.7
Water Temperature (°C)	26.8	26.1	26.6	27.1	26.8	27.2	27.5	27.5
pH	6.1	6.5	6.7	6.7	6.9	6.8	6.8	5.2
Transparency (cm)	5.0	6.5	4.5	8.5	3.3	2.0	8.0	3.5
Coliforms (c/mℓ)	30,000	150,000	75,000	90,000	150,000	90,000	150,000	150,000
Conductivity (μv/cm)	2,000	470	2,800	500	340	840	320	340
COD (mg/ℓ)	35.0	85.0	100.0	90.0	70.0	60.0	60.0	50.0
DO (mg/ℓ)	1.0	0.4	0.8	1.1	1.8	1.8	0.5	2.1
NH_3-N (mg/ℓ)	2.63	8.73	3.21	11.53	10.70	4.28	9.39	1.32
PO_4-P (mg/ℓ)	0.36	0.13	0.18	0.23	0.30	0.26	0.20	0.42
BOD (mg/ℓ)	15.0	30.0	38.0	35.0	30.0	25.0	26.0	20.0
Remarks								

Tabel B.6. Results of Water Quality Analysis of Main Rivers and Drains at Kapar and Meru

Conditions and Constituents	Sampling Point						
	K-1	K-2	K-3		M-1	M-2	M-3
Date	8 May				11 May		
Time	14:00	13:20	13:40		14:20	14:30	14:45
Rate of Effluent (m^3/day)	-	-	-		-	-	-
Atmospheric Temperature (°C)	32.5	36.5	32.0		30.0	31.0	31.0
Water Temperature (°C)	29.4	31.4	28.0		27.4	27.6	28.1
pH	5.5	6.9	6.5		6.7	5.8	5.8
Transparency (cm)	7.0	10.3	10.0		2.5	5.5	21.0
Coliforms (c/mℓ)	4,500	1,800	7,500		900	1,200	3,000
Conductivity (μv/cm)	680	380	2,300		530	200	220
COD (mg/ℓ)	45.0	35.0	150.0		330.0	95.0	160.0
DO (mg/ℓ)	1.1	1.9	0.4		1.5	2.7	1.0
NH_3-N (mg/ℓ)	0.82	0.74	0.82		18.80	1.73	6.45
PO_4-P (mg/ℓ)	0.57	0.06	0.37		0.57	0.46	0.46
BOD (mg/ℓ)	23.0	15.0	55.0		120.0	30.0	65.0
Remarks							



Sampling Points Fig. B. 5.

APPENDIX C

STUDY ON THE DOMESTIC WASTEWATER FROM TWO HOUSING AREAS

APPENDIX C. STUDY ON THE DOMESTIC WASTEWATER FROM TWO HOUSING AREAS

C.1. Introduction

In order to calculate or to confirm BOD load per capita, investigation of the quality and the quantity of domestic wastewater at Taman Gembira and Taman Precious Tree were conducted. The reason for selection of Taman Gembira and Taman Precious Tree as the points of investigation is as follows:

1) Taman Gembira and Taman Precious Tree are average residential sections recently developed as new housing schemes.

2) There were ditches where weirs could be installed for investigation of the quality and the quantity of domestic wastewater at Taman Gembira and Taman Precious Tree, respectively.

3) Each ditch was made to receive domestic wastewater from a selected section of both Taman Gembira and Taman Precious Tree. Thus, the flow rates could be confirmed by means of investigation of water consumption in cooperation with the Water Works Dept. and much knowledge about each of the selected section of Taman Gembira and Taman Precious Tree, such as occupation, monthly average income and population, could be obtained.

C.2. Conditions Concerning the Sampling and Measuring Points

Fig. C.1, and Fig. C.2 show conditions concerning the sampling and measuring points.

Fig. C.1 Conditions Concerning the Sampling and Measuring Point at Taman Gembira

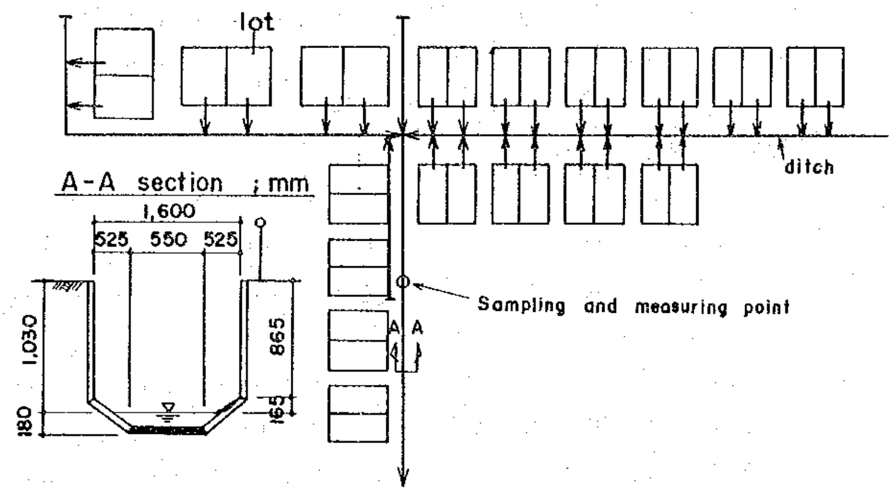
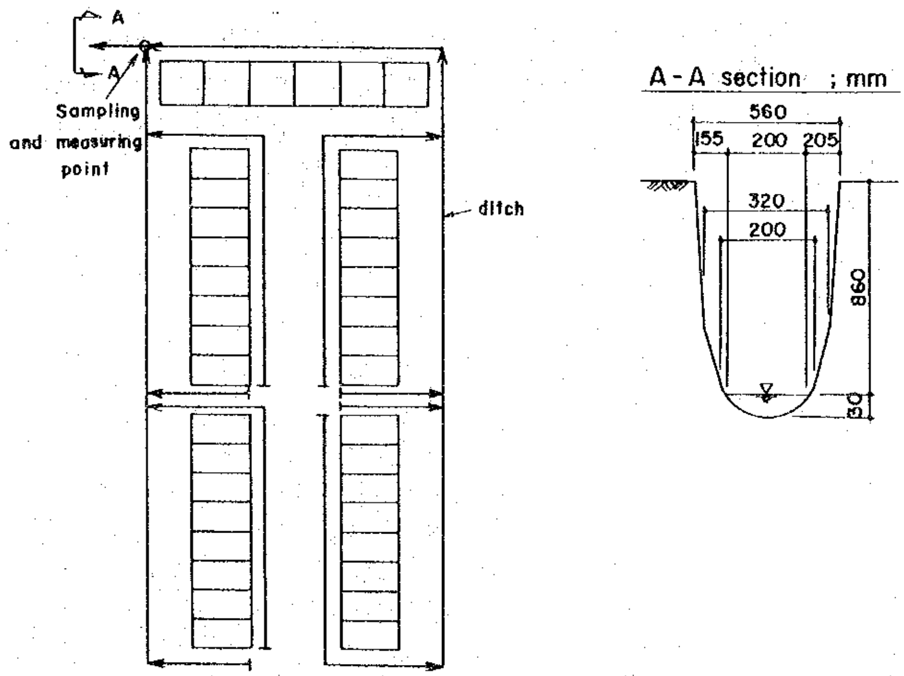
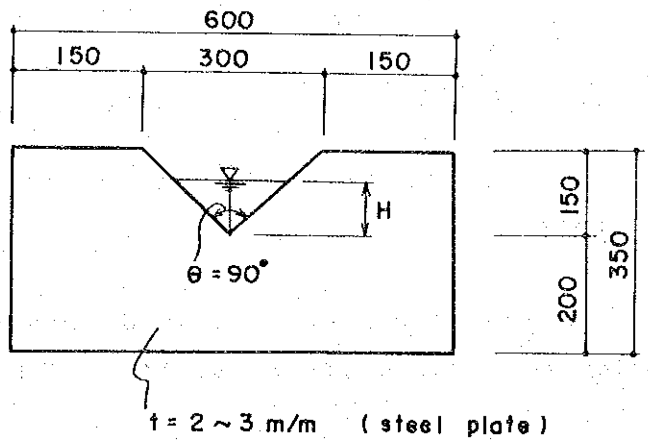


Fig. C.2. Conditions Concerning the Sampling and Measuring Point at Taman Precious Tree

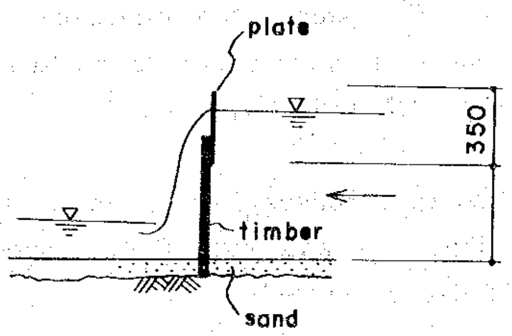


The shape and size of the weir are shown in Fig. C.3 below:

Fig. C.3. The Shape and Size of the Weir



Front : mm



Section : mm

Measurement items are flow rate (actually, the overflow depth was measured and the flow rate calculated by means of the following flow rate formula:

$$Q = 60(1,334 + \frac{0.0205}{\sqrt{H}})H^{5/2} \quad , Q:M^3/min, \ H:m$$

pH, turbidity, coliforms conductivity, COD, BOD, etc.

The measurement was scheduled to begin at 5 a.m. and end at 11 p.m. on May 18th at Taman Gembira and on May 25th at Taman Precious Tree, but because of rain the first measurement was held over until 1 p.m. on May 18th.

C.3. Results of Investigation

Table C.1 shows flow rates for both Taman Gembira and Taman Precious Tree at fixed times.

Table C.2 shows the result from questionnaires and water meter readings for water consumption per household at Taman Gembira on May 19th and May 20th.

Table C.3 shows the results from questionnaires and water consumption per household at Taman Precious Tree on May 25th and May 26th.

Table C.4 and Table C.5 show results of water quality analysis at each point. Also Fig. C.4 shows the relationship between flow rate and BOD. General flow rate-time curves for Taman Gembira and Taman Precious Tree are shown in Fig. C.5 and C.6, respectively.

General BOD-time curves for Taman Gembira and Taman Precious Tree are shown in Fig. C.7 and Fig. C.8, respectively. But the curve during times of rainfall is estimated.

BOD load per capita is calculated from the first day's data of measurements and sampling, starting at 1 p.m. on May 19th and ending at 11 a.m. on May 20th.

Also, groundwater infiltration was taken into consideration, because of excessive discharge from residences during the night as well as calculation of the flow rate of ditches based on sampling and measurement data at the most appropriate point at both Taman Gembira and Taman Precious Tree.

Table C.1. Flow Rates of Domestic Waste Water

$$Q = 60(1,334 + \frac{0.0205}{\sqrt{H}})\ H^{5/2}$$

Time	TAMAN GEMBIRA (May 19)			TAMAN PRECIOUS TREE (May 25)		
	Overflow Depth: H (m)	Discharge : Q		Overflow Depth: H (m)	Discharge : Q	
		m^3/min.	$m^3/sec \times 10^{-3}$		m^3/min.	$m^3/sec \times 10^{-3}$
5:00	0.046	0.0389	0.648	0.025	0.0087	0.145
6:00	0.046	0.0389	0.648	0.025	0.0087	0.145
6:30	0.048	0.0432	0.720	0.041	0.0293	0.488
7:00	0.049	0.0455	0.758	0.046	0.0389	0.648
7:30	0.051	0.0503	0.838	0.056	0.0633	1.055
8:00			(1.15)*	0.050	0.0478	0.797
8:30			(1.54)*	0.051	0.0503	0.838
9:00			(1.43)*	0.050	0.0478	0.797
10:00			(1.00)*	0.046	0.0389	0.648
11:00			(0.70)*	0.043	0.0330	0.550
12:00			(0.62)*	0.039	0.0259	0.432
12:30			(0.58)*	0.035	0.0199	0.332
13:00	0.044	0.0349	0.582	0.054**	0.0579	0.965 (0.53)*
14:00	0.055	0.0605	1.008	0.055**	0.0605	1.008 (0.49)*
15:00	0.054	0.0579	0.965	0.038	0.0243	0.405
16:00	0.052	0.0527	0.878	0.042	0.0311	0.518
17:00	0.057	0.0662	1.103	0.044	0.0349	0.582
18:00	0.070	0.1099	1.832	0.058	0.0690	1.150
18:30	0.063	0.0846	1.410	0.056	0.0633	1.055
19:00	0.062	0.0814	1.357	0.066	0.0950	1.583
19:30	0.067	0.0986	1.643	0.059	0.0503	1.200
20:00	0.057	0.0662	1.103	0.051	0.0503	0.838
21:00	0.054	0.0579	0.965	0.052	0.0527	0.878
22:00	0.052	0.0527	0.878	0.040	0.0276	0.460
23:00	0.050	0.0478	0.797	0.042	0.0311	0.518

* Estimated figure

** Rainfall

Table C.2. Results of Questionnaire and Water Consumption per Household -- TAMAN GEMBIRA

(30 Semi-detached Houses)

House-hold No.	No. of Persons	Monthly Income (M$)	Occupation	Monthly Water Bill (M$)	Willingness to Pay for Sewerage System (M$/month)	Amount of Consumption * May 19th (m^3/day)	Amount of Consumption * May 20th (m^3/day)
1	4	3,000	Engineer, Teacher	12	20	1.123	1.527
2	(5)	-	-	-	-	0.273	0.409
3	7	1,000	Salesman	10	Same as others	0.891	0.804
4	2	-	Sales agent	-	-	0.664	0.895
5	7	5,000	Supervisor, Manager, Nurse	40	20	2.791	2.500
6	6	2,000	Manager	41	20	1.850	5.427
7	8	450	Carpenter	30	10	2.477	1.182
8	(5)	-	-	-	-	0.182	0.173
9	6	2,000	Police officer, -	36	Indefinite	1.854	2.082
10	10	1,200	Contractor, -	30	10	1.459	1.659
11	2	400	Supervisor	16	Indefinite	0.373	0.595
12	5	300	Nurse and Domestic Helper	22	10	0.832	1.018
13	10+1	1,000	Businessman	20	Indefinite	2.259	2.186
14	10	-	Businessman	15	20	1.618	1.859
15	4	Own business	Manager (car air-cond. Co.)	28	10	1.373	0.850
16	6+1	2,000	Businessman	25	20	1.045	1.232
17	4	>1,000	Officer	20	Indefinite	1.077	1.300
18	5	1,000	Nurse, Clerk	20	5~10	1.404	1.127
19	2	2,500	Teacher of Secondary School	20	20	0.491	0.882
20	(5)	-	-	-	-	0.254	0.323
21	3	2,000	Officer, Shipping assistant	5	20	0.941	0.941
22	3	400	Proprietor, -	20	Unable to pay	0.941	1.064
23	0	-	-	-	-	-	-
24	4	-	Noodle Salesman	10	Indefinite	0.718	0.750
25	4	3,000	Teacher, -	30	20	(8.358)	(8.358)
26	9	900	Teacher	25	30		
27	4	2,200	Businessman	20	30		
28	3	1,000	Clerk, Insurance Agent	20	20		
29	7	2,000	Police officer, Container Co.	15	10		
30	6	1,000	Trader	20	Indefinite		
31	5	-	-	-	-		
Sub Total (No.1~No.24)	125					26.890 Av. 28.838m^3/23 houses 0.246m^3/person	30.785
Total	163	Av. (5.3 persons/household)			(m^3/day) Av.	35.248 37.196	39.143
					(m^3/day/house) Av.	1.175 1.240	1.305
					(m^3/day/person) Av.	0.261 0.251	0.240

* Meter readings were taken at 10 a.m. on May 19th, 20th and 21st. The May 19th figure represents the difference between readings taken on May 19th and 20th, while the May 20th figure represents that for May 20th and 21st.

Table C.3. Results of Questionnaire and Water Consumption per Household -- TAMAN PRECIOUS TREE

(42 Terrace Houses)

House-hold No.	No. of Persons	Monthly Income (M$)	Occupation	Monthly Water Bill (M$)	Willingness to Pay for Sewerage System (M$/month)	Amount of Consumption * May 25th (m^3/day)	May 26th (m^3/day)
1	8	600	Shipping Co.	7	Indefinite	1.782	1.904
2	(4)	-	-	-	-	0.950	0.995
3	11	1,000	Supervisor	20	20	0.532	1.932
4	5+1	4,000	Oil Co.	20	10	1.441	2.150
5	6+1	Indefinite	Court	8	Indefinite	(1.000)	(1.000)
6	(4)	-	-	-	-	0.600	0.904
7	3	500	Welder	12~14	Indefinite	0.886	0.523
8	5+1	600 700	Foreman	15	Indefinite	1.268	1.609
9	7	300	Foreman, - , -	Not sure	Indefinite	0.991	0.886
10	9	Indefinite	Teacher	20~30	Indefinite	0.782	0.782
11	4	1,500	Clerk, Policeman	17~18	5	3.368	1.636
12	6	800	Watchman	20	Indefinite	0.116	1.677
13	(5)	-	-	-	-	0.895	1.568
14	(5)	-	-	-	-	0.673	1.618
15	5	2,000	Teacher	20	Any amount	1.218	0.645
16	11	300	Clerk, - , -	20	Indefinite	1.568	1.682
17	11	300	Gardener	50	Indefinite	2.100	3.163
18	(10)	-	-	-	-	1.809	2.286
19	4	1,000	Clerk	25	20	1.418	2.204
20	4	1,000	Supervisor	5.5	Indefinite	1.182	0.632
21	8	Indefinite	Businessman	15	15	1.314	2.195
22	7	Indefinite	Salesman	7	Indefinite	0.754	1.073
23	5+1	Indefinite	Plumber	13	Indefinite	0.477	0.768
24	5	Own business	Contractor	20	20	1.823	3.245
25	6	1,500	Assistant director	10	20	0.609	0.964
26	6	800~900	Shipping executive	12~13	Indefinite	1.159	1.141
27	5	500	Salesman, -	27	20	0.682	0.468
28	3	1,000	Farmer	13	Indefinite	0.718	0.586
29	(2)	-	-	-	-	0.123	0.182
30	4+1	Indefinite	Clerk	17	Indefinite	0.709	1.014
31	2	1,000	Technician	6	0	0.159	0.364
32	8	Indefinite	Fisherman	9~11	Indefinite	1.264	0.286
33	10	-	Student	20	Indefinite	1.623	1.936
34	5	-	Clerical Work	4~5	Indefinite	1.332	1.222
35	2	600	Teacher	4~5	Any amount	0.277	0.182
36	12	700	Clerk	15	Indefinite	4.245	4.813
37	5	-	Ship mechanic	10.5	4	0.618	1.236
38	2	650	Technician, -	6.5	10	0.101	0.532
39	6	2,000	Clerk	7	Any amount	1.927	0.668
40	4	2,100	Police Inspectors(3)	5	25	2.318	2.341
41	9	2,000	Assistant manager	13	Any amount	0.964	1.700
42	4	300	Lorry driver	10	5	0.464	0.741
Total	252	Av. (6.0 persons/household)			(m^3/day)	48.239	57.453
					Av.	52.846	
					(m^3/day/house)	1.149	1.368
					Av.	1.258	
					(m^3/day/person)	0.191	0.228
					Av.	0.210	

* Meter readings were taken at 10 am. on May 25th, 26th and 27th. The May 25th figure represents the difference between readings taken on May 25th and 26th, while the May 26th figure represents that for May 26th and 27th.

Table C.4. Water Quality Analysis Data (TAMAN GEMBIRA, 19 MAY - 20 MAY)

Sampling Point	1	2	3	4	5	6	7	8
Visual Observation								
Date	18, May						19, May	
Time	13:00	15:00	17:00	18:30	19:30	21:00	6:00	7:00
Rate of Effluent (m^3/day)	0.582	0.965	1.103	1.410	1.643	0.965	0.648	0.758
Atmospheric Temperature (°C)	34.0	32.0	28.5	-	28.5	28.5	26.5	26.0
Water Temperature (°C)	31.5	30.6	28.4	27.8	27.4	26.8	26.7	26.8
PH	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
Transparency (cm)	13.5	13.0	13.0	16.0	15.0	14.0	15.0	16.0
Coliforms (c/ml)	2,400	1,800	2,400	2,400	900	1,800	2,400	1,200
Conductivity (μU/cm)	330	410	400	370	330	360	400	410
COD (mg/l)	55.0	60.0	75.0	55.0	40.0	60.0	35.0	70.0
DO (mg/l)	2.6	0.9	0.7	0.9	1.0	1.2	1.5	1.7
NH_3-N (mg/l)	1.30	2.70	12.60	1.70	1.50	3.90	3.10	2.0
PO_4-P (mg/l)	0.02	0.05	0.08	0.04	0.02	0.53	0.02	0.03
BOD (mg/l)	25.0	25.0	44.0	35.0	20.0	25.0	20.0	30.0

Table C.5. Water Quality Analysis Data (TAMAN PRECIOUS TREE, 25 MAY)

Sampling Point	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Visual Observation														
Date	25,May													
Time	6:00	7:00	7:30	8:00	8:30	10:00	12:00	13:00	15:00	17:00	18:30	19:30	21:00	23:00
Rate of Effluent (m^3/day)	0.145	0.648	1.055	0.797	0.838	0.648	0.432	0.965	0.405	0.582	1.055	1.200	0.878	0.518
Atmospheric Temperature (°C)	24.6	24.2	25.0	25.0	27.0	28.0	27.3	29.0	28.0	28.8	28.5	28.9	28.5	27.0
Water Temperature (°C)	DO meter was out of order													
PH	6.7	6.9	7.1	6.7	7.1	7.1	7.0	6.4	6.9	6.9	7.1	6.8	6.9	7.0
Transparency (cm)	4.0	5.0	8.0	7.0	6.0	7.0	8.0	8.0	10.0	10.0	9.0	9.0	10.0	5.0
Coliforms (c/ml)	2,100	1,200	1,200	900	300	300	0	300	900	600	900	300	300	900
Conductivity (μΰ/cm)	640	720	630	680	820	600	510	540	520	610	490	520	470	720
DOD (mg/l)	260.0	215.0	275.0	295.0	240.0	175.0	195.0	240.0	135.0	165.0	190.0	250.0	175.0	190.0
DO (mg/l)	DO meter was out of order													
NH_3-N (mg/l)	25.9	38.0	27.2	28.3	41.6	25.9	15.2	20.2	17.4	22.4	21.4	21.9	18.9	33.7
PO_4-P (mg/l)	0.40	6.10	1.60	0.40	0.95	0.70	0.40	0.65	<0.01	<0.01	<0.01	0.53	<0.01	<0.01
BOD (mg/l)	95.0	65.0	115.0	140.0	90.0	60.0	70.0	85.0	50.0	70.0	130.0	145.0	75.0	125.0

Fig. C.4. Flow Rate-BOD Relationship

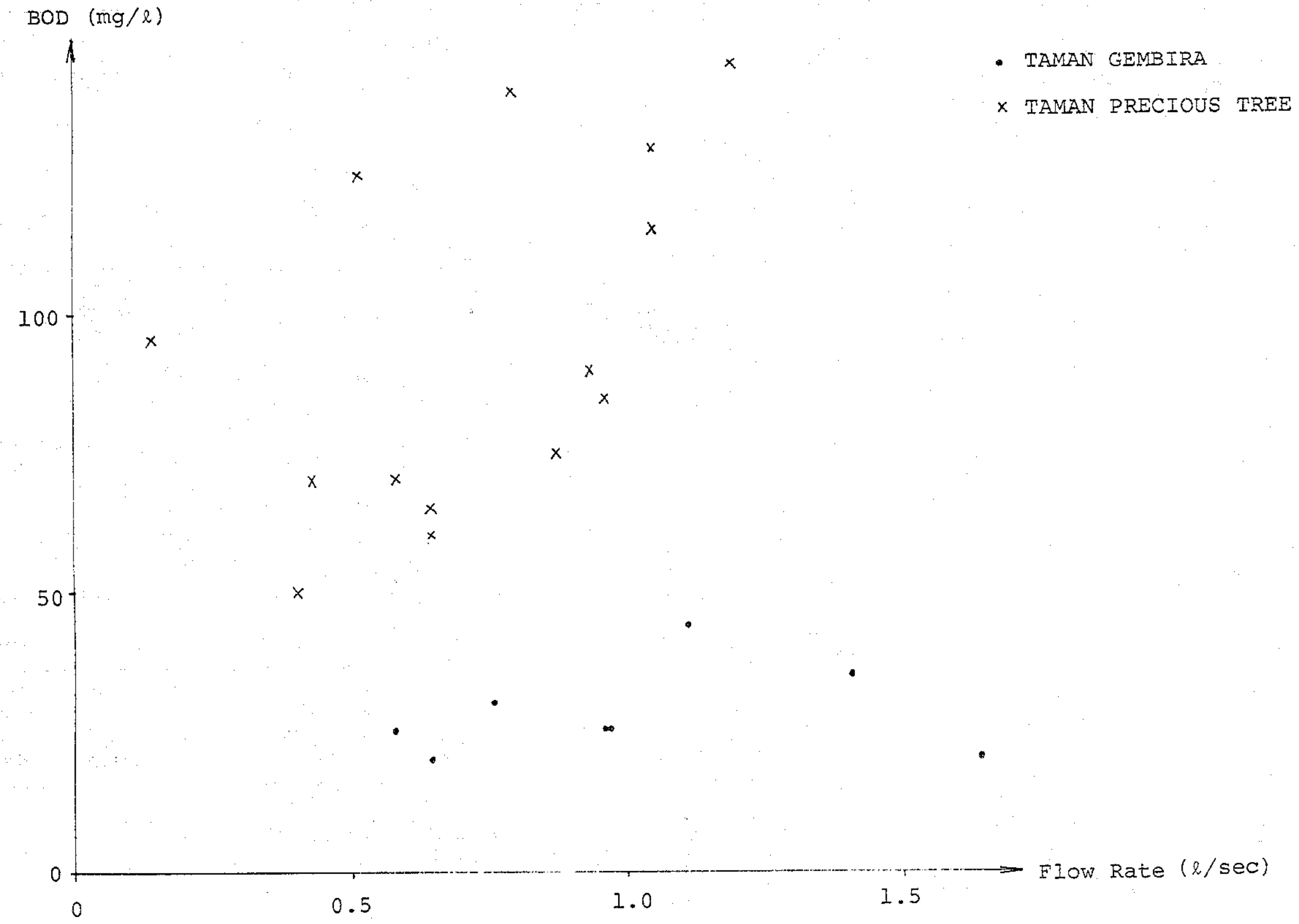


Fig. C.5. Flow Rate-Time Relationship at Taman Gembira (May 18 ~ 19, 1981)

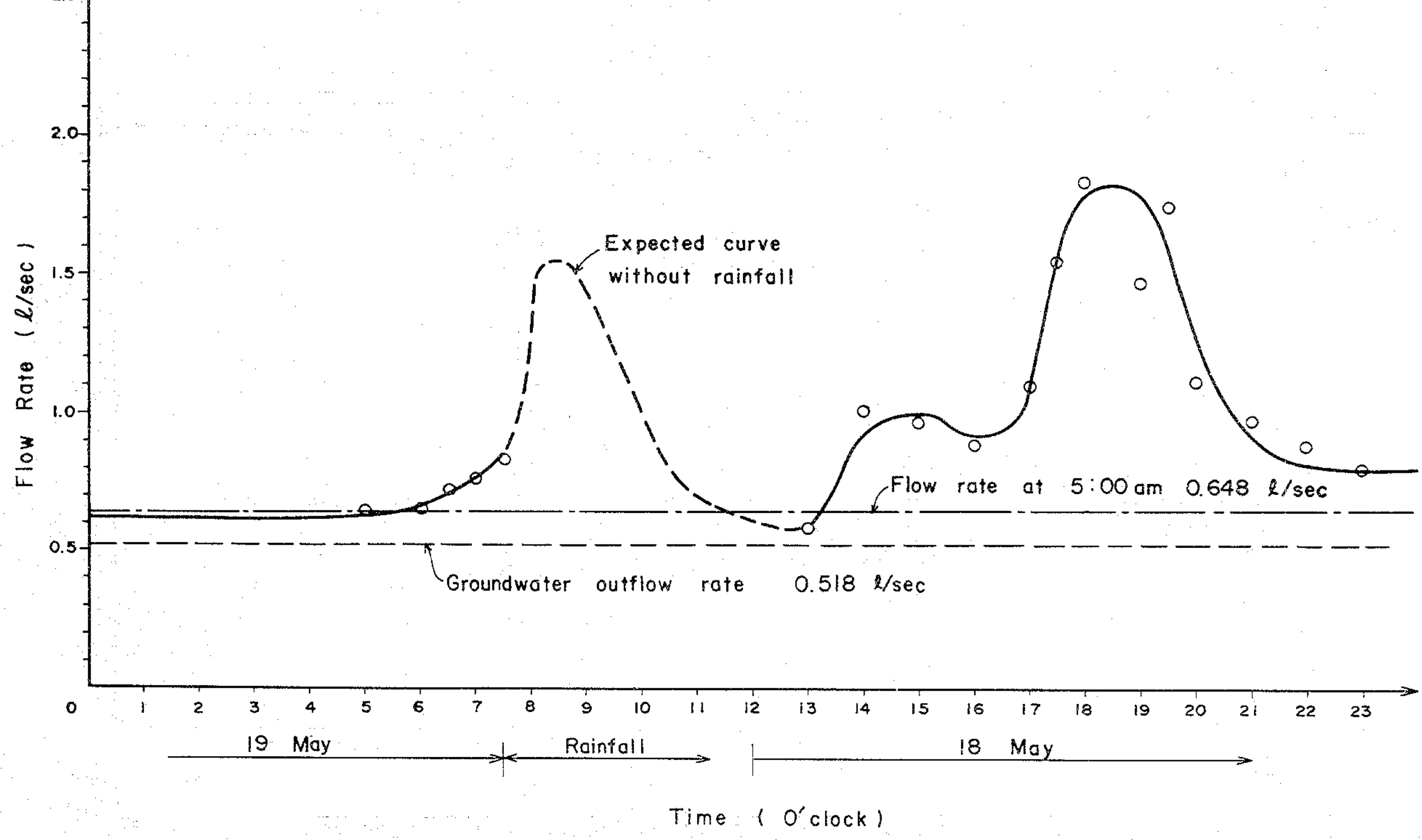
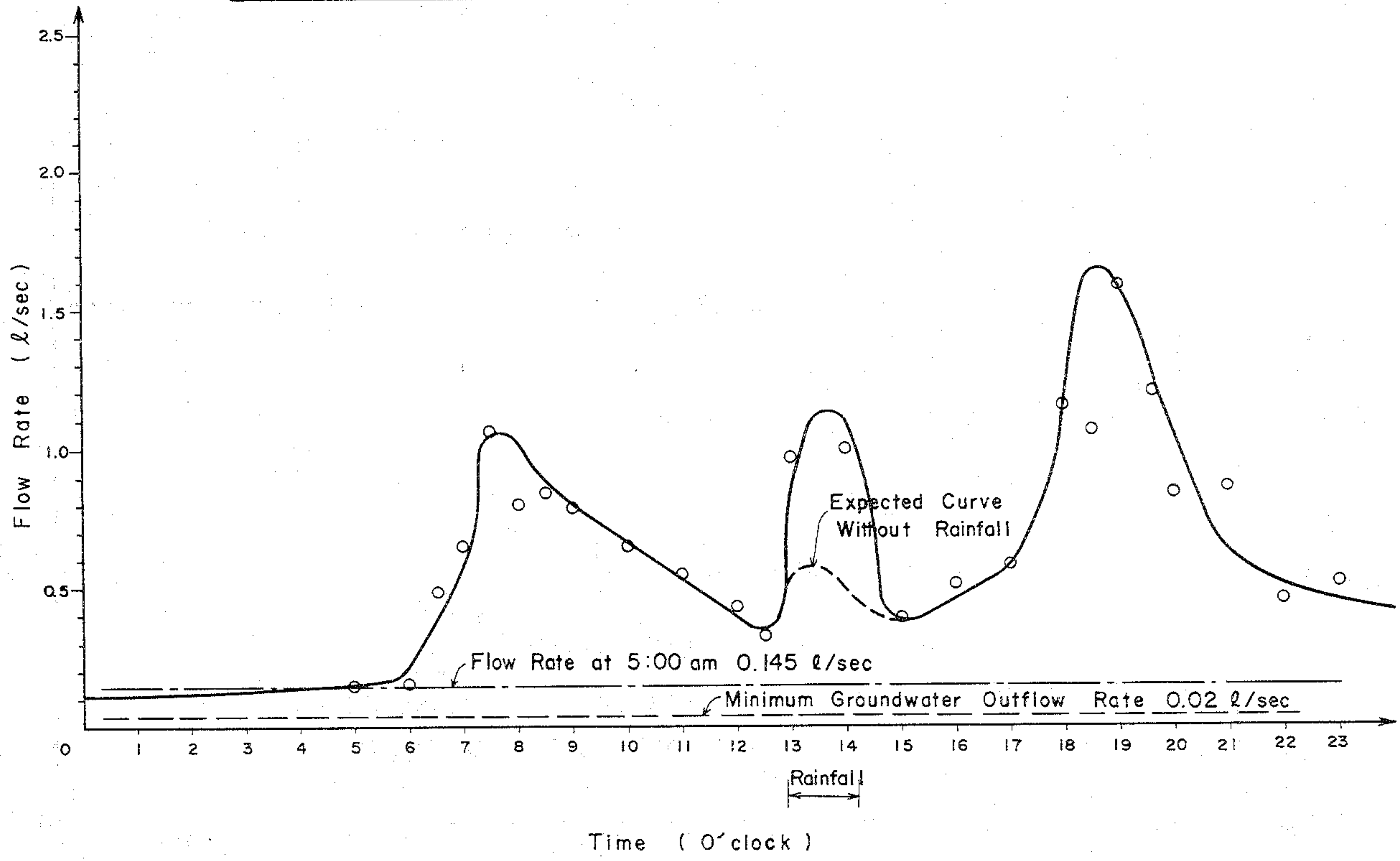


Fig. C.6. Flow Rate - Time Relationship at Taman Precious Tree (May 25, 1981)



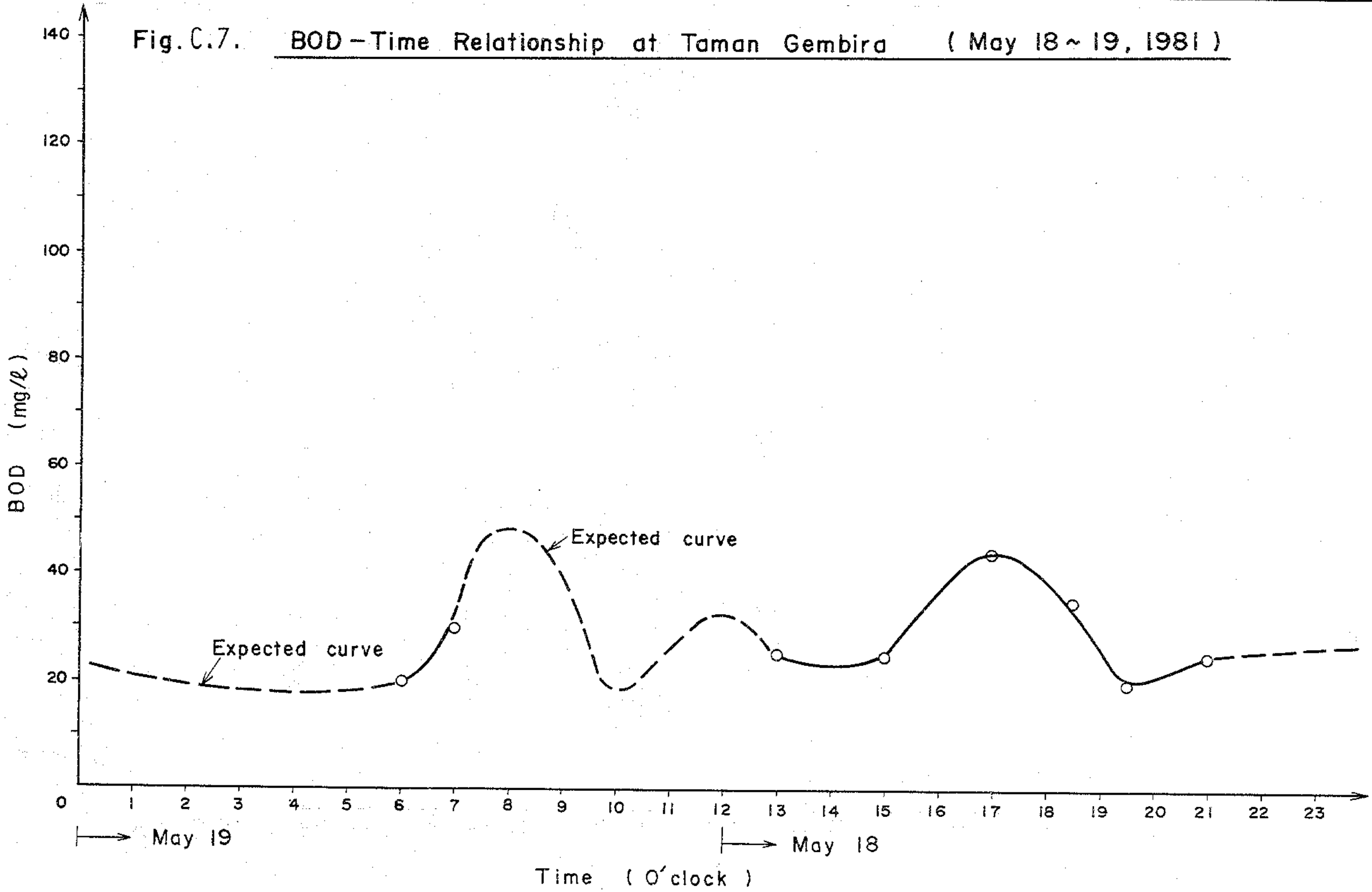
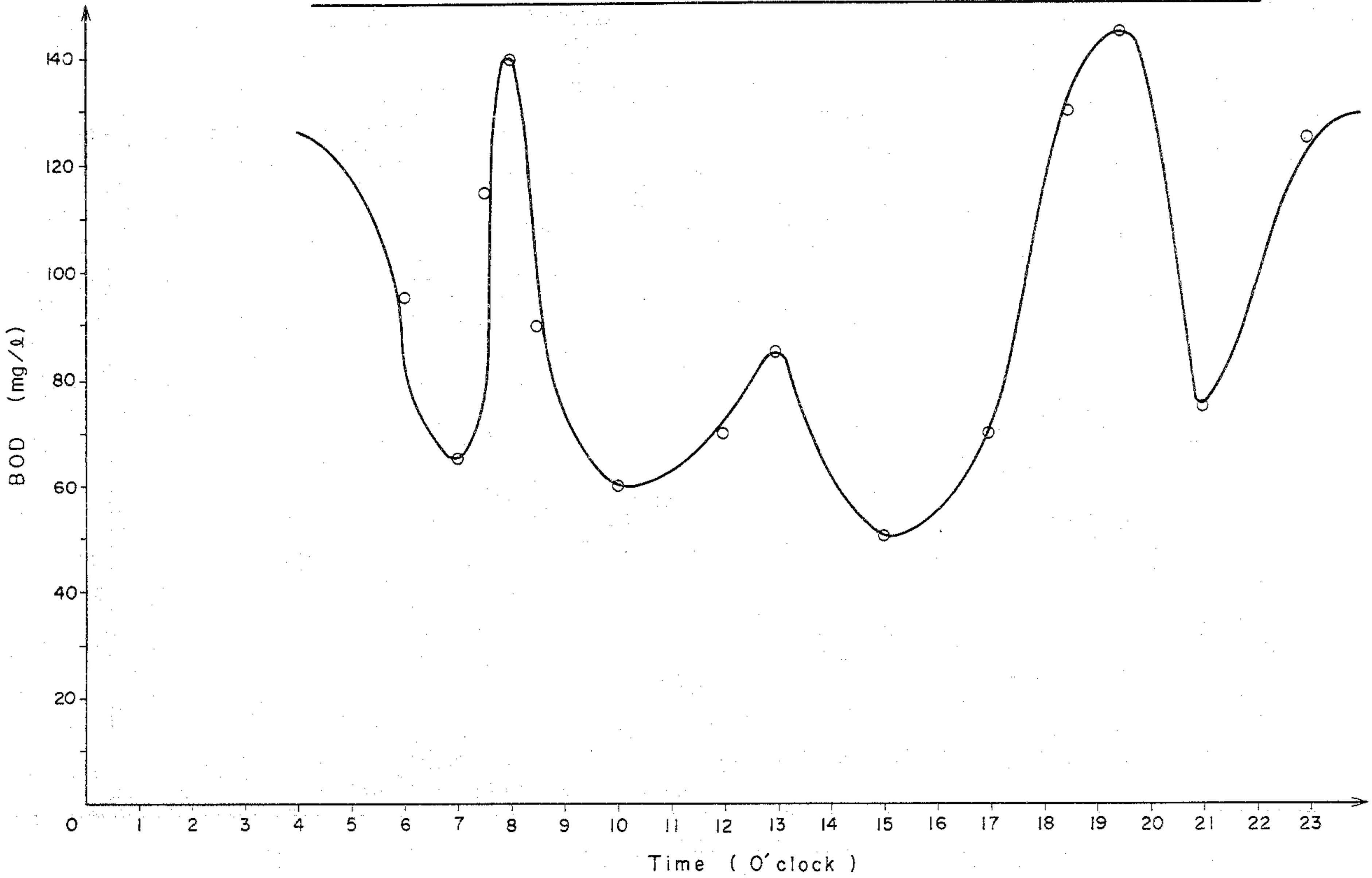


Fig. C.7. BOD – Time Relationship at Taman Gembira (May 18 ~ 19, 1981)

Fig. C.8. BOD - Time Relationship at Taman Precious Tree (May 25, 1981)



C.4. Calculation of BOD Load Per Capita at Taman Gembira

1) Calculation of Ground Water Flow Rate

Provided that the ground water outflow rate is x ℓ/sec at any fixed time, a certain "i" data is taken at ti o'clock (for example, 7.5 o'clock means 7:30 a.m.) and the flow rate in the ditch at the measuring point at ti o'clock is Atiℓ/sec, the actual outflow rate of domestic wastewater is calculated at (Ati-x)ℓ/sec. Outflow rate per day of domestic wastewater (Rd) is calculated by (1):

$$Rd = 3{,}600\sum_i(t_i - t_{i-1}) \times \frac{(At_i - x) + (At_{i-1} - x)}{2}$$

$$= 3{,}600\sum_i(t_i - t_{i-1}) \times \frac{At_i + At_{i-1}}{2} - x) \quad \ldots\ldots (1)$$

But when t_{i-1} > ti, change $(t_i - t_{i-1})$ for $(t_i - t_{i-1} + 24)$

when i = 1, change (i-1) for i max

Table C.6 shows i, t_i, At_i, $\frac{At_i + At_{i-1}}{2}$ and $t_i - t_{i-1}$ or $t_i - t_{i-1} + 24$. Rd must be almost equal to the daily water consumption obtained from the Water Works Dept. Calculating by using Table C.6, Rd amounts to (80,0008.2 - 86,400x) m³/day. Thus the following equation is realized:

80,008.2 - 86,400x = 35,248

x = 0.518 ℓ/sec

Table C.6. Data for Calculation of Domestic Wastewater Outflow Rate Per Day

i	ti	At_i	$(At_i+At_{i-1})/2$	(t_i-t_{i-1}) or $(t_i-t_{i-1}+24)$
1	13.0	0.582	0.581	0.5
2	14.0	1.008	0.795	1.0
3	15.0	0.965	0.987	1.0
4	16.0	0.878	0.922	1.0
5	17.0	1.103	0.991	1.0
6	18.0	1.832	1.468	1.0
7	18.5	1.410	1.621	0.5
8	19.0	1.357	1.384	0.5
9	19.5	1.643	1.500	0.5
10	20.0	1.103	1.373	0.5
11	21.0	0.965	1.034	1.0
12	22.0	0.878	0.922	1.0
13	23.0	0.797	0.838	1.0
14	5.0	0.648	0.723	6.0
15	6.0	0.648	0.648	1.0
16	6.5	0.720	0.684	0.5
17	7.0	0.758	0.739	0.5
18	7.5	0.838	0.798	0.5
19	8.0	(1.15)*	0.994	0.5
20	8.5	(1.54)*	1.354	0.5
21	9.0	(1.43)*	1.485	0.5
22	10.0	(1.00)*	1.215	1.0
23	11.0	(0.70)*	0.850	1.0
24	12.0	(0.62)*	0.660	1.0
25	12.5	(0.58)*	0.600	0.5

*Estimated figures

2) Calculation of Daily Average Per Capita BOD Load

a) The daily average BOD load per capita was calculated by the following three methods.

i) Based on the Average Flow Rate and Average BOD Concentration

The daily average BOD load per capita, based on the daily average flow rate of 1.006 ℓ/sec, obtained from the 25 measurements shown on Table C.1. and the daily average BOD concentration of 28.0 mg/ℓ is calculated as follows:

$$1.006 \times 24 \times 60 \times 60 \times 28.0 \times 10^{-3} / 163 = 14.9 \text{ g/capita/day}$$

ii) Based on the Average BOD Load

BOD load per capita based on the average BOD load calculated by rate of effluent and BOD concentration at each sampling time, as shown in Table C.4, is calculated as follows:

$$(0.582 \times 25 + 0.965 \times 25 + 1.103 \times 44 + 1.410 \times 35 + 1.643 \times 20 + 0.965 \times 25 + 0.648 \times 20 + 0.758 \times 30) \times 1/8 \times 10^{-3} \times 24 \times 60 \times 60 \times 1/163$$
$$= 15.2 \text{ g/capita/day}$$

iii) Based on a Weighted Average BOD Load

BOD load per capita based on a weighted average BOD load is calculated as follows:

Table C.7. Data for Calculation of BOD Load per Capita at TAMAN GEMBIRA

i	1	2	3	4	5	6	7	8	
Q_i	0.582	0.965	1.103	1.410	1.643	0.965	0.648	0.758	(ℓ/sec)
BOD_i	25.0	25.0	44.0	35.0	20.0	25.0	20.0	30.0	(mg/ℓ)
$Q_i \times BOD_i$	14.55	24.13	48.53	49.35	32.86	24.13	12.96	22.74	(mg/sec)
t_i	7,200	7,200	5,400	3,600	5,400	32,400	3,600	21,600	(sec)
Outflow BOD Load	139.32	261.58	264.76	147.98	153.87	600.86	64.26	402.73	(g)

(139.32+261.58+246.76+147.98+153.87+600.86+64.26+402.73)/163
= 2017.36/163 = 12.4 g/capita/day

b) Although calculation based on weighted average is theoretically the most suitable for obtaining accurate BOD load, the high infiltration rate observed in this case makes it unreliable because of the relatively long period when sampling was not conducted. Thus, the per capita BOD load of 15.2 g, based on average BOD load calculation, is adopted to provide allowance for infiltration.

Since all the houses in Taman Gembira are provided with septic tanks and from the observation that these tanks were functioning properly, BOD reduction of human excreta by septic tanks should be considered. In calculating per capita BOD load generation, the above-mentioned BOD reduction should be taken into account because the flow in the ditch includes treated effluent from these tanks, thus reduced BOD is not included.

The BOD removal rate by septic tank is expected to be 80 percent, on the basis of data compiled form the Alor Setar report. If the actual BOD load of excreta per capita is 13 g/capita/day, as generally adopted, the actual BOD load per capita is calculated as follows:

15.2+13.0x0.8 = 25.6 g/capita/day

If 228ℓ /capita/day is adopted, according to Table C.2, the BOD concentration is calculated as follows:

$$25.6 \times 10^{3} \div 228 = 112.3 \ (mg/\ell)$$

C.5. Calculation of BOD Load Per Capita at Taman Precious Tree

The outflow rate of groundwater and daily average BOD load per capita can be calculated in the same manner as in the case of Taman Gembira.

1) Calculation of Groundwater Flow Rate

The outflow rate of groundwater is calculated as follows:

$$49{,}566.6 - 86{,}400x = 48{,}239$$
$$x = 0.02 \ \ell/sec$$

2) Calculation of Daily Average BOD Load Per Capita

a) The daily average BOD load per capita at Taman Precious Tree was calculated by the following three methods.

i) Based on the Average Flow Rate and Average BOD Concentration

The daily average BOD load per capita, based on the daily average flow rate of 0.710 ℓ/sec, obtained from the 25 measurements shownon Table C.1, and the daily average BOD concentration of 93.9 mg/ℓ , is calculated as follows:

$$0.710 \times 24 \times 60 \times 60 \times 93.9 \times 10^{-3} / 252 = 22.9 \ g/capita/day$$

ii) Based on the Average BOD Load

$$(0.145x95+0.648x65+1.055x115+0.797x140+0.838x90 +0.648x60+0.432x70+0.965x85.0+0.405x50+0.582x70 +1.055x130+1.200x145+0.878x75+0.158x125)x1/14x10^{-3} x24x60x60x1/252 = 24.9 \text{ g/capita/day}$$

iii) Based on a Weighted Average BOD Load

Table C.8. Data for Calculation of BOD Load per Capita at TAMAN PRECIOUS TREE

i	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Q_i	0.145	0.648	1.055	0.797	0.838	0.648	0.432	0.965	0.405	0.582	1.055	1.200	0.878	0.518
BOD_i	95	65	115	140	90	60	70	85	50	70	130	145	75	125
$Q_i x BOD_i$	13.775	42.120	121.325	111.580	75.420	38.880	30.240	82.025	20.250	40.749	137.150	174.000	65.850	64.750
t_i	3,600	1,800	1,800	1,800	5,400	7,200	3,600	7,200	7,200	5,400	3,600	5,400	7,200	25,200
Outflow BOD load	100.61	147.10	209.61	168.30	308.61	248.83	202.08	368.19	219.56	480.30	560.07	647.60	470.16	989.42

(100.61+147.10+209.61+168.30+308.61+248.83+202.08+368.19+
219.56+480.30+560.07+647.60+470.16+989.42)/252
= 5,120.44/252 = 20.3 g/capita/day

c) The BOD load per capita calculation of 24.9 g/capita/day based on the average BOD load is adopted to provide allowance for infiltration for the same reason mentioned previously. Next, the actual BOD load per capita is calculated in the same way as in the case of Taman Gembira.

Thus the actual BOD load per capita is calculated as follows:

$$24.9+13.0\times 0.8 = 35.3 \text{ g/capita/day}$$

If 210 ℓ/capita/day is adopted, according to Table C.3, the BOD concentration of raw sewage is calculated as follows:

$$35.3\times 10^{3} \div 210 = 168.1 \text{ (mg/ℓ)}$$

C.6. Conclusion

1) First, BOD load per capita which is to be applied to the Master Plan and the Feasibility Study must be fixed on the basis of the investigation at Taman Gembira and Taman Precious Tree.

At the time of the investigation at Taman Gembira, the rainfall seemed to have a serious effect on the results of the investigation. In comparison, the investigation at Taman Precious Tree did not seem to be influenced so much by rainfall. Thus, it was decided to put emphasis on the investigation of Taman Precious Tree.

2) When these two places were selected as points of investigation, it was considered that the monthly income would have a great influence on the BOD load per capita.

Thus, graphs of the monthly income and water consumption relationship (shown in Fig. C.9 and Fig. C10) were prepared. However, no conspicuous interrelation between monthly income and water consumption could be observed.

Next, the interrelation between the number of persons in a household and per capita water consumption (shown in Fig. C.11) was considered. However, no conspicuous interrelation between the number of persons in a household and per capita water consumption was observable either.

Based on the above observations, it is concluded that the daily habits and/or customs and life style of the Malaysian people or other factors must have some bearing on the results.

3) Taking into consideration that at about 5 a.m. no discharge of domestic wastewater would have entered the ditch where the overflow depth was measured, and if the flow rate of ditch at 5 a.m. was equal to the outflow rate of ground water, discharge rate can be calculated as follows:

a) <u>Taman Gembira</u>

$$\text{discharge rate (DR)} = \frac{80{,}008.2-0.648\text{x}86{,}400}{35{,}248}$$

$$= 0.68$$

b) <u>Taman Precious Tree</u>

$$\text{discharge rate (DR)} = \frac{49{,}566.6-0.145\text{x}86{,}400}{48{,}239}$$

$$= 0.77$$

Using the above DR, the BOD concentration of raw sewage is calculated as follows:

a) <u>Taman Gembira</u>

$$25.6\text{x}10^{3} \div (251\text{x}0.68) = 150.0 \text{ (mg/}\ell\text{)}$$

b) <u>Taman Precious Tree</u>

$$35.3\text{x}10^{3} \div (210\text{x}0.77) = 218.3 \text{ (mg/}\ell\text{)}$$

Based on both results of BOD concentration calculation in this and the previous sections, BOD concentration in raw sewage is considered to fall somewhere between 168 to 218 mg/ℓ.

Fig.C.9. Monthly Income and Water Consumption at TAMAN GEMBIRA
(per capita)

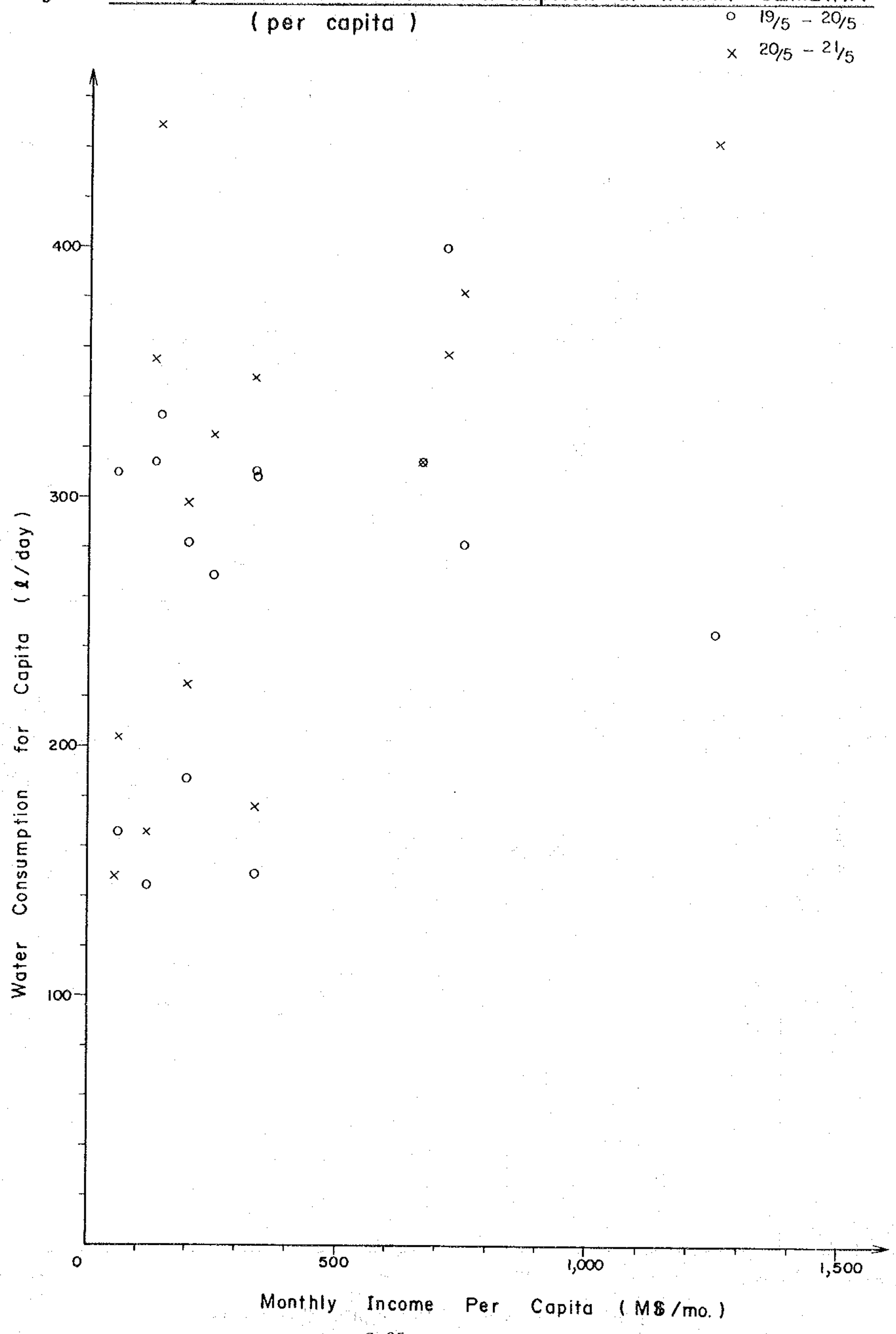


Fig. C.10. Monthly Income and Water Consumption at TAMAN PRECIOUS TREE

(per capita)

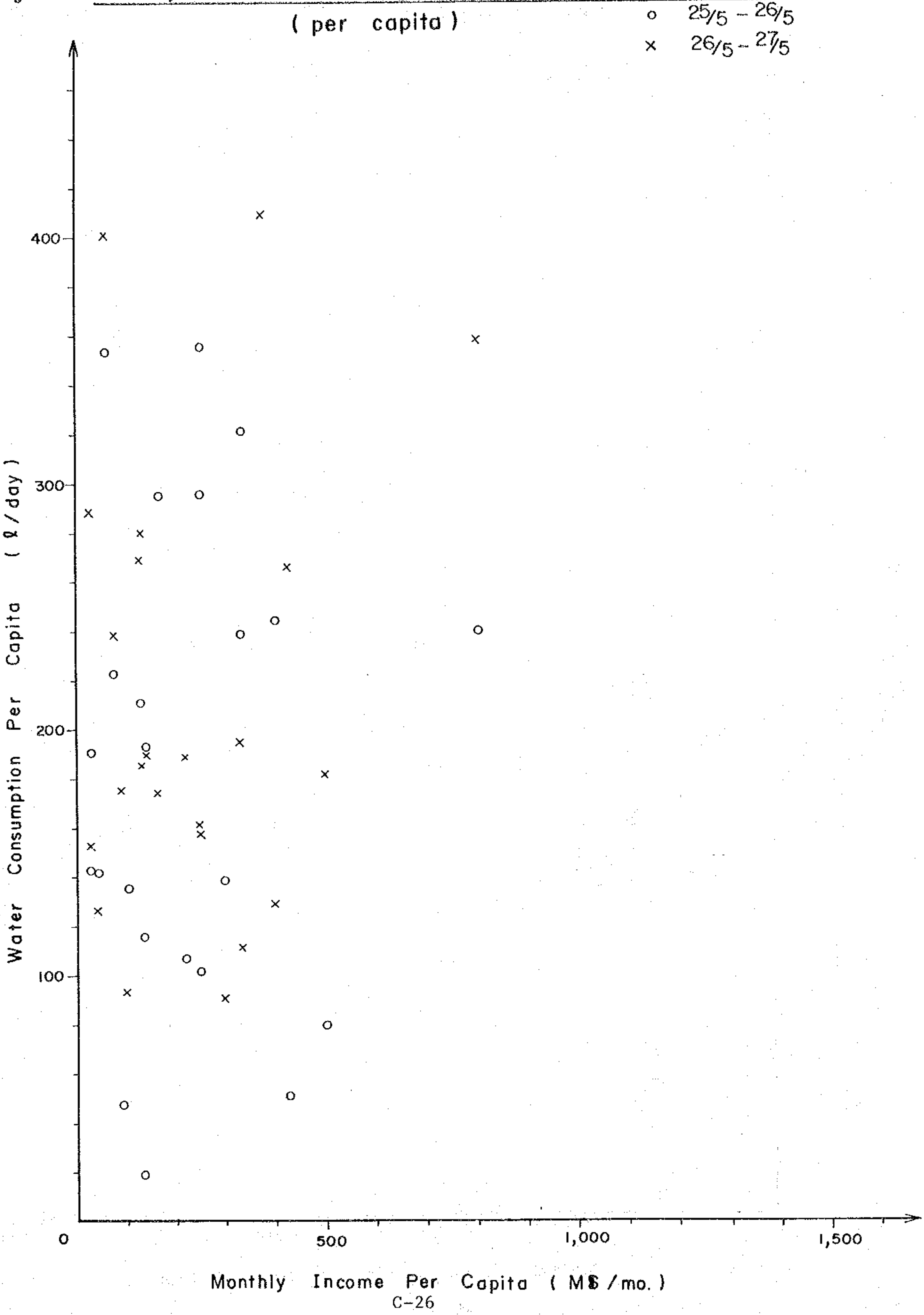
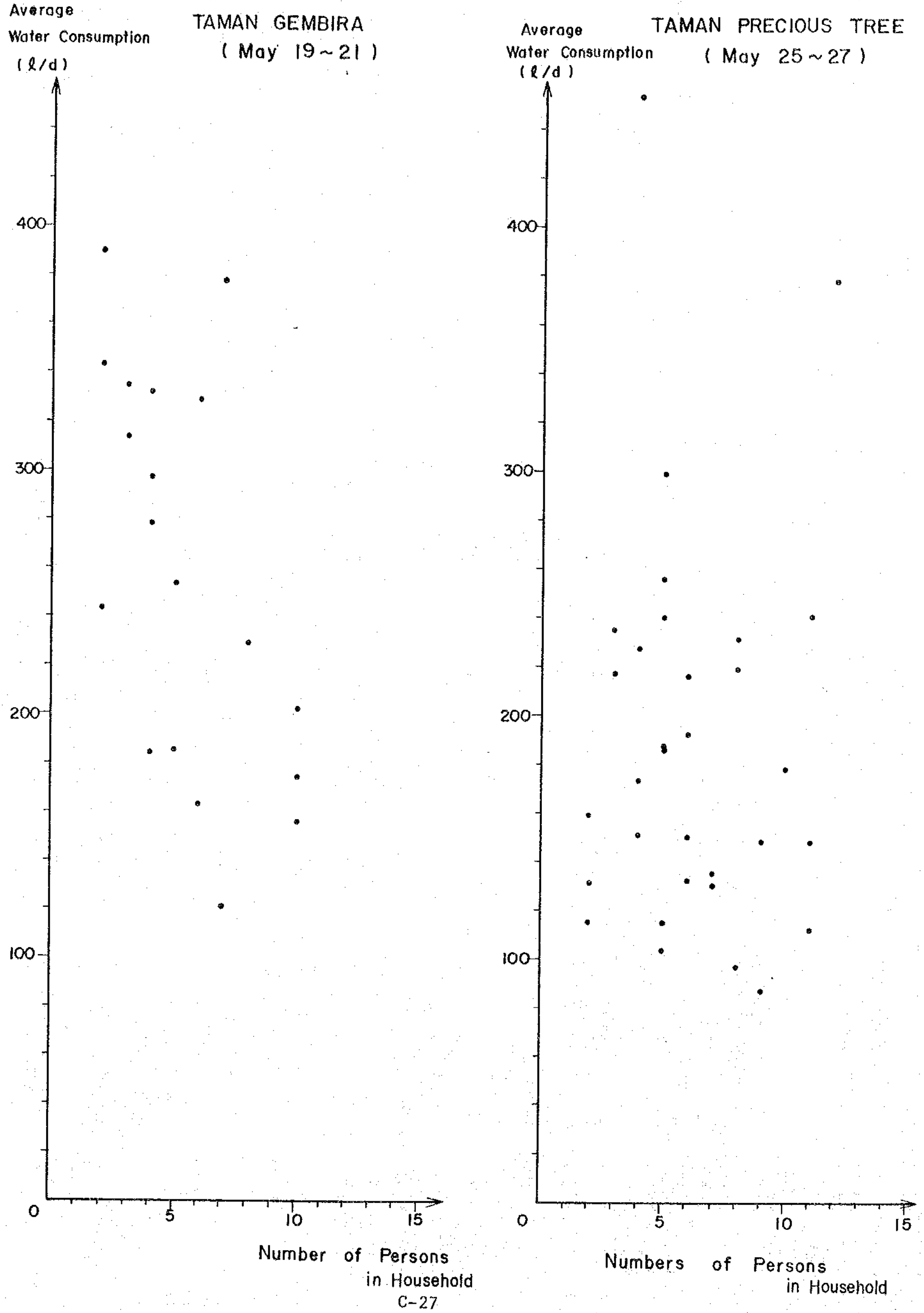


Fig. C.11. Numbers of persons and Average Water Consumption Per Capita



APPENDIX D

LIST OF FACTORIES

APPENDIX D. LIST OF FACTORIES

Table D.1. List of Factories

Number	Name of Factory	Location	Type of Factory	Category
1	Malaysia International Palm Oil	Kawasan Perusahaan Pendamaran	Palm Oil	2
2	Marco Shoe	Kawasan Perusahaan Pendamaran	Shoes	13
3	Delima Furniture	Kawasan Perusahaan Pendamaran, PKNS	Furniture	4
4	IPI	Kawasan Perusahaan Pendamaran	Printing Ink	5
5	Far East Rubber Products	Kawasan Perusahaan Pendamaran	Rubber	7
6	Lee Rubber	Batu 2, Jalan Batu Tiga, Sungai Rasa	Rubber	7
7	Fung Keong Rubber	Kilang Fung Keong, Jalan Kapar	Rubber Products	7
8	Lee Oil Mills	Jalan Kapar	Food Oil	2
9	Perusahaan Sawit Oil Mill	Lerong Petai, Kawasan Perusahaan, Pendamaran	Soap	2
10	Koe	Kawasan Persahaan Pendamaran	Hair Shampoo	13
11	ABC Plastik	Jalan Meru	Plastics	13
12	Kelang Hock Plastik	Lerong Petai, Pendamaran	Plastics	13
13	Ng. Danc	Batu 2, Jalan Batu Tiga, Sungai Rasa	Plastics	13
14	Yong Plastik	Batu 2, Jalan Batu 3, Lama	Plastics	13
15	Mega	Sungai Rasa, Batu 3	Sodium Chlorate	5
16	Brimal	Batu 5 1/2, Jalan Kapar	Seat Belt	13
17	Asia Envelopes	Kawasan Perusahaan Pendamaran	Envelope	13
18	Fusan Fishing Net	Dijalan Selat, Kelang Utara Pelabohan Kelang	Fishing Net	13
19	Basteec Oil Refinery	Batu 4, Jalan Kapar	Coconut Oil	2
20	Sun Cheong	Jalan Raya Timor	Package	13
21	Tructy Flour Mill	Batu 2 1/2, Jalan Kapar	Spice	1

Table D.1. (Cont.)

Number	Name of Factory	Location	Type of Factory	Category
22	Ambika Flour Mill	Jalan Kapar	Spice	1
23	K. Rajalakshim	Jalan Harpar	Spice	1
24	Yer s/o Andy	Jalan Harpar	Flour	1
25	Tamil Selvam	Jalan Camp, Pelabohan Kelang	Flour	1
26	Federal Flour Mill	Pelabohan Kelang	Flour	1
27	Cold Storage	Jalan Raja Hassan	Ice	1
28	Eng Huat Chan Trading	Jalan Sena	Ice Cream	1
29	Yew Yew Cold Storage	Jalan Raya Timor	Ice Cream	1
30	Eng Huat Heng	Pendamaran	Ice Cream	1
31	Scoil	Jalan Kem, Pelabohan Kelang	Palm Oil	2
32	Tan Ngiam	Jalan Kpg. Jawa	Coffee	1
33	Hiap Heng	Jalan Besar Kapar	Coffee	1
34	Tee Por.	Jalan Bukit, Kapar	Coffee	1
35	Koh Kim Cham	Batu 11, Kapar	Coffee	1
36	Lee Chin Hoo	Batu 11, Kapar	Coffee	1
37	United Desicated Coconut	Kaw MIEL Kaw Perusahaan, Pendamaran	Biscuit	1
38	Amisan Products	Batu 4, Jalan Kapar	Biscuit	1
39	Region Foods	Batu 1 1/2, Jalan Meru	Chili Sauce	1
40	Amoy Canning	Jalan Harper	Canned Food	1
41	F.M.S.	Leboh Raya Petai, Kawasan Perusahaan, Pendamaran	Medicine	5
42	Hoechst	Kg. Bahoru, Pendamaran	Storage	13
43	Behn Meyer	Jalan Kim Chuan, Pendamaran	Storage	13
44	Astraco	Jalan Pendamaran, Pendamaran	Timber Drying	4
45	Angro American	Jalan Low, Pendamaran	Storage	13
46	Linberg	Batu 5 1/4, Jalan Meru	Storage	13
47	Goodwill Veneer & Plywood	Jalan Kapar	Storage	13
48	Pendamaran Oil	Kawasan Perusahaan, Pendamaran	Food Oil	2

Table D.2. Number of Factories According to the Category (Existing)

	Category	Number of Factories
1	Food Products	19
2	Oils and Fats	7
3	Textiles	-
4	Wood and Wood Products	2
5	Chemicals	3
6	Petroleum Products	-
7	Rubber Products	3
8	Cement and Non-Metallic	-
9	Basic Metal	-
10	Fabricated Metal	-
11	Electrical Machinery	-
12	Transport Equipment	-
13	Other Manufactures	15
	Total	49

Table D.3. Number and Lot Area of Factories According to Category in Pendamaran and North Port Industrial Estates

Item		Pendamaran		North Port	
		Number	Area (ha)	Number	Area (ha)
1	Food Products	1	1.62	7	5.24
2	Oils and Fats	4	14.01	5	8.54
3	Textile	-		3	2.02
4	Wood and Wood Products	6	22.09	8	14.15
5	Chemicals	4	3.27	4	4.85
6	Petroleum Products	-		-	
7	Rubber Products	2	1.16	8	8.49
8	Cement and Non-Metallic	1	0.40	1	1.21
9	Basic Metal	2	1.60	4	10.02
10	Fabricated Metal	2	1.27	14	15.14
11	Electrical Machinery	1	0.11	2	2.02
12	Transport Machinery	-		6	10.51
13	Other Manufactures	6	3.69	10	8.67
14	Store Houses, Office and Grid Station	-		16	31.62
15	Not Identified	13	12.56	6	5.65
	Total	42	61.78	94	128.13

APPENDIX E

STUDY ON THE BOD LOADING AT WARDIEBURN STABILIZATION PONDS

APPENDIX E. STUDY ON THE BOD LOADING AT WARDIEBURN STABILIZATION PONDS

E.1. Purpose and Description of Study

The sewage treatment plant selected for study, named "The Wardieburn Waste Stabilization Ponds", is located 100 m from the Wardieburn military camp in Kuala Lumpur. Monthly statistics on the average flow rate, BOD and SS concentrations in raw sewage (CS), effluent from first pond (Eff-1) and final effluent (FE) during six years from 1975 to 1980 were obtained from the Ministry of Health.

In order to determine design parameters for stabilization pond for the Project, results of the operation, particularly BOD loading, are analyzed based on the above-mentioned statistics.

E.2. Capacity and Size of the Wardieburn Ponds

The ponds of this treatment facility are designed to treat sewage for a population of 8,000, which is approximately the present population of this area.

The capacity and size of the ponds are described in "Kuala Lumpur and Environs - Master Plan for Sewerage and Sewage Disposal", a report issued in Kuala Lumpur City Hall, which is quoted as follows:

> "The treatment process consists of a deep settlement cell and two equal-sized ponds which are operated in series, but they can be operated in parallel if required. The settlement cell is located at the head of the first pond and measures 21.6m x 4m x 7.3m deep. The surface area of each pond is about 0.57 ha with an operating depth of 1.37 m and a freeboard of 1.3 m. The pond depth can be increased to 1.82 m if required. The mean retention time in the ponds is 8 days."

E.3. Results of the Study

The annual average BOD load was calculated and summarized, based on tables showing the monthly average rate of BOD load and overall BOD load. The annual average BOD load during the six-year period from 1975 to 1980, and the results of the annual average water quality analysis are shown in Table E.1 and the results of analysis for MOH data are shown in Table E.2.

Figure E.1 also shows the relationship between the BOD load and final effluent BOD during the past six years. The above tables and figure illustrate the trend or tendency and the operational conditions of the ponds.

1) From 1975 to 1977

Comparatively little crude sewage was treated at the Wardieburn Treatment Plant during 1975 to 1977 in relation to the period from 1978 to 1980. Its monthly average discharge of crude sewage was 1,400 m^3/day. However, the average monthly discharge from 1978 increased to 2,100 m^3/day.

The low average rate of BOD during 1975 to 1977 indicates a high degree of BOD removal with an increasingly higher rate of BOD removal in the past three years.

2) From 1978 to 1980

During 1978 to 1980, more than half of the monthly BOD showed a constant average, ranging from 200 to 260 kg/ha.day, with the F.E. BOD averaging from 25 to 40 mg/ℓ in 1978.

In 1979, water quality analysis results of the F.E. BOD showed a higher rate of 50 to 70 mg/ℓ. However, in 1980, the Final Effluent averaged between 25 to 50 mg/ℓ and the BOD load increased to a range from 300 to 480 kg/ha.day, indicating design capacity of the pond.

3) The Suitable BOD Loading

High quality effluents were obtained during 1980 when the ponds were operated at high BOD loading. However, data obtained in 1979, when BOD loading were relatively high, show more than 50 mg/ℓ BOD concentration. Interrelation between BOD loading and effluent BOD concentration is analyzed from all data obtained from 1979 to 1980, without any significant results. At present, it is difficult to determine a suitable BOD loading for stabilization ponds based on the Wardieburn operation results.

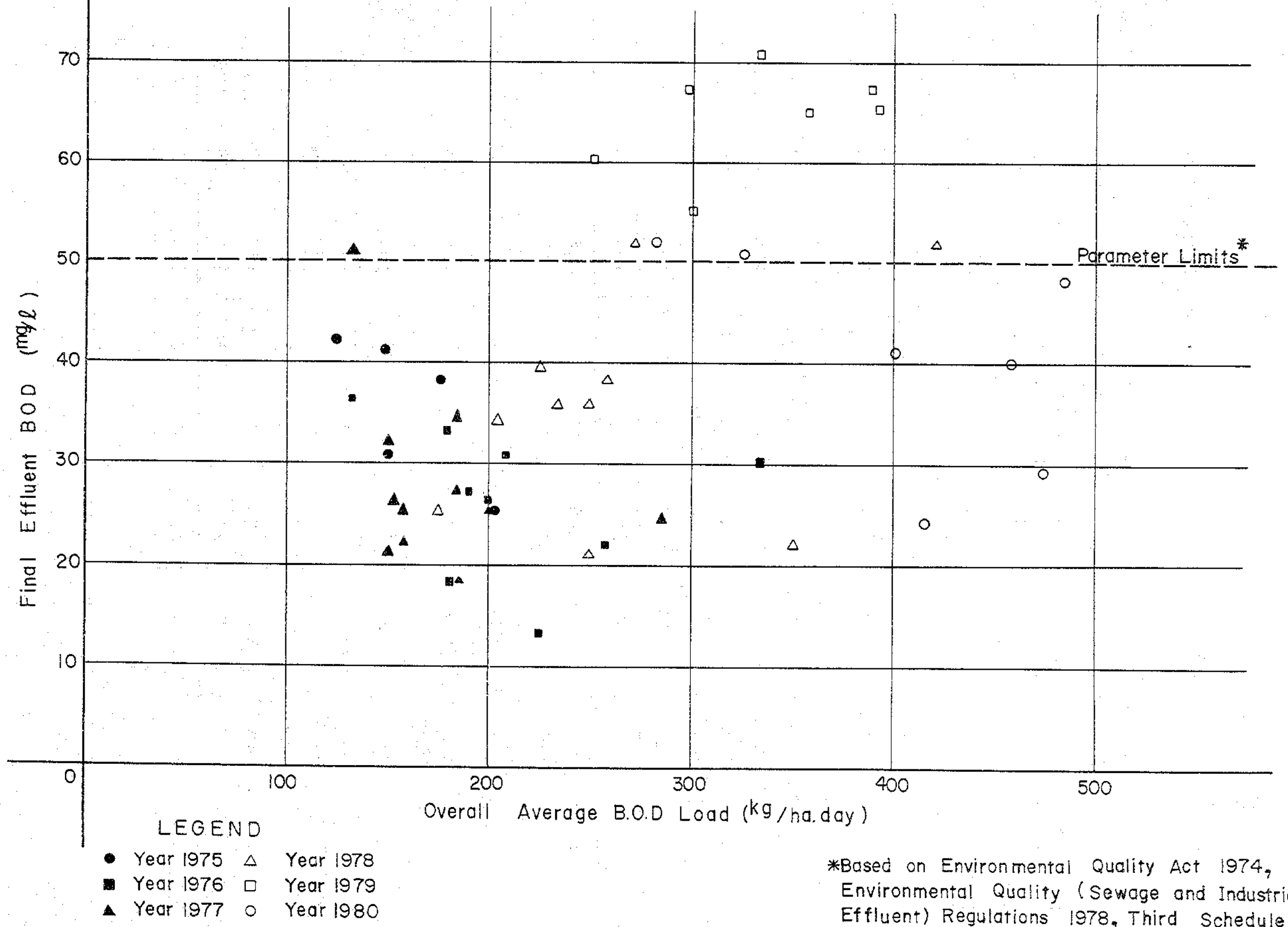
Table E.1. Average BOD Loading at Wardieburn Stabilization Pond

Item \ Year	1975	1976	1977	1978	1979	1980	Remarks
Average Flow (m^3/day)	1,081	1,724	1,383	1,641	1,939	2,684	
C.S. BOD_5 (mg/ℓ)	155	137	143	188	204	160	
F.E. BOD_5 (mg/ℓ)	33	27	28	37	54	36	
Overall BOD Load (kg/ha.day)	144	201	182	269	378	407	
Rate of BOD Removal (%)	78.7	80.3	80.4	80.3	73.5	77.5	
C.S. SS (mg/ℓ)	183	185	180	184	208	142	
F.E. SS (mg/ℓ)	78	96	90	86	94	62	
Rate of SS Removal (%)	57.4	48.1	50.0	53.3	54.8	56.3	

Key: C.S. = Crude Sewage
F.E. = Final Effluent

Source: MOH data

Fig. E. 1. Relationship of B O D and F.E. BOD in Wardieburn Pond



*Based on Environmental Quality Act 1974, Environmental Quality (Sewage and Industrial Effluent) Regulations 1978, Third Schedule Standard B.

Table E.2. Analysis of Wardieburn Stabilization Pond

Year	Month	Flow (m^3/day)	BOD (mg/ℓ) CS	Eff-1	FE	SS (mg/ℓ) CS	Eff-1	FE
1975	Jan	-	145	58	26	141	66	92
	Feb	-	220	33	26	124	71	70
	Mar	-	150	53	41	249	114	99
	Apr	-	200	55	34	242	105	95
	May	1,046	150	44	25	128	85	42
	Jun	1,159	123	49	31	328	104	74
	Jul	1,432	110	57	42	111	77	55
	Aug	-	80	33	26	127	78	65
	Sep	1,137	175	54	41	210	96	102
	Oct	714	117	-	-	161	105	88
	Nov	1,114	-	-	-	-	-	-
	Dec	1,046	235	49	38	195	77	81
	Av.	1,093	155	49	33	183	89	78
1976	Jan	886	185	51	36	186	105	132
	Feb	-	123	55	32	113	113	95
	Mar	1,891	-	-	-	-	-	-
	Apr	1,932	128	38	31	312	252	196
	May	1,841	138	36	28	172	68	84
	Jun	1,991	-	-	-	-	-	-
	Jul	1,987	160	51	22	192	86	92
	Aug	1,818	130	46	33	134	122	96
	Sep	-	145	30	33	162	96	22
	Oct	1,909	125	31	13	224	130	122
	Nov	1,868	100	40	27	140	40	40
	Dec	1,309	140	41	16	216	98	76
	Av.	1,743	137	42	27	185	111	96

Table E.2. (Cont.)

Year	Month	Flow (m^3/day)	BOD (mg/ℓ) CS	BOD Eff-1	BOD FE	SS (mg/ℓ) CS	SS Eff-1	SS FE
1977	Jan	1,518	125	48	22	186	136	88
	Feb	1,546	135	42	18	72	106	44
	Mar	1,550	155	38	25	234	162	130
	Apr	1,677	140	40	24	260	174	120
	May	1,718	140	39	27	138	80	58
	Jun	1,173	155	46	21	133	112	76
	Jul	1,036	117	98	51	134	228	98
	Aug	1,309	-	-	-	-	-	-
	Sep	1,096	160	62	25	280	146	140
	Oct	1,759	132	58	34	-	-	-
	Nov	2,391	117	77	32	120	48	64
	Dec	927	195	66	26	242	134	84
	Av.	1,475	143	59	28	180	133	90
1978	Jan	946	155	43	25	242	134	84
	Feb	-	196	85	-	268	196	136
	Mar	1,623	215	63	36	232	150	116
	Apr	1,991	155	40	21	120	78	80
	May	2,132	195	46	22	66	94	62
	Jun	1,673	194	80	38	266	92	126
	Jul	1,514	174	66	39	118	106	60
	Aug	-	194	75	48	152	82	72
	Sep	1,214	209	74	34	120	96	80
	Oct	2,218	201	93	52	352	148	130
	Nov	1,514	158	94	52	116	74	32
	Dec	1,491	214	107	36	150	104	52
	Av.	1,632	188	72	37	184	113	86

Table E.2. (Cont.)

Year	Month	Flow (m^3/day)	BOD (mg/ℓ) CS	Eff-1	FE	SS (mg/ℓ) CS	Eff-1	FE
1979	Jan	1,759	255	96	71	362	158	140
	Feb	1,863	163	102	67	180	142	124
	Mar	1,546	229	78	59	264	154	136
	Apr	-	199	80	24	110	96	90
	May	-	199	81	39	174	126	98
	Jun	2,346	188	57	30	282	118	80
	Jul	2,218	195	78	55	150	130	122
	Aug	2,078	229	88	65	316	98	122
	Sep	2,655	199	78	63	144	48	88
	Oct	2,573	179	57	67	98	66	60
	Nov	3,119	-	-	-	-	-	-
	Dec	2,173	-	-	-	-	-	-
	Av.	2,233	204	80	54	208	114	94
1980	Jan	2,066	163	52	52	134	164	124
	Feb	2,219	163	52	51	146	98	116
	Mar	2,979	184	94	43	120	84	82
	Apr	3,101	174	96	29	86	70	82
	May	2,853	161	70	41	104	80	55
	Jun	2,651	179	38	22	223	69	52
	Jul	2,921	181	48	40	107	76	76
	Aug	-	125	60	19	76	52	40
	Sep	-	140	65	53	86	48	32
	Oct	-	150	73	25	124	58	40
	Nov	-	165	65	27	102	56	34
	Dec	-	160	73	30	394	144	54
	Av.	2,684	150	66	36	142	83	62

APPENDIX F

COMPARISON OF ALTERNATIVE TREATMENT PROCESSES

APPENDIX F. COMPARISON OF ALTERNATIVE TREATMENT PROCESSES

In order to compare the costs of the three alternative treatment processes; namely, stabilization pond, aerated lagoon and oxidation ditch, design of the treatment plants and estimation of costs are carried out. Three daily average flows of 7,000 m^3 , 25,000 m^3 and 33,000 m^3 are selected as representative flow rates, taking into account the planned flow rates of treatment plants in the Project Area.

F.1. Design of Treatment Plants

Components of the three processes are shown in Fig. F.1. Stabilization pond process consists of facultative pond and maturation pond. Aerated lagoon process consists of aerated lagoon and maturation pond. Oxidation ditch process consists of oxidation ditch, sedimentation tank and sludge drying bed.

Design basis is as follows:

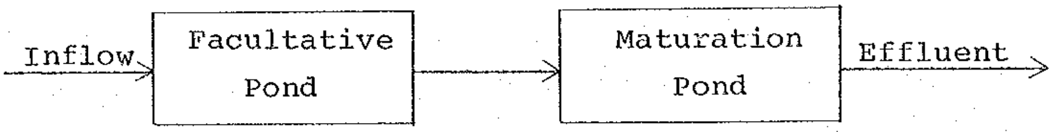
1) Effluent BOD : less than 50 mg/

2) Design temperature: 22°C
The mean daily minimum temperature of the coldest month based on Meteorological Department data.

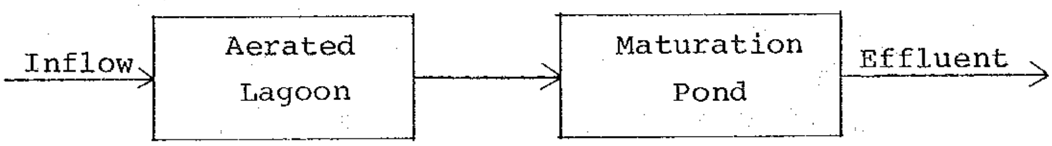
3) Fecal coliform in effluent: less then 1,000,000 N/100 mℓ

Fig. F.1. Components of the Three Processes

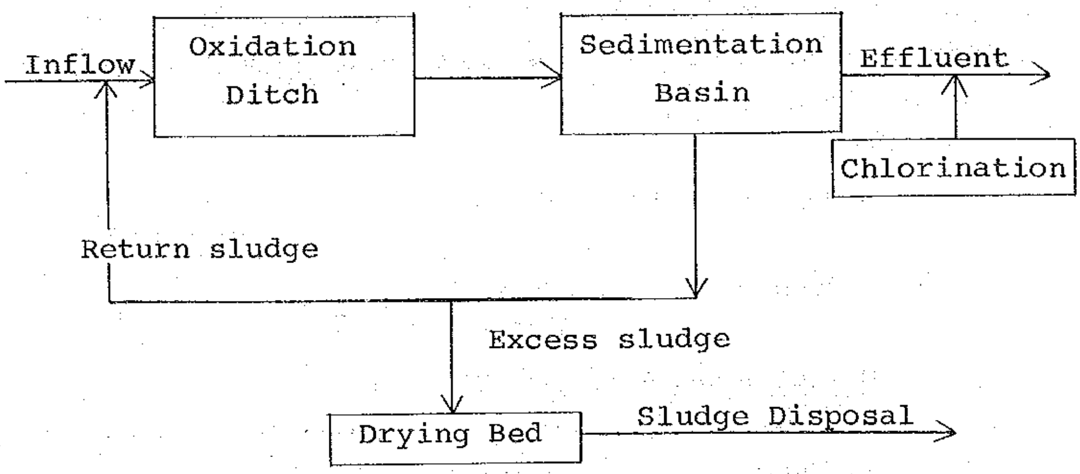
(1) Stabilization Pond process



(2) Aerated Lagoon process



(3) Oxidation Ditch process



Design procedure for each process is as follows:

1) Stabilization Pond

a) Facultative Pond

i) Required Surface Area

$$A = \frac{Qi(Li - Le)}{18D(1.05)^{T-20}}$$

where

A : required surface area in m^2; wanted

Qi : design inflow in m^3/day; given

Li : inflow BOD_5 in mg/ℓ; given

Le : effluent BOD_5 in mg/ℓ; (50 mg/ℓ)

D : depth of pond in m; (1.5 m)

T : design temperature in °C; (22°C)

ii) Design BOD Loading

$$\lambda s = 20T - 120$$

where

λs : design BOD loading in kg/day/ha

T : design temperature in °C; (22°C)

$$\lambda s = 20 \times 22 - 120 = 320 \text{ kg/day/ha}$$

b) Maturation Pond

i) Retention Time in Facultative Pond

$$R = \frac{Qo}{Qi}$$

where

R : retention time in days

Qo : volume of facultative pond in m^3

Qi : design inflow in m^3/day

ii) Number of Coliforms in Effluent

$$N = \frac{Ni}{(1 + Kb.tf)\ (1 + Kb.tm)^{n}}$$

where

N : number of coliforms in effluent in N/100 mℓ

Ni : number of coliforms in influent in N/100 mℓ; (4×10^{7})

Kb : first order rate constant for coliform reduction

$Kb = 2.6 \times (1.19)^{22-20} = 3.7$

tf : retention time in facultative pond in days

tm : retention time in maturation pond in days

n : numbers of maturation pond (2)

iii) Required Surface Area

$$A = \frac{Qi.tm}{D} \quad (m^2)$$

where

A : required surface area in m^2

Qi : design flow in m^3/day

tm : retention time in maturation pond in day

2) Aerated Lagoon

a) Aerated Lagoon

i) Effluent BOD_5

$$Fe = \frac{Li}{1 + k.t}$$

where

Fe : soluble BOD_5 in effluent in mg/ℓ

Li : influent BOD_5 in mg/ℓ

k : first order rate constant for soluble BOD_5 reduction in day^{-1}

t : retention time in day

ii) First Order Rate

$k = 5 \times (1.035)^{T-20}$

where

k : first order rate in day^{-1}

T : design temperature in °C; (22°C)

$k = 5 \times (1.035)^{22-20} = 5.4\ day^{-1}$

b) Maturation Pond

Similar to that of stabilization pond.

3) Oxidation Ditch

a) Oxidation Ditch

i) Ditch Volume

$$V = \frac{LiQ}{S\nu}$$

where

V : required ditch volume in m^3

Li : influent BOD_5 in mg/ℓ

Qi : design inflow in m^3/day

S : ditch liquor suspended solids concentration in mg/ℓ (4,000 mg/ℓ)

ν : sludge loading factor in day^{-1} (0.20 day^{-1})

ii) Retention Time

$$t = \frac{V}{Qi}$$

where

t : retention time in days

V : required volume in m^3

Qi : design inflow in m^3/day

iii) Oxygen Transfer Rate

$$N = No\,\alpha\,(1.024)^{T-20}\,[\frac{\beta Cs(T,A) - CL}{Cs(20,0)}]$$

where

N : oxygen transfer rate in field in kgO_2/mh

No : oxygen transfer rate under standard test condition in kgO_2/mh ($3.0\ kgO_2/mh$)

α : ratio of oxygen transfer rate (0.7)

T : design temperature in °C; (22°C)

β : ration of O_2 saturation concentration (0.9)

Cs(T,A) : O_2 saturation concentration at design temperature in mg/ℓ (8.74 mg/ℓ)

Cs(20,0) : O_2 saturation concentration at 20°C in mg/ℓ (8.74 mg/ℓ)

CL : DO concentration in ditch in mg/ℓ (1.0 mg/ℓ)

$$N = 3,0 \times 0.7 \times 1.024^2 \times (\frac{0.9 \times 8.74 - 1}{8.74})$$

$$= 1.73\ kgO_2/mh$$

iv) Required Rotor Length

$$L = \frac{Ro}{N}$$

where

L : required length of rotor in m

Ro : BOD load in kg/hr

N : oxygen transfer rate in kgO_2/mh ($1.73\ kgO_2/mh$)

b) Sedimentation Tank

i) Required Area of Tank

$$A = \frac{Qi}{\nu}$$

where

A : required area of tank in m^2

Qi : design inflow in m^3/day

ν : overflow rate in $m^3/m^2/day$ ($30\ m^3/m^2/day$)

ii) Depth of Tank

$$h = \frac{V.t}{A}$$

where

h : required depth of tank in m

v : volume of tank in m^3

t : retention time in hours (2 hours)

A : area of tank in m^2

Results of design calculation are summarized in Table F.1 - F.3. Layout plan of each process in each inflow rate is attached to Appendix I. Preliminary Engineering Design.

Table F.1. Design of Stabilization Pond

Facultative Pond							
Qi (m^3/day)	Li (mg/ℓ)	Le (mg/ℓ)	D (m)	T (°C)	Required Surface Area: A by Effluent BOD (ha)	Required Surface Area: A by BOD Loading (m)	Size of Pond (WxLxDxNo. of Ponds) (m)
33,000	163	50	1.5	22	13.3	17.8	150x300x1.5x4
25,000	147	50	1.5	22	8.1	11.5	100x250x1.5x3
7,000	137	50	1.5	22	2.9	4.3	150x220x1.5x1

Maturation Pond								
Retention time $tf = \frac{AxD}{Qi}$ (day)	No. of FC/100mℓ of Effluent: Ni (No.)	Kb (d^{-1})	tm (day)	Ne (No.)	Required Surface Area: D (m)	$A=\frac{Qi.tm}{D}$ (ha)	Size of Pond (WxLxDx No. of Ponds) (m)	Required Land Space (ha)
7.7	$4x10^7$	3.7	3	31,616	1.5	7.1	150x120x1.5x4	32
4.5	$4x10^7$	3.7	3	52,824	1.5	5.1	150x120x1.5x3	22
5.0	$4x10^7$	3.7	3	47,813	1.5	2.0	150x140x1.5x1	10

Table F.2. Design of Aerated Lagoon

Aerated Lagoon (h=3.0m)						
Qi	Li	BOD of Effluent			Required Area by BOD Loading	Size of Pond (WxLxDxNo. of Ponds)
		K	t	$Fe=\frac{Li}{1+K.t}$		
(m^3/day)	(mg/ℓ)	(d^{-1})		(mg/ℓ)	(ha)	(m)
33,000	163	5.4	3	10	3.8	100x125 x3.0x3
25,000	147	5.4	3	9	2.5	100x125 x3.0x2
7,000	137	5.4	3	8	3.9	100x50 x3.0x2

Maturation Pond								Required Land Space
Retention time	No. of FC/100mℓ of Effluent				Required Surface Area		Size of Pond (WxLxDx No. of Ponds)	
$tf=\frac{AxD}{Qi}$	Ni	Kb	tm	Ne	D	$A=\frac{Qi.tm}{D}$		
(day)	(No.)	(d^{-1})	(day)	(No.)	(m)	(ha)	(m)	(ha)
3.2	$4x10^7$	3.7	3	72,613	1.5	7.1	100x240 x1.5x3	14
3.0	$4x10^7$	3.7	3	77,053	1.5	5.1	100x250 x1.5x2	10
3.0	$4x10^7$	3.7	3	77,053	1.5	2.0	100x100 x1.5x2	6

Table F.3. Design of Oxidation Ditch

Oxidation Ditch (h=2.0m)							
Qi (m^3/day)	Li (mg/ℓ)	$V=\frac{LiQi}{S\nu}$ (m^3)	$t=\frac{V}{Q}$ (hr)	Ro=BOD Load (kg/hr)	Oxygen Transfer Rate: N (kgO_2/mhr)	$L=\frac{Ro}{N}$ (m)	Size of Ditch (WxLxD) (m)
33,000	163	7,131	4.9	227	1.73	134	6x600x2
25,000	147	4,594	4.4	157	"	92	6x400x2
7,000	137	1,713	4.1	60	"	25	6x150x2

Sedimentation Tank					Required Land Space (ha)
Over Flow Rate (m^3/m^2/day)	Required Area of Tank: A (m^2)	Depth: h (m)	Required Area of Drying Beds (m^2)	Size of Tank (Dia. x D x Tank) (m)	
30	$\frac{Qi}{\nu}$ = 1,200	$\frac{2 \times Qi \times \frac{2}{24}}{A}$ = 2.5	$0.025m^2 \times P^*$ 2,500	20x2.5x4	5
"	850	"	1,300	23x2.5x2	3
"	400	2.3	500	16x2.5x2	2

Note: * Served Population

F.2. Cost Estimation

Land acquisition, construction, operation and maintenance costs are estimated based on the following procedures.

1) Construction costs are estimated based on the assumption that all civil works can be done by Malaysian contractors while mechanical and electrical equipment should be imported. Costs for civil works are estimated by volume of main components and unit costs. Costs for mechanical and electrical equipment are based on the written estimates of manufactures.

2) Operation and maintenance costs are estimated based on payroll, electricity consumption and repair cost. Assumptions and basic rates are shown in Appendix H.

3) Depreciation is calculated by sinking fund method. Durable years are thirty (30) for civil works and seven (15) years for mechanical and electrical equipment.

4) Land acquisition costs are calculated based on the required land areas and unit costs obtained from Kelang Municipality and State Valuation Section. Unit land costs at various possible treatment plant sites are shown in Table H.14 in Appendix H. Cost Estimation. Unit cost of M$ 20 per square meter is used as a representative figure for the cost comparison.

All cost estimation is done at 1981 price level, without any consideration of cost escalation.

Table F.4 shows construction, operation and maintenance and land acquisition costs. Total initial costs which includes construction cost and land acquisition cost are summarized in Table F.5. Total annual costs, sums of depreciation and operation and maintenance cost are shown in Table F.6. Depreciation costs and interests are shown in Tables F.7 and F.8 respectively.

Table F.4. Cost Comparison of Selected Alternatives

Alternative Process		Daily Average Flow (m^3/day)		
		a) 7,000	b) 25,000	c) 33,000
1) Construction Costs (M$1,000)				
Alt. I Stabilization Pond Process		5,400	11,400	15,720
	C + A	(4,080)	(9,900)	(13,720)
	M + E	(1,320)	(1,500)	(2,000)
Alt. II Aerated Lagoon Process		5,700	8,550	11,650
	C + A	(3,900)	(5,800)	(7,970)
	M + E	(1,800)	(2,750)	(3,680)
Alt. III Oxidation Ditch Process		6,580	11,100	16,760
	C + A	(3,700)	(6,860)	(10,760)
	M + E	(2,880)	(4,240)	(6,000)
2) Operation & Maintenance Costs (M$1,000/year)				
Alt. I Stabilization Pond Process		82	138	199
Alt. II Aerated Lagoon Process		302	625	771
Alt. III Oxidation Ditch Process		337	636	936
3) Land Acquisition Costs (M$1,000)				
Alt. I Stabilization Pond Process		2,000	4,400	6,400
Alt. II Aerated Lagoon Process		600	2,000	2,800
Alt. III Oxidation Ditch Process		400	600	1,000

Note: Assuming that unit of land is M\$20.0/m^2 in a), b) and c) plant.

Table F.5. Total Initial Costs of Alternatives

Alternative	Flow Rate (m^3/day)		
	a) 7,000	b) 25,000	c) 33,000
Alt. I Stabilization Pond Process	7,400	15,800	22,120
Alt. II Aerated Lagoon Process	6,300	10,550	14,450
Alt. III Oxidation Ditch Process	6,980	11,700	17,760

where a) plant is located at Kelang North (Outer Area)
b) plant is located at Port Kelang
c) plant is located at Kapar (Outer Area)

Table F.6. Total Annual Cost of Each Alternative

(Unit: M$1,000/year)

Alternative	Flow Rate (m^3/day)		
	a) 7,000	b) 25,000	c) 33,000
Alt. I Stabilization Pond Process	686	1,394	1,954
Alt. II Aerated Lagoon Process	767	1,514	1,986
Alt. III Oxidation Pond Process	957	1,662	2,481

Note: Anuual cost consists of operation and maintenance costs, depreciation costs, and interest.

Table F.7. Depreciation Cost of Alternative Treatment Process

(Unit: M$1,000/year)

Alternative Treatment Process		Flow Rate (m^3/day)		
		a) 7,000	b) 25,000	c) 33,000
Alt. I Stabilization Pond Process	C+A	24	60	83
	M+E	42	47	63
Alt. II Aerated Lagoon Process	C+A	24	35	48
	M+E	57	87	116
Alt. III Oxidation Ditch Process	C+A	22	42	65
	M+E	91	133	189

Note: 1) Calculated by sinking fund method, applying 10 percent annual interest rate.

2) C+A ... Civil and Architectural
M+E ... Mechanical and Electrical

Table F.8. Interest of Each Alternative Treatment Process

(Unit: M$1,000/year)

Alternative Treatment Process	Flow Rate (m^3/day)		
	a) 7,000	b) 25,000	c) 33,000
Alt. I Stabilization Pond Process	538	1,149	1,609
Alt. II Aerated Lagoon Process	458	767	1,051
Alt. III Oxidation Ditch Process	507	851	1,291

Note: Calculated by capital recovery factor, applying 10 percent annual interest rate.

APPENDIX G

IMPLEMENTATION PRIORITIES

APPENDIX G. IMPLEMENTATION PRIORITIES

G.1. Introduction

A vast investment is required to construct sewerage facilities in the Project Area. Therefore, construction work in each sub-zone shall be carried out according to an appropriate schedule. Construction time is divided into three phase, and the construction schedule is proposed according to these phases. To establish an appropriately phased program, priority of implementation by sub-zone requires determination. An arbitrary rating procedure, described below, is used for establishing such priorities.

G.2. Implementation Priorities

1) Parameters for Determining Priorities

The sewerage construction schedule will be based on the priorities of the zones and sub-zones. An arbitrary rating system is used to assign reasonably relative weights to the five following parameters.

	Rating Points
a) Population density	400
b) Development condition	200
c) Waste load generation	200
d) Excreta disposal system	100
e) Flood condition	100
Total	1,000 points

2) Procedures and Results of Rating

a) Population Density

The rating points assigned both to present and future population densities is 200. Scales of population density are given points as shown in Table G.1. The same scale is applied to present and future population densities. Rating results by sub-zone are shown in Table G.6. Total points vary from 0 to 280, and the highest points were scored by Kelang North, Zone 1, Sub-zone 1, and Kelang South, Zone 2, Sub-zone 2.

b) Development Condition

Evaluation of this parameter was made by using a ratio of currently developed and developing areas against the total area of each sub-zone. The scale and points are shown in Table G.2, and results of the evaluation are shown in Table G.7. The rations within the sub-zones varied as much as 100 percent. Kelang North, Zone 1, Sub-zone 1, and Port kelang, Zone 1, Sub-zone 1 had the highest marks of 200.

c) Waste Load Generation

According to field survey results, water pollution has become serious. To establish pollution control, attention should be given to waste load generation.

Conditions of waste load generation are expressed by BOD load per area. One hundred points is given to both present and possible future conditions. The scale is shown in Table G.3, with results shown in Table G.8. The highest score of 200 was marked by Kelang North, Zone 2, Sub-zone 1.

d) Excreta Disposal Systems

The ratio of households which use pit privies or the bucket system against the total number of households, forms the index for this parameter. Scale and points are shown in Table G.4, with results in Table

G.9. Port Kelang, Zone 2, Sub-zone 1, and Port Kelang, Zone 2, Sub-zone 2 had the highest score of 100 each.

e) Flood Conditions

The ratio of flood-prone area to the total area is used for this evaluation. The scale is shown in Table G.5 and the results in G.10. Kelang South, Zone 2, Sub-zone 1 received the highest score of 100.

Total points evaluated by these five parameters are summarized in Table G.11.

Table G.1. Population Density Rating Standard

Rating Points	Population Density	
	Present (person/ha)	Future (person/ha)
200	>100	>100
160	80 - 100	80 - 100
120	60 - 80	60 - 80
80	40 - 60	40 - 60
40	20 - 40	20 - 40
0	0 - 20	0 - 20

Table G.2. Development Condition Rating Standard

Rating Points	Ratio of Development Area (%)
200	>80
150	60 - 80
100	40 - 60
50	20 - 40
0	0 - 20

Table G.3. Waste Load Generation Rating Standard

Rating Points	Waste Land	
	1980 (kgBOD/ha/day)	2000 (kgBOD/ha/day)
100	>4	>8
75	3 - 4	6 - 8
50	2 - 3	4 - 6
25	1 - 2	2 - 4
0	0 - 1	0 - 2

Table G.4. Excreta Disposal System Rating Standard

Rating Points	Bucket and Pit Privy Ratio (%)
100	>20
50	10 - 20
25	0 - 10
0	0

Table G.5. Flood Condition Rating Standard

Points	Flood Area Ratio (%)
100	>60
75	40 - 60
50	20 - 40
25	0 - 20
0	0

Table G.6. Rating Points by Population Density

Sewerage Division			Population Density		Rating Points		Total
District	Zone	Sub-zone	1980	2000	1980	2000	
Kelang North	1	1	59.2	106.5	80	200	280
" "	1	2	25.4	69.3	40	120	160
" "	2	1	52.3	79.8	80	120	200
" "	2	2	12.5	31.0	0	40	40
" "	2	3	2.9	3.4	0	0	0
Kelang South	1	1	31.0	29.3	40	40	80
" "	1	2	18.2	79.3	0	120	120
" "	2	1	40.3	76.9	80	120	200
" "	2	2	46.7	112.9	80	200	280
Port Kelang	1	1	99.0	50.1	160	80	240
" "	1	2	3.4	0	0	0	0
" "	2	1	36.4	89.3	40	160	200
" "	2	2	34.6	52.6	40	80	120
" "	2	3	22.4	93.4	40	160	200
" "	3		5.2	22.1	0	40	40
North Port	1		4.4	10.3	0	0	0
" "	2		0	15.7	0	0	0
Kapar			17.0	27.5	0	40	40
Meru			11.3	18.1	0	0	0

Table G.7. Points by Development Condition

Sewerage Division			Area		Ratio	Points
District	Zone	Sub-zone	Total Area (ha)	Developed or Developing Area (ha)	(%)	
Kelang North	1	1	338	286	85	200
" "	1	2	589	352	60	150
" "	2	1	401	195	49	100
" "	2	2	458	0	0	0
" "	2	3	418	0	0	0
Kelang South	1	1	306	163	53	100
" "	1	2	353	299	85	200
" "	2	1	315	147	47	100
" "	2	2	512	316	62	150
Port Kelang	1	1	410	410	100	200
" "	1	2	225	2	1	0
" "	2	1	445	323	73	150
" "	2	2	186	90	48	100
" "	2	3	248	71	29	50
" "	3		230	0	0	0
North Port	1		461	344	75	150
" "	2		349	115	33	50
Kapar			621	89	14	0
Meru			573	17	3	0

Table G.8. Rating Points by Waste Load Generation

Sewerage Division			Area (ha)	1980			2000			Total Points
District	Zone	Sub-zone		BOD Load (kg/day)	Density (kg/ha/day)	Points	BOD Load (kg/day)	Density (kg/ha/day)	Points	
Kelang North	1	1	338	1,133	3.4	75	2,760	8.2	100	175
" "	1	2	589	1,284	2.2	50	2,675	4.5	50	100
" "	2	1	401	3,280	8.2	100	3,744	9.3	100	200
" "	2	2	458	245	0.5	0	982	2.1	25	25
" "	2	3	418	56	0.1	0	1,013	2.4	25	25
Kelang South	1	1	306	943	3.1	75	1,078	3.5	25	100
" "	1	2	353	288	0.8	0	1,518	4.3	50	50
" "	2	1	315	549	1.7	25	1,321	4.2	50	75
" "	2	2	512	1,019	2.0	50	3,465	6.8	75	125
Port Kelang	1	1	410	4,379	10.7	100	2,708	6.6	75	175
" "	1	2	225	404	1.8	25	1,097	4.9	50	75
" "	2	1	445	902	2.0	50	2,533	5.7	50	100
" "	2	2	136	280	1.5	25	1,046	5.6	50	75
" "	2	3	248	237	1.0	25	1,257	5.1	50	75
" "	3		230	50	0.2	0	676	2.9	25	25
North Port	1		461	1,715	3.7	75	3,778	8.2	100	175
" "	2		349	1	0	0	1,916	5.5	50	50
Kapar			621	546	0.9	0	1,051	1.7	0	0
Meru			573	315	0.5	0	1,438	2.5	25	25

Table G.9. Rating Points by Excreta Disposal System

Sewerage Division			Number of house-holds	Bucket and Pit Privy		Points
District	Zone	Sub-zone		Number	Ratio (%)	
Kelang North	1	1	3,813	232	6	25
" "	1	2	2,853	0	0	0
" "	2	1	3,998	390	10	50
" "	2	2	1,093	0	0	0
" "	2	3	235	0	0	0
Kelang South	1	1	1,807	198	11	50
" "	1	2	1,304	0	0	0
" "	2	1	2,422	325	13	50
" "	2	2	4,557	71	2	25
Port Kelang	1	1	7,738	480	6	25
" "	1	2	146	0	0	0
" "	2	1	3,090	755	24	100
" "	2	2	1,229	300	24	100
" "	2	3	1,060	0	0	0
" "	3		228	0	0	0
North Port	1		383	0	0	0
" "	2		0	0	0	0
Kapar			2,008	0	0	0
Meru			1,237	0	0	0

Table G.10. Rating Points by Flood Condition

Sewerage Division			Total Area (ha)	Flood Area		Rating Points
District	Zone	Sub-zone		(ha)	Ratio (%)	
Kelang North	1	1	338	44	13	25
" "	1	2	589	13	2	25
" "	2	1	401	92	23	50
" "	2	2	458	149	33	50
" "	2	3	418	0	0	0
Kelang South	1	1	306	27	9	25
" "	1	2	353	0	0	0
" "	2	1	315	224	71	100
" "	2	2	512	149	29	50
Port Kelang	1	1	410	151	37	50
" "	1	2	225	0	0	0
" "	2	1	445	97	22	50
" "	2	2	186	11	6	25
" "	2	3	248	4	2	25
" "	3		230	0	0	0
North Port	1		461	0	0	0
" "	2		349	0	0	0
Kapar			621	0	0	0
Meru			573	0	0	0

Table G.11. Implementation Priorities Evaluated by Parameters

Sewerage Division			Rating Points according to Parameters						Priority Order
District	Zone	Sub-zone	Population Density	Development Condition	Waste Load Generation	Excreta Disposal	Flooding Condition	Total	
Kelang North	1	1	280	200	175	25	25	705	1
" "	1	2	160	150	100	0	25	435	7
" "	2	1	200	100	200	50	50	600	4
" "	2	2	40	0	25	0	50	115	13
" "	2	3	0	0	25	0	0	25	18
Kelang South	1	1	80	100	100	50	25	355	10
" "	1	2	120	200	50	0	0	370	9
" "	2	1	200	100	75	50	100	525	6
" "	2	2	280	150	125	25	50	630	3
Port Kelang	1	1	240	200	175	25	50	690	2
" "	1	2	0	0	75	0	0	75	15
" "	2	1	200	150	100	100	50	600	4
" "	2	2	120	100	75	100	25	420	8
" "	2	3	200	50	75	0	25	350	11
" "	3		40	0	25	0	0	65	16
North Port	1		0	150	175	0	0	325	12
" "	2		0	50	50	0	0	100	14
Kapar			40	0	0	0	0	40	17
Meru			0	0	25	0	0	25	18