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NATIONAL WATER RESOURCES STUDY, MALAYSIA
PERLIS-KEDAH-PULAU PINANG
REGIONAL WATER RESOURCES STUDY
PART I

VOL. 6

ANNEX

G. WATER QUALITY

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NATIONAL WATER RESOURCES STUDY, MALAYSIA
PERLIS-KEDAH-PULAU PINANG
REGIONAL WATER RESOURCES STUDY
PART 1

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G. WATER QUALITY

FEBRUARY 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

NATIONAL WATER RESOURCES STUDY, MALAYSIA
PERLIS-KEDAH-PULAU PINANG
REGIONAL WATER RESOURCES STUDY
PART 1

LIST OF VOLUMES

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ABBREVIATIONS

(1) Organization/Plan

4MP	:	Fourth Malaysia Plan
DID (JPT)	:	Drainage and Irrigation Department
EPU	:	Economic Planning Unit
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
GSD	:	Geological Survey Department
JICA	:	Japan International Cooperation Agency
MADA	:	Muda Agricultural Development Authority
NEB (LIN)	:	National Electricity Board
NWRS	:	National Water Resources Study
PWD (JKR)	:	Public Works Department
RISDA	:	Rubber Industry Small-Holders Development Authority
WHO	:	World Health Organization

(2) Others

B	:	Benefit
BOD	:	Biochemical Oxygen Demand
C	:	Cost
COD	:	Chemical Oxygen Demand
D&I	:	Domestic and Industrial
dia.	:	Diameter
EIRR	:	Economic Internal Rate of Return
El.	:	Elevation Above Mean Sea Level
Eq.	:	Equation
Fig.	:	Figure
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
H	:	Height, or Water Head
NHWL	:	Normal High Water Level
O&M	:	Operation and Maintenance
Q	:	Discharge
Ref.	:	Reference
SS	:	Suspended Solid

ABBREVIATIONS OF MEASUREMENT

<u>Length</u>

mm = millimeter
cm = centimeter
m = meter
km = kilometer
ft = foot
yd = yard

<u>Area</u>

cm^2 = square centimeter
m^2 = square meter
ha = hectare
km^2 = square kilometer

<u>Volume</u>

cm^3 = cubic centimeter
l = lit = liter
kl = kiloliter
m^3 = cubic meter
gal. = gallon

<u>Weight</u>

mg = milligram
g = gram
kg = kilogram
ton = metric ton
lb = pound

<u>Time</u>

s = second
min = minute
h = hour
d = day
y = year

<u>Electrical Measures</u>

V = Volt
A = Ampere
Hz = Hertz (cycle)
W = Watt
kW = Kilowatt
MW = Megawatt
GW = Gigawatt

<u>Other Measures</u>

% = percent
PS = horsepower
° = degree
' = minute
" = second
°C = degree in centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)

<u>Derived Measures</u>

m^3/s = cubic meter per second
cusec = cubic feet per second
mgd = million gallon per day
kWh = kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
kWh/y = kilowatt hour per year
kVA = kilovolt ampere
BTU = British thermal unit
psi = pound per square inch

<u>Money</u>

M$ = Malaysian ringgit
US$ = US dollar
¥ = Japanese Yen

CONVERSION FACTORS

	From Metric System	To Metric System
Length	1 cm = 0.394 inch	1 inch = 2.54 cm
	1 m = 3.28 ft = 1.094 yd	1 ft = 30.48 cm
	1 km = 0.621 mile	1 yd = 91.44 cm
		1 mile = 1.609 km
Area	1 cm^2 = 0.155 sq.in	1 sq.ft = 0.0929 m^2
	1 m^2 = 10.76 sq.ft	1 sq.yd = 0.835 m^2
	1 ha = 2.471 acres	1 acre = 0.4047 ha
	k km^2 = 0.386 sq.mile	1 sq.mile = 2.59 km^2
Volume	1 cm^3 = 0.0610 cu.in	1 cu.ft = 28.32 lit
	1 lit = 0.220 gal.(imp.)	1 cu.yd = 0.765 m^3
	1 kl = 6.29 barrels	1 gal.(imp.) = 4.55 lit
	1 m^3 = 35.3 cu.ft	1 gal.(US) = 3.79 lit
	10^6 m^3 = 811 acre-ft	1 acre-ft = 1,233.5 m^3
Weight	1 g = 0.0353 ounce	1 ounce = 28.35 g
	1 kg = 2.20 lb	1 lb = 0.4536 kg
	1 ton = 0.984 long ton	1 long ton = 1.016 ton
	= 1.102 short ton	1 short ton = 0.907 ton
Energy	1 kWh = 3,413 BTU	1 BTU = 0.293 Wh
Temperature	°C = (°F − 32)·5/9	°F = 1.8°C + 32
Derived Measures	1 m^3/s = 35.3 cusec	1 cusec = 0.0283 m^3/s
	1 kg/cm^2 = 14.2 psi	1 psi = 0.703 kg/cm^2
	1 ton/ha = 891 lb/acre	1 lb/acre = 1.12 kg/ha
	10^6 m^3 = 810.7 acre-ft	1 acre-ft = 1,233.5 m^3
	1 m^3/s = 19.0 mgd	1 mgd = 0.0526 m^3/s
Local Measures	1 lit = 0.220 gantang	1 gantang = 4.55 lit
	1 kg = 1.65 kati	1 kati = 0.606 kg
	1 ton = 16.5 pikul	1 pikul = 60.6 kg

ANNEX G

WATER QUALITY

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1. INTRODUCTION

This Sectoral Report presents a study on projection of river water quality in 1990 and 2000 in the 5 river basins, i.e. Perlis river, Kedah river, Merbok river, Muda river and Perai river, including historical and present condition of river water quality, present water quality monitoring stations, development plans for public sewerage systems and pollutant load abatement plans for river water.

Pollutant load abatement plans for river water were projected to keep the river water quality less than 5 mg/l in BOD concentration for D&I water supply and less than 10 mg/l in BOD concentration for conservation of river environment. As these plans, improvement of purification systems in rubber factories and public sewerage systems in cities with many people and industries like Kangar, Alor Setar, Sg. Petani, Kulim, Butterworth and Georgetown were proposed in the Study. To carry out the river water pollutant load abatement plans will be expected to decrease the pollutant load into rivers and keep the river water clean.

In making the analysis and reporting, necessary data were collected from the ministries and agencies of the Government of Malaysia and state and district authorities. And the Study team could carry out sampling and analysing of river water in 7 river basins in Jan. 1983 with the help of DOE in Butterworth.

2. EXISTING FACILITIES IN CITIES FOR POLLUTANT LOAD ABATEMENT

2.1 Sewerage System in Georgetown and its Vicinity

Georgetown Sewerage System

In Georgetown, the sewerage system which serves an estimated 217,000 people conveys an average dry weather sewage flow of 3.7×10^6 l/d. The collection system comprises 188 km sewers. Flows are conveyed through 4 km interceptors to 13 pump stations, which lift sewage flows through 11 km of force main to the Jelutong Outfall.

The collection system is divided into twenty sewer services. Because a major portion of the urban area is flat, each sewer service area is relatively small in extent. In addition to the areas presently sewered, there are six areas that are not yet connected to the Georgetown sewerage system.

Pump stations range in peak flow capacity from 773 l/min to 33.6 m^3/min. Several stations discharge to common force mains. In a number of cases sewage is pumped twice.

Three force mains convey all Georgetown area sewage to the meter house, located on a reclaimed land at 335 m from seashore. The outfall jetty extends another 366 m seaward from the meter house; sewage flow through an open channel flume, above high tide level, and is discharged to the Western Channel. Tidal currents in the channel ranges between 1.0 and 1.5 m/s on an average. These are sufficiently strong to create effective dispersion of the present sewage discharge within approximately 1.6 km of the outfall (Ref. 1).

Bandar Bayan Baru Sewerage System

The present sewerage system in Bandar Bayan Baru consists of approximately 3000 m gravity sewers, 805 m of force mains, a 6.1 m^3/min peak flow capacity pump station and two stabilization ponds designed to treat an average flow of 3.4×10^6 l/d. This small system provides sewerage for an estimated 5,000 persons which is 20% of total population of 25,000 in Bandar Bayan Baru. From estimated 1,000 premises, the average dry weather flow was 660 m^3/d. All flows are conveyed through the pump station to the treatment site. Here, in two ponds (one of which is mechanically aerated), waste water undergoes an intermediate secondary level of treatment prior to discharging at the mouth of Kluang river (Ref. 1).

North Coast Sewerage System

Most hotels in the North Coast area presently relay on septic tank for waste disposal; several hotels, including Golden Sand Beach Hotel, Rasa Sayang Beach Hotel, Lone Pine Hotel, Palm Beach Hotel, have small waste water treatment systems. Although some residences in the area are also connected with septic tanks, many premises rely on pit privies or pour flush latrines (Ref. 1).

Septic Tank System

Estimated 10,000 premises or 96,000 people corresponding to 20% of the total population of 480,000, use septic tanks for disposal of sanitary wastes.

The private septic tank system consists of a tank with a design capacity of 114 l/person for residential, or 68 l/person for public building, plus 50% additional volume for sludge storage (Ref. 1).

Conservancy System

Premises served by night-soil collection service are equipped with latrines or urinals which discharge to special buckets. The 28 lit. rubber buckets are collected either daily or on alternate days. They are transported to the Kg. Jave Baru Depot and discharged to the sewer for conveyance to the Jelutong Outfall (Ref. 1).

2.2 Sewerage System in Other Cities

2.2.1 Butterworth, Bukit Mertajam

At present there is one community served by a modern sewerage system which collects and treats both sullage and toilet flush water. And current practice of night soil disposal is generally classified into three categories; namely (1) Septic tank system, (2) Bucket system, and (3) Pit privy/over-river latrine system. There are 50 communal septic tank systems and approximately 16,300 bucket systems in Butterworth, Bukit Mertajam and Seberang Jaya (Ref. 2).

Based on the Feasibility Study for Sewerage and Drainage Project Butterworth/Bukit Mertajam Metropolitan Area Malaysia, the public sewerage system is under construction in the center of Butterworth and Bukit Mertajam. The facilities under construction are 3 treatment plants, i.e., Sg. Juru Treatment Plant with 34×10^3 m^3/d in treatment capacity, Mak Madin Treatment Plant with 14×10^3 m^3/d and Sg. Nyor Treatment Plant with 3×10^3 m^3/d. Total served population and served area will be 84,000 people and 1,066 ha in 1990.

2.2.2 Sungai Petani

There are 2 septic tank and oxidation pond systems, 3 Imhof tank systems and bucket system in Sungai Petani Town. At present 90,000 people which is about 70% of total population of 130,000 in Sungai Petani are served by septic tank and oxidation pond system and oxidation pond system is planned in each new house scheme area. Very few people is served by bucket system. This bucket system will be changed to septic tank system.

2.2.3 Alor Setar

At present there are several waste disposal systems in Alor Setar. They are 4 oxidation pond systems, 12,000 private septic tank systems, 21 communal septic tank systems, 2,355 bucket systems and 405 conservancy systems, and number of served premises are 1,530, 18,000, 1,700, 4,840 and 770, respectively (Ref. 3).

2.2.4 Kangar

There are two waste disposal systems in Kangar Town. They are septic tank system and bucket system. Septic tank system serves 18,000 people which is 95% of total population of 19,000 people and bucket system serves 1,000 people in operation area in Town Council.

3. HISTORICAL AND PRESENT CONDITION OF WATER QUALITY BY RIVER

3.1 Water Quality

Since March, 1978, regular river water quality monitoring program has been carried out partly to assess the existing conditions of public waters by DOE.

The number of Water Quality Monitoring Station (WQMS) in Water Quality Control Regions (WQCR) 1-7 carried out by the branch of DOE in Butterworth were 55 in 1978, 68 in 1979 and 1980, 67 in 1981 and 55 in 1982.

According to data obtained from DOE in 1978 - 1982, the mean, maximum and minimum values of the five selected parameters namely BOD_5, COD, pH, SS and NH_4-N are as shown in Tables 1 to 5.

In January 1983, the Study team has done a field survey for river water quality, and then water sampling collection was carried out at most WQMS in the Study area with the help of the branch of DOE in Butterworth and all water samples were analysed in the laboratory of the Chemistry Department, Pulau Pinang. The results of the analysis are as shown in Tables 6 to 10.

3.1.1 BOD_5

BOD is the most suitable parameter as a primary indicator of organic pollution. Distribution of mean BOD_5 levels by WQMS of 8 rivers from 1978 to 1982 are as shown in Figs. 1 and 2. An acceptable U.K. classification initiated by D. Balfour and Sons (Ref. 4) is based on BOD_5 at 20°C as follows:

BOD_5	Classification
0 - 4 mg/l	Clean
4 - 8 mg/l	Mildly Polluted
8 - 12 mg/l	Moderately Polluted
More than 12 mg/l	Grossly Polluted

If this BOD_5 classification is applied on the data in Tables 1 to 5 for the 8 rivers, some stretches in Perlis river, Kedah river, Merbok river and Juru river were grossly polluted in 1978 to 1982 as shown in Table 11.

3.1.2 Suspended solid (SS)

SS in the Study area is mainly caused by the operation of sugar mills and rubber factories as same as the sugarcane field, young rubber tree field and development area. Distribution of mean SS levels by WQMS of 8 rivers from 1978 to 1982 are as shown in Figs. 3 and 4.

REPORT ON WATER POLLUTION CONTROL JURU RIVER BASIN shows a SS classification as follows:

SS	Classification
0 - 50 mg/l	Class A
50 - 100 mg/l	Class B
100 - 150 mg/l	Class C
More than 150 mg/l	Class D

If this SS classification is applied on the data in Tables 1 to 5 for the 8 rivers, some stretches in all rivers except Muda river were polluted in SS levels more than 150 mg/l as shown in Table 12.

3.1.3 Other pollutants

The distributions of mean COD, pH and NH_4-N levels by WQMS of 8 rivers from 1978 to 1982 are as shown in Figs. 5 to 10.

3.1.4 Water quality conditions by river

Using 5 parameters, i.e. BOD_5, COD, pH, SS and NH_4-N, water quality conditions in Perlis river, Kuar river, Kedah river, Merbok river, Muda river, Perai river, Juru river and Jejawi river are described as follows:

(1) Perlis river

The Perlis river shows high BOD_5 concentration, 15 mg/l in 1979 and 7 mg/l in 1982, at the upper reaches of the river, higher SS concentration than 50 mg/l between 1978 and 1982 at the middle and lower reaches and high NH_4-N concentration at the upper reaches. The pollution source of the high BOD_5 and HN_4-N concentration at the upper reaches seems to be a big sugar mill of KILANG GULA FELDA PERLIS SDN. BHD. There is no big pollution source downstream from the sugar mill except Kangar urban area. There are many population and several kind of industries in Kangar urban area. Therefore, Kangar is the biggest pollution source in the Perlis basin. The pollution sources of high SS concentration seems to be sugarcane field, cultivated land and development area.

(2) Kuar river

The Kuar river is generally clean.

(3) Kedah river

Big pollution sources in the Kedah river basin are a sugar mill of KILANG GULA PADANG TERAP BHD., and Alor Setar urban area. In 1978, there was no purification facilities in a sugar mill, so water quality downstream of the sugar mill recorded very high concentration of BOD_5, COD, SS, NH_4-N and other parameters. After purification facilities were installed on an advice of DOE the situation improved. Characteristics of treated effluent from KILANG GULA PADANG TERAP BHD. are as follows:

Sampling date	:	Oct. 2, 1982
pH	:	6.6
BOD_5	:	688 mg/l
COD	:	1,500 mg/l
Ammoniacal Nitrogen	:	0.88 mg/l
Nitrate Nitrogen	:	$<$ 0.05 mg/l
SS	:	230 mg/l
Oil and Grease	:	5 mg/l

Waste water from Alor Setar urban area deteriorates river water quality organically.

It is considered that pollution source of higher SS concentration than 150 mg/l in the Padang Terap river basin is a large scale sugarcane field.

(4) Merbok river

Merbok river is the most polluted river in the Study area. The biggest pollution sources in this river basin seem to be 3 rubber factories, LEE LATEX (PTE) LTD., UNIROYAL MALAYSIAN PLANTATIONS SDN. BHD. and PLANTATION LATEX (M) SDN. BHD. The second biggest pollution source is Sg. Petani urban area.

Concentrations of BOD_5, COD and NH_4-N were very high level at the downstream of these rubber factories, and high NH_4-N level was recorded downstream of Sg. Petani urban area.

According to a study by DOE (Ref. 5), BOD load produced from the rubber factories is estimated to be 3.3 ton/d which is 53% of the total BOD of 6.7 ton/d in the basin and BOD load from domestic sewage is estimated to be 2.9 ton/d which is 46% of the total BOD. The Tok Pawan river and its tributaries and the Sungai Petani river was very polluted, however, water quality in the Merbok Ketil river, the Baharu river, the Pasir river, the Bangkok river, the Labang river and the Bujang river is good and suitable for breeding fresh water fishes, farming, drinking and other domestic uses.

(5) Muda river

In spite of the existence of several rubber factories in the Muda river basin as pollution sources, the river water of the Muda river is not polluted by organic matters.

The discharge volume of the Muda river is very large and, therefore, the concentrations of BOD_5, COD, SS and NH_4-N are so low that the river water of the Muda river basin is useful for D&I water supply to Sg. Petani, Butterworth, Bukit Mertajam and Georgetown, breeding of fresh water fishes and irrigation.

(6) Perai river

There are many cities/towns, rubber factories and animal husbandries as pollution sources in the Perai river. Out of these pollution sources, almost cities/towns are located in coastal area except Kulim. Waste water from these cities/towns and a few animal husbandries in coastal area is discharged to the sea directly. Therefore, river water of the Perai river is not polluted, though sampling stations located at the downstream of rubber factories showed comparably high BOD_5 and NH_4-N in 1979, 1980 and 1982.

(7) Juru river

Juru river water is very polluted by domestic waste water and effluent from a rubber factory. Domestic waste water is discharged from Bukit Mertajam urban area to the river and effluent is discharged from ALMA RUBBER ESTATE SDN. BHD. Animal husbandry is also main pollution source in this river basin. In the urban area, level of NH_4-N was very high in 1979, 1981 and 1982.

(8) Jejawi river

Jejawi river water is not so polluted because there are only few pollution sources such as urban areas, rubber factories and animal husbandry. However, sampling stations which are located in a urban area or at the downstream of rubber factories showed high levels of BOD_5 and NH_4-N like other river basins.

3.2 Pollution Sources and Their Locations

Major/industrial towns, rubber factories, palm oil mills and animal husbandry are considered as main pollution sources of river water pollution in the Region.

Among 20 major/industrial towns, the towns whose waste water affects river water quality are Kangar, Alor Setar, Sg. Petani and Kulim. Treated or not treated waste water from other cities including Georgetown and Butterworth are discharged to the river mouth or the sea directly.

There are 33 rubber factories in Kedah and 9 rubber factories in Pulau Pinang. In these 42 factories, 24 factories have the purification system like an anaerobic/facultative pond.

There are a palm oil mill in Kedah and 4 in Pulau Pinang. Among them 4 palm oil mills have the purification system like a biological anaerobic pond.

Number of pigs in animal husbandry has been increasing in 12 cities/towns, especially in Pulau Pinang. No treatment facilities for waste water are installed in almost pig farms.

The locations of existing pollution sources are as shown in Plates 1 and 2. An inventory including data on existing effluent treatment system is as shown in Tables 13 and 14 for rubber factories and in Table 15 for palm oil mills. Projected water demand with indication of effluent treatment system is as shown in Table 16 for rubber factories and Table 17 for palm oil mills. Projected pig production by city/town is as shown in Table 18.

3.3 Major Pollutants by Pollution Source

Major pollutants in domestic waste water are BOD, COD, SS and Ammoniacal Nitrogen. Domestic waste water has also N and P which trend to cause eutrophication in rivers, lakes and sea.

Industrial waste water contain various kind of matters, but BOD, COD, SS, oil and grease, N and P are generally as major pollutants in industrial waste water (Ref. 6).

In the effluent of rubber factory the concentrations of BOD, COD, total solids, SS, dissolved solids, and N are very high (Ref. 7).

In the palm oil waste water the concentrations of BOD, COD, SS, P and N are very high (Refs. 8, 9).

Major pollutants of animal husbandry effluent are BOD, COD, SS, P and N.

4. PRESENT MONITORING SYSTEM OF WATER QUALITY

4.1 Water Quality Monitoring Stations and Their Locations

The water quality sampling and analysing system was initiated by DOE in the northern region in 1978.

Number of water quality monitoring station (WQMS) by water quality control region (WQCR) is as shown in Table 19.

Monitoring stations by river are listed in Tables 20 to 22 and the location of these stations are shown in Plates 3 and 4.

Monitoring stations are mainly located on the downstream of the water quality pollution sources, i.e. rubber factories, sugar mills, main cities and other sources. Therefore there are a lot of stations in the river basin which has the many water quality pollution sources. Waste water from pollution sources are surveied by these monitoring stations.

4.2 Water Quality Parameters and Frequency of Sampling

The national waters are principally used for agricultural irrigation, the generation of power, domestic and industrial water supply, waste disposal, transportation, recreation, environmental conservation, fishing, bathing and propagation of aquatic life. Water quality requirements are most demanding for domestic water supply, less so for water used in recreation and propagation of aquatic life, and least so for waters used in the industries and agricultural irrigation. Water quality parameters are varied in accordance with above-mentioned four sectors of water uses. Water quality parameters to which limits are provided in the Environmental Quality Act are Alkalinity, Colour, Hardness, Odour, 8 Organics, pH, Dissolved Solids, Turbidity, SS, Temperature, 14 Biocides and 37 Inorganic Chemicals. Water quality parameters which are generally analysed in laboratories in order to know the state of river water quality are pH, BOD 5 days at 20°C, COD, Ammoniacal Nitrogen as N, Total Kjedahl Nitrogen as N, Nitrate Nitrogen as N, Chloride as Cl^-, Phosphate as P, Total Solids dried at 105°C, SS dried at 105°C, Dissolved Solids, Iron as Fe, Colour, Turbidity, Total Hardness as $CaCO_3$, Calcium as Ca and Magnecium as Mg. For the river water sampled in the field survey in January 1983 for the Study, these 17 parameters were analysed in the laboratory in Pulau Pinang and these analysis data are shown in Tables 6 and 10.

Sampling frequency in 1983 which is planned by the Branch of DOE in Butterworth (Ref. 10) are as follows:

Name of Station	Sampling Frequency
Perlis	4 times per year
Kuar	4
Kedah	4
Merbok	12
Muda	6
Perai	6
Juru	6
Jejawi/Tengah	4

Quantitative analysis of all river water quality samples in the northern region is carried out by the laboratory in Pulau Pinang belonging to Department of Chemistry.

5. DEVELOPMENT PLANS FOR PUBLIC SEWERAGE SYSTEM

There are several cities having 4MP continuation projects or projects with master plan under the 4MP for their sewerage systems. These cities are Pulau Pinang including Georgetown, Bandar Bayan Baru and the Northern Coast, Butterworth/Bukit Mertajam and Alor Setar. The sewerage development plans of these cities are as described below.

5.1 Sewerage System Master Plan for Pulau Pinang

The recommended master plans of sewerage systems for Pulau Pinang including Georgetown, Bandar Bayan Baru and the Northern Coast are as follows (Ref. 1):

(1) The recommended improvements include extension of lateral and trunk sewers that convey flows to the disposal sites, several new pump stations, improvements to existing pump stations, additional force mains, and a new ocean outfall with preliminary treatment facilities throughout the Greater Georgetown.

(2) The Bandar Bayan Baru system should remain a separate entity with all sewage conveyed to a purification treatment plant which provides secondary level of purification.

(3) The Northern Coast should be connected into the Greater Georgetown Sewer System. All hotel, commercial, and residential sewage generated in the recreation area along the North Coast would be collected by a major trunk sewer. And the sewage would flow to the Jelutong Outfall through the pump station, force main and a gravity sewer.

(4) The development period according to the Master Plan is divided into four stages, namely, 1981 - 1985, 1986 - 1990, 1991 - 1995, and 1996 - 2000. The designed population, capital and operation and maintenance (O&M) costs at 1980 price level are as follows:

	Designed Population (10^3)	Costs at 1980 Price Level	
		Capital (M$$10^6$)	O&M (M$$10^6$/y)
1980	197	18.6	0.99
1981 - 1985	-	41.2	1.57
1986 - 1990	348	47.1	2.02
1991 - 1995	-	44.9	2.43
1996 - 2000	589	17.9	2.80

5.2 Sewerage System Plans for Butterworth/Bukit Mertajam Metropolitan Area

The proposed plans of sewerage system for Butterworth/Bukit Mertajam Metropolitan Area are as follows (Ref. 2):

(1) The sewerage system should be principally a separate system.

(2) The physical facilities recommended to be developed include (i) system of sanitary main, branch and lateral sewers, (ii) pumping stations, and (iii) sewage purification facilities in the form of stabilization ponds.

(3) Industrial waste water should also be taken into account for sewerage planning. The joint purification of industrial waste water with domestic waste using stabilization ponds should be implemented from the economic point of view.

(4) It is considered appropriate to divide the program into four construction stages, namely 1980 - 1985 (1st stage), 1986 - 1990 (2nd stage), 1991 - 1995 (3rd stage) and 1996 - 2000 (4th stage). Total cost of construction and O&M at current price of the first stage is as follows:

	1980	1981	1982	1983	1984	1985
Construction	6,078	5,377	6,404	8,717	3,518	7,655
O&M	110	204	214	506	689	858
Total	6,188	5,581	6,618	9,223	4,207	8,513

Note: Escalated at 5% per annum from end 1977 price.

(5) The First Stage program should comprise the main sewer with total length of about 55 km to convey sewage to the purification plant with four stabilization ponds, which will be then discharged into either the Perai river or the Juru river directly through nearby waterway.

(6) Projected connected population and households in Butterworth/ Bukit Mertajam Metropolitan area is as follows:

Year	Total Population	Estimated Connected Population	Estimated Households Connected
1981	310,700		
1982	327,800		
1983	345,800	24,700	4,330
1984	364,900	43,200	7,620
1985	385,000	63,900	11,300
1986	398,600	76,400	13,700
1987	412,700	85,100	15,400
1988	427,300	86,200	15,700
1989	442,400	87,300	16,000
1990	458,000	88,500	16,300

5.3 Sewerage System Plans for Alor Setar

The proposed plans of sewerage system for Alor Setar are as follows (Ref. 3):

(1) Waste water from residential areas, commercial areas, institutional areas and schools should be purified at the proposed purification plant.

(2) The physical facilities recommended to be developed include (i) system of sanitary main, branch and lateral sewers, (ii) pumping stations, and (iii) sewage purification facilities in the form of stabilization ponds with facultative ponds and maturation ponds in series.

(3) To achieve the objectives, the program is divided into several periods. The first 5 years are proposed as the first stage with the recommended items as follows:

- Proposed Sewerage Facilities:

· Sewer Facilities	21.9 km
· Pumping Stations	6 pumps
· Waste Stabilization Pond	Sedimentation Cell Facultative Pond Maturation Pond
· Cleaning Machine	1 set
· Laboratory	

- Total Cost of Construction and O&M at current price (Escalated at 8% per annum from original price of the year 1979)

Unit: M$$10^3$

	1981	1982	1983	1984	1985
Construction	4,354	4,911	5,738	5,045	2,774
O & M	217	258	493	602	713
Total	4,571	5,169	6,231	5,647	3,487

- Projected Connected Population and Households

Year	Total Population in Master Plan Study Area	Estimated Connected Population	Estimated Households Connected
1982	157,000		
1983	163,300		
1984	169,900	10,100	1,836
1985	176,700	17,900	3,255
1986	183,800	23,000	4,182
1987	191,100	23,200	4,218
1988	198,800	23,000	4,236
1989	206,700	23,500	4,273
1990	215,000	23,600	4,291

6. PROJECTION OF WATER QUALITY

6.1 General

Pollutant load and water quality of rivers by Basin were projected based on projection of D&I water demand. Major pollution sources are 5 cities/towns, rural areas in 17 districts, 42 rubber factories, 4 palm oil mills and animal husbandry in the Study area. These sources are grouped into nine categories; i.e., (1) Urban domestic sewerage, (2) Urban domestic non-sewerage, (3) Rural domestic, (4) Urban manufacturing sewerage, (5) Urban manufacturing non-sewerage, (6) Rural manufacturing, (7) Palm oil processing, (8) Rubber processing and (9) Animal husbandry. Each category has its own values in net unit pollutant load, discharge ratio, runoff ratio and infiltration ratio. Composition of the above pollution sources is illustrated in Fig. 11.

In order to know the degree of organic water pollution in rivers, BOD was selected among five parameters for living environment such as BOD, SS, DO, pH and NH_4-N.

Projected pollutant load and water quality by Basin are as shown in Tables 23 and 24. And projected maximum BOD concentration distributions in 1990 and 2000 for the condition of 4MP and lower economic growth are illustrated in Figs. 12 to 17.

6.2 Water Quality Projection

6.2.1 Methodology

Water quality of river was projected for all Basins in the Study area.

Water quality was calculated by the following order:

(1) Pollutant load from pollution source (PLS)
= Customer demand (C.D.) x Discharge ratio (D-ratio)
x Net unit pollutant load (NUPL)

(2) Pollutant load inflow to river (PLR)
= PLS x Runoff ratio (R-ratio)
x (1 + Infiltration ratio (I-ratio))

(3) Pollutant load at some point (PLSP)
= PLR x Residual purification ratio (RP-ratio)

(4) Water quality at some point (W.Q.)
= CD x D-ratio x NUPL x R-ratio x (1 + I-ratio)
x RP-ratio/Maintenance flow at some point

Water quality was calculated by return point of polluted waste water in a Basin.

Water quality projection flow-chart is given in Fig. 18.

Calculation of water quality was carried out on the following assumptions:

(1) Hydraulic discharge used for water quality projection is Basin discharge in 1977 which is the driest year between 1961 and 1980;

(2) When the river water is abstracted at intake, pollutant load of the river is decreased. The decreased load is expressed as (Abstracted volume x Water quality);

(3) Urban domestic and manufacturing waste water in the coastal area is discharged not to river, but to sea directly after treating;

(4) A part of abstracted water from river is reduced by (SD-CD)/2;

(5) The effluent from pollution sources is discharged at the return point; and

(6) I-ratio of groundwater into sewer pipe in city/town having public sewerage system is 20% of the average daily treatment capacity.

6.2.2 Net unit pollutant load (NUPL)

In order to know the degree of water pollution in the river, five parameters such as pH, BOD, SS, DO and NH_4-N will be used. Of these parameters, BOD is the most suitable parameter to know the organic pollution of river water. The reason is described hereunder.

The river water is, first of all, polluted organically because of the direct discharge of domestic waste water and night soil. Then industrial effluent containing heavy metal and chemical materials pollutes the river water chemically but industrial effluent with heavy metal should not be discharged to water body without treatment. Therefore, heavy metals are not suitable parameters to know man-made pollution of river water. River has the self purification mechanism which purifies organic pollution. This mechanism is caused by the fact that aerobic bacteria in river water transforms organic matters to inorganic matters using dissolved oxygen. The volume of dissolved oxygen used by aerobic bacteria is BOD. For the above reasons, BOD load was used in the Study as pollutant load.

Data for NUPL of sewerage, urban, rural, manufacturing, processing and animal husbandry were available in Malaysia (Ref. 12).

NUPL was estimated based on several reports (Refs. 2, 11, 12 & 13), assuming that the purification measures remain at the present level of BOD concentration in 1990 and 2000. NUPL of non-sewerage-urban-domestic was estimated based on assumed development of septic tank in urban area as shown in Tables 25 and 26. NUPL of manufacturing by state was estimated by weighted average of water demand by state and NUPL by type of manufacturing. NUPL by type of manufacturing and water demand by state are given in Table 27. NUPL of manufacturings by state is as shown in Table 28. Estimated NUPL is given in Table 29.

6.2.3 Discharge ratio (D-ratio)

Water consumers use clean water and then discharge polluted water to drainage, river or sea directly. D-ratio is the ratio of consumer water demand and discharged water. D-ratio of domestic consumer was determined based on the Malaysian data. D-ratio by pollution source is as shown in Table 29.

In manufacturing, D-ratio was determined with consideration of the recyclic water use development. In palm oil mills and rubber factories the land disposal system is assumed to be progressively applied as shown in Table 30. D-ratio of palm oil mills and rubber factories was determined with consideration of land disposal development and outflow of 10% of pollutant load from land disposal area as shown in Table 31. In animal husbandry no water is used.

6.2.4 Runoff ratio (R-ratio)

The ratio of the reduction in discharged pollutant loads, which is the ratio before and after discharged pollutant reaches a river, is called the runoff ratio.

R-ratio is about 0.1 in rural areas but increases with the progress of urbanization. For a drainage channel made of concrete, R-ratio rises to nearly 1.0. R-ratio by pollution source is as shown in Table 29.

6.2.5 Infiltration ratio (I-ratio)

The infiltration ratio in the existing sewerage systems in the Region is equivalent to about 25% to 30% of the average flow. Since existing systems are constructed with rigid cement joints, it is to be expected that, with the provision of flexible, water tight joints in the future, the infiltration ratio will be about 20% of the average daily flow (Refs. 12, 14, 15 & 16). I-ratio is assumed to be 20% in the Study.

6.2.6 Residual purification ratio (RP-ratio)

Pollutant load in river reduces by deposition, adsorption, biological decomposition and so on. The ratio of reduced pollutant load by these mechanism to the original pollutant load is called the residual purification ratio. In other words, RP-ratio is the ratio of pollutant load of upperstream and downstream. RP-ratio has a figure in the range of 0 to 1 by conditions of water quality, water velocity, water discharge, water depth, and riverbed of the river basin. The relationships between RP-ratio and water quality is close. RP-ratio is about 0.7 in a river with clean water and RP-ratio rises to nearly 1.0 in a river with polluted water. In the Study, RP-ratio by basin is assumed to be 0.7 - 0.9 with consideration of the river water quality in 1980 and 1982. RP-ratio by basin is as shown in Table 32.

6.2.7 River maintenance flow

The river maintenance flow used for water quality projection is the minimum natural runoff in the river among those between 1961 and 1980.

6.2.8 Projection of water quality

Water quality of 8 Basins, i.e., the Perlis river basin, the Kedah river basin, the Merbok river basin, the Muda river basin, the Perai river basin, the Juru river basin, the Jejawi river basin and the Pulau Pinang basin was projected for two cases, i.e., the condition of 4MP and lower economic growth. Projected BOD load and BOD concentration by basin in 1990 and 2000 are as shown in Table 33 for the condition of 4MP and Table 34 for the condition of lower economic growth. Total BOD load from pollution sources in the Study area will be 118 ton/d in 1990 and 209 ton/d in 2000 under the condition of 4MP, and 107 ton/d in 1990 and 141 ton/d in 2000 under the condition of lower economic growth, respectively.

It is assumed that waste water from 15 cities mentioned hereunder out of 20 cities is discharged to the sea directly because these 15 cities are located near the sea coast. These 15 cities are Butterworth, Bukit Mertajam, Georgetown, Jitra, Guar Chempedak, Yan Kuala Ketil, Kg. Pmtg Kuching, Perai, Bandar Seberang Jaya, Air Itam, Tg. Tokong, Gelugor, Tg. Bunga and Bandar Bayan Baru.

BOD load from these 15 cities will be 18 ton/d in 1990 and 47 ton/d in 2000 under the condition of 4MP and 14 ton/d in 1990 and 25 ton/d in 2000 under the condition of lower economic growth, respectively.

BOD load into main stream will be 37 ton/d in 1990 and 67 ton/d in 2000 under the condition of 4MP, and 32 ton/d in 1990 and 41 ton/d in 2000 under the condition of lower economic growth, respectively.

Composition of BOD load into river is as shown in Tables 35 and 36. In case of the condition of 4MP, in 1990, urban domestic, urban industry, rubber factories and palm oil mills will be the biggest pollution sources and those BOD load will be 16 ton/d being equivalent to 43% of the total BOD load of 37 ton/d. In 2000, the biggest pollution sources will be urban domestic and urban industry followed by rubber factories and palm oil mills, and BOD load of urban domestic and urban industry into river will be 38 ton/d being equivalent to 57% of the total BOD load of 67 ton/d. That of rubber factories and palm oil mills will be 21 ton/d being equivalent to 31% of the total. In case of the condition of lower economic growth, in 1990, rubber factories and palm oil mills will be the biggest pollution sources and its BOD load will be 14 ton/d being equivalent to 44% of the total BOD load of 32 ton/d. In 2000, they will be also the biggest pollution sources having the BOD load of 21 ton/d being equivalent to 51% of the total BOD load of 41 ton/d.

The projection of BOD concentration was conducted in consideration of the river maintenance flow. Projected maximum and minimum BOD concentration by basin are as shown in Tables 33 and 34.

In case of the condition of 4MP, the highest BOD concentration, 81 mg/l in 1990 and 111 mg/l in 2000, was projected for the Merbok river basin because of the non-treated effluent from urban and rural area and rubber factories. In case of the condition of low economic growth, the Merbok river basin also shows the highest BOD concentration of 71 mg/l in 1990 and 92 mg/l in 2000. Distribution of BOD concentration along the rivers of 5 basins is illustrated as in Figs. 12 to 14 for the condition of 4MP and Figs. 15 to 17 for the condition of lower economic growth. These 5 basins are the Perlis river basin, the Kedah river basin, the Merbok river basin, the Muda river basin and the Perai river basin.

In case of the condition of 4MP, these basins except the Muda river basin show a stretch of higher BOD concentration than 25 mg/l in 2000. It is projected that these stretches are polluted by the waste water from urban domestic and urban industry, i.e. Kangar, Alor Setar, Sg. Petani and Kulim where are located near coast. And all intakes for domestic and industry water supply are located at the upper part of these polluted stretches. Therefore, polluted river water is not abstracted for D&I water supply.

7. POLLUTANT LOAD ABATEMENT PLANS FOR RIVER WATER

7.1 General

As the result of the water quality projection in the Study area for 1990 and 2000, downstream of almost rivers, especially, the Merbok river will be polluted. Therefore it is necessary to consider the pollutant load abatement from viewpoints of water use and environmental quality in river. The best method for pollutant load abatement is that pollution sources control polluted effluent from sources by themselves.

7.2 Setting of Water Quality Criteria

Water quality standards are of two kinds as follows:

(1) standards for drinking water which pertain to water delivered to consumers after treatment; and

(2) standards for raw water which are classified depending upon the purpose of utilization, i.e., domestic and industrial water supply, fishery, irrigation, bathing and conservation of environment.

International Standards for Drinking Water have been promulgated by the World Health Organization (WHO) as a worldwide guide to the improvement of water quality and treatment. In Malaysia, there are Standards of Bacteriological Quality of Water and Standards for Toxic Substances derived from the WHO Standards and they have been used by relevant agencies.

The Standards for Toxic Substances include Toxicity Limits and Water Quality Criteria for 4 categories, i.e., (i) municipal water supply, (ii) recreation, propagation of fish and other aquatic wildlife, (iii) agricultural irrigation and (iv) industrial water supply. Adopted parameters are 74 in number but they do not include BOD. Standards of raw water in some countries, Holland, U.S.A., U.S.S.R., Philippines and Japan have adopted several parameters including BOD. Concerns the living environment, river water quality is classified according to water usage, and environmental quality standards values for BOD, DO, SS, pH and Coliform are established for each class. Japanese Standards relating to living environment is as shown in Table 37 and Philippines' water quality criteria is as shown in Table 38. In the Study, BOD is adopted in order to observe the river water quality. Some relationships between BOD concentration in a river and environmental quality, and river water quality standard in some countries are illustrated as in Fig. 19.

As the water quality criteria, two targets for the water pollution abatement are proposed from the viewpoint of environmental quality in the Study. One target is BOD concentration in a river at less than 5 mg/l for the purpose of D&I water supply and another target is BOD concentration in a river at less than 10 mg/l for the conservation of river environment.

7.3 Planning of Treatment Facilities

To reduce BOD concentration to the proposed limit in a river, the improvement of treatment facilities in pollution sources should be conducted.

First of all, the improvement of purification methods in all palm oil mills and rubber factories is assumed. Improved purification methods are rubber investigation in Palm Oil Research Institute of Malaysia (PORIM) and Rubber Research Institute of Malaysia (RRIM) to attain the limit of BOD concentration for watercourse discharge from palm oil mills and rubber factories. DOE proposed 50 ppm for the future limit. Present limits for watercourse discharge in palm oil mills and rubber factories are as shown in Table 39.

If there still remains a river stretch of higher BOD concentration than the proposed limit, the construction of a sewerage system in the urban area immediately upstream of the river stretch is assumed.

Urban domestic and manufacturing waste water is collected and treated in public sewerage treatment facilities. BOD concentration in the effluent from a sewerage system is estimated to be 30 mg/l.

No purification measure is assumed for the effluent from rural area and animal husbandry.

For purification method of effluent from palm oil mills, anaerobic digestion with extended aeration or land disposal are proposed. As treatment method of effluent from rubber factories, aerobic and facultative pond for SMR and oxidation ditch for Latex Concentrate. The layout of the stabilization pond process, combining facultative pond with maturation pond, is shown in Fig. 20.

For public sewerage system, aerated lagoon process is proposed in the Study. This process is historically developed from stabilization pond. Floating aerator for surface aeration is commonly used to supply the necessary oxygen and arise reduction level of laod. Maturation pond is necessary to reduce coliform after treating in the aerated lagoon. The layout of aerated lagoon process is shown in Fig. 21.

7.4 Planning of Pollutant Load Abatement for River Water

As mentioned in 6.3.8, high BOD concentration was projected at the downstream of big pollution sources, i.e., rubber factories or cities/towns. Therefore, it is necessary to plan the treatment facilities in the Perlis river basin, the Kedah river basin, the Merbok river basin and the Perai river basin.

The purification methods in the rubber factories to be improved and the public sewerage systems in the urban area to be constructed in 1990 and 2000 by basin are as follows:

Basin Name	City/Town	Rubber, Palm or Sugar
Perlis	Kangar	Sugar
Kedah	Alor Setar	Rubber
Merbok	Sg. Petani	Rubber
Muda	-	Rubber
Perai	Kulim	Rubber
P. Pinang	-	Rubber

Georgetown and Butterworth are located in coastal area, therefore the effluent from these cities is discharged to the sea directly. However from the viewpoints of public health and environment, public sewerage system has been already installed in Georgetown and under construction in Butterworth. Outlines of proposed public sewerage system under two conditions are as shown in Tables 40 and 41. And effluent volume to be treated in rubber factories in 1990 and 2000 is as shown in Table 42.

According to the result of the river water quality projection on the assumption of the improvement of purification system in rubber factories and the construction of public sewerage system in urban area in 1990 and 2000, BOD concentration at the every intake point for D&I water supply will be less than 5 mg/l, however BOD concentration of the stretch near river mouth in the Perlis river basin, the Kedah river basin and the Merbok river basin in 2000 under the condition of 4MP and lower economic growth will be more than 10 mg/l. BOD load in 1990 and 2000 by basin with and without project under the condition of 4MP and lower economic growth are as shown in Tables 43 and 44. To reduce BOD concentration to 10 mg/l, it is necessary to increase river water discharge. As the river maintenance flow, river water discharge which includes the discharge to keep lower BOD concentration than 10 mg/l is proposed in the Study. The river water discharge to keep BOD concentration at less than 10 mg/l by river are as follows:

Basin Name	Year	Intake No.	Maintenance Flow (10^3 m^3/s) Condition of 4MP	Condition of Lower Economic Growth
Perlis	2000	11	1.5	0.4
Kedah	2000	28	6.2	2.3
Merbok	2000	2	3.7	1.4

7.5 Recommended Pollutant Load Abatement Plan

It is assumed that BOD concentration should not be more than 5 mg/l in river stretches where intakes are located and 10 mg/l in other river stretches.

The recommended measures to attain the above-mentioned standard are the improvement of purification facilities in all the rubber factories, palm oil mills and sugar factories and sewerage development in large towns. There is no significant measures to reduce BOD load from small towns, rural areas and animal husbandry. If the standard cannot be attained with all the above-mentioned measures, either augmentation of river flow by operation of storage dams or diversion of urban sewerage to the sea through a conduit.

Three alternative plans are proposed to attained the above-mentioned standard in the Perlis river basin, the Kedah river basin and the Merbok river basin.

Alternative 1: to provide a sewerage system in large towns and to augment the river flow with dams.

Alternative 2: to provide a sewerage system in large towns and conduit which conveys sewage into the sea.

Alternative 3: to augment the river flow with dams and with no sewerage development in large towns.

Construction cost of sewerage system and conduit and augmentation of river flow with dams by alternative by river basin for the condition of 4MP are summarized as follows:

Basin Name	Measures		Condition of 4MP Alternatives			Condition of Lower Economic Growth Alternatives		
			1	2	3	1	2	3
Perlis	Sewerage	(M$$10^6$)	74	74	-	33	33	-
	Conduit	(M$$10^6$)	-	6	-	-	6	-
	Dam	(10^6 m^3)	3	-	91	3	-	91
Kedah	Sewerage	(M$$10^6$)	247	247	-	89	89	-
	Conduit	(M$$10^6$)	-	10	-	-	10	-
	Dam	(10^6 m^3)	19	-	110	19	-	110
Merbok	Sewerage	(M$106)	155	155	-	60	60	-
	Conduit	(M$$10^6$)	-	7	-	-	7	-
	Dam	(10^6 m^3)	-	-	370	-	-	370

Selection between Alternative 1 and 3 by basin depends on the cost of dams, which are being studied by a study team. It is herein assumed that Alternative 1 is selected in 3 basin.

In the Muda river basin, the improvement of purification method in all the rubber factories and the palm oil mill is recommended.

In the Perai river basin, the recommended plan includes the improvement of purification method for the rubber factories and sewerage system in Kulim.

8. PLANNING MATERIALS, ECONOMIC BENEFIT AND COST AND MANPOWER REQUIREMENT

8.1 Planning Materials

8.1.1 Construction cost

Construction costs of purification facilities for palm oil mills, rubber factories and sewerage facilities for urban area composed of sewer, pumping station and treatment facilities are estimated, basing on the data from DOE and the previous studies available, i.e. Master Plan and Feasibility Study for Sewerage and Drainage System Project in Alor Setar and its Urban Environs Malaysia Report. The construction cost of pretreatment facilities for domestic and industrial water supply are estimated using the data of the previous studies available.

Construction cost is estimated in the four categories, i.e. (1) direct construction cost, (2) engineering service & administration, (3) land acquisition, and (4) physical contingency. Engineering service and administration costs are assumed to be 10% of the direct cost. Physical contingency is assumed to be 30% of the total of the above (1) to (3).

For the sewerage facilities, direct construction costs by facilities in reference of the hearing data of Butterworth Project as shown in Table 45 are as follows:

$$C_S = 0.666Q$$
$$C_T = 4.33 + 0.067Q$$

where, C_S: Direct construction cost of sewer, M10^6

C_T: Direct construction cost of treatment facilities, M10^6

Q : Treatment capacity, 10^3 m^3/d

Unit direct construction cost of sewerage facilities per 100 x 10^3 m^3/d of treatment capacity is M$77.6 x 10^6.

Land acquisition cost for sewerage facilities in reference of the hearing data of Butterworth Project as shown in Table 45 are as follows:

$$C_L = 0.107Q$$

where, C_L: Land acquisition cost of treatment facilities, M10^6

Q : Treatment capacity, 10^3 m^3/d

Unit land acquisition cost of sewerage facilities per 100 x 10^3 m^3/d of treatment capacity is estimated to be M$10.7 x 10^6.

Construction and land acquisition costs of sewerage facilities are generally born by the public and the private sector. Therefore calculation of costs for sewerage systems was carried out on the following assumptions:

(1) In the existing urban area, cost of house connection pipe is born by the private; and

(2) In the new development urban area, costs of branch sewer and house connection pipe are born by the private.

Cost and share of branch sewer and house connection pipe to total costs of sewerage systems are as shown in Table 46.

For the purification facilities for palm oil mills, direct construction costs are M$3,600/$m^3$/d of treatment capacity for anaerobic digestion with extended aeration and M$2,400/$m^3$/d of treatment capacity for anaerobic digestion with land disposal. In consideration of land disposal development; 50% in 1990 and 75% in 2000, direct construction costs in 1990 and 2000 are as follows:

$$Cp = (3.6 \times 0.5 + 2.4 \times 0.5) \times Q = 3.0 \times Q \text{ in } 1990$$
$$Cp = (3.6 \times 0.25 + 2.4 \times 0.75) \times Q = 2.7 \times Q \text{ in } 2000$$

where, Cp: Direct construction cost of purification facilities, M$$10^3$
Q : Treatment capacity, m^3/d

Unit direct construction cost of purification facilities of palm oil mills are estimated to be M$3,000/$m^3$/d of treatment capacity in 1990 and M$2,700/$m^3$/d in 2000.

Purification facilities of palm oil mills is assumed to be constructed in the palm oil mills area, so no land acquisition cost is need.

For the purification facilities for rubber factories, direct construction costs are M$700/$m^3$/d of treatment capacity for SMR production and M$2,100/$m^3$/d of treatment capacity for Latex concentrate production.

Percentage of rubber factories by type of rubber production in 1980 is as follows:

Type of Rubber Production	Number of Rubber Factory	Share
Conventional and SMR	146	70%
Latex Concentrate, Mixed and Others	60	30%

On the assumption of the same share in 1990 and 2000 as in 1980, direct construction cost in 1990 and 2000 is estimated as follows:

$$C_R = (0.7 \times 0.7 + 2.1 \times 0.3) \times Q = 1.12 \times Q$$

where, C_R: Direct construction cost of purification facilities, M$$10^3$
Q : Treatment capacity, m^3/d

Unit direct construction cost of purification facilities of rubber factory is estimated to be M$1,120/m^3/d of treatment capacity in 1990 and 2000.

As the pretreatment facilities, two treatment methods are proposed. For BOD concentration in raw water between 2 mg/l and 20 mg/l, pretreatment is carried out by the rapid sand-filter and activated carbon absorption (Secondary treatment). For BOD concentration between 20 mg/l and 200 mg/l, an aerated lagoon process such as aerated lagoon or maturation pond (Primary treatment) is further needed. The direct construction cost of the above-mentioned pretreatment facilities are estimated as follows:

$$C_{pre}\ 1 = 3.75 \times 10^{-6} \times L^{2.9} \times (Q_D + Q_Z)$$
$$C_{pre}\ 2 = 22.9 \times 10^{-6} \times L^{2.9} \times (Q_D + Q_Z)$$

where, C_{pre} 1: Direct construction cost of primary pretreatment facilities, M$10^6

C_{pre} 2: Direct construction cost of secondary pretreatment facilities, M$10^6

L : Reduction level of pretreatment facilities, %

Q_D : Treatment capacity for domestic water supply, 10^3 m^3/d

Q_Z : Treatment capacity for industrial water supply, 10^3 m^3/d

Unit direct construction cost of pretreatment facilities are estimated to be M$31.7 x 10^6 per 100 x 10^3 m^3/d of treatment capacity for primary pretreatment facilities and M$193.6 x 10^6 per 100 x 10^3 m^3/d of treatment capacity for secondary pretreatment facilities as 50% reduction level.

Pretreatment facilities is assumed to be constructed in the treatment plant area, so no land acquisition cost is need.

The unit construction cost by type of treatment facilities are estimated as shown in Table 47 and summarized below.

Type of Treatment Facility	Unit Construction Cost (M$10^6/100 x 10^3 m^3/d)
Public sewerage system	120
Purification facilities of palm oil mills in 1990	430
Purification facilities of palm oil mills in 2000	390
Purification facilities of rubber factory in 1990 & 2000	160
Primary pretreatment facilities	45
Secondary pretreatment facilities	280

For the proposed river water pollution abatement, estimated public and private development expenditure for public sewerage system under the condition of 4MP and lower economic growth are as shown in Tables 48 to 51 respectively. For the proposed improvement of purification in rubber factories, estimate private development expenditure is as shown in Table 52.

8.1.2 O&M cost

The O&M costs include O&M cost of sewer, pumping station and aerated lagoon process for public sewerage system, O&M cost of ponding process for purification facilities in palm oil mills and rubber factories and O&M cost of aerated lagoon for primary pretreatment and rapid sand filter bed for secondary pretreatment.

Relationship between construction cost and ratio of O&M cost and construction cost by city is shown in Fig. 22. The ratio has the range from 1 to 4%. In the Study, the annual O&M cost is assumed to be 4% of the total construction cost for public sewerage system and 2% of the total construction cost for purification facilities of palm oil mills and rubber factories and pretreatment facilities.

8.2 Economic Benefit and Cost

Economic benefit for water pollution abatement is assumed to be composed with the sewerage benefit and the saving in pretreatment facility.

The sewerage benefit is the willingness-to-pay by served people and saving in the cost of purification of industrial waste water. It is assumed to be 0.6% of real income of served people and gross value of manufacturing production of served industries in this Study.

Pretreatment facilities are necessary if BOD concentration in raw water is more than 2 mg/l for domestic water supply or 5 mg/l for industrial water supply. Its cost can be saved, if the proposed water pollution abatement measures reduced BOD concentration in the river across this limit. This saving in cost is counted as a part of water pollution abatement benefit. This benefit, however, is nil because the intakes in the Region are located in relatively clean river stretches.

Economic cost for water pollution abatement is estimated to be 80% of the financial cost of public sewerage system, purification facilities of palm oil mills and rubber factories and pretreatment facilities for D&I water supply.

Beneficial and adverse effects of water pollution abatement plans under the condition of 4MP and lower economic growth are as shown in Tables 53 and 54.

8.3 Manpower Requirement

8.3.1 Manpower requirement for construction

Manpower requirement for construction is estimated, basing on the data of Ministry of Local Government and Federal Territory. The staff in the Construction Division of Sewerage Department is composed with four categories as follows:

Staff Category	Number of Staff
Executive Engineer	1
Assistant Engineer	3
Technical Assistant	2
Technician	3
Total	9

In consideration of the above staff-requirement and construction schedule, manpower requirement is estimated for construction schedule of every 50 x 10^3 m^3/d per year as follows:

Staff Category	Number of Staff	Share (%)
Engineer	2	25
Technical Assistant	2	25
Technician	2	25
Others	2	25
Total	8	100

Estimated manpower requirement for construction by city with public sewerage system under the condition of 4MP and lower economic growth are as shown in Tables 57 to 60 respectively.

8.3.2 Manpower requirement for O&M

Manpower requirement for O&M is estimated, basing on the data of the staff-requirement of the Operation Division, Sewerage Department, Ministry of Local Government and Federal Territory as well as manpower requirement for construction. The staff in the Operation Division of Sewerage Department is composed with categories as follows:

Staff Category	Number of Staff
Treatment Plant	
- Laboratory Assistants	3
IMG Workers	18
Pumping Stations	
- Mechanical Supervisors	1
IMG Workers	11
- Sewer Inspectors	2
IMG Workers	29
Other Operations	
Works Manager	1
Chemist/Biologist	2
Technical Assistant (Electrical)	1
Supervisors (Works)	1
Assistant Clerk/Typist	2
Technicians (Sampling Meter Reader)	1
Security	3
IMG Workers	22
Driver	1
Total	98

In consideration of the above staff-requirement and staff required in the D&I water supply, manpower requirement is estimated for treatment capacity of every 200 x 10^3 m^3/d as follows:

Staff Category	Number of Staff	Share (%)
Engineer	2	4
Technical Assistant	3	6
Technician	18	38
Others	24	52
Total	47	100

Manpower requirement for O&M by city with public sewerage system under the condition of 4MP and lower economic growth are as shown in Tables 57 to 60 respectively.

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TABLES

Table 1 POLLUTANT LEVELS OF RIVERS IN 1978

Unit: mg/l except pH

River Name & WQCR No.	WQMS No.	No. of Samples	pH (Lab) Mean	pH (Lab) Max	pH (Lab) Min	BOD5 Mean	BOD5 Max	BOD5 Min	COD Mean	COD Max	COD Min	Suspended Solids Mean	Suspended Solids Max	Suspended Solids Min	Ammoniacal Nitrogen Mean	Ammoniacal Nitrogen Max	Ammoniacal Nitrogen Min
Kedah 3	6103601	5	6.4	7.0	5.8	5	10	2	94	230	20	49	100	25	0.36	0.67	<0.01
	6204602	5	6.6	7.5	6.3	3	4	2	13	20	10	36	55	10	0.08	0.21	0.01
	6204603	5	6.7	7.3	6.3	5	10	2	26	60	10	41	70	5	0.12	0.44	0.01
	6204620	5	6.0	7.3	3.7	6	13	<1	24	69	10	33	60	5	0.04	0.08	0.01
	6206605	5	6.8	7.2	6.6	9	35	2	35	115	10	42	60	20	0.11	0.44	0.01
	6206606	4	6.8	7.2	6.5	17	56	1	65	185	10	43	75	15	0.15	0.52	0.01
	6206607	4	6.7	6.7	6.6	2	4	<1	19	30	10	36	60	5	0.02	0.02	0.01
	6206608	4	6.0	6.7	4.0	88	208	3	155	500	Nil	91	210	40	0.35	1.35	0.01
	6306609	5	6.6	7.2	6.0	2	4	1	13	25	Nil	34	40	30	0.02	0.05	<0.01
	6306611	5	6.7	7.3	6.2	3	4	1	12	30	Nil	57	175	5	0.02	0.05	<0.01
	6306612	5	6.7	7.4	6.3	2	3	1	14	20	Nil	51	115	5	0.04	0.14	0.01
	6386610	4	6.0	7.4	4.5	150	464	<1	663	2178	10	95	175	40	0.44	0.94	0.01
Merbok 4	5604601	1	6.7	6.7	6.7	3	3	3	252	252	252	80	80	80	0.01	0.01	0.01
	5604602	1	6.5	6.5	6.5	14	14	14	131	131	131	90	90	90	0.01	0.01	0.01
	5604603	1	6.5	6.5	6.5	6	6	6	223	223	223	65	65	65	0.01	0.01	0.01
	5705604	1	6.3	6.3	6.3	6	6	6	267	267	267	50	50	50	0.01	0.01	<0.01
	5705605	1	6.3	6.3	6.3	23	23	23	44	44	44	50	50	50	1.14	1.14	1.14
	5705606	1	6.5	6.5	6.5	188	188	188	447	447	447	85	85	85	13.9	13.9	13.9
	5704607	1	5.8	5.8	5.8	4	4	4	10	10	10	40	40	40	0.01	0.01	<0.01
Muda 5	5503601	5	6.6	6.8	6.5	1	2	<1	16	<30	<4	40	110	15	0.22	1.00	<0.01
	6007615	2	6.8	6.8	6.7	4	4	4	10	20	0	28	30	25	0.03	0.05	<0.01
	5505603	4	6.3	6.7	6.0	3	6	1	12	18	8	41	50	35	0.02	0.03	<0.01
	5504602	5	6.5	6.8	6.3	2	3	<1	15	<30	0	37	80	20	0.03	0.06	<0.01
	5606604	5	6.5	6.7	6.4	3	5	<1	20	51	<4	63	95	25	0.03	0.08	<0.01
	5505612	3	6.3	6.6	6.0	2	4	<1	17	40	0	37	60	5	0.03	0.06	<0.01
	5606605	4	6.5	6.7	6.3	4	8	<1	17	55	<4	59	80	20	0.09	0.33	<0.01
	5806614	5	6.4	6.6	6.2	1	2	<1	20	37	<4	59	90	5	0.02	0.05	<0.01
	5906607	5	6.4	6.8	6.0	2	4	<1	28	74	10	40	70	5	0.07	0.23	<0.01
	6007608	5	6.6	6.7	6.4	1	4	<1	22	56	4	46	80	20	0.02	0.03	0.01
Perai 6	5404601	9	7.0	7.3	6.1	2	5	<1	130	226	38	105	235	10	0.31	0.85	<0.05
	5403602	9	6.9	7.7	5.4	4	11	<1	135	300	38	104	210	20	0.26	0.90	<0.05
	5404603	9	6.8	7.2	6.5	3	6	<1	106	196	Nil	84	180	10	0.37	0.60	Nil
	5404604	9	6.6	6.9	6.0	2	3	<1	58	120	Nil	58	150	10	0.20	0.52	<0.01
	5404605	8	6.2	7.4	5.3	2	4	<1	15	31	Nil	46	110	5	0.41	1.37	0.05
	5404606	9	6.0	7.0	5.4	2	5	<1	20	39	Nil	61	140	10	0.30	1.10	Nil
	5404607	9	6.2	9.6	5.2	4	15	<1	26	67	9	48	130	10	0.13	0.64	<0.01
	5404608	9	6.2	8.0	5.4	2.7	8	<0.5	18	48	Nil	48	130	15	0.36	0.98	<0.01
	5504609	9	6.3	7.0	5.7	3	9	1	20	30	<5	53	115	10	0.44	1.85	<0.01
	5405621	8	5.8	6.2	5.1	2	3	<1	11	38	Nil	44	115	15	0.05	0.18	<0.01
	5505610	9	5.8	7.2	5.1	3	5	1	36	76	10	61	120	25	0.38	1.87	<0.01
Juru 6	5304601	9	7.5	8.5	6.4	6	12	1	195	315	124	117	255	10	0.46	1.94	<0.01
	5304602	8	6.8	7.9	4.6	11	46	<1	152	264	10	63	120	5	0.11	0.30	<0.05
	5304603	9	6.0	7.8	3.4	7	18	<1	126	260	19	130	420	10	1.49	4.25	0.01
	5304604	9	5.5	7.3	3.1	5	10	<1	89	226	Nil	53	110	15	2.71	4.10	0.56
	5304605	9	6.4	8.0	5.4	158	320	6	327	740	20	348	800	145	8.20	18.1	0.43
	5304606	9	6.7	7.4	6.4	53	320	5	72	160	Nil	64	110	5	7.55	20.0	0.80
	5304607	9	6.9	8.9	6.2	32	65	2	84	170	20	116	345	55	8.31	16.3	1.13
	5304608	9	6.5	7.1	5.8	12	25	2	26	48	10	66	110	10	1.49	3.84	<0.01
	5304609	9	6.3	7.2	4.9	33	160	4	88	305	20	139	545	5	8.08	33.0	0.03
Jejawi 7	5204601	1	8.0	8.0	8.0	1	1	1	153	153	153	5	5	5	0.01	0.01	0.01
	5204602	1	7.6	7.6	7.6	3	3	3	184	184	184	40	40	40	0.02	0.02	0.02
	5205603	1	6.9	6.9	6.9	1	1	1	10	10	10	50	50	50	0.06	0.06	0.06
	5205604	1	7.2	7.2	7.2	3	3	3	30	30	30	25	25	25	0.32	0.32	0.32
	5204606	1	6.7	6.7	6.7	3	3	3	10	10	10	30	30	30	0.01	0.01	0.01
	5204607	1	7.9	7.9	7.9	1	1	1	20	20	20	45	45	45	0.14	0.14	0.14

Source; Ref. 17

Table 2 POLLUTANT LEVELS OF RIVERS IN 1979

Unit: mg/l except pH

River Name & WQCR No.	WQMS No.	No. of Samples	pH (Lab) Mean	pH (Lab) Max	pH (Lab) Min	BOD_5 Mean	BOD_5 Max	BOD_5 Min	COD Mean	COD Max	COD Min	Suspended Solids Mean	Suspended Solids Max	Suspended Solids Min	Ammoniacal Nitrogen Mean	Ammoniacal Nitrogen Max	Ammoniacal Nitrogen Min
Perlis 1	6401601	1	7.7			120			320			-			0.18		
	6401602	1	6.9			1			130			-			0.50		
	6401603	1	7.2			1			210			-			0.01		
	6402604	1	7.2			3			45			-			0.04		
	6402605	1	6.4			3			35			-			0.01		
	6402606	1	7.8			3			5			-			0.01		
	6402634	1	6.7			15			30			375			0.62		
	6402635	1	7.2			1			95			50			2.88		
	6502607	1	7.9			2			5			55			0.01		
Kuar 2	6102601	1	6.3			5			70			100			0.07		
	6103602	1	6.4			8			30			95			0.10		
	6204603	1	6.0			3			30			70			0.07		
	6204604	1	6.4			3			30			100			0.10		
	6304605	1	6.0			3			35			75			0.33		
	6304606	1	6.3			2			40			65			0.20		
Kedah 3	6103601	5	6.4	7.1	5.6	2	3	<1	78	185	20	69	155	30	0.67	1.90	0.15
	6103613	3	6.0	6.3	5.6	2	3	1	45	70	30	53	65	45	1.00	2.00	0.25
	6203614	2	7.1	7.5	6.7	2	3	1	265	310	220	73	85	60	0.54	0.70	0.37
	6204602	5	6.3	6.8	6.0	2	4	1	31	105	5	69	110	45	0.24	0.50	0.01
	6204603	5	6.6	7.3	6.1	1	2	1	12	20	5	60	80	45	0.11	0.26	0.01
	6204620	5	6.6	7.1	6.0	7	25	<1	27	90	10	67	75	55	0.11	0.24	0.03
	6206605	4	6.7	7.2	6.0	1	2	<1	11	20	5	96	135	75	0.05	0.10	0.01
	6206606	4	6.6	7.1	6.1	3	7	1	50	160	5	170	360	60	0.13	0.25	0.05
	6206607	4	6.5	7.1	6.0	2	2	1	11	15	5	84	110	60	0.03	0.15	0.01
	6306609	4	6.9	7.2	6.4	2	4	1	14	40	5	70	140	35	0.09	0.15	0.01
	6306610	4	6.9	7.3	6.3	2	6	1	14	35	5	78	120	45	0.21	0.65	0.04
	6386611	4	6.9	7.3	6.5	1	1	<1	6	15	Nil	50	55	35	0.09	0.15	0.01
	6306612	4	6.8	7.2	6.5	2	3	1	14	30	5	41	85	20	0.06	0.10	0.01
Merbok 4	5604601	4	7.7	8.0	7.5	6	20	1	200	305	5	120	160	90	0.07	0.15	0.01
	5604602	5	7.0	7.2	6.6	8	19	Nil	194	365	90	103	175	65	2.31	3.82	0.85
	5604603	3	7.1	7.3	7.0	13	35	2	238	385	140	133	215	75	2.48	6.25	0.13
	5705604	3	6.9	7.1	6.7	10	28	1	121	260	55	70	130	20	6.58	15.95	0.60
	5705605	5	6.9	7.2	6.6	100	455	Nil	132	495	15	75	159	30	12.69	47.35	1.73
	5705606	4	6.9	7.2	6.5	169	340	4	358	570	40	116	205	80	21.91	45.50	0.40
	5704607	3	7.6	7.8	7.5	35	100	Nil	278	315	220	117	165	80	8.17	23.55	0.15
Muda 5	5503601	3	7.2	7.5	6.7	2	2	1	148	275	5	58	120	25	0.11	0.18	0.07
	5504602	3	6.9	7.4	6.5	2	2	<1	17	35	0	13	25	5	0.05	0.06	0.03
	5505603	4	6.5	6.7	6.1	2	3	1	13	30	5	60	90	30	0.41	1.30	0.05
	5506604	6	6.8	7.5	6.5	2	3	1	4	10	0	59	100	15	0.08	0.15	0.01
	5606605	6	7.1	7.6	6.4	1	2	<1	9	30	0	84	180	35	0.07	0.15	0.02
	5906607	6	6.6	6.9	6.3	1	2	1	9	30	0	68	130	25	0.08	0.15	0.01
	6007608	3	6.5	6.7	6.4	1	1	1	13	25	5	40	60	20	0.10	0.15	0.05
	5505612	6	6.8	7.6	6.3	1	2	1	14	20	5	72	125	10	0.10	0.20	0.05
	5806614	6	6.6	7.1	6.3	2	4	1	9	20	0	45	60	25	0.08	0.15	0.01
Perai 6	5403602	11	7.3	7.9	6.5	3	7	1	259	505	100	78	140	15	0.22	0.51	0.01
	5403601	11	7.1	7.8	6.5	3	4	<1	192	580	15	66	225	10	0.28	0.45	0.01
	5404603	11	7.0	7.7	6.0	3	7	2	121	395	10	68	105	20	0.30	0.60	0.01
	5404604	11	6.7	7.6	4.8	4	15	2	97	345	5	87	190	45	0.21	0.64	0.01
	5404605	11	6.7	7.5	6.1	3	8	<1	53	180	15	95	300	20	0.23	0.48	0.06
	5404606	11	6.0	7.1	4.0	4	8	1	27	45	5	57	110	10	0.33	0.72	0.06
	5405607	11	5.5	6.8	4.4	5	25	1	31	80	5	51	75	20	0.28	0.88	0.10
	5404608	11	5.9	7.1	4.3	3	7	1	22	35	10	64	100	25	0.64	1.30	0.15
	5404609	11	6.1	6.6	5.5	2	5	1	20	45	5	60	90	25	0.50	0.95	0.05
	5505610	3	6.2	6.5	5.9	2	4	1	23	40	5	80	100	60	0.25	0.32	0.12
	5405621	11	6.2	6.4	5.6	3	6	1	17	35	5	119	420	25	0.11	0.26	0.02
Juru 6	5304601	11	6.4	7.7	4.8	3	5	1	227	525	95	55	130	15	1.44	2.83	0.20
	5304602	11	5.5	7.9	3.0	3	8	1	170	385	25	75	130	15	1.37	2.95	0.10
	5304603	10	5.9	7.8	3.4	5	15	1	184	590	10	70	130	35	1.93	3.00	0.90
	5304604	10	5.2	7.4	3.3	3	5	1	106	320	15	63	105	15	2.64	4.91	1.12
	5304605	11	6.4	7.4	3.5	107	290	3	195	695	5	102	250	40	6.42	16.68	0.10
	5304606	11	6.9	7.5	5.9	27	80	5	102	350	30	65	105	40	9.45	21.00	0.50
	5304607	11	6.8	7.5	6.4	77	200	8	218	520	60	81	170	10	14.86	34.90	1.00
	5304608	9	6.5	7.0	5.9	14	80	<1	36	130	10	63	130	35	1.30	3.95	0.03
	5304609	9	6.9	7.5	6.4	48	112	.4	97	230	30	106	295	20	11.25	22.05	3.90
Jejawi 7	5204601	2	8.0	8.0	7.9	3	3	2	1.75	875	1.75	70	90	50	0.16	0.25	0.06
	5204607	2	6.4	6.8	6.0	5	7	2	20	20	20	40	55	25	0.27	0.45	0.08
	5205603	2	6.1	6.1	6.0	8	10	6	15	15	15	40	65	15	0.46	0.90	0.02
	5205604	2	6.0	6.5	5.5	2	3	1	15	25	5	30	45	15	0.23	0.25	0.20
	5205606	2	6.1	6.2	6.0	3	4	1	8	10	5	33	50	15	0.40	0.55	0.25

Source; Ref. 18

Table 3 POLLUTANT LEVELS OF RIVERS IN 1980

Unit: mg/l except pH

River Name & WQCR No.	WQMS No.	No. of Samples	pH (Lab) Mean	pH (Lab) Max	pH (Lab) Min	BOD5 Mean	BOD5 Max	BOD5 Min	COD Mean	COD Max	COD Min	Suspended Solids Mean	Suspended Solids Max	Suspended Solids Min	Ammoniacal Nitrogen Mean	Ammoniacal Nitrogen Max	Ammoniacal Nitrogen Min
Perlis 1	6401601	2	7.5	7.8	7.2	2	2	2	50	70	30	115	160	70	0.39	0.45	0.32
	6401602	2	7.3	7.4	7.2	2	2	1	20	20	20	228	380	75	0.23	0.45	0.01
	6401603	2	7.5	7.8	7.1	2	2	1	30	40	20	545	1040	50	0.14	0.26	0.01
	6402604	1	7.7	7.7	7.7	1	1	1	10	10	10	60	60	60	0.23	0.23	0.23
	6402605	2	7.0	7.0	7.0	2	2	1	20	30	10	213	310	115	0.20	0.38	0.01
	6402606	2	8.3	8.4	8.2	1	1	1	45	50	40	28	30	25	0.55	0.10	0.01
	6502607	2	8.1	8.2	8.0	1	1	1	25	30	20	40	50	30	0.07	0.13	0.01
	6402608	2	8.4	8.4	8.3	2	2	1	30	50	10	43	65	20	0.02	0.02	0.01
	6402634	2	8.0	8.1	7.9	2	2	2	30	40	20	65	65	65	1.29	2.10	0.47
	6402635	2	7.5	7.6	7.3	1	1	1	40	50	30	55	85	25	0.09	0.17	0.01
Kuar 2	6102601	2	6.9	6.9	6.8	5	8	2	60	60	60	435	650	220	0.52	0.53	0.50
	6103602	2	6.7	6.8	6.6	3	3	2	50	60	40	238	330	145	0.30	0.50	0.10
	6204603	2	6.7	6.9	6.5	3	4	<1	20	30	10	100	140	60	0.08	0.08	0.08
	6204604	2	6.6	6.9	6.2	1	1	<1	20	30	10	123	185	60	0.02	0.02	0.01
	6304605	2	6.5	6.8	6.2	1	1	<1	10	10	10	88	130	45	0.14	0.26	0.01
	6304606	2	6.5	6.7	6.3	2	3	1	15	20	10	90	125	55	0.10	0.13	0.06
Kedah 3	6103601	5	6.8	7.4	6.5	3	7	1	30	60	10	92	150	30	0.62	1.09	0.26
	6103613	5	6.6	7.0	6.0	2	4	1	21	40	10	56	150	15	0.29	3.56	0.01
	6204602	6	6.8	7.2	0.1	1	2	1	13	20	10	58	90	35	0.21	0.40	0.02
	6204603	5	6.9	7.3	6.5	1	3	<1	16	20	10	51	90	15	0.59	2.50	0.03
	6204620	5	6.8	7.1	6.6	1	2	1	26	60	10	65	110	30	0.15	0.45	0.01
	6206605	6	7.0	7.1	6.4	4	19	<1	22	60	10	88	205	35	0.11	0.25	0.03
	6206606	6	6.9	7.2	6.0	3	9	<1	25	60	10	83	195	20	0.21	0.41	0.07
	6206607	6	6.8	7.1	6.2	1	1	1	13	20	10	51	95	25	0.09	0.20	0.01
	6306609	4	7.1	7.3	6.7	1	1	<1	15	30	10	41	60	30	0.04	0.10	0.01
	6306610	4	6.7	7.0	6.0	1	2	<1	18	40	10	366	1255	35	0.04	0.06	0.01
	6306611	6	6.9	7.2	6.0	1	2	<1	25	50	10	255	1210	20	0.05	0.09	0.02
	6306612	6	7.0	7.3	6.8	1	1	<1	27	55	10	78	205	35	0.06	0.15	0.01
Merbok 4	5604601	4	7.2	8.0	6.7	1	2	1	103	275	20	70	125	35	0.15	0.24	0.01
	5604602	4	7.2	7.6	6.7	5	6	1	66	95	20	58	95	30	1.87	3.27	0.52
	5705604	4	7.4	7.8	6.6	3	8	1	24	35	10	65	110	25	1.76	4.01	0.10
	5705605	4	6.4	7.1	4.7	8	27	1	34	55	20	76	150	25	7.16	19.78	0.43
	5705606	4	7.5	8.1	6.9	221	380	3	380	640	50	63	100	35	21.96	46.44	0.23
	5704607	3	7.1	8.0	6.3	2	3	<1	80	110	30	108	145	75	0.23	0.30	0.20
Muda 5	5503601	3	7.0	7.2	6.8		2	1	23	45	10	103	160	45	0.13	0.26	0.02
	5504602	3	6.9	7.1	6.7	1	1	1	20	30	10	60	120	30	0.14	0.22	0.09
	5505603	3	6.8	7.0	6.7	2	3	1	18	25	10	40	65	15	0.09	0.12	0.08
	5606604	3	7.0	7.2	6.8	1	2	1	12	15	10	65	120	25	0.06	0.13	0.02
	5505612	3	6.9	7.1	6.6	1	1	1	13	20	10	83	155	25	0.04	0.05	0.03
	5606605	3	7.4	7.5	7.3	2	8	1	47	90	20	62	120	25	0.09	0.15	0.05
	5806614	3	6.7	6.9	6.5	1	1	1	17	30	10	63	100	35	0.08	0.13	0.04
	5906607	3	6.7	6.9	6.6	1	2	1	30	55	10	42	55	25	0.67	0.10	0.02
	6007608	2	6.9	6.9	6.8	2	2	1	28	45	10	33	40	25	0.12	0.18	0.06
Perai 6	5403602	9	7.6	8.0	7.0	2	6	<1	117	200	45	122	345	50	0.399	1.03	0.16
	5404601	9	7.5	8.1	7.0	2	3	1	108	235	30	91	110	10	0.96	6.23	0.04
	5404603	9	7.3	7.8	6.7	1	4	<1	59	180	10	116	345	60	0.28	0.99	0.04
	5404604	9	7.0	7.4	6.5	2	4	<1	4	80	10	93	205	40	0.14	0.27	0.08
	5404605	6	6.0	6.8	5.1	2	2	1	40	120	20	180	340	40	0.27	0.27	0.08
	5404606	9	6.4	7.4	5.6	2	3	<1	24	40	10	92	310	15	1.33	0.37	0.01
	5405607	9	6.1	7.3	4.7	2	4	1	23	40	10	62	105	15	0.199	10.37	0.07
	5404608	10	6.7	7.4	6.3	2	2	1	25	75	10	53	65	40	0.55	2.18	0.04
	5504609	9	6.8	7.3	6.1	2	4	1	19	30	5	52	70	15	0.57	1.48	0.01
	5505610	1	6.5	6.5	6.5	2	2	2	20	20	20	30	30	30	0.92	0.92	0.92
	5405621	9	6.4	7.3	5.2	1	3	2	23	35	10	85	230	30	0.12	0.27	0.01
Juru 6	5304601	10	7.32	8.0	5.2	2	6	1	151	300	50	104	275	25	0.63	1.55	0.07
	5304602	10	6.58	7.9	4.3	2	8	1	122	200	40	121	540	50	1.51	4.48	0.36
	5304603	10	6.34	7.9	4.3	5	19	1	124	210	30	149	430	65	2.40	4.10	0.19
	5304604	10	5.96	7.8	4.6	7	31	1	81.5	170	20	159	735	40	3.19	4.56	1.80
	5304605	10	6.8	7.5	5.9	61	290	2	187	350	20	105	230	35	4.38	12.16	0.07
	5304606	10	7.04	7.8	6.2	19	40	4	77	130	40	58	125	35	7.63	11.92	2.81
	5304607	10	7.17	7.8	6.4	33	88	1	119	220	30	88	115	45	6.83	17.04	0.65
	5304608	10	6.94	7.4	6.2	11	57	1	85	300	20	68	110	40	1.83	5.66	0.12
	5304609	10	7.11	7.7	6.1	23	84	4	171	1200	20	124	285	20	7.51	16.26	0.97
Jejawi 7	5204601	3	7.57	7.9	7.0	1	2	1	60	100	10	63	110	20	0.26	0.51	0.10
	5205603	3	6.81	7.2	6.5	3	4	1	40	70	20	22	30	10	0.14	0.26	0.08
	5205604	3	6.23	6.6	5.5	2	3	1	17	30	10	132	325	35	0.11	0.33	0.03
	5205606	3	6.73	6.8	6.6	2	2	1	13	20	10	37	50	30	0.05	0.11	0.01
	5204607	3	6.57	6.8	6.1	2	3	1	78	160	20	602	1425	140	0.21	0.41	0.03

Source; Ref. 19

Table 4 POLLUTANT LEVELS OF RIVERS IN 1981

Unit: mg/l except pH

River Name & WQCR No.	WQMS No.	No. of Samples	pH (Lab) Mean	pH (Lab) Max	pH (Lab) Min	BOD_5 Mean	BOD_5 Max	BOD_5 Min	COD Mean	COD Max	COD Min	Suspended Solids Mean	Suspended Solids Max	Suspended Solids Min	Ammoniacal Nitrogen Mean	Ammoniacal Nitrogen Max	Ammoniacal Nitrogen Min
Perlis 1	6401602	4	6.8	7.3	6.2	2	3	1	35	45	20	76	120	20	0.03	0.04	0.02
	6402603	4	7.0	7.3	6.6	2	3	1	41	60	25	84	135	30	0.03	0.05	0.01
	6402604	2	7.2	7.4	6.9	-	-	-	30	40	20	110	180	40	0.02	0.02	0.01
	6402605	4	6.5	6.8	6.2	1	2	<1	38	65	20	121	185	50	0.04	0.08	0.01
	6402606	3	7.2	7.8	6.5	2	3	<1	20	30	10	35	55	20	0.03	0.04	0.01
	6402607	1	7.7	7.7	7.7	1	1	1	10	10	10	55	55	55	0.01	0.01	0.01
	6402608	3	7.3	7.9	7.0	1	2	1	32	55	10	82	105	50	0.02	0.03	0.01
	6402634	4	7.1	7.4	6.9	-	-	-	26	35	15	81	145	25	0.03	0.04	0.01
	6402635	4	6.5	6.9	6.2	1	2	<1	23	40	10	75	175	25	0.05	0.07	0.02
	6502601	4	7.7	7.9	7.4	-	-	-	13	20	5	46	80	25	0.02	0.04	0.01
Kuar 2	6102601	2	6.4	6.6	6.1	-	-	-	65	90	40	68	70	65	0.03	0.04	0.02
	6103602	1	6.2	6.2	6.2	3	3	3	3	3	3	85	85	85	0.40	0.40	0.40
	6204603	2	6.4	6.5	6.3	2	2	<1	25	30	20	88	100	75	0.085	0.16	0.01
	6204604	2	6.3	6.4	6.1	2	2	<1	-	-	-	143	185	100	0.025	0.03	0.02
	6304605	1	7.2	7.2	7.2	<1	<1	<1	5	5	5	55	55	55	0.01	0.01	0.01
	6304606	2	-	-	-	-	-	-	13	20	5	68	75	60	0.065	0.08	0.05
Kedah 3	6103601	6	6.7	7.6	6.0	1	2	<1	41	120	10	55	115	20	0.18	0.53	<0.01
	6204602	6	6.6	7.0	6.1	2	4	1	19	30	10	44	80	20	0.09	0.35	0.01
	6204603	5	6.8	7.1	6.4	1	2	<1	15	20	10	58	125	20	0.01	0.01	0.01
	6204620	5	6.7	7.2	6.2	2	4	<1	18	30	10	61	125	10	0.012	0.02	<0.01
	6206606	5	6.8	7.4	6.3	4	10	1	21	40	10	56	170	20	0.02	0.04	0.01
	6206607	5	6.9	7.8	6.2	2	4	1	19	20	15	69	170	20	0.012	0.02	<0.01
	6306609	6	6.9	7.5	6.1	2	3	<1	8	10	5	68	250	10	0.02	0.06	0.01
	6306610	6	6.6	7.4	5.9	5	13	<1	25	40	10	90	260	40	0.08	0.33	0.01
	6306611	6	7.1	7.5	6.8	-	-	-	14	25	10	54	70	20	0.02	0.04	0.01
	6306612	6	6.7	7.4	6.1	2	5	<1	16	30	10	125	605	15	0.04	0.06	0.01
	6103613	6	6.3	6.9	5.6	2	2	1	32	50	10	69	130	25	0.16	0.42	0.01
	6306611(A)	1	7.3	7.3	7.3	<1	<1	<1	10	10	10	30	30	30	0.01	0.01	0.01
Merbok 4	5604601	5	7.1	7.2	7.0	1	2	<1	106	200	10	55	125	15	0.022	0.06	0.01
	5604602	5	6.7	6.7	6.6	3	5	1	98	220	20	47	65	25	0.52	1.57	0.02
	5705604	5	6.6	6.8	6.4	2	3	<1	82	220	20	35	50	20	0.13	0.41	0.01
	5705605	5	6.4	6.6	6.1	3	8	1	31	60	15	63	180	10	1.796	4.67	0.01
	5705606	5	6.2	6.5	5.8	88	196	13	320	540	45	51	75	15	21.38	52.20	2.97
	5704607	4	6.9	7.0	6.6	1	1	<1	119	300	10	130	230	55	0.35	1.18	0.01
	5705606(S)	3	6.3	6.5	6.0	2	2	1	30	70	10	35	55	20	0.11	0.14	0.06
Muda 5	5503601	5	6.7	7.8	6.1	1	2	<1	17	35	10	118	360	35	0.026	0.05	0.01
	5504602	5	6.7	7.6	6.1	1	1	<1	15	25	10	101	285	20	0.02	0.05	0.01
	5505603	5	6.5	7.2	6.2	<1	<1	<1	16	30	10	45	85	20	0.02	0.05	0.01
	5606604	5	6.7	7.4	6.2	<1	1	<1	22	45	10	80	185	10	0.016	0.04	0.01
	5606605	5	7.0	7.8	6.3	<1	<1	<1	18	30	10	112	255	20	0.016	0.04	0.01
	5906607	5	6.4	7.1	6.1	<1	1	<1	14	20	10	53	100	20	0.03	0.06	0.01
	6007608	2	6.6	6.6	6.5	<1	<1	<1	10	10	10	45	70	20	0.07	0.08	0.05
	5505612	5	6.5	7.2	6.1	<1	1	<1	16	30	15	90	245	30	0.02	0.04	0.01
	5806614	5	6.5	7.1	6.2	<1	1	<1	15	20	10	56	95	20	0.02	0.04	0.01
Perai 6	5403602	6	7.5	8.1	6.6	<1	1	<1	137	230	80	79	125	30	0.078	0.18	0.01
	5404601	6	7.3	7.8	6.5	1	2	<1	103	220	20	46	85	20	0.12	0.28	0.02
	5404603	6	6.9	7.3	6.2	1	2	<1	104	160	25	79	160	20	0.14	0.37	0.01
	5404604	6	6.7	6.8	5.9	2	4	<1	48	90	15	52	80	20	0.12	0.30	0.01
	5404605	6	6.4	7.1	5.5	1	2	<1	18	30	10	44	70	10	0.09	0.25	0.02
	5404606	6	6.0	6.5	5.3	2	3	<1	15	20	10	46	70	20	0.165	0.59	0.01
	5405607	6	5.8	6.1	5.5	1	2	<1	18	25	10	44	95	25	0.13	0.30	0.01
	5404608	6	6.2	6.5	5.6	2	3	<1	20	30	10	48	75	25	0.35	1.10	0.01
	5504609	6	6.0	6.5	5.3	1	2	<1	53	225	10	47	85	25	0.70	2.73	0.01
	5405621	6	6.0	6.5	5.5	2	5	<1	15	20	5	51	80	20	0.04	0.08	0.01
Juru 6	5304602	4	5.4	6.8	3.5	2	3	1	146	250	50	39	55	20	0.35	0.94	0.03
	5304603	4	6.4	6.8	5.7	4	5	2	96	250	40	145	445	30	2.02	3.20	0.05
	5304604	6	6.4	6.9	6.0	3	8	<1	95	175	20	68	210	15	3.24	6.79	0.01
	5304605	6	6.6	7.5	5.9	97	231	15	376	735	60	197	790	35	10.35	20.20	0.02
	5304606	4	6.7	6.9	6.4	36	61	2	120	200	20	46	55	25	12.495	20.65	0.04
	5304607	6	6.8	7.5	6.3	47	123	10	157	400	65	72	100	45	11.223	25.00	0.08
	5304608	6	6.6	7.3	6.2	19	40	4	66	120	20	67	110	25	4.278	8.55	0.02
	5304609	5	6.7	6.9	6.3	19	27	9	84	130	65	76	100	35	4.62	9.05	0.17
Jejawi 7	5204601	4	7.4	7.7	6.9	2	3	.1	161	400	50	135	225	45	0.05	0.10	0.02
	5204607	4	6.3	7.0	5.3	2	3	1	44	115	15	173	505	40	0.02	0.02	0.01
	5205603	4	6.1	6.9	5.0	-	-	-	11	15	10	51	80	25	0.06	0.10	0.01
	5205604	4	6.2	6.7	5.6	1	1	<1	10	15	5	43	70	30	0.02	0.03	0.01
	5205606	4	6.1	6.7	5.4	-	-	-	14	25	10	43	45	35	0.01	0.02	0.01

Source; Ref. 19

Table 5 POLLUTANT LEVELS OF RIVERS IN 1982

Unit: mg/l except pH

River Name & WQCR No.	WQMS No.	No. of Samples	pH (Lab) Mean	pH (Lab) Max	pH (Lab) Min	BOD_5 Mean	BOD_5 Max	BOD_5 Min	COD Mean	COD Max	COD Min	Suspended Solids Mean	Suspended Solids Max	Suspended Solids Min	Ammoniacal Nitrogen Mean	Ammoniacal Nitrogen Max	Ammoniacal Nitrogen Min
Perlis 1	6502601	1	7.8	7.8	7.8	1	1	1	5	5	5	15	15	15	0.02	0.02	0.02
	6401602	1	7.2	7.2	7.2	1	1	1	40	40	40	55	55	55	0.03	0.03	0.03
	6401603	4	7.4	7.9	6.9	2	4	1	44	65	15	190	500	60	0.28	0.58	0.03
	6402605	4	7.0	7.0	6.8	2	2	1	34	40	25	198	255	110	0.28	0.46	0.02
	6402606	4	8.2	8.3	8.0	1	2	1	14	25	5	43	70	20	0.11	0.29	0.01
	6402608	1	7.4	7.4	7.4	7	7	7	35	35	35	65	65	65	0.02	0.02	0.02
	6402634	3	7.5	8.0	7.1	2	2	2	32	50	15	72	95	40	0.19	0.39	0.02
	6402635	1	6.5	6.5	6.5	4	4	4	40	40	40	60	60	60	0.03	0.03	0.03
Kuar 2	6102601	3	7.0	7.1	6.8	1	2	<1	33	40	30	45	60	35	0.50	0.84	0.24
	6204603	3	6.7	6.8	6.7	1	2	1	18	25	10	123	180	80	0.67	1.31	0.08
	6204604	2	6.3	6.8	5.8	2	2	2	23	30	15	185	215	155	0.48	0.86	0.10
	6204606	1	6.7	6.7	6.7	2	2	2	15	15	15	20	20	20	0.15	0.15	0.15
Kedah 3	6103601	3	6.4	6.9	5.9	2	2	<1	35	40	30	45	85	25	0.42	0.51	0.25
	6204602	2	6.8	7.0	6.6	3	4	2	23	30	15	38	45	30	0.045	0.07	0.02
	6204603	3	6.8	7.0	6.3	1	1	<1	17	35	5	95	215	30	3.057	3.12	0.02
	6306610	3	7.0	7.4	6.5	5	8	1	22	30	10	182	360	65	0.04	0.06	0.03
	6306611	3	7.0	7.4	6.7	1	2	1	15	35	5	210	550	20	0.037	0.06	0.02
	6206607	2	6.6	6.6	6.5	<1	<1	<1	20	30	10	55	55	55	0.04	0.05	0.03
	6306609	2	6.8	7.0	6.5	1	2	<1	13	20	5	55	90	20	0.03	0.04	0.02
	6103613	2	6.3	6.3		2	3	<1	30	40	20	88	90	85	0.18	0.32	0.03
Merbok 4	5604601	6	6.9	7.6	6.4	3	9	<1	120	335	35	126	435	25	0.67	1.94	0.01
	5604602	8	7.5	8.7	6.3	4	6	1	125	265	45	51	95	20	2.00	2.93	0.02
	5705604	8	7.3	7.8	6.7	2	4	<1	70	230	10	45	75	20	0.82	1.78	0.01
	5705605	8	6.1	7.5	3.7	12	76	<1	44	140	10	147	785	30	11.73	54.00	0.01
	5705606	8	5.9	7.4	4.2	243	1260	10	515	2895	15	118	650	25	65.10	302.00	11.70
	5704607	7	7.2	7.5	6.8	1	2	<1	167	255	75	75	95	40	0.27	0.75	0.03
	5604601A	2	6.9	7.0	6.8	2	3	2	35	45	25	170	260	80	7.00	13.60	0.40
Muda 5	5503601	1	7.7	7.7	7.7	1	1	1	140	140	140	75	75	75	0.02	0.02	0.02
	5504602	7	6.7	7.4	6.2	1	2	<1	16	25	10	34	65	5	0.14	0.66	0.01
	5505603	7	6.9	7.6	6.5	1	1	<1	13	25	5	55	80	40	0.107	0.37	0.01
	5505604	7	7.0	7.5	6.7	1	1	<1	13	25	5	44	65	30	0.07	0.12	<0.01
	5606605	2	7.2	7.2	7.1	1	<1	<1	13	20	5	28	30	25	0.24	0.47	0.01
	5906607	6	6.9	7.4	6.8	1	1	<1	13	20	5	49	95	5	0.16	0.74	0.01
	5505612	1	7.3	7.3	7.3	1	<1	<1	5	5	5	60	60	60	0.02	0.02	0.02
	5806614	7	6.6	7.2	6.2	1	2	<1	11	20	5	50	150	10	0.08	0.30	<0.01
	5709605A	1	7.4	7.4	7.4	1	<1	<1	5	5	5	55	55	55	0.12	0.12	0.12
	5808605	4	7.4	7.7	7.1	1	1	<1	11	20	5	40	55	10	0.135	0.36	0.02
	S.T.	1	7.1	7.1	7.1	1	<1	<1	10	10	10	50	50	50	0.32	0.32	0.32
Perai 6	5604601	1	7.6	7.6	7.6	1	1	1	315	315	315	65	65	65	0.02	0.02	0.02
	5403602	8	7.2	7.5	6.7	2	5	<1	108	245	40	59	95	20	0.32	17.00	0.01
	5403603	1	7.4	7.7	7.4	1	1	1	110	110	110	65	65	65	0.01	0.01	0.01
	5403604	8	6.9	7.4	6.4	1	2	<1	52	160	10	59	105	20	0.15	0.33	0.01
	5404605	1	7.6	7.6	7.6	1	1	1	35	35	35	95	95	95	0.02	0.02	0.02
	5404606	7	6.5	7.1	5.8	1	2	<1	21	35	5	49	75	20	0.33	0.58	0.02
	5405607	2	6.6	6.9	6.2	3	5	1	38	45	30	55	70	40	0.145	0.27	0.02
	5404608	8	6.6	7.1	6.1	1	2	<1	24	40	10	69	105	20	0.93	2.80	0.02
	5504609	1	7.3	7.3	7.3	1	1	1	15	15	15	60	60	60	0.02	0.02	0.02
	5405621	7	6.3	6.7	5.2	1	1	<1	16	40	5	94	255	55	0.09	0.32	0.01
	5404621	1	7.1	7.1	7.1	1	<1	<1	30	30	30	60	60	60	0.01	0.01	0.01
	SG.MENGKUANG	1	5.2	5.2	5.2	1	<1	<1	10	10	10	125	125	125	-	-	-
Juru 6	5304604	9	4.4	7.0	2.9	5	11	<1	66	165	10	88	225	35	5.67	11.90	0.07
	5304605	9	6.6	7.3	4.6	35	108	3	92	190	25	73	185	20	8.34	31.30	0.99
	5304606	7	6.6	7.1	6.1	19	30	5	73	90	30	56	100	35	15.50	20.20	11.10
	5304607	9	6.7	7.6	5.0	70	186	10	178	360	30	95	185	40	15.22	29.50	2.80
	5304608	4	6.4	7.0	5.7	30	44	15	85	125	60	55	70	25	9.61	11.20	6.80
	5304609	4	6.8	7.2	6.3	27	51	9	84	150	40	79	100	65	9.78	19.70	3.10
	5304603	1	6.4	6.4	6.4	4	4	4	195	195	195	110	110	110	5.00	5.00	5.00
	5304604A	1	3.3	3.3	3.3	1	<1	<1	55	55	55	35	35	35	5.10	5.10	5.10
Jejawi 7	5204601*	6	6.0	7.6	3.8	1	2	<1	252	635	50	78	170	30*	0.70	1.14	0.01
	5205603	6	6.3	6.9	4.5	1	2	<1	13	20	10	34	50	20	0.13	0.34	0.04
	5205604	1	6.4	6.4	6.4	1	1	1	5	5	5	35	35	35	0.01	0.01	0.01
	5205606	1	6.6	6.6	6.6	1	1	1	10	10	10	30	30	30	0.01	0.01	0.01
	5204607	6	6.5	7.1	5.9	4	11	<1	25	65	4	100	135	20	0.31	0.75	0.02

Source; Ref. 19

Table 6 WATER QUALITY ANALYSIS DATA, SAMPLING IN JANUARY 1983 BY RIVER (1/5)

	Chemical Analysis (mg/l)	Perlis			
		6401603	6402605	6402606	6402634
	Sampling Time	0940	1010	1040	1110
	Sampling Date	21.1.83	21.1.83	21.1.83	21.1.83
1.	pH at 26°C	7.7	7.1	8.1	7.9
2.	B.O.D. 5 Days @20°C	1	2	2	2
3.	Chemical Oxygen Demand	10	15	5	20
4.	Ammoniacal Nitrogen as N	1.07	0.38	0.29	0.20
5.	Total Kjeldahl Nitrogen as N	1.90	1.40	0.98	0.28
6.	Nitrate Nitrogen as N	0.50	0.35	0.10	0.25
7.	Chloride (as Cl^-)	44	7	8	16
8.	Fluoride (as F)	-	-	-	-
9.	Sulphate (as SO_4^{--})	-	-	-	-
10.	Phosphate (as P)	0.10	0.11	0.03	0.05
11.	Total Solids Dried at 105°C	310	340	315	160
12.	Suspended Solids Dried at 105°C	130	175	35	45
13.	Dissolved Solids	180	165	280	115
14.	Oil and Grease	-	-	-	-
15.	Salinity % (Parts per thousand)	0	0	0	0
16.	Conductivity (umhos/cm)	260	60	500	170
17.	Arsenic (as As)	-	-	-	-
18.	Iron (as Fe)	0.8	1.6	0.1	0.1
19.	Color (Hazen units)	70	70	10	20
20.	Turbidity (FTU)	80	130	5	10
21.	Total Hardness as $CaCO_3$	55	25	255	70
22.	Cadmium (as Cd)	-	-	-	-
23.	Sodium (as Na)	-	-	-	-
24.	Potassium (as K)	-	-	-	-
25.	Calcium (as Ca)	16.0	5.2	49.2	18.4
26.	Magnesium (as Mg)	4.1	2.4	31.6	5.6
27.	Dissolved Oxygen	2.1	5.0	2.9	2.0

Table 7 WATER QUALITY ANALYSIS DATA, SAMPLING IN JANUARY 1983 BY RIVER (2/5)

	Chemical Analysis (mg/l)	Kedah						
		6103601	6103613	6204603	6206607	6306609	6306610	6306611
	Sampling Time	1000	0940	1230	1740	1600	1710	1645
	Sampling Date	22.1.83	22.1.83	21.1.83	21.1.83	21.1.83	21.1.83	21.1.83
1.	pH at 26°C	7.1	7.1	7.3	7.3	7.4	7.5	7.4
2.	B.O.D. 5 Days @20°C	3	1	1	2	1	1	1
3.	Chemical Oxygen Demand	30	30	10	40	10	10	10
4.	Ammoniacal Nitrogen as N	1.30	0.82	0.08	0.21	0.10	0.21	0.18
5.	Total Kjeldahl Nitrogen as N	1.51	1.18	0.31	0.32	0.34	0.42	0.34
6.	Nitrate Nitrogen as N	0.05	0.15	0.10	0.10	0.10	0.10	0.10
7.	Chloride (as Cl^-)	10	7	2	3	4	5	5
8.	Fluoride (as F)	-	-	-	-	-	-	-
9.	Sulphate (as SO_4^{--})	-	-	-	-	-	-	-
10.	Phosphate (as P)	0.27	0.19	0.06	0.05	0.03	0.04	0.03
11.	Total Solids Dried at 105°C	125	140	65	65	60	75	110
12.	Suspended Solids Dried at 105°C	15	45	10	5	5	45	50
13.	Dissolved Solids	110	95	55	60	55	30	60
14.	Oil and Grease	-	-	-	-	-	-	-
15.	Salinity % (Parts per thousand)	0	0	0	0	0	0	0
16.	Conductivity (umhos/cm)	85	60	40	40	60	70	60
17.	Arsenic (as As)	-	-	-	-	-	-	-
18.	Iron (as Fe)	0.4	0.4	0.6	0.4	0.1	0.1	0.8
19.	Color (Hazen units)	70	70	30	20	10	10	70
20.	Turbidity (FTU)	25	65	10	5	5	5	40
21.	Manganese (as Mn)	-	-	-	-	-	-	-
22.	Cadmium (as Cd)	-	-	-	-	-	-	-
23.	Sodium (as Na)	-	-	-	-	-	-	-
24.	Total Hardness as $CaCO_3$	20	15	15	15	25	25	20
25.	Calcium (as Ca)	4.4	4.8	4.0	4.4	8.0	8.4	5.6
26.	Magnesium (as Mg)	2.2	1.2	1.0	0.7	1.0	1.2	1.2
27.	Dissolved Oxygen	1.2	1.1	6.7	7.4	8.5	5.0	7.9

Table 8 WATER QUALITY ANALYSIS DATA, SAMPLING IN JANUARY 1983 BY RIVER (3/5)

	Chemical Analysis (mg/l)	Kuar			Merbok					
		6102601	6204603	6204604	5604601	5604602	5704604	5705605	5705606	5704607
	Sampling Time	0840	1200	1140	1010	1240	1340	1400	1520	1420
	Sampling Date	21.1.83	21.1.83	21.1.83	20.1.83	20.1.83	20.1.83	20.1.83	20.1.83	20.1.83
1.	pH at 26°C	7.3	7.1	7.0	7.2	7.8	7.7	5.0	5.2	7.7
2.	B.O.D. 5 Days @20°C	1	2	1	3	14	4	14	325	2
3.	Chemical Oxygen Demand	10	15	10	115	85	40	80	500	44
4.	Ammoniacal Nitrogen as N	0.23	0.96	0.50	0.17	3.25	5.9	16.8	95.25	0.36
5.	Total Kjeldahl Nitrogen as N	0.53	1.68	1.90	0.39	4.20	6.16	17.08	99.12	0.42
6.	Nitrate Nitrogen as N	0.05	0.20	0.15	0.05	0.10	0.50	0.20	0.30	0.15
7.	Chloride (as Cl^-)	4	5	4	4	8,525	5,025	1	5	13,025
8.	Fluoride (as F)	-	-	-	-	-	-	-	-	-
9.	Sulphate (as SO_4^{--})	-	-	-	-	-	-	-	-	-
10.	Phosphate (as P)	0.06	0.11	0.05	0.04	0.28	0.20	1.55	9.55	0.05
11.	Total Solids Dried at 105°C	105	90	165	70	21,645	11,705	135	690	29,535
12.	Suspended Solids Dried at 105°C	15	10	85	20	25	20	15	30	40
13.	Dissolved Solids	90	80	80	50	21,620	11,685	120	660	29,495
14.	Oil and Grease	-	-	-	-	-	-	-	-	-
15.	Salinity % (Parts per thousand)	0	0	0	0	2.0	0.8	0	0.2	2.2
16.	Conductivity (umhos/cm)	60	60	40	42	35,000	15,000	210	1,100	38,000
17.	Arsenic (as As)	-	-	-	-	-	-	-	-	-
18.	Iron (as Fe)	0.4	1.4	0.4	0.4	0.1	0.1	1.2	0.8	0.1
19.	Color (Hazen units)	70	10	70	10	15	15	15	70	10
20.	Turbidity (FTU)	35	5	45	5	5	5	5	35	5
21.	Manganese (as Mn)	-	-	-	-	-	-	-	-	-
22.	Cadmium (as Cd)	-	-	-	-	-	-	-	-	-
23.	Sodium (as Na)	-	-	-	-	-	-	-	-	-
24.	Total Hardness as $CaCO_3$	20	15	10	20	2,780	1,700	30	45	4,710
25.	Calcium (as Ca)	4.8	4.8	3.2	4.8	192	112	6.0	14.4	288
26.	Magnesium (as Mg)	1.5	1.0	0.7	1.5	559	345	3.4	2.7	970
27.	Dissolved Oxygen	2.0	1.1	6.7	2.0	0.6	4.1	0.8	1.5	7.4

Table 9 WATER QUALITY ANALYSIS DATA, SAMPLING IN JANUARY 1983 BY RIVER (4/5)

	Chemical Analysis (mg/l)	Muda						
		5504602	5505603	5606604	5608605	5906607	5906614	5607606
	Sampling Time	1730	1550	1450	1220	1110	1030	1420
	Sampling Date	16.1.83	16.1.83	16.1.83	16.1.83	16.1.83	16.1.83	16.1.83
1.	pH at 26°C	7.4	7.2	7.2	7.8	7.3	7.3	7.2
2.	B.O.D. 5 Days @20°C	1	1	1	1	1	1	1
3.	Chemical Oxygen Demand	20	20	20	5	20	5	5
4.	Ammoniacal Nitrogen as N	0.30	0.06	0.04	0.10	0.20	0.07	0.08
5.	Albuminoid Nitrogen	-	-	-	-	-	-	-
6.	Nitrate Nitrogen as N	0.25	0.20	0.25	0.20	0.15	0.74	0.40
7.	Chloride (as Cl^-)	2	2	2	3	2	2	2
8.	Fluoride (as F)	-	-	-	-	-	-	-
9.	Sulphate (as SO_4^{--})	-	-	-	-	-	-	-
10.	Phosphate (as PO_4^{---})	-	-	-	-	-	-	-
11.	Total Solids Dried at 105°C	55	55	70	95	55	50	55
12.	Suspended Solids Dried at 105°C	30	30	10	10	10	20	20
13.	Dissolved Solids	25	25	60	85	45	30	35
14.	Oil and Grease	-	-	-	-	-	-	-
15.	Salinity % (Parts per thousand)	0	0	0	0	0	0	0
16.	Conductivity (umhos/cm)	40	40	50	90	30	30	30
17.	Arsenic (as As)	-	-	-	-	-	-	-
18.	Iron (as Fe)	0.4	0.2	0.4	0.4	0.4	0.4	0.4
19.	Color (Hazen units)	5	10	5	5	5	5	5
20.	Turbidity (FTU)	5	10	5	5	5	5	5
21.	Manganese (as Mn)	-	-	-	-	-	-	-
22.	Cadmium (as Cd)	-	-	-	-	-	-	-
23.	Sodium (as Na)	-	-	-	-	-	-	-
24.	Total Hardness as $CaCO_3$	15	15	20	40	10	10	15
25.	Calcium (as Ca)	4.8	4.8	5.6	12.8	3.2	2.8	3.6
26.	Magnesium (as Mg)	0.7	0.7	1.0	1.9	1.0	1.0	1.0
27.	Dissolved Oxygen	7.3	7.2	7.5	7.5	8.1	6.5	8.2

Table 10 WATER QUALITY ANALYSIS DATA, SAMPLING IN JANUARY 1983 BY RIVER (5/5)

	Chemical Analysis (mg/l)	Juru			Perai				
		5304604	5304605	5304607	5403602	5404604	5404606	5404608	5405621
	Sampling Time	1230	1150	1130	1400	0910	1000	0940	1020
	Sampling Date	6.1.83	6.1.83	6.1.83	6.1.83	6.1.83	6.1.83	6.1.83	6.1.83
1.	pH at 26°C	4.3	7.2	7.1	7.4	6.7	5.6	6.5	6.4
2.	B.O.D. 5 Days @20°C	1	19	15	1	1	1	1	1
3.	Chemical Oxygen Demand	20	45	35	345	15	50	5	5
4.	Ammoniacal Nitrogen as N	2.24	1.56	4.68	0.56	0.28	0.30	0.83	0.29
5.	Total Kjeldahl Nitrogen as N	2.74	2.52	5.88	1.01	0.63	0.78	0.94	0.39
6.	Nitrate Nitrogen as N	0.05	1.00	1.50	0.25	0.30	0.15	0.30	0.35
7.	Chloride (as Cl^-)	32	8	32	3,020	12	5	3	3
8.	Fluoride (as F)	0.20	0.08	0.24	0.24	0.07	0.05	0.06	0.04
9.	Sulphate (as SO_4^{--})	95	14	14	1,010	4.5	5.0	2.0	2.5
10.	Phosphate (as P)	0.10	1.61	0.97	0.11	0.12	0.19	0.23	0.13
11.	Total Solids Dried at 105°C	235	125	210	6,210	100	55	85	130
12.	Suspended Solids Dried at 105°C	40	65	65	35	65	30	50	100
13.	Oil and Grease	18	33	4	Not detected				
14.	Color (Hazen units)	10	15	30	15	15	40	60	70
15.	Turbidity (FTU)	5	5	5	5	5	10	15	40
16.	Zinc (as Zn)	0.10	0.24	0.08	0.10	0.09	0.07	0.06	0.15
17.	Arsenic (as As)	0.002	0.002	0.002	0.003	0.001	0.001	0.003	Not detected
18.	Iron (as Fe)	1.6	0.8	1.0	0.2	0.4	0.4	0.4	0.1
19.	Lead (as Pb)	Not detected			0.05	Not detected	0.08	Not detected	0.04
20.	Chromium (as Total Cr)	Not detected			0.03	Not detected			
21.	Manganese (as Mn)	0.11	0.03	0.05	0.04	0.03	0.02	0.02	0.01
22.	Total Hardness as $CaCO_3$	55	20	50	970	10	10	15	5
23.	Phenol	Not detected			Not detected				
24.	Detergents	Not detected			Not detected				
25.	Calcium (as Ca)	10	4.4	14	64	2.4	2.4	4.0	1.2
26.	Magnesium (as Mg)	7.5	2.2	3.2	197	1.2	1.0	1.0	0.7
27.	Boron (as B)	Not detected			Not detected				
28.	Mercury (as Hg)	0.002	0.002	0.002	0.004	0.001	0.002	0.003	0.002

Table 11 CLASSIFICATION OF WQMS ACCORDING TO BOD5 CLASSIFICATION USING MEAN BOD5

River Name	WQCR No.	1978 No. of WQMS	Cl	Mip	MoP	GP	1979 No. of WQMS	Cl	Mip	Mop	GP
Perlis	1	-	-	-	-	-	9	7	0	0	2
Kuar	2	-	-	-	-	-	6	4	2	0	0
Kedah	3	12	5	3	1	3	13	12	1	0	0
Merbok	4	7	2	2	0	3	7	0	2	1	4
Muda	5	10	10	0	0	0	9	9	0	0	0
Perai	6	11	11	0	0	0	11	10	1	0	0
Juru	6	9	0	3	2	4	9	3	1	0	5
Jejawi	7	6	6	0	0	0	5	3	2	0	0

River Name	WQCR No.	1980 No. of WQMS	Cl	Mip	Mop	GP	1981 No. of WQMS	Cl	Mip	Mop	GP
Perlis	1	10	10	0	0	0	7	7	0	0	0
Kuar	2	6	5	1	0	0	4	4	0	0	0
Kedah	3	12	12	0	0	0	11	10	1	0	0
Merbok	4	6	3	2	0	1	7	6	0	0	1
Muda	5	9	9	0	0	0	9	9	0	0	0
Perai	6	11	11	0	0	0	10	10	0	0	0
Juru	6	9	2	2	1	4	8	3	0	0	5
Jejawi	7	5	5	0	0	0	3	3	0	0	0

River Name	WQCR No.	1982 No. of WQMS	Cl	Mip	Mop	GP
Perlis	1	8	6	1	0	0
Kuar	2	4	4	0	0	0
Kedah	3	8	7	1	0	0
Merbok	4	7	5	0	0	2
Muda	5	11	11	0	0	0
Perai	6	12	12	0	0	0
Juru	6	8	2	1	0	5
Jejawi	7	5	5	0	0	0

Remarks; Cl : Clean 0 - 4 mg/l
Mip: Mildly polluted 4 - 8 mg/l
Mop: Moderately polluted 8 - 12 mg/l
GP : Grossly polluted >12 mg/l

Table 12 CLASSIFICATION OF WQMS ACCORDING TO SS CLASSIFICATION USING MEAN SS

River Name	WQCR No.	1978 No. of WQMS	1978 0-50 mg/l	1978 50-100 mg/l	1978 100-150 mg/l	1978 >150 mg/l	1979 No. of WQMS	1979 0-50 mg/l	1979 50-100 mg/l	1979 100-150 mg/l	1979 >150 mg/l
Perlis	1	-	-	-	-	-	3	1	1	0	1
Kuar	2	-	-	-	-	-	6	0	6	0	0
Kedah	3	12	8	4	0	0	13	2	10	0	1
Merbok	4	7	3	4	0	0	7	0	2	5	0
Muda	5	10	7	3	0	0	9	3	6	0	0
Perai	6	11	4	5	2	0	11	0	10	1	0
Juru	6	9	0	4	4	1	9	0	7	2	0
Jejawi	7	6	6	0	0	0	5	4	1	0	0

River Name	WQCR No.	1980 No. of WQMS	1980 0-50 mg/l	1980 50-100 mg/l	1980 100-150 mg/l	1980 >150 mg/l	1981 No. of WQMS	1981 0-50 mg/l	1981 50-100 mg/l	1981 100-150 mg/l	1981 >150 mg/l
Perlis	1	10	3	3	1	3	10	2	6	2	0
Kuar	2	6	0	3	1	2	6	0	5	1	0
Kedah	3	12	1	9	0	2	12	2	9	1	0
Merbok	4	6	0	5	1	0	7	3	3	1	0
Muda	5	9	3	5	1	0	9	2	4	3	0
Perai	6	11	1	7	2	1	10	6	4	0	0
Juru	6	9	0	3	5	1	8	2	4	1	1
Jejawi	7	5	2	1	1	1	5	2	1	1	1

River Name	WQCR No.	1982 No. of WQMS	1982 0-50 mg/l	1982 50-100 mg/l	1982 100-150 mg/l	1982 >150 mg/l
Perlis	1	8	2	4	0	2
Kuar	2	4	2	0	1	1
Kedah	3	8	2	4	0	2
Merbok	4	7	1	2	3	1
Muda	5	11	7	4	0	0
Perai	6	12	1	10	1	0
Juru	6	8	1	6	1	0
Jejawi	7	5	3	2	0	0

Table 13 INVENTORY OF RUBBER FACTORIES (1/2)

Code No.	Name of Factory	State	Type of Production	Actual Production (mt/d)	Purification System	Quantity of Effluent (10^3 m^3/y)	BOD_3 & SS of Treated or Raw Effluent BOD_3(mg/l)	SS(mg/l)
1	Ban Seng Rubber Co. Sdn. Bhd.	Kedah	Conventional (RSS)	6.6	No Treatment	65.5	168	68
2	Eng. Joo Seng Rubber Dealers Co. Sdn. Bhd.	Kedah	Conventional (RSS)	12.0	Sedimentation Trap	5.2	48	16
3	Plantation Latex (M) Sdn. Bhd.	Kedah	Conventional	7.5	Anaerobic & Aerobic Pond	65.7	200	250
4	Ladang Perbadanan Kedah	Kedah	SMR	7.5	Anaerobic & Aerobic	60.0	200	600
5	Lam Eng. Rubber Factory (M) Sdn. Bhd.	Kedah	Conventional (Crepe)	2.5	No Treatment	45.8	200	250
6	Uniroyal M'sia Plantations Sdn. Bhd.	Kedah	Mixed (LC/SMR)	48.0	Data Not Available	203.0	2,350	275
7	Lean Hoe Rubber Factory	Kedah	SMR	25.0	Anaerobic/Facultative Pond	31.7	53.8	24
8	Lee Latex (Pte) Ltd.	Kedah	Mixed (LC/SMR)	50.0	Proposed Oxidation Pond	231.0	520	84
9	Teh Ah Yau Rubber Factory Sdn. Bhd.	Kedah	SMR	24.0	Anaerobic/Facultative Pond	162.0	200	200
10	Lubuk Segintah Estate	Kedah	SMR	3.5	Anaerobic & Aerobic Pond	30.0	200	250
11	Tiong Huat Rubber Factory Sdn. Bhd.	Kedah	SMR	20.0	Data Not Available	43.2	589	353
12	Badenoch Estate	Kedah	Latex Concentration	10.6	Land Disposal	54.0	-	-
13	Lee Rubber Co. (Pte) Ltd.	Kedah	Conventional (RSS)	30.0	Proposed Aeration Pond	13.5	874	315
14	Kuala Ketil Factory	Kedah	Conventional (Crepe/RSS)	18.0	Anaerobic/Aerobic Pond	121.0	88	60
15	Sungai Tawar Latex Co. Sdn. Bhd.	Kedah	Mixed (SMR/LC/ Crepe)	18.0	No Treatment	16.4	315	96
16	Kilang Getah Mardel (Jeniang Estate)	Kedah	SMR	43.0	Treatment System to be in Commission	324.0	382	840
17	Kilang Getah Mardel (Baling Estate)	Kedah	SMR	25.0	No Treatment	355.0	97	207
18	Selangor Coconut Bhd.	Kedah	Mixed (LC/Skim/ Crepe Drain Rubber)	18.0	Data Not Available	77.0	500	1,000
19	Thye Group SMR Factory	Kedah	Mixed (SMR/Sheet Rubber)	10.2	Anaerobic/Aerobic Pond	64.8	63.3	114
20	Kuala Muda Estate	Kedah	Conventional (ADS)	9.0	No Treatment	57.6	963	114
21	Ladang Pinang Tunggal	Kedah	SMR	5.45	Anaerobic/Aerobic Pond	41.8	200	250
22	Bertam Consolidated Rubber Co., Ltd.	Penang	SMR	15.0	Anaerobic/ Stabilization Pond	39.3	68	64

Table 14 INVENTORY OF RUBBER FACTORIES (2/2)

Code No.	Name of Factory	State	Type of Production	Actual Production (mt/d)	Purification System	Quantity of Effluent (10^3 m^3/y)	BOD3 & SS of Treated or Raw Effluent BOD3(mg/l)	SS(mg/l)
23	Tong Teik Co. Sdn. Bhd.	Penang	Conventional (RSS/Crepe)	27.8	Anaerobic/Facultative Pond	54.6	7	65
24	Tai Teong Rubber Factory Sdn. Bhd.	Penang	SMR	24.0	Land Disposal	197.0	470	124
25	Lee Rubber Co. (Pte) Ltd.	Penang	Mixed (SMR/RSS)	65.0	No Treatment	154.0	685	309
26	Hock Heng Co. Sdn. Bhd.	Kedah	SMR	26.0	Anaerobic/ Stabilization Complete Recycling	-	40	53
27	Tong Teik Rubber Products Sdn. Bhd.	Kedah						
28	Highlands and Lowlands Bhd.	Kedah	Conventional (RSS/ADS)	4.4	Anaerobic/Facultative Pond	47.0	19	80
29	Malakoff Factory	Penang	Mixed (SMR/LC)	14.4	Anaerobic/Aerobic	84.9	40.6	-
30	Henrietta Rubber Estate Ltd.	Kedah	SMR	11.0	Anaerobic/Aerobic Pond	81.9	46.8	-
31	Padang Meika Factory	Kedah	Concentrate	100.0	Anaerobic/Facultative Pond	106.0	450	1,000
32	Alma Rubber Estate Sdn. Bhd.	Penang	Mixed (Crepe/SMR)	17.0	No Treatment	163.0	74	6
33	Highland and Lowlands Bhd.	Kedah	Conventional (RSS/ADS)	5.0	Anaerobic/Facultative Pond	22.5	300	250
34	Ladang Victoria	Kedah	Conventional (SMR/RSS)	2.92	No Treatment	23.4	1,850	850
35	Sungai Ular Estate	Kedah	Mixed (ADS/SMR etc.)	2.1	Anaerobic/Aerobic Pond	57.0	80	91
36	Pelam Estate Sdn. Bhd.	Kedah	Conventional (RSS/ADS)	5.49	Anaerobic/Aerobic Pond	9.52	200	250
37	Lee Rubber Co. (Pte) Ltd.	Penang	SMR	100.0	No Treatment	1,430.0	119	188
38	Selama Estate Factory	Kedah	Mixed (SMR/OENR)	16.0	Anaerobic/Aerobic Pond, Aeration	74.7	100	120
39	Batu Lintang Rubber Co. Bhd.	Kedah	SMR	16.0	Anaerobic/Aerobic Pond	132.0	58	120
40	Southern Rubber Works Sdn. Bhd.	Penang	SMR	35.0	No Treatment	45.5	241	49.7
1001	Lee Bee Rubber Factory Sdn. Bhd.	Kedah						
1002	Bukit Mertajam Estate	Penang						

Table 15 INVENTORY OF PALM OIL MILLS

Code No.	Name of Factory	State	Average Production of FFB (mt/d)	Purification System	Average Quantity of Effluent (10^3 m^3/y)	BOD3 & SS of Treated or Raw Effluent	
						BOD_3(mg/l)	SS(mg/l)
1	Kilang Kelapa Sawit, Bukit Mertajam	Kedah	160	Biological-Anaerobic Ponds	W: 33.4	W: 80	W: 180
2	Batu Kawan Palm Oil Mill	Penang	130	Biological-Anaerobic & Aerobic, Land Disposal	W: 33.9	W: 43	
3	Malpom Industries Behad	Province Wellesley	300	Oxidation Pond	W: 52.4	W: 500	W: 500
4	Guan Palm Oil Mill Sdn. Bhd.	Penang	80	Oil Trap, Anaerobic Pond, Facultative Pond, Land Application, Land Disposal	L: 14.4	L: 5,000	L: 2,500
5	Kilang Sawit Dilot 1808	Penang	-	Data Not Available			

Table 16 WATER DEMAND PROJECTION OF RUBBER FACTORIES

Unit: 10^3 m^3/y

Basin No.	Rubber Factory No.	Water Demand 1982	1985	1990	2000	Remarks
3	1	48	51	56	66	Without P.S.
	2	96	102	112	133	Without P.S.
4	3	57	62	68	81	With P.S.
	4	57	62	68	95	With P.S.
	5	19	21	23	27	Without P.S.
	6	370	394	432	610	N.A.
	7	193	205	225	368	With P.S.
	8	386	410	450	637	With P.S.
	9	178	178	178	178	With P.S.
	11	145	158	179	312	N.A.
	13	217	237	269	325	With P.S.
	19	70	70	70	70	With P.S.
	1001	21	76	152	440	N.A.
5	10	25	25	25	25	With P.S.
	12	73	73	73	73	L.D.
	14	123	123	123	123	With P.S.
	15	130	142	162	229	With P.S.
	16	294	294	294	294	With P.S.
	17	171	171	171	171	Without P.S.
	18	123	123	123	123	N.A.
	20	62	62	62	62	Without P.S.
	21	37	37	37	37	With P.S.
	31	620	632	649	959	With P.S.
	34	18	18	18	18	Without P.S.
	36	34	34	34	34	With P.S.
6	22	109	119	135	191	With P.S.
	23	173	176	180	267	With P.S.
	24	183	247	346	916	L.D.
	25	404	411	422	825	Without P.S.
	26	161	164	169	330	With P.S.
	27	111	115	120	329	With P.S.
	28	27	27	27	27	With P.S.
	29	89	91	93	138	With P.S.
	30	68	68	68	68	With P.S.
	32	105	105	105	105	Without P.S.
	33	31	31	31	31	With P.S.
	35	9	9	9	9	With P.S.
	1002	2	8	14	261	N.A.
7	37	741	821	902	1,582	Without P.S.

Remarks; P.S.: Purification system
L.D.: Land disposal
N.A.: Not available

Table 17 WATER DEMAND PROJECTION OF PALM OIL MILLS

Unit: 10^3 m^3/y

Basin No.	Palm Oil Mill No.	Water Demand 1982	1985	1990	2000	Remarks
5	1	29	48	48	60	With P.S.
6	2	3	12	12	40	With P.S.
	3	5	23	24	80	With P.S.
	4	1	24	25	40	L.D. with P.S.

Remarks; P.S.: Purification system
L.D.: Land disposal
N.A.: Not available

Table 18 PROJECTION OF PIG PRODUCTION

Animal Husbandry No.	City/Town	Basin No.	Number of Pigs (Head) 1980	1990	2000
1	Bertam	5	8,960	11,300	13,600
2	Tasek Gelugor	6	30,100	37,900	45,900
3	Bagan Ajam Bagan Jarmal	6	8,980	11,300	13,700
4	Machang Bubok	6	7,830	9,850	11,900
5	Bukit Tengah	6	7,690	9,680	11,700
6	Bukit Taubun	6	27,800	34,900	42,300
7	Sungei Bakap	6	12,000	15,200	18,300
8	Telok Bahang	7	10,500	13,200	16,000
9	Tanjong Bunga	7	5,020	6,310	3,070
10	Paya Terubong	7	17,900	22,500	27,300
11	Sungei Nibong	7	18,100	22,800	27,600
12	Bayau Lepas	7	37,900	47,700	57,800

Table 19 NUMBER OF WATER QUALITY MONITORING STATION BY WATER QUALITY CONTROL REGION IN NORTHERN REGION

WQCR	State	River	Catchment Area (km^2)	Number of WQMS 1978	1979	1980	1981	1982	1983
1	Perlis	Perlis	653	0	9	10	10	8	4
2	Kedah	Kuar	249	0	6	6	6	4	3
3	Kedah	Kedah	3,100	12	13	12	12	8	8
4	Kedah	Merbok	746	7	7	6	7	7	6
5	Kedah/ P. Pinang	Muda	3,792	10	9	9	9	11	7
6	P. Pinang	Perai/ Juru	560	20	20	20	18	20	9
7	P. Pinang	Jejawi/ Tengah	186	6	5	5	5	5	4
Total				55	69	68	67	57	41

Table 20 LIST OF WATER QUALITY MONITORING STATION (WQMS) BY RIVER (1/3)

River Name & WQCR No.	WQMS No.	River Name	Latitude	Longitude	Distance from River Mouth (km)	Note
Perlis 1	6401602	Perlis	6° 26'	100° 11'	6.76	Jambatan Jalan Bahru di Kangar
	6401603	Perlis	6° 26'	100° 9'	12.88	Hujung jalan di Kg. Tebing Tinggi
	6402604	Jejawi	6° 26'	100° 12'	17.22	Jambatan Sg. Jejawi di Sena
	6402605	Arau	6° 25'	100° 13'	16.30	Jambatan Sg. Arau di antara Kg. Padang, Behordan Kg. Guar Syed Alwi
	6402606	Chuping	6° 29'	100° 15'	22.74	Jambatan di Kg. Perawah
	6402634	Gial	6° 27'	100° 16'	23.55	Titi jalan Arau ke Kangar
	6402635	Arau	6° 25'	100° 17'	30.97	Titi jalan Arau
	6502601	Jernih	6° 32'	100° 16'	25.32	Titi Tampang
	6402608	Gial	6° 28'	100° 16'	26.77	Jambatan Sg. Gial dekat Pusat Kesihatan Kecil di Kg. Gial
Kuar 2	6102601	Kuar	6° 11'	100° 17'	1.61	Jambatan Sg. Kuar daripada Alor Janggus
	6103602	Padang Hang	6° 11'	100° 20'	4.83	Jambatan di Kawasan Gunung Keriang
	6204603	Tanjung Pauh	6° 15'	100° 25'	11.91	Jambatan dekat Jitra
	6204604	Bata	6° 17'	100° 26'	14.65	Jambatan dekat Kg. Biak dan Jitra
	6304605	Wang	6° 18'	100° 28'	16.74	Tepi jalan dekat Kg. Padang Panjang
	6304606	Bata	6° 20'	100° 26'	18.03	Jambatan Jalan Ansun Ke Kg. Teluk

Source; Ref. 20

Table 21 LIST OF WATER QUALITY MONITORING STATION (WQMS) BY RIVER (2/3)

River Name & WQCR No.	WQMS No.	River Name	Latitude	Longitude	Distance from River Mouth (km)	Note
Kedah 3	6103601	Kedah	6° 7'	100° 21'	13.20	Di Kuala Kedah (Tidal Barrage)
	6103613	Kedah	6° 6'	100° 23'	17.22	Di Alor Setar
	6204602	Anak Bukit	6° 12'	100° 25'	29.94	Di Belakang Loji Pembersihan Air Bukit Pinang
	6204603	Padang Terap	6° 13'	100° 28'	38.47	Pelubong Barrage pertemuan Sg. Padang Terap dan Taliair
	6204620	Padang Terap	6° 13'	100° 28'	38.31	Sg. Padang Terap di Pelubong Barrage
	6206606	Padang Terap	6° 15'	100° 37'	64.40	Sg. Padang Terap sebelum pertemuan Sg. Padang Terap/ Sg. Pedu di Kuala Nerang
	6206607	Pedu	6° 15'	100° 37	64.40	Sg. Pedu sebelum pertemuan Sg. Padang Terap/Sg. Pedu di Kuala Nerang
	6306609	Padang Terap	6° 18'	100° 40'	65.68	Takat Pengambilan Air di Kilang Gula
	6306610	Padang Terap	6° 18'	100° 40'	71.68	Sg. Padang Terap selepas pertemuan Sg. Padang Terap/ Sg. Sari
	6306611	Sari	6° 18'	100° 40'	75.34	Di Jambatan sebelum takat pelepasan effluen Kilang Gula Padang Terap
	6306612	Padang Sanai	6° 20'	100° 39'	90.16	Berhampiran di Balai Polis di Padang Sanai
Merbok 4	5604601	Merbok	5° 38'	100° 24'	10.46	Di Kg. Batu Lintang
	5604602	Petani	5° 38'	100° 29'	20.12	Jambatan di Pekan Sg. Petani
	5705607	Merbok	5° 44'	100° 29'	20.52	Jambatan di Semiling
	5705604	Merbok	5° 42'	100° 30'	28.98	Di Pekan Sg. Lalang
	5705605	Merbok	5° 43'	100° 31'	32.20	Jambatan dekat Bedong
	5705606	Merbok	5° 45'	100° 31'	38.64	Jambatan di Sg. Tok Pawang
	5604601(A)	Simpor				Kota Kuala Muda
Muda 5	5503601	Muda	5° 35'	100° 22'	5.15	Di Kota Kuala Muda
	5504602	Muda	5° 33'	100° 25'	12.88	Jambatan Merdeka di Bumbong Lima
	5505603	Muda	5° 34'	100° 30'	25.76	Jambatan keretapi di Pinang Tunggal
	5505612	Muda	5° 31'	100° 34'	39.44	Jambatan Sidam di Kg. Sidam Kanan
	5606604	Muda	5° 35'	100° 37'	53.93	Jambatan Syed Omar
	5608605	Muda	5° 35'	100° 39'	65.20	Di Kuala Ketil
	5806614	Muda	5° 49'	100° 38'	102.23	Jambatan di Jeniang
	5906607	Muda	5° 56'	100° 41'	123.16	Di Jereri
	6007608	Muda	6° 0'	100° 43'	142.48	Di Kg. Lubok Merbau
	5608605	Ketil	5° 35'	100° 49'		Di Kuala Pegang
	S.T.	Tawar				Pekan Tawar

Source; Ref. 20

Table 22 LIST OF WATER QUALITY MONITORING STATION (WQMS) BY RIVER (3/3)

River Name & WQCR No.	WQMS No.	River Name	Latitude	Longitude	Distance from River Mouth (km)	Note
Perai 6	5403602	Perai	5° 24'	100° 23'	2.89	Jambatan Tunku Abdul Rahman menyeberangi Sg. Perai ke Butterworth
	5404601	Perai	5° 24'	100° 24'	7.40	Jambatan di Permatang Pauh ke Mak Mandin
	5404603	Perai	5° 25'	100° 24'	10.94	Jalan Mati di Kg. Sama Gagah
	5404604	Perai	5° 26'	100° 26'	15.29	Jalan Mati di Kg. Kota
	5404605	Perai	5° 26'	100° 27'	19.64	Jalan Mati di Kg. Terus
	5404606	Jarak	5° 27'	100° 28'	29.94	Jambatan menyeberangi Sg. Jarak ke Padang Menora
	5404608	Kereh	5° 28'	100° 28'	28.33	Jambatan menyeberangi Sg. Kereh dekat Lahar Yooi
	5405607	Jarak	5° 28'	100° 30'	33.32	Jambatan menyeberangi Sg. Jarak ke Tasik Gelugor
	5405621	Kulim	5° 26'	100° 30'	34.45	Jambatan di Sg. Ara Kuda
	5504609	Kereh	5° 28'	100° 28'	32.36	Jambatan menyeberangi Sg. Kereh ke Tasik Gelugor daripada Pokok Machang
	5505610	Kereh	5° 32'	102° 31'	42.02	Jambatan menyeberangi Sg. Kereh Kg. Bahau dalam Ladang Ekor Kuching
Juru 6	5304602	Derhaka	5° 21'	100° 25'	1.04	Pertemuan antara Sg. Tok Kedidi dan Sg. Juru
	5304603	Juru	5° 20'	100° 26'	6.11	Selepas Kg. Tok Kangar
	5304604	Juru	5° 20'	100° 27'	8.21	Di Jambatan Tun Abdul Razak
	5304605	Kilang Ubi	5° 20'	100° 28'	10.30	Jambatan Keretapi di Sungai Kilang Ubi
	5304606	Pasir	5° 21'	100° 28'	12.55	Jambatan di Pelandok Jatuh
	5304607	Rambai	5° 22'	100° 27'	13.04	Jambatan di Kg. Sg. Rambai
	5304608	Ara	5° 22'	100° 28'	16.10	Jambatan dekat Bukit Mertajam di Kg. Tanah Liat
	5304609	Rambai	5° 23'	100° 28'	16.42	Jambatan dekat Bukit Mertajam ke Kubang Semang
Jejawi 7	5204601	Jejawi	5° 16'	100° 27'	4.02	Pengkalan Feri di Bukit Tambun
	5204607	Junjong	5° 17'	100° 28'	10.14	Jambatan dekat Simpang Ampat
	5205603	Jejawi	5° 12'	100° 30'	20.44	Jambatan dekat Kg. Jawi
	5205604	Jejawi	5° 12'	100° 31'	25.27	Jambatan selepas Kg. Lima
	5205606	Jejawi	5° 14'	100° 33'	28.65	Jambatan Sg. Jawi di Kg. Relau
	S.T.C.	Tasek Chempedak				Di Tasek

Source; Ref. 20

Table 23 PROJECTED BOD LOAD IN 1990 AND 2000 UNDER THE CONDITION OF 4MP

Basin Name	Intake No.	1990 BOD Load from Pollution Sources (ton/d)	1990 BOD Load into Main Stream (ton/d)	2000 BOD Load from Pollution Sources (ton/d)	2000 BOD Load into Main Stream (ton/d)	Pollution Sources
Perlis	4	0.3	0.0	0.5	0.0	Rural
	6	0.2	0.0	0.4	0.0	Rural
	8	0.2	0.0	0.4	0.0	Rural
	11	4.0	1.9	11.0	5.9	Kangar,Rural
(Sg. Arau)	8	0.2	0.0	0.4	0.0	Rural
(Sg. Gial)	11	0.3	0.0	0.4	0.0	Rural
	Sub-total	5.2	1.9	13.1	5.9	
Kedah	7	1.0	0.1	1.4	0.1	Rural
	15	0.0	0.0	0.1	0.0	Rural
	27	7.5	1.5	11.0	1.8	Rural RF(1,2)
	28	5.8	3.8	15.1	10.3	Alor Setar
(Sg. Temin)	22	0.4	0.0	0.6	0.1	Rural
(Sg. Temin)	24	0.9	0.5	1.8	1.1	Rural
	Sub-total	15.6	5.9	30.0	13.4	
Merbok	1	5.0	3.0	8.2	4.8	RF(3,4,6,7,8,9, 1001)
	2	8.1	4.9	21.8	13.1	Sg.Petani,RF(9, 11,13)
	3	0.2	0.1	0.2	0.1	RF(5)
	4	0.8	0.5	3.0	1.8	Tikam Batu
	Sub-total	14.1	8.5	33.2	19.8	
Muda	11	0.1	0.0	0.0	0.0	RF(16)
	12	0.6	0.1	0.8	0.1	Rural
	14	1.0	0.1	1.4	0.1	Rural
	16	1.1	0.1	1.5	0.2	Rural
	17	0.1	0.1	0.3	0.2	Kuala Ketil
	18	0.0	0.0	0.0	0.0	RF(10)
	19	1.3	0.6	1.2	0.6	Rural,RF(18), P(1)
(Sg. Sedim)	22	0.1	0.1	0.2	0.1	RF(12,31,36)
(Sg. Sedim)	23	0.0	0.0	0.0	0.0	RF(14)
	26	0.8	0.4	0.7	0.4	Rural,RF(20,21,34)
(Sg. Ketil)	46	2.7	1.0	3.0	1.0	Rural,RF(15,17)
	Sub-total	7.8	2.5	9.1	2.7	
Perai	6	2.1	1.0	6.0	3.4	Kulim,Rural RF(26,28,35,1002)
	8	13.5	1.4	16.9	1.7	Rural, RF(22,24,30,33) A(1,2)
	9	3.6	2.1	6.2	3.7	RF(23,25)
	Sub-total	19.2	4.5	29.1	8.8	
P.Pinang	1	3.9	2.1	5.4	2.9	Air Itam
		12.0	5.0	17.2	7.6	RF(37),A(10)
	Sub-total	15.9	7.1	22.6	10.5	

Remarks; RF: Rubber factory
P : Palm oil mill
A : Animal husbandry

Table 24 PROJECTED BOD LOAD IN 1990 AND 2000 UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin Name	Intake No.	1990 BOD Load from Pollution Sources (ton/d)	1990 BOD Load into Main Stream (ton/d)	2000 BOD Load from Pollution Sources (ton/d)	2000 BOD Load into Main Stream (ton/d)	Pollution Sources
Perlis	4	0.2	0.0	0.4	0.0	Rural
	6	0.2	0.0	0.3	0.0	Rural
	8	0.2	0.0	0.3	0.0	Rural
	11	2.5	1.1	3.4	1.5	Kangar, Rural
(Sg. Arau)	8	0.2	0.0	0.3	0.0	Rural
(Sg. Gial)	11	0.2	0.0	0.3	0.0	Rural
	Sub-total	3.5	1.1	5.0	1.5	
Kedah	7	0.8	0.1	1.0	0.1	Rural
	15	0.1	0.0	0.1	0.0	Rural
	27	6.9	1.4	9.1	1.7	Rural RF(1,2)
	28	5.0	3.1	5.2	3.4	Alor Setar
(Sg. Temin)	22	0.3	0.0	0.4	0.0	Rural
(Sg. Temin)	24	0.7	0.4	0.8	0.5	Rural
	Sub-total	13.8	5.0	16.6	5.7	
Merbok	1	5.0	3.0	8.0	4.8	RF(3,4,6,7,8,9,1001)
	2	5.4	3.2	7.2	4.3	Sg. Petani, RF(9,11,13)
	3	0.2	0.1	0.2	0.1	RF(5)
	4	0.4	0.3	0.7	0.4	Tikan Batu
	Sub-total	11.0	6.6	13.1	9.6	
Muda	11	0.1	0.0	0.0	0.0	RF(16)
	12	0.5	0.1	0.6	0.1	Rural
	14	0.8	0.1	1.1	0.1	Rural
	16	0.9	0.1	1.1	0.1	Rural
	17	0.1	0.1	0.1	0.1	Kuala Ketil
	18	0.0	0.0	0.0	0.0	RF(10)
	19	1.3	0.6	1.2	0.6	Rural,RF(18),P(1)
(Sg. Sedim)	22	0.1	0.1	0.2	0.1	RF(12,31,36)
(Sg. Sedim)	23	0.0	0.0	0.0	0.0	RF(14)
	26	0.8	0.4	0.7	0.4	Rural,RF(20,21,34)
(Sg. Ketil)	46	2.5	1.0	2.6	0.9	Rural,RF(15,17)
	Sub-total	7.1	2.5	7.6	2.4	
Perai	6	1.3	0.8	3.3	2.0	Kulim,Rural RF(26,28,35,1002)
	8	13.3	1.5	16.3	1.8	Rural, RF(22,24,30,33) A(1,2)
	9	3.6	2.1	6.2	3.7	RF(23,25)
	Sub-total	18.2	4.4	25.8	7.5	
P.Pinang	1	3.2	1.7	3.1	1.6	Air Itam
		12.0	5.0	17.2	7.6	RF(37),A(10)
	Sub-total	15.2	6.7	20.3	9.2	

Remarks; RF: Rubber factory
P : Palm oil mill
A : Animal husbandry

Table 25 ASSUMED DEVELOPMENT OF SEPTIC TANK IN URBAN AREA

Unit: %

Pollution Source	1980	1990	2000
Septic tank	20	35	50
Others	80	65	50

Table 26 ASSUMED BOD CONCENTRATION OF NON-SEWERAGE-URBAN-DOMESTIC

Unit: mg/l

Pollution Source	NUPL	1980	1990	2000
Septic tank	80	16	28	40
Others	200	160	130	100
Non sewerage urban domestic		180	160	140

Table 27 NUPL BY CLASSIFICATION OF MANUFACTURING AND CUSTOMER WATER DEMAND BY STATE

Classification of Manufacturing	NUPL (mg/l)	Customer Water Demand (10^6 m^3/y)			
		Kedah/Perlis		P.Pinang	
		1990	2000	1999	2000
Condition of 4MP					
Food	250	27.0	66.7	20.8	16.1
Textile	400	0.0	0.0	21.3	23.0
Wood Product	610	0.7	1.4	0.2	0.1
Paper Product	150	0.0	0.0	13.7	17.2
Publishing	150	0.0	0.3	1.5	4.3
Chemicals	160	3.4	24.4	44.5	98.6
Rubber	10	14.3	67.8	6.4	9.5
Non-metal	10	1.0	5.2	1.2	2.1
Basic Metal	10	0.1	0.7	16.9	43.7
Machinery	10	0.8	6.4	26.0	64.3
Miscellaneous	350	0.0	0.0	0.0	0.0
Condition of Lower Economic Growth					
Food	250	17.6	21.3	19.5	15.7
Textile	400	0.0	0.0	17.2	19.3
Wood Product	610	0.5	0.5	0.1	0.1
Paper Product	150	0.0	0.0	11.2	13.0
Publishing	150	0.0	0.0	1.1	2.1
Chemicals	160	1.8	5.3	29.8	66.5
Rubber	10	8.8	16.1	5.0	6.9
Non-metal	10	0.6	1.1	0.9	1.4
Basic Metal	10	0.0	0.1	12.2	23.0
Machinery	10	0.0	0.0	18.5	34.0
Miscellaneous	350	29.8	45.7	0.0	0.0

Table 28 NUPL OF INDUSTRIAL EFFLUENT BY STATE

State	BOD Concentration (mg/l)			
	Condition of 4MP		Condition of Lower Economic Growth	
	1990	2000	1990	2000
Kedah/Perlis	210	185	170	145
P. Pinang	155	180	165	140

Table 29 ASSUMED DISCHARGE RATIO, RUNOFF RATIO, INFILTRATION RATIO AND BOD CONCENTRATION OF EFFLUENT ASSUMED UNDER PRESENT PURIFICATION LEVEL

Pollution Source	Year	Discharge Ratio	NUPL (mg/l)	Runoff Ratio	Infil-tration Ratio
Domestic					
Urban sewerage	1990 & 2000	0.9	30	1.0	0.2
Urban non-sewerage	1990	0.9	160	0.6	0
	2000	0.9	140	0.6	0
Rural	1990 & 2000	0.8	200	0.1	0
Manufacture					
Urban sewerage	1990 & 2000	1.0	30	1.0	0.2
Urban non-sewerage	1990 & 2000	1.0	/3	0.6	0
Rural	1990 & 2000	1.0	/3	0.1	0
Palm Oil Mill					
With P.S.	1990	0.55	50	0.6	0
	2000	0.3	50	0.6	0
Without P.S./1	1990	0.55	22,000	0.6	0
	2000	0.3	22,000	0.6	0
Land disposal	1990	0.1	50	0.6	0
	2000	0.1	50	0.6	0
Rubber Factories					
With P.S.	1990	0.9	50	0.6	0
	2000	0.8	50	0.6	0
Without P.S.	1990	0.9	2,320	0.6	0
	2000	0.8	2,320	0.6	0
Land disposal	1990	0.1	50	0.6	0
	2000	0.1	50	0.6	0
Animal Husbandry	1990 & 2000	1.0	200/2	0.1	0

Remarks; /1: Purification System
/2: g/d/head
/3: See Table 28

Table 30 ASSUMED DEVELOPMENT OF LAND DISPOSAL IN PALM OIL MILLS AND RUBBER FACTORIES

Unit: %

	1980	1990	2000
Palm oil mills	25	50	75
Rubber factories	0	10	20

Table 31 ASSUMED DISCHARGE RATIO OF PALM OIL MILLS AND RUBBER FACTORIES

	1980	1990	2000
Palm Oil Mills			
Surface runoff ratio of land disposal area	0.25 x 0.1	0.5 x 0.1	0.75 x 0.1
Discharge ratio of palm oil mills	0.75	0.5	0.25
Discharge ratio	0.8	0.55	0.3
Rubber Factories			
Surface runoff ratio of land disposal area	0 x 0.1	0.1 x 0.1	0.2 x 0.1
Discharge ratio of rubber factories	1.0	0.9	0.8
Discharge ratio	1.0	0.9	0.8

Table 32 RESIDUAL PURIFICATION RATIO BY BASIN

Basin No.	RP Ratio
1	0.7
2	0.7
3	0.9
4	0.9
5	0.7
6	0.9
7	0.7

Table 33 SUMMARY OF PROJECTED BOD LOAD AND BOD CONCENTRATION UNDER THE CONDITION OF 4MP

Basin Name	1990			2000		
	BOD Load		BOD	BOD Load		BOD
	From Source (ton/d)	Into River (ton/d)	Concentration in River (mg/l)	From Source (ton/d)	Into River (ton/d)	Concentration in River (mg/l)
Perlis	5	2	0 - 44	13	6	0 - 86
Kedah	16 (1)	6	0 - 27	30 (3)	13	0 - 37
Merbok	14	9	0 - 81	33	20	0 - 111
Muda	8	3	0 - 3	9	3	0 - 4
Perai	19(11)	5	0 - 9	29(29)	9	0 - 25
Juru	8	4	0 - 46	7	3	0 - 35
Jejawi	14	1	0 - 3	18	2	0 - 5
P. Pinang	16 (6)	7	-	23(15)	11	-
Total	100(18)	37		162(47)	67	

Remarks; ( ): BOD Load discharge to the sea directly

Table 34 SUMMARY OF PROJECTED BOD LOAD AND BOD CONCENTRATION UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin Name	1990 BOD Load From Source (ton/d)	1990 BOD Load Into River (ton/d)	1990 BOD Concentration in River (mg/l)	2000 BOD Load From Source (ton/d)	2000 BOD Load Into River (ton/d)	2000 BOD Concentration in River (mg/l)
Perlis	4	1	0 - 32	5	2	0 - 80
Kedah	14 (1)	5	0 - 27	17 (1)	6	0 - 28
Merbok	11	7	0 - 71	13	10	0 - 92
Muda	7	3	0 - 3	8	2	0 - 4
Perai	18 (8)	4	0 - 7	26(17)	8	0 - 17
Juru	10	4	0 - 46	10	2	0 - 23
Jejawi	14	1	0 - 3	17	2	0 - 5
P. Pinang	15 (5)	7	-	20 (7)	9	-
Total	93(14)	32		116(25)	41	

Remarks; ( ): BOD Load discharge to the sea directly

Table 35 COMPOSITION OF BOD LOAD INTO RIVER UNDER THE CONDITION OF 4MP

Unit: ton/d

Basin Name	1990 BOD Load into River				2000 BOD Load into River			
	PR	UI	RA	Total	PR	UI	RA	Total
Perlis	0	2	0	2	0	6	0	6
Kedah	1	4	1	6	1	11	1	13
Merbok	4	5	0	9	6	14	0	20
Muda	2	0	1	3	2	0	1	3
Perai	3	1	1	5	5	2	2	9
Juru	1	2	1	4	0	2	1	3
Jejawi	0	0	1	1	0	0	2	2
P. Pinang	5	2	0	7	7	3	1	11
Total	16 (43)	16 (43)	5 (14)	37 (100)	21 (31)	38 (57)	8 (12)	67 (100)

Remarks; PR : Palm oil mill and rubber factory effluent
UI : Urban domestic and urban industry effluent
RA : Rural and animal husbandry
( ): % of the total BOD load

Table 36 COMPOSITION OF BOD LOAD INTO RIVER UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: ton/d

Basin Name	1990 BOD Load into River				2000 BOD Load into River			
	PR	UI	RA	Total	PR	UI	RA	Total
Perlis	0	1	0	1	0	2	0	2
Kedah	1	3	1	5	1	4	1	6
Merbok	4	3	0	7	6	4	0	10
Muda	2	0	1	3	2	0	0	2
Perai	2	1	1	4	5	1	2	8
Juru	1	2	1	4	0	1	1	2
Jejawi	0	0	1	1	0	0	2	2
P. Pinang	4	2	1	7	7	1	1	9
Total	14 (44)	12 (37)	6 (19)	32 (100)	21 (51)	13 (32)	7 (17)	41 (100)

Remarks; PR : Palm oil mill and rubber factory effluent
UI : Urban domestic and urban industry effluent
RA : Rural and animal husbandry
( ): % of the total BOD load

Table 37 STANDARD RELATING TO LIVING ENVIRONMENT FOR RIVERS IN JAPAN

Category	Purpose of Utilization	Standard Values/1: pH	BOD (mg/l)	SS (mg/l)	DO (mg/l)	Number of Coliform Groups (MPN/10^{-1} l)
AA	Water supply, class 1; conservation of natural environment & uses listed in A-E	6.5 - 8.5	1 or less	25 or less	7.5 or more	50 or less
A	Water supply, class 2; fishery, class 1; bathing & uses listed in B-E	6.5 - 8.5	2 or less	25 or less	7.5 or more	1,000 or less
B	Water supply, class 3; fishery, class 2, & uses listed in C-E	6.5 - 8.5	3 or less	25 or less	5 or more	5,000 or less
C	Fishery, class 3; industrial water, class 1, & uses listed in D-E	6.5 - 8.5	5 or less	50 or less	5 or more	
D	Industrial water, class 2; agricultural water/2, & uses listed in E	6.0 - 8.5	8 or less	100 or less	2 or more	
E	Industrial water, class 3; conservation of environment	6.0 - 8.5	10 or less	Floating matter such as garbage should not be observed.	2 or more	

Remarks; /1: The standard value is based on the daily average value. (The same applies to the standard values of lakes and coastal waters.)
/2: At the point of abstraction for agriculture, pH shall be between 6.0 and 7.5 and dissolved oxygen shall not be less than 5 mg/l.

(The same applies to the standard values of lakes.)

1. Conservation of natural environment: Conservation of scenic spots and other natural resources.
2. Water supply, class 1: Water treated by simply cleaning operation, such as filtration.
   Water supply, class 2: Water treated by normal cleaning operation such as sedimentation and filtration.
   Water supply, class 3: Water treated through a highly sophisticated cleaning operation including pretreatment.
3. Fishery, class 1: For aquatic life such as trout and bull trout inhabiting oligosaprobic water, and those of fishery classes 2 & 3
   Fishery, class 2: For aquatic life, such as the salmon family and sweetfish inhabiting oligosaprobic water and those of fishery class 3.
   Fishery, class 3: For aquatic life such as carp and silver carp inhabiting B-mesosaprobic water.
4. Industrial water, class 1: Water given normal cleaning treatment such as sedimentation.
   Industrial water, class 2: Water given sophisticated treatment by chemicals.
   Industrial water, class 3: Water given special cleaning treatment.
5. Conservation of environment: Up to the limits at which no unpleasantness is caused to people in their daily life (including a walk by the riverside, etc.).

Source; Ref. 21

Table 38 WATER QUALITY CRITERIA FOR FRESH SURFACE WATER PROPOSED BY THE NATIONAL POLLUTION CONTROL COMMISSION IN PHILIPPINES

Classification	Purpose of Utilization	Standard Values			
		pH	BOD (mg/l)	DO (mg/l)	Coliform (MPN/100 ml)
AA	Domestic Water Supply/1	7 - 8.5	-	-	50 or less
A	Domestic Water Supply/2	6.5 - 8.5	5 or less	5 or more	500 or less
B	Bathing	6.5 - 8.5	10 or less	5 or more	1,000 or less
C	Fishing	6.5 - 8.5	15 or less	5 or more	5,000 or less
D	Agricultural and Industrial Water Supply	6.5 - 8.5	-	3 or more	-

Remarks; /1: Domestic water supply: Water from watersheds which are uninhabited and otherwise protected and can be used for water supply with limited treatment.

/2: Domestic water supply: A conventional treatment is necessary for water supply use of these waters.

Source; Ref. 22

Table 39 PRESENT BOD_3 CONCENTRATION LIMITS FOR WATERCOURSE DISCHARGE FOR PALM OIL MILLS AND RUBBER FACTORIES

Unit: mg/l

Year	Palm Oil Mill	SMR & Conventional Grade Factory	Latex Concentration Factory
1978	5,000	-	-
1979	2,000	300	-
1980	1,000	200	450
1981	1,000 - 500	100 (50)*	300
1982	500 - 250	-	200
1983	250	-	100 (50)*

Remarks; *: This additional limit is the arithmetic mean value determined on the basis of a minimum of four samples taken at least once a week for four weeks consecutively.

Source; Refs. 23, 24

Table 40 OUTLINE OF PROPOSED PUBLIC SEWERAGE SYSTEM FOR POLLUTANT LOAD ABATEMENT FOR RIVER WATER UNDER THE CONDITION OF 4MP

Basin No.	City/Town No.	City/Town Name	1990 Treatment Capacity (10^3 m^3/d)	1990 Service Factor (%)	1990 Served Population (10^3)	2000 Treatment Capacity (10^3 m^3/d)	2000 Service Factor (%)	2000 Served Population (10^3)
1	C1	Kangar	16	85	18	63	100	29
3	C2	Alor Setar	52	85	70	201	100	96
4	C3	Sg. Petani	34	85	52	130	100	75
6	C4	Kulim	7	65	25	26	100	50
6	C5	Butterworth	36	40	33	92	80	66
7	C8	Georgetown	72	70	207	100	80	237
	Total		217	-	405	612	-	553

Remarks; Public sewerage systems in C5 & C8 are not affecting to river water quality.

Table 41 OUTLINE OF PROPOSED PUBLIC SEWERAGE SYSTEM FOR POLLUTANT LOAD ABATEMENT FOR RIVER WATER UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Basin No.	City/Town No.	City/Town Name	1990 Treatment Capacity (10^3 m^3/d)	1990 Service Factor (%)	1990 Served Population (10^3)	2000 Treatment Capacity (10^3 m^3/d)	2000 Service Factor (%)	2000 Served Population (10^3)
1	C1	Kangar	2	20	4	15	80	18
3	C2	Alor Setar	12	30	23	48	80	59
4	C3	Sg. Petani	8	30	17	32	80	46
6	C4	Kulim	1	10	4	8	80	30
6	C5	Butterworth	17	25	19	51	70	44
7	C8	Georgetown	46	55	149	57	70	159
	Total		86	-	216	181	-	356

Remarks; Public sewerage systems in C5 & C8 are not affecting to river water quality.

Table 42 TREATMENT CAPACITY TO BE TREATED IN RUBBER FACTORIES, PALM OIL MILLS AND A SUGAR MILL UNDER THE CONDITION OF 4MP AND LOWER ECONOMIC GROWTH

Unit: 10^3 m^3/d

Basin No.	Basin Name	Treatment Capacity 1990	Treatment Capacity 2000
2	Perlis	0.05	0.05
3	Kedah	0.60	0.64
4	Merbok	7.60	10.04
5	Muda	1.20	1.28
6	Perai	5.04	9.36
7	P. Pinang	3.25	5.06

Remarks; Operation days per year by industry are as follows:

Rubber factories: 250 days
Palm oil mills : 250 days
Sugar mills : 120 days

Table 43 POLLUTANT LOAD IN 1990 AND 2000 BY BASIN WITH AND WITHOUT PROJECT UNDER THE CONDITION OF 4MP

1 9 9 0

Basin		Without Project					With Project				
		BOD Load into River (ton/d)				Max. BOD in River	BOD Load into River (ton/d)				Max. BOD in River
No.	Name	PR	UI	RA	Total	(mg/l)	PR	UI	RA	Total	(mg/l)
1	Perlis	0	2	0	2	44	0	1	0	1	10
3	Kedah	1	4	1	6	27	0	2	1	3	10
4	Merbok	4	5	0	9	81	0	2	0	2	10
5	Muda	2	0	1	3	3	1	0	1	2	2
6	Perai	3	1	1	5	9	0	0	1	1	3
6	Juru	1	2	1	4	46	0	1	1	2	23
6	Jejawi	0	0	1	1	3	0	0	1	1	3
7	P. Pinang	5	2	0	7	-	0	2	0	2	-
Total		16	16	5	37		1	8	5	14	

2 0 0 0

Basin		Without Project					With Project				
		BOD Load into River (ton/d)				Max. BOD in River	BOD Load into River (ton/d)				Max. BOD in River
No.	Name	PR	UI	RA	Total	(mg/l)	PR	UI	RA	Total	(mg/l)
1	Perlis	0	6	0	6	86	0	2	0	2	17
3	Kedah	1	11	1	13	37	0	5	1	6	16
4	Merbok	6	14	0	20	111	0	4	0	4	15
5	Muda	2	0	1	3	4	1	0	1	2	3
6	Perai	5	2	2	9	25	0	1	2	3	5
6	Juru	0	2	1	3	35	0	1	1	2	23
6	Jejawi	0	0	2	2	5	0	0	2	2	5
7	P.Pinang	7	3	1	11	-	0	3	1	4	-
Total		21	38	8	67		1	16	8	25	

Remarks; PR: Palm oil mill and rubber factory effluent
UI: Urban domestic and urban industry effluent
RA: Rural and animal husbandry

Table 44 POLLUTANT LOAD IN 1990 AND 2000 BY BASIN WITH AND WITHOUT PROJECT UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

1 9 9 0

Basin		Without Project					With Project				
		BOD Load into River (ton/d)				Max. BOD in River	BOD Load into River (ton/d)				Max. BOD in River
No.	Name	PR	UI	RA	Total	(mg/l)	PR	UI	RA	Total	(mg/l)
1	Perlis	0	1	0	1	32	0	1	0	1	8
3	Kedah	1	3	1	5	27	0	2	1	3	10
4	Merbok	4	3	0	7	71	0	2	0	2	9
5	Muda	2	0	1	3	3	1	0	1	2	2
6	Perai	2	1	1	4	7	0	0	1	1	2
6	Juru	1	2	1	4	46	0	1	1	2	23
6	Jejawi	0	0	1	1	3	0	0	1	1	3
7	P.Pinang	4	2	1	7	-	0	2	1	3	-
Total		14	12	6	32		1	8	6	15	

2 0 0 0

Basin		Without Project					With Project				
		BOD Load into River (ton/d)				Max. BOD in River	BOD Load into River (ton/d)				Max. BOD in River
No.	Name	PR	UI	RA	Total	(mg/l)	PR	UI	RA	Total	(mg/l)
1	Perlis	0	2	0	2	80	0	1	0	0	15
3	Kedah	1	4	1	6	28	0	2	1	3	13
4	Merbok	6	4	0	10	92	0	1	0	1	12
5	Muda	2	0	0	2	4	1	0	0	1	3
6	Perai	5	1	2	8	17	0	0	2	2	3
6	Juru	0	1	1	2	23	0	0	1	1	11
6	Jejawi	0	0	2	2	5	0	0	2	2	5
7	P.Pinang	7	1	1	9	-	0	1	1	2	-
Total		21	13	7	41		1	4	7	12	

Remarks; PR: Palm oil mill and rubber factory effluent
UI: Urban domestic and urban industry effluent
RA: Rural and animal husbandry

Table 45 DIRECT CONSTRUCTION COST AND LAND ACQUISITION COST OF SEWERAGE FACILITIES IN CASE OF BUTTERWORTH PROJECT

Item	Treatment Plant Sg. Juru T.P.	 Mak Madin T.P.	 Sg. Nyor T.P.
Served Population (10^3)			
1985 & 1990		84	
Final		103	
Served Area (ha)			
1985 & 1990		1,066	
Final		1,200	
Treatment Capacity (10^3 m^3/d)			
1985 & 1990	34	14	3
Final	53	17	3
Treatment Plant Area (ha)	13.2	11.8	6.5
Construction Cost (M$$10^6$)	6.7	5.0	4.7
Land Acquisition Cost (M$$10^6$)	3.3	2.9	1.6
Sewer Length (km)		51	
Construction Cost of Sewer (M$$10^6$)		34	

Table 46 BREAKDOWN OF CONSTRUCTION COST OF PUBLIC SEWERAGE SYSTEMS FOR BUTTERWORTH AND BUKIT MERTAJAM

	Cost ($M\$10^6$)	Share (%)
Trunk Sewer	166	27
Pumping Facilities	5	1
Treatment Facilities	50	8
Land	45	7
Sub-total	266	44
Branch Sewer	281	46
House Connection Pipe	62	10
Sub-total	343	56
Total	609	100

Remarks; (1): At 1976 price
(2): Excluding engineering cost and physical contingency

Source; Ref. 2

Table 47 ASSUMED UNIT CONSTRUCTION COST FOR POLLUTANT LOAD ABATEMENT FACILITIES

Unit: M$\$10^6/100 \times 10^3$ m^3/d

Item	Public Sewerage Systems	Purification Facilities: Palm 1990	Purification Facilities: Palm 2000	Purification Facilities: Rubber 1990 & 2000	Pretreatment Facilities: Primary Pre-treatment	Pretreatment Facilities: Secondary Pre-treatment
Direct Const. Cost	77.6	300.0	270.0	112.0	31.7	193.6
Land Acquisition	10.7	-	-	-	-	-
Engineering	7.8	30.0	27.0	11.2	3.2	19.4
Sub-total	96.1	330.0	297.0	123.2	34.9	213.0
Physical Contingency	28.8	99.0	89.1	37.0	10.5	63.9
Total	121.9	429.0	386.1	160.2	45.4	276.9

Table 48 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE FOR SEWERAGE SYSTEM UNDER THE CONDITION OF 4MP

Unit: M$$10^6$

Basin No.	City/Town No.	City/Town Name	4MP	5MP	6MP	7MP	Total
1	C1	Kangar	10	23	24	17	74
3	C2	Alor Setar	32	74	83	58	247
4	C3	Sg. Petani	21	47	51	36	155
6	C4	Kulim	6	13	14	10	43
6	C5	Butterworth	24	48	49	35	156
7	C8	Georgetown	13	26	26	18	83
Total			106	231	247	174	758

Table 49 ESTIMATED PRIVATE DEVELOPMENT EXPENDITURE FOR SEWERAGE SYSTEM UNDER THE CONDITION OF 4MP

Unit: M$$10^6$

Basin No.	City/Town No.	City/Town Name	4MP	5MP	6MP	7MP	Total
1	C1	Kangar	3	13	19	13	48
3	C2	Alor Setar	5	26	41	27	99
4	C3	Sg. Petani	4	20	31	20	75
6	C4	Kulim	1	5	7	5	18
6	C5	Butterworth	3	5	5	4	17
7	C8	Georgetown	6	9	5	4	24
Total			22	78	108	73	281

Table 50 ESTIMATED PUBLIC DEVELOPMENT EXPENDITURE FOR SEWERAGE SYSTEM UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: M$$10^6$

Basin No.	City/Town No.	City/Town Name	4MP	5MP	6MP	7MP	Total
1	C1	Kangar	4	10	11	8	33
3	C2	Alor Setar	10	26	31	22	89
4	C3	Sg. Petani	7	18	21	14	60
6	C4	Kulim	4	8	9	6	27
6	C5	Butterworth	13	32	37	25	107
7	C8	Georgetown	2	9	13	9	33
Total			40	103	122	84	349

Table 51 ESTIMATED PRIVATE DEVELOPMENT EXPENDITURE FOR SEWERAGE SYSTEM UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: M$$10^6$

Basin No.	City/Town No.	City/Town Name	4MP	5MP	6MP	7MP	Total
1	C1	Kangar	1	3	4	3	11
3	C2	Alor Setar	1	2	3	2	8
4	C3	Sg. Petani	1	3	4	3	11
6	C4	Kulim	1	2	2	1	6
6	C5	Butterworth	1	1	0	0	2
7	C8	Georgetown	0	0	0	0	0
Total			5	11	13	9	38

Table 52 ESTIMATED PRIVATE DEVELOPMENT EXPENDITURE FOR PURIFICATION SYSTEM IN RUBBER FACTORIES UNDER THE CONDITION OF 4MP AND LOWER ECONOMIC GROWTH

Unit: M$$10^6$

Basin No.	Basin Name	4MP	5MP	6MP	7MP	Total
3	Kedah	0.5	0.5	0.2	0.1	1.3
4	Merbok	5.9	7.1	3.4	2.4	18.8
5	Muda	0.9	1.0	0.3	0.2	2.4
6	Perai	3.9	6.1	4.6	2.8	17.4
7	P.Pinang	2.5	3.4	2.1	1.4	9.4
Total		13.7	18.1	10.6	6.9	49.3

Table 53 BENEFICIAL AND ADVERSE EFFECTS OF WATER POLLUTION ABATEMENT PLAN UNDER THE CONDITION OF 4MP

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Sewerage	(M$ 10^6)	170
Saving in pre-treatment for D&I water supply	(M$ 10^6)	0
Total	(M$ 10^6)	170
1.2 Economic Cost		
Sewerage	(M$ 10^6)	240
Private purification facilities	(M$ 10^6)	27
Pre-treatment for D&I water supply	(M$ 10^6)	0
Total	(M$ 10^6)	267
1.3 EIRR	(%)	-
2. Environmental Quality		
2.1 Beneficial Effects		
Reduction in length of river stretch where BOD concentration is more than 10 mg/l in 2000 (see Table 55)	(km)	52
3. Social Well-Being		
3.1 Beneficial Effects		
Number of people served by proposed sewerage system in 2000	(10^3)	250
3.2 Adverse Effect		-

Table 54 BENEFICIAL AND ADVERSE EFFECTS OF WATER POLLUTION ABATEMENT PLAN UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Item		Amount
1. National Economic Development		
1.1 Economic Benefit		
Sewerage	($M\$10^6$)	47
Saving in pre-treatment for D&I water supply	($M\$10^6$)	0
Total	($M\$10^6$)	47
1.2 Economic Cost		
Sewerage	($M\$10^6$)	104
Private purification facilities	($M\$10^6$)	27
Pre-treatment for D&I water supply	($M\$10^6$)	0
Total	($M\$10^6$)	131
1.3 EIRR	(%)	-
2. Environmental Quality		
2.1 Beneficial Effects		
Reduction in length of river stretch where BOD concentration is more than 10 mg/l in 2000 (see Table 56)	(km)	52
3. Social Well-Being		
3.1 Beneficial Effects		
Number of people served by proposed sewerage system in 2000	(10^3)	153
3.2 Adverse Effect		

Table 55 LENGTH OF RIVER STRETCHES WHERE BOD CONCENTRATION IS MORE THAN 10 MG/L WITH AND WITHOUT PROJECT UNDER THE CONDITION OF 4MP

Unit: km

Basin No.	Basin Name	Studied Length	Length of Stretch where BOD Concentration is more than 10 mg/l: 1990 Without	1990 With	2000 Without	2000 With
1	Perlis	33	10	0	10	0
3	Kedah	102	12	0	12	0
4	Merbok	22	22	0	22	0
5	Muda	164	0	0	0	0
6	Perai	40	0	0	8	0
Total		361	44	0	52	0

Table 56 LENGTH OF RIVER STRETCHES WHERE BOD CONCENTRATION IS MORE THAN 10 MG/L WITH AND WITHOUT PROJECT UNDER THE CONDITION OF LOWER ECONOMIC GROWTH

Unit: km

Basin No.	Basin Name	Studied Length	Length of Stretch where BOD Concentration is more than 10 mg/l: 1990 Without	1990 With	2000 Without	2000 With
1	Perlis	33	10	0	10	0
3	Kedah	102	12	0	12	0
4	Merbok	22	22	0	22	0
5	Muda	164	0	0	0	0
6	Perai	40	0	0	8	0
Total		361	44	0	52	0

Table 57 ESTIMATED MANPOWER REQUIREMENT FOR PUBLIC SEWERAGE SYSTEMS BY CITY UNDER THE CONDITION OF 4MP (1/2)

Category	Construction				O & M			
	4MP	5MP	6MP	7MP	4MP	5MP	6MP	7MP
C1 Kangar								
Engineer	1	1	1	1	0	1	1	1
T. Assistant	1	1	1	1	0	1	1	1
Technician	1	1	1	1	0	2	4	6
Others	1	1	1	1	0	2	5	8
Total Government Staff	4	4	4	4	0	6	11	16
C2 Alor Setar								
Engineer	1	1	1	1	0	1	2	3
T. Assistant	1	1	1	1	0	1	2	4
Technician	1	1	1	1	0	5	12	19
Others	1	1	1	1	0	7	16	25
Total Government Staff	4	4	4	4	0	14	32	51
C3 Sg. Petani								
Engineer	1	1	1	1	0	1	1	2
T. Assistant	1	1	1	1	0	1	2	2
Technician	1	1	1	1	0	4	8	12
Others	1	1	1	1	0	5	10	16
Total Government Staff	4	4	4	4	0	11	21	32

Table 58 ESTIMATED MANPOWER REQUIREMENT FOR PUBLIC SEWERAGE SYSTEMS BY CITY UNDER THE CONDITION OF 4MP (2/2)

Category	Construction				O & M			
	4MP	5MP	6MP	7MP	4MP	5MP	6MP	7MP
C4 Kulim								
Engineer	1	1	1	1	0	1	1	1
T. Assistant	1	1	1	1	0	1	1	1
Technician	1	1	1	1	0	1	2	3
Others	1	1	1	1	0	1	2	4
Total Government Staff	4	4	4	4	0	4	6	9
C5 Butterworth								
Engineer	1	1	1	1	0	1	1	1
T. Assistant	1	1	1	1	0	1	1	2
Technician	1	1	1	1	0	4	6	9
Others	1	1	1	1	0	5	8	12
Total Government Staff	4	4	4	4	0	11	16	24
C8 Georgetown								
Engineer	1	1	1	1	1	1	1	2
T. Assistant	1	1	1	1	1	2	2	2
Technician	1	1	1	1	6	7	8	10
Others	1	1	1	1	8	9	11	13
Total Government Staff	4	4	4	4	16	19	22	27

Table 59 ESTIMATED MANPOWER REQUIREMENT FOR PUBLIC SEWERAGE SYSTEMS BY CITY UNDER THE CONDITION OF LOWER ECONOMIC GROWTH (1/2)

Category	Construction				O & M			
	4MP	5MP	6MP	7MP	4MP	5MP	6MP	7MP
C1 Kangar								
Engineer	1	1	1	1	0	1	1	1
T. Assistant	1	1	1	1	0	1	1	1
Technician	1	1	1	1	0	1	2	2
Others	1	1	1	1	0	1	2	3
Total Government Staff	4	4	4	4	0	4	6	7
C2 Alor Setar								
Engineer	1	1	1	1	0	1	1	1
T. Assistant	1	1	1	1	0	1	1	1
Technician	1	1	1	1	0	2	4	6
Others	1	1	1	1	0	3	5	8
Total Government Staff	4	4	4	4	0	7	11	16
C3 Sg. Petani								
Engineer	1	1	1	1	0	1	1	1
T. Assistant	1	1	1	1	0	1	1	1
Technician	1	1	1	1	0	2	3	4
Others	1	1	1	1	0	2	4	5
Total Government Staff	4	4	4	4	0	6	9	11

Table 60 ESTIMATED MANPOWER REQUIREMENT FOR PUBLIC SEWERAGE SYSTEMS BY CITY UNDER THE CONDITION OF LOWER ECONOMIC GROWTH (2/2)

Category	Construction				O & M			
	4MP	5MP	6MP	7MP	4MP	5MP	6MP	7MP
C4 Kulim								
Engineer	1	1	1	1	0	1	1	1
T. Assistant	1	1	1	1	0	1	1	1
Technician	1	1	1	1	0	1	1	1
Others	1	1	1	1	0	1	1	2
Total Government Staff	4	4	4	4	0	4	4	5
C5 Butterworth								
Engineer	1	1	1	1	0	1	1	1
T. Assistant	1	1	1	1	0	1	1	1
Technician	1	1	1	1	0	3	4	6
Others	1	1	1	1	0	4	6	7
Total Government Staff	4	4	4	4	0	9	12	15
C8 Georgetown								
Engineer	1	1	1	1	1	1	1	1
T. Assistant	1	1	1	1	1	1	1	1
Technician	1	1	1	1	5	5	6	6
Others	1	1	1	1	6	7	8	8
Total Government Staff	4	4	4	4	13	14	16	16

FIGURES

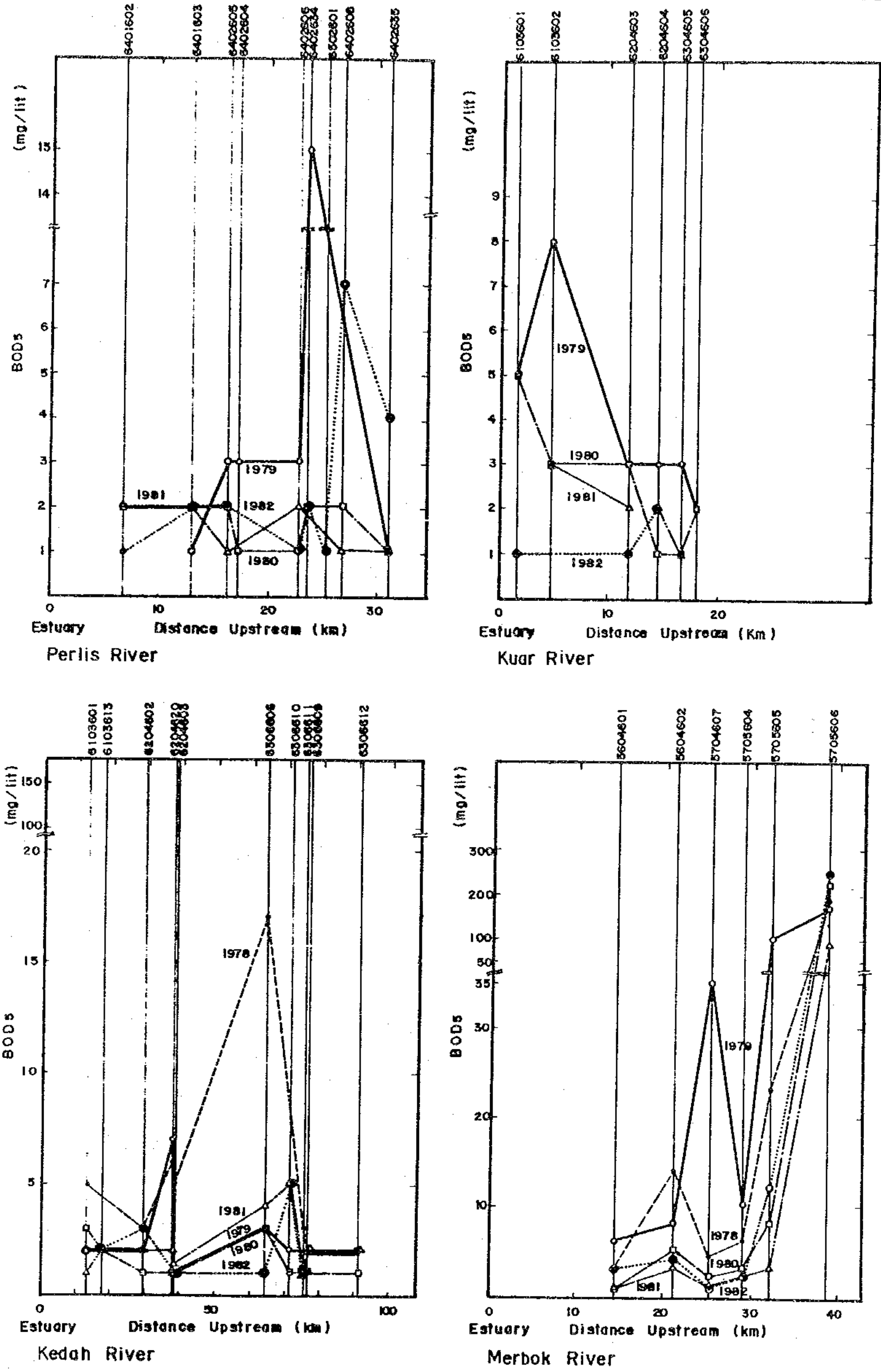

Fig. 1 Distribution of Mean BOD_5 Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (1/2)

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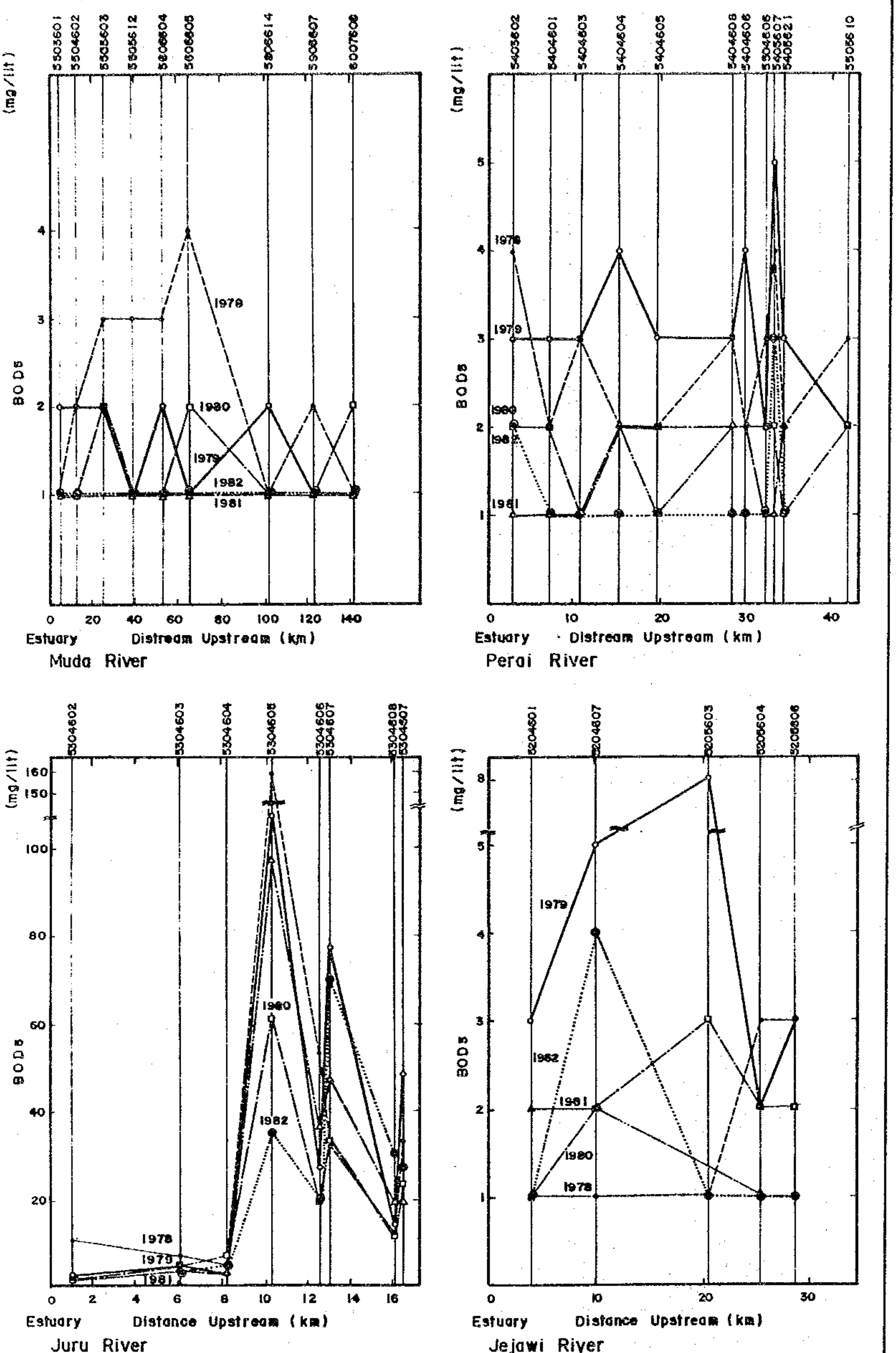

Fig. 2 Distribution of Mean BOD5 Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (2/2)

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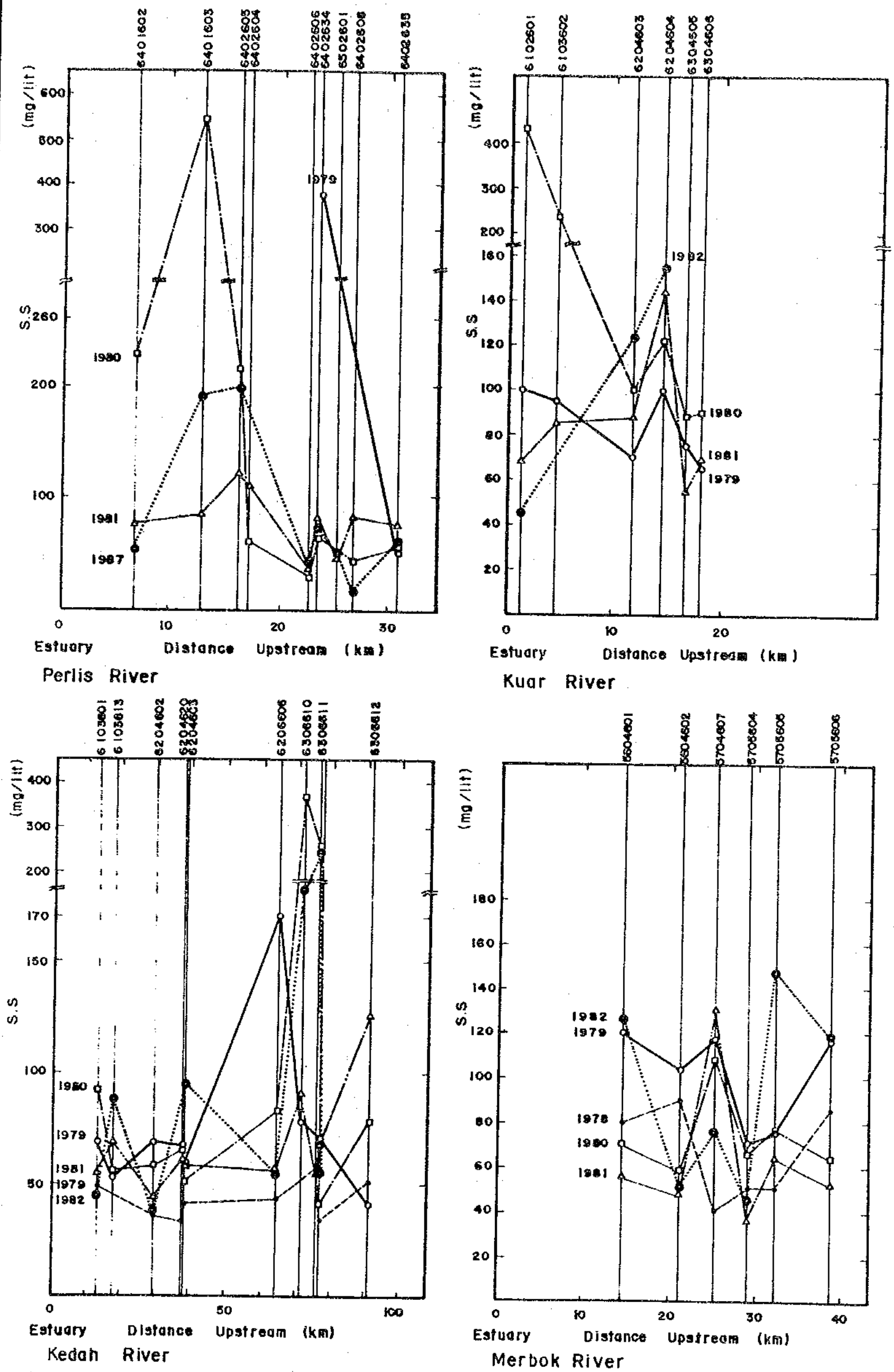

Fig. 3 Distribution of Mean S.S Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (1/2)

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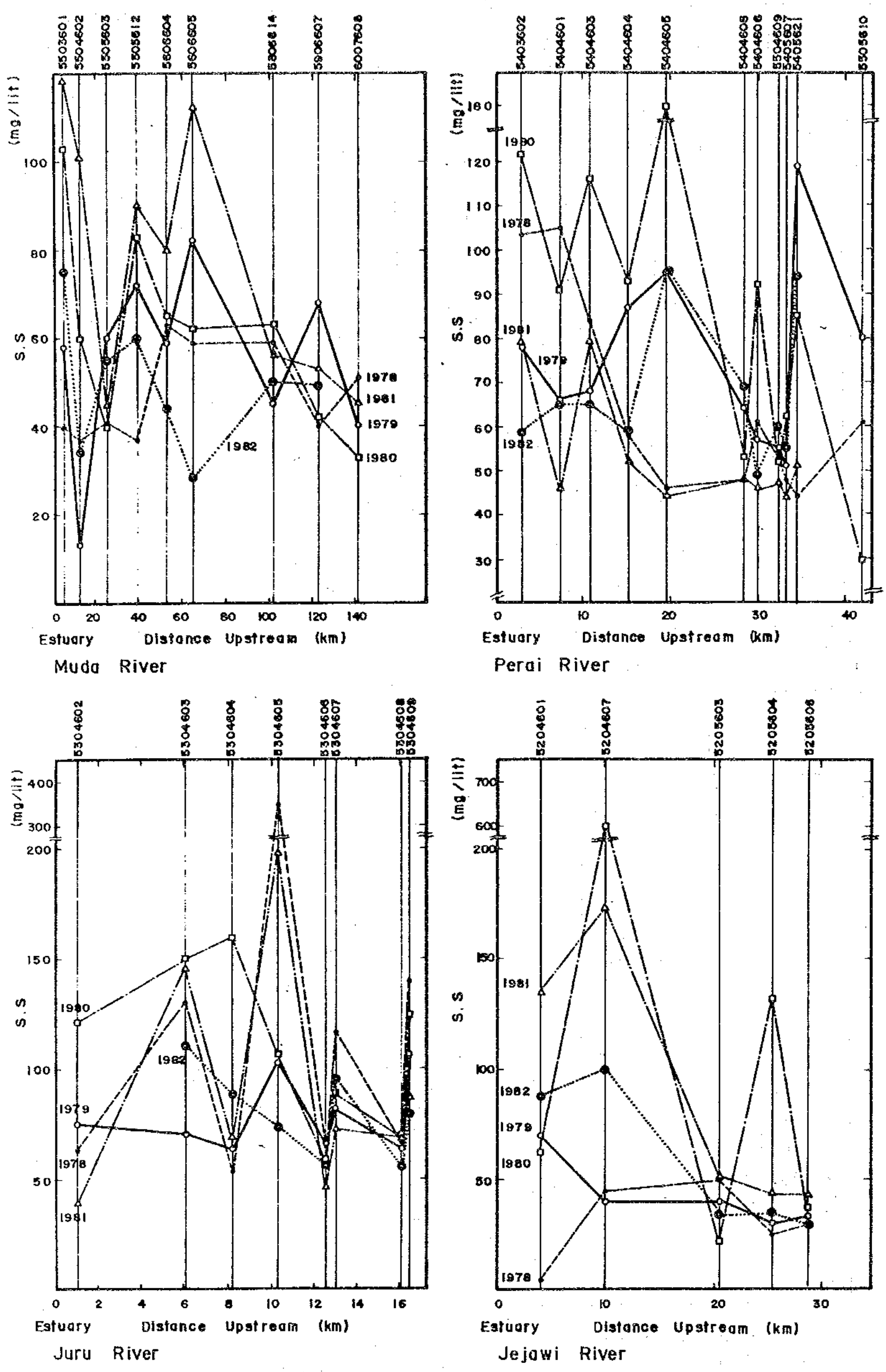

Fig. 4 Distribution of Mean S.S Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (2/2)

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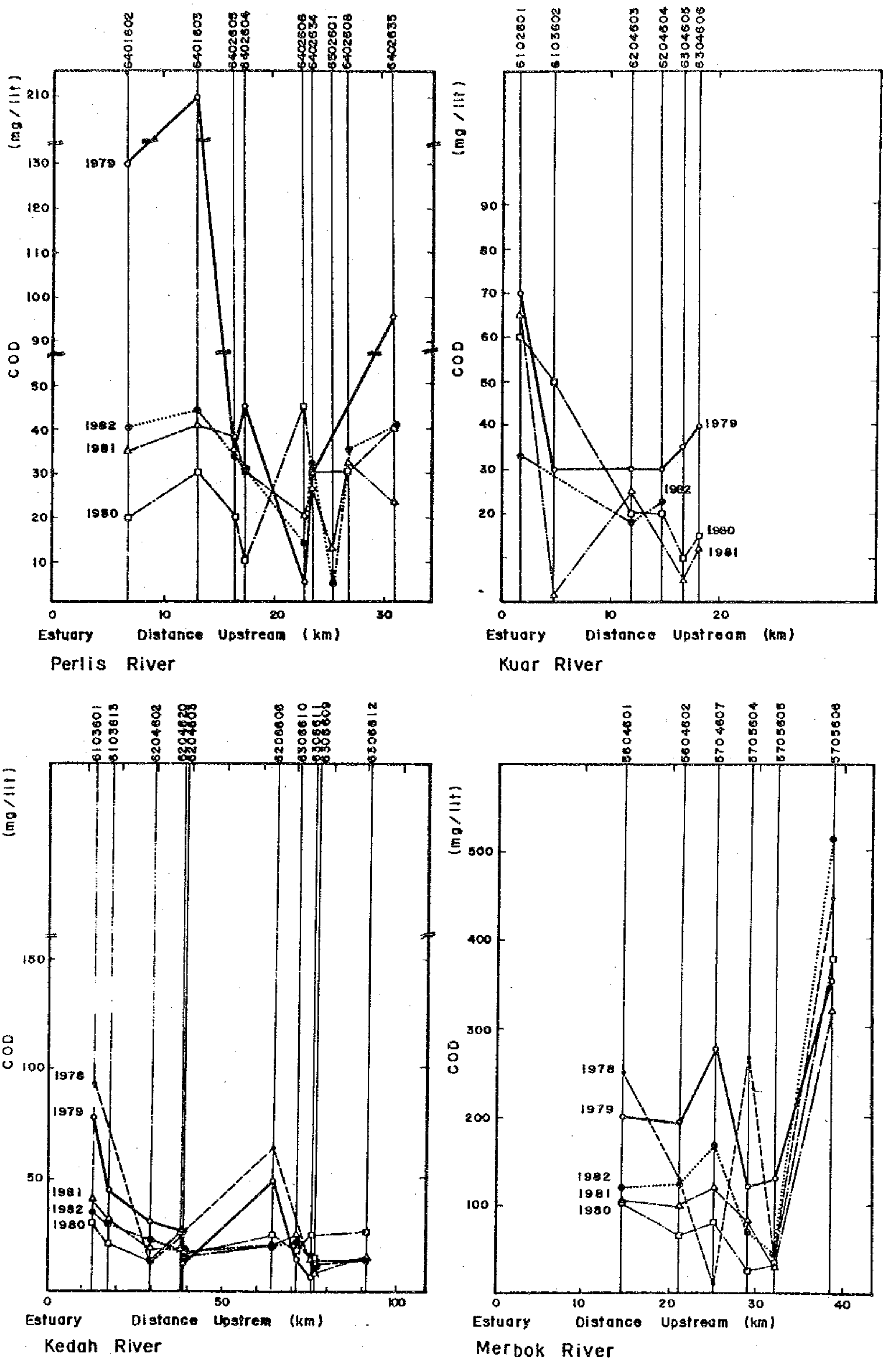

Fig. 5 Distribution of Mean COD Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (1/2)

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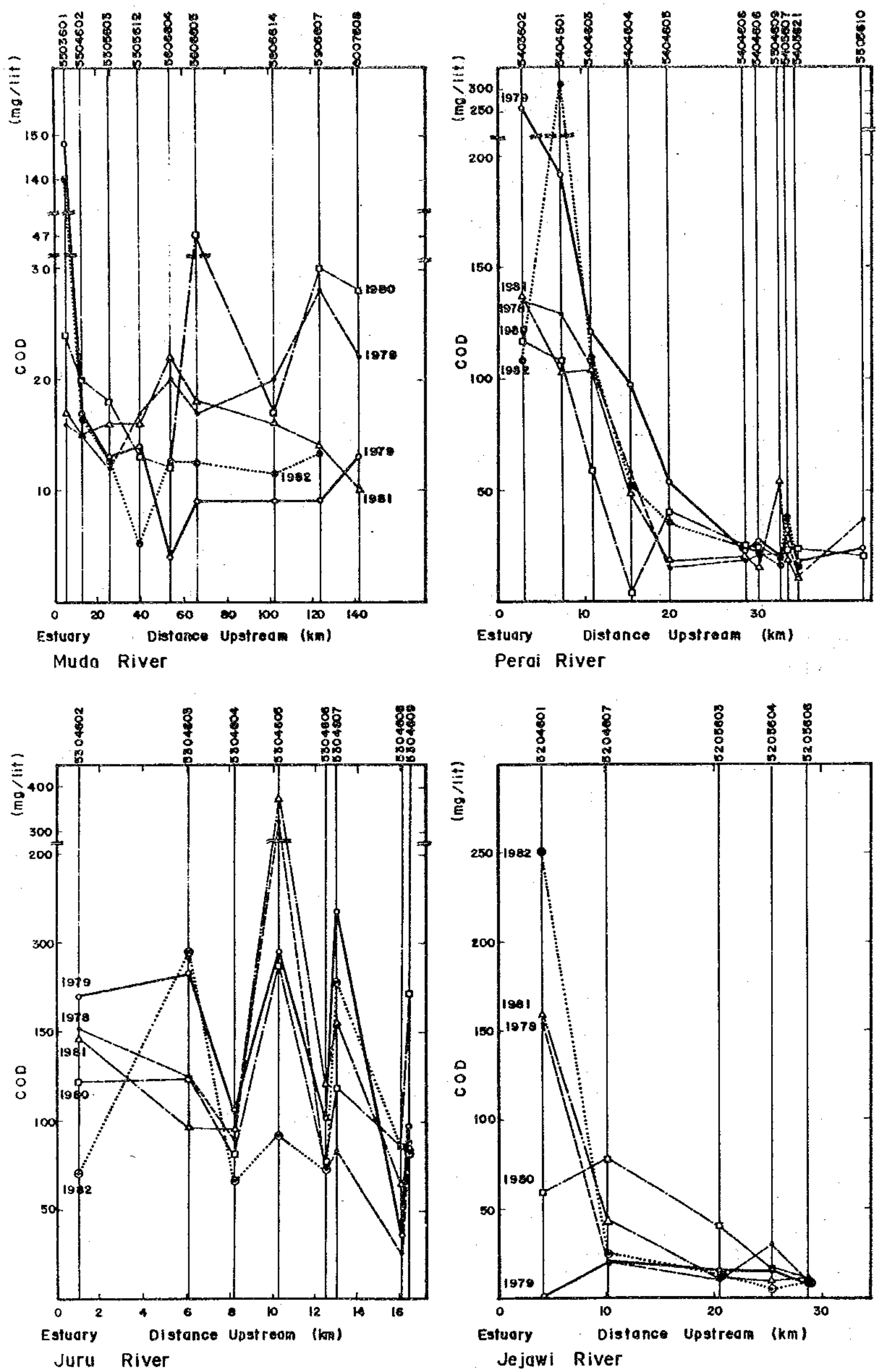

Fig. 6 Distribution of Mean COD Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (2/2)

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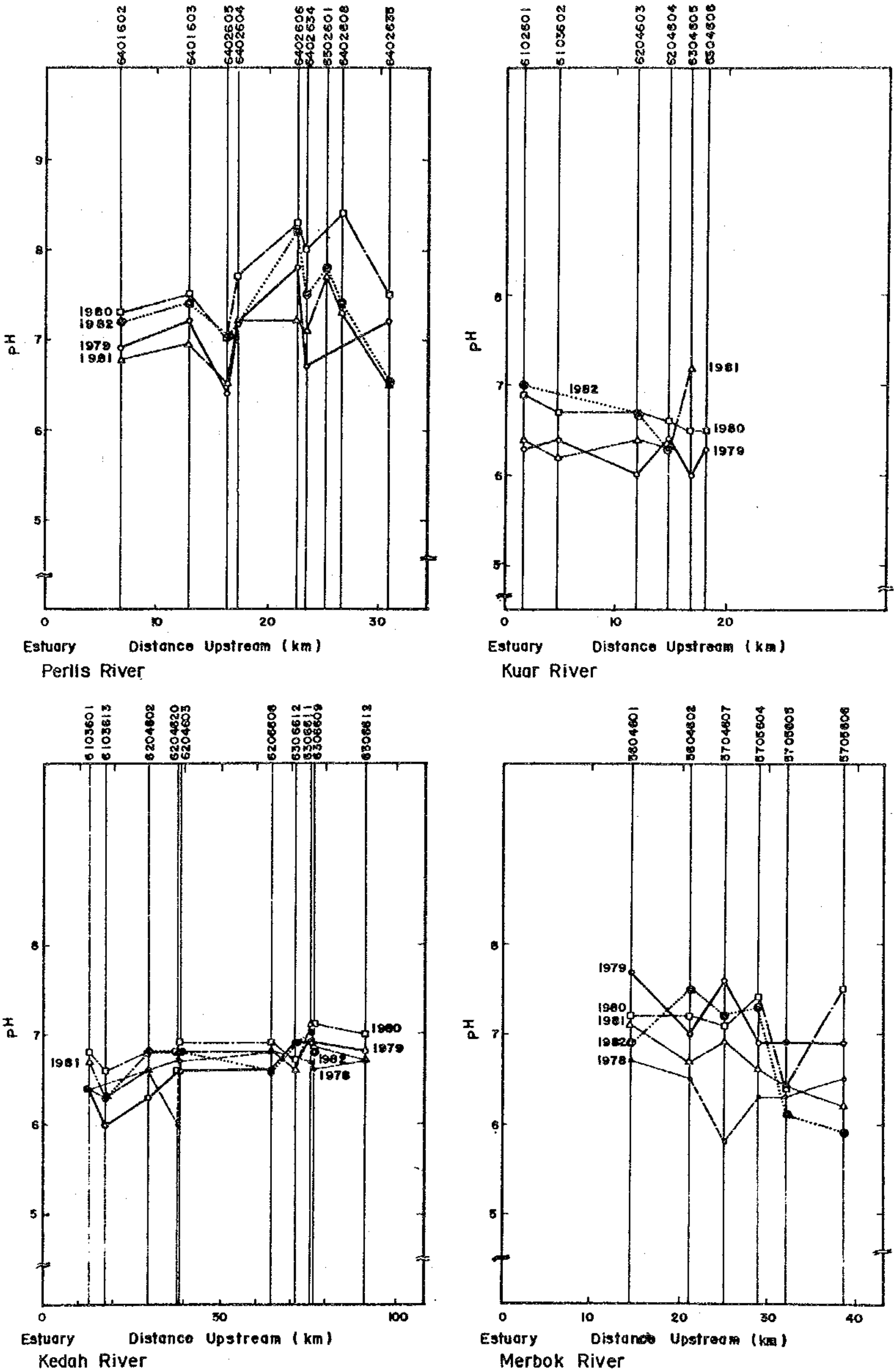

Fig. 7 Distribution of Mean pH Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (1/2)

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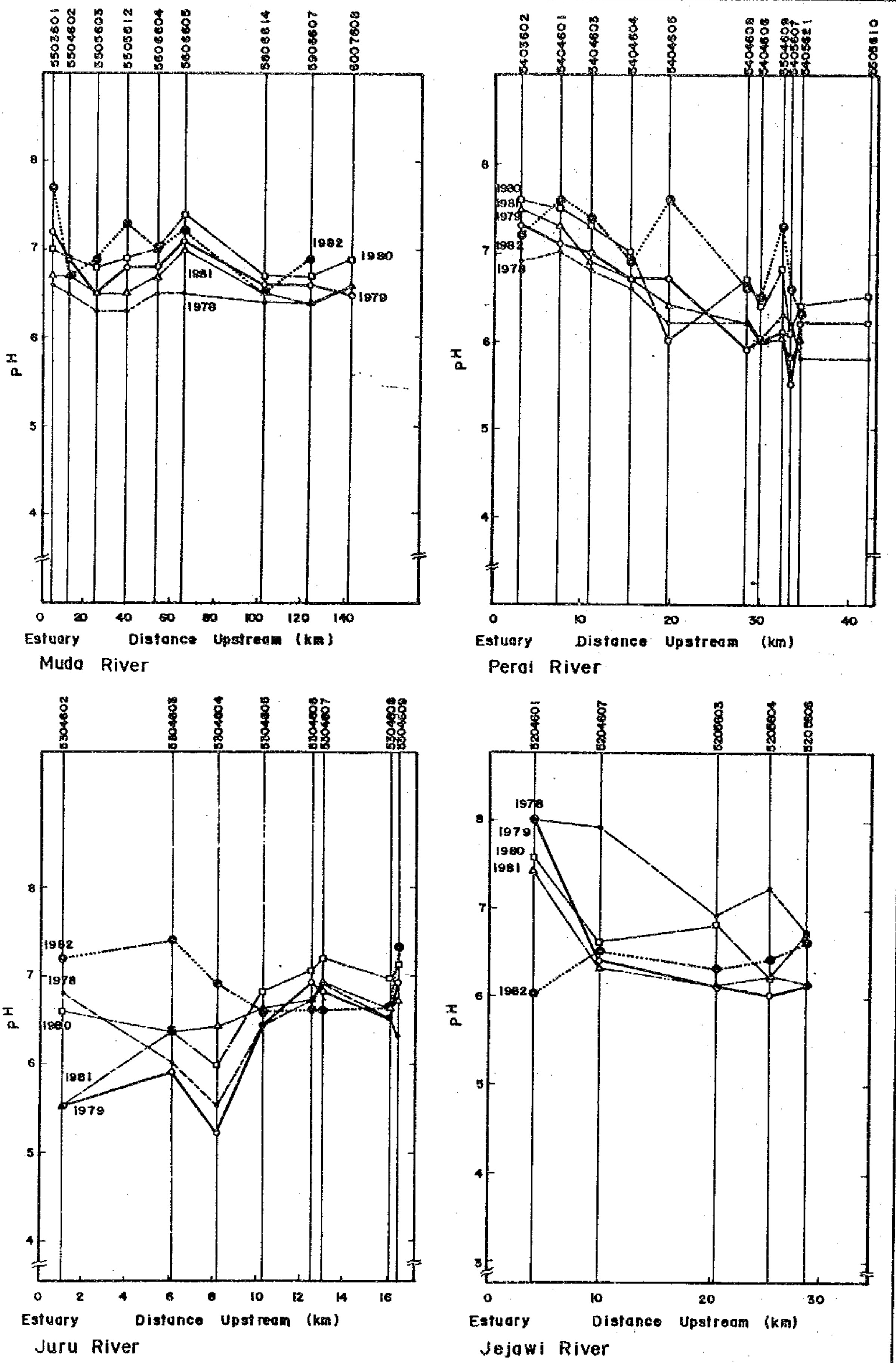

Fig. 8 Distribution of Mean pH Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (2/2)

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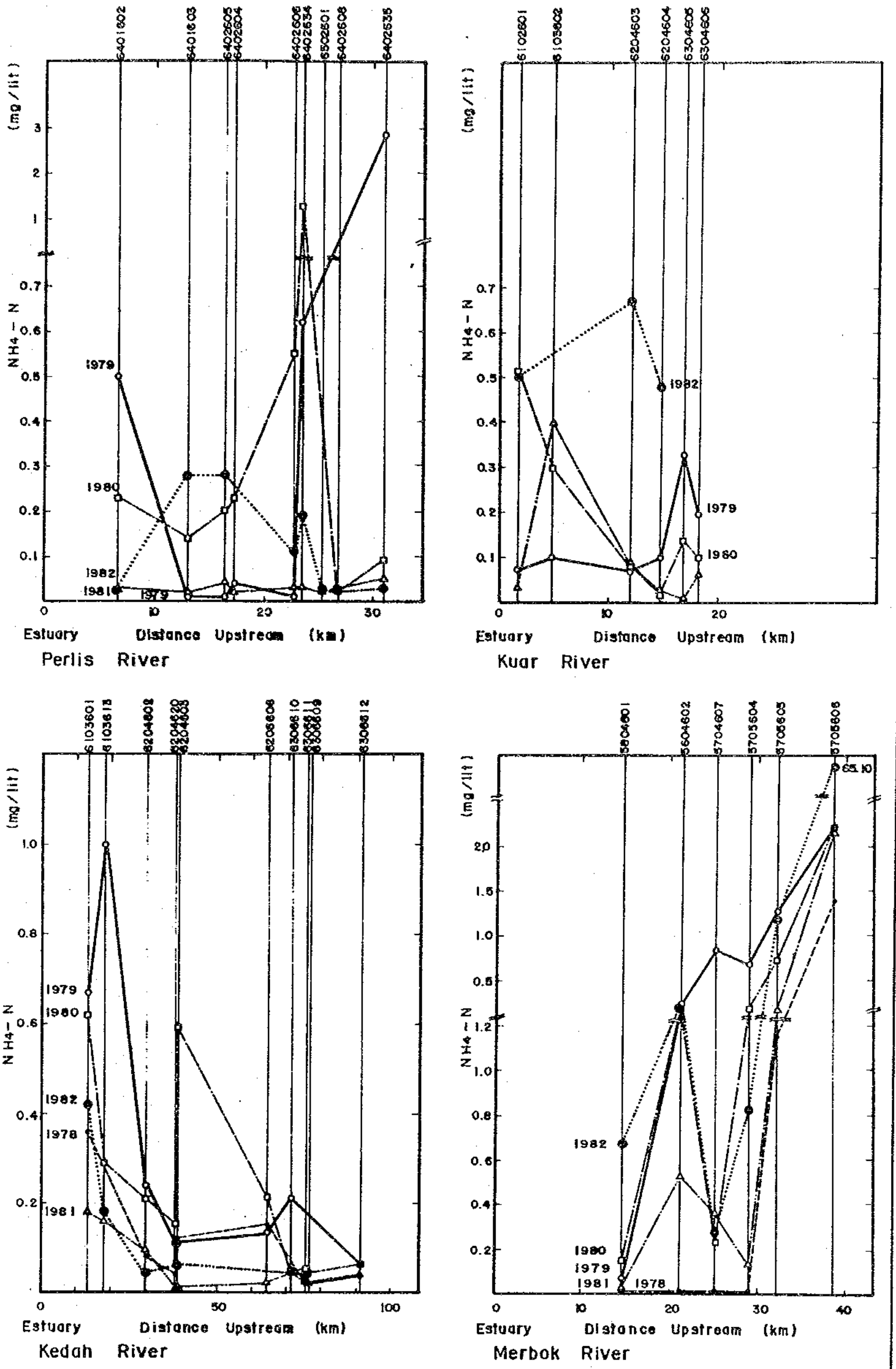

Fig. 9 Distribution of Mean NH4-N Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (1/2)

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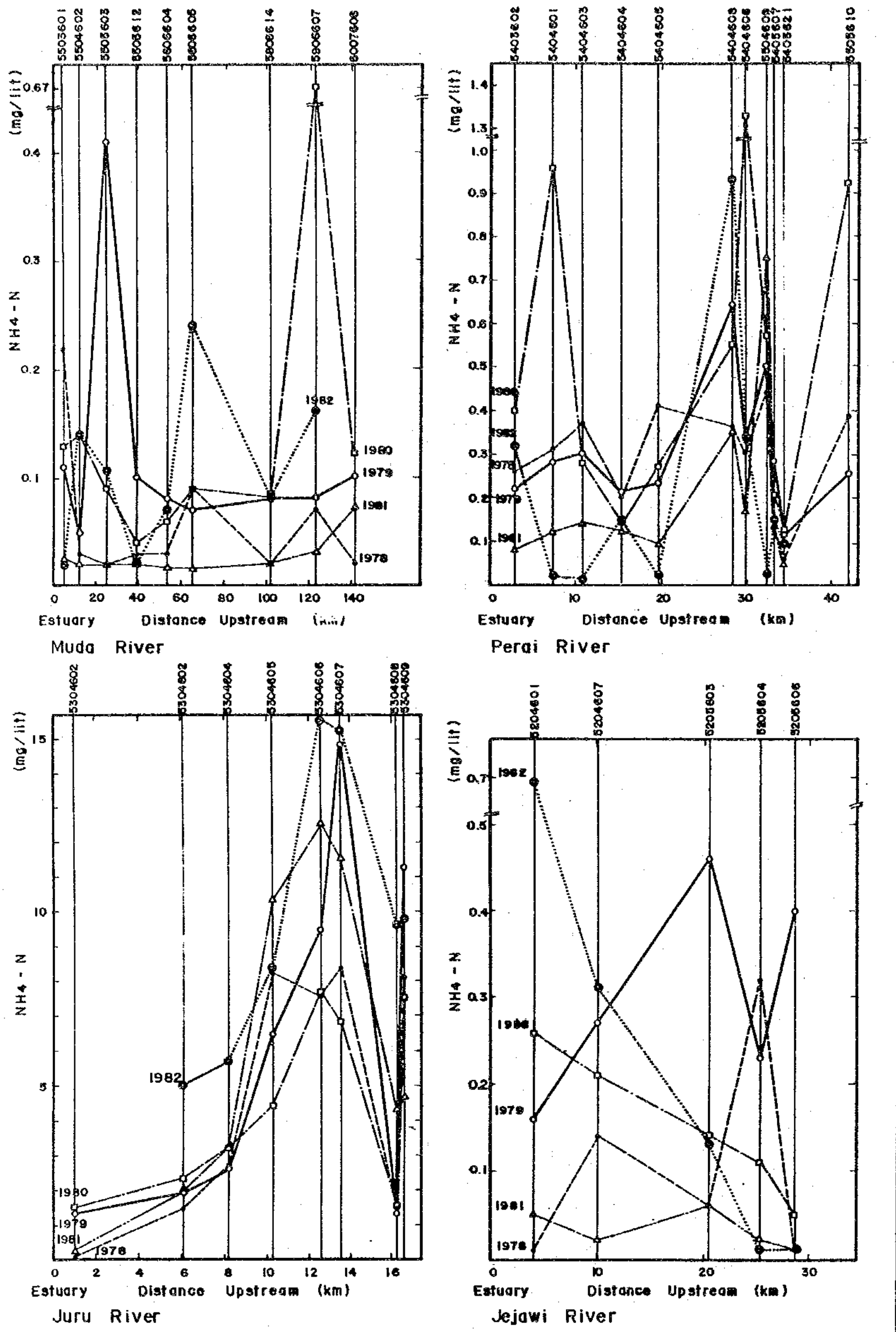

Fig. 10 Distribution of Mean NH4-N Levels by WQMS in 1978, 1979, 1980, 1981 and 1982 (2/2)

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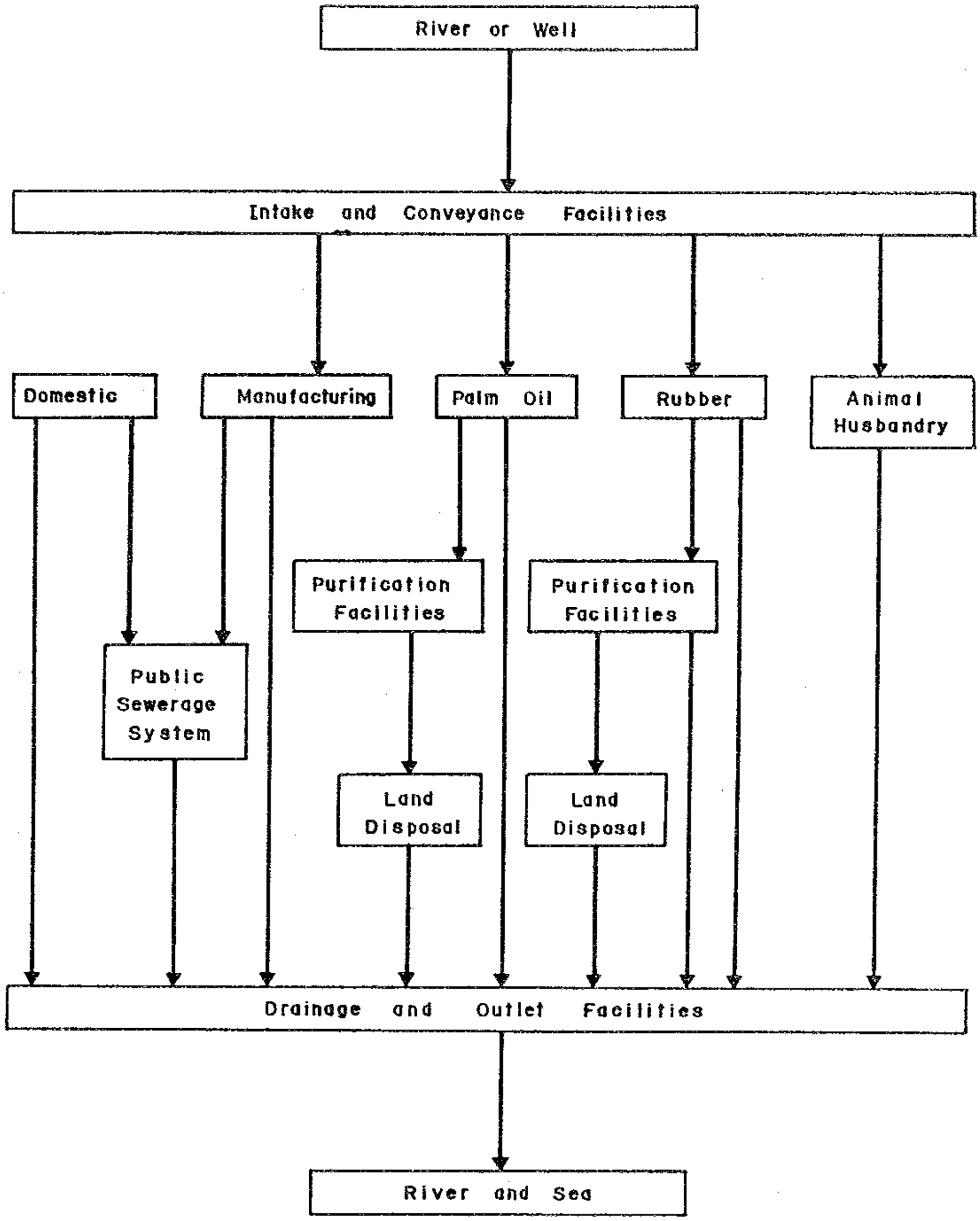

Fig. 11 Composition of Pollution Sources

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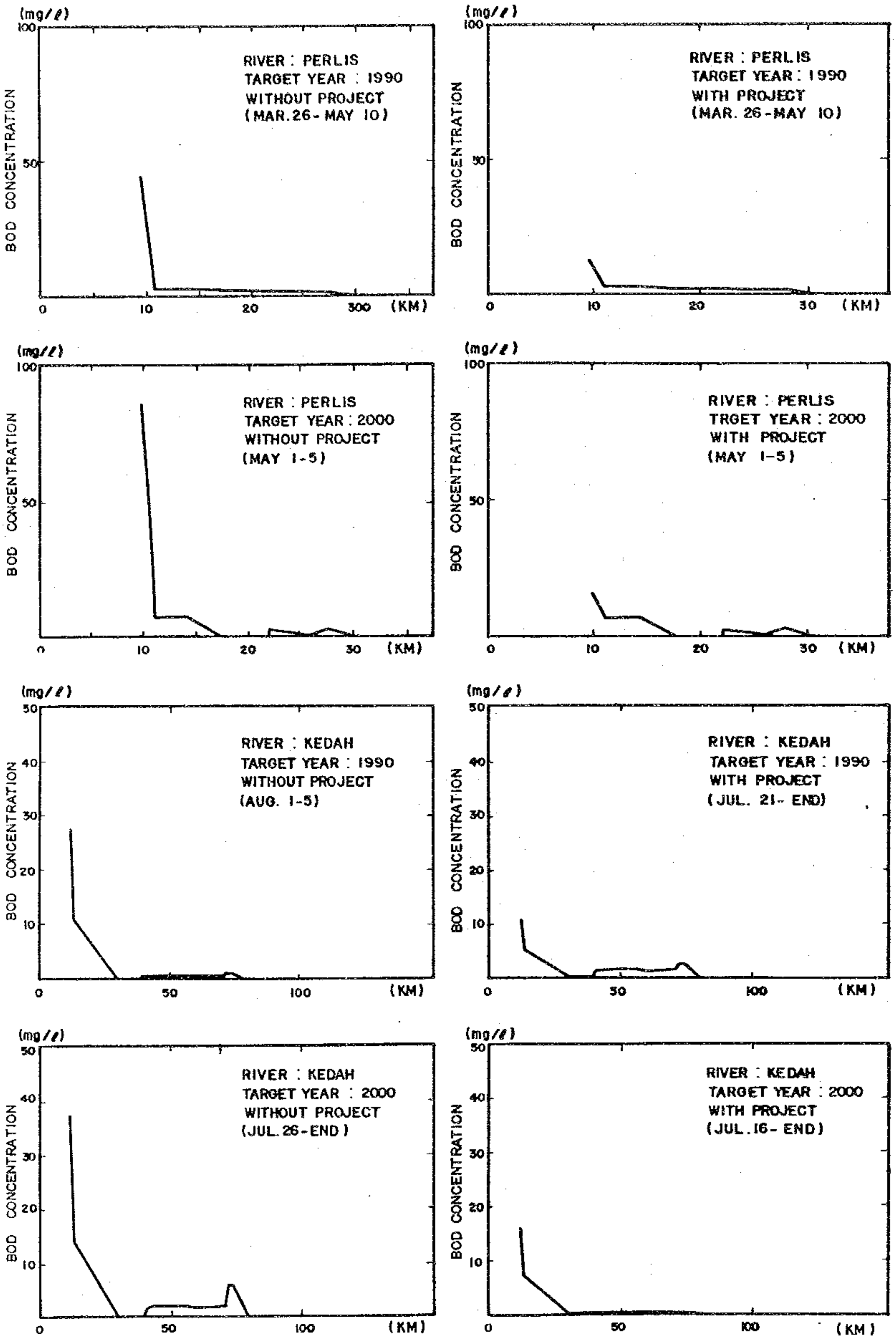

Fig. 12 Distribution of Projected BOD Concentration in 1990 and 2000 Under the Condition of 4MP (1/3)

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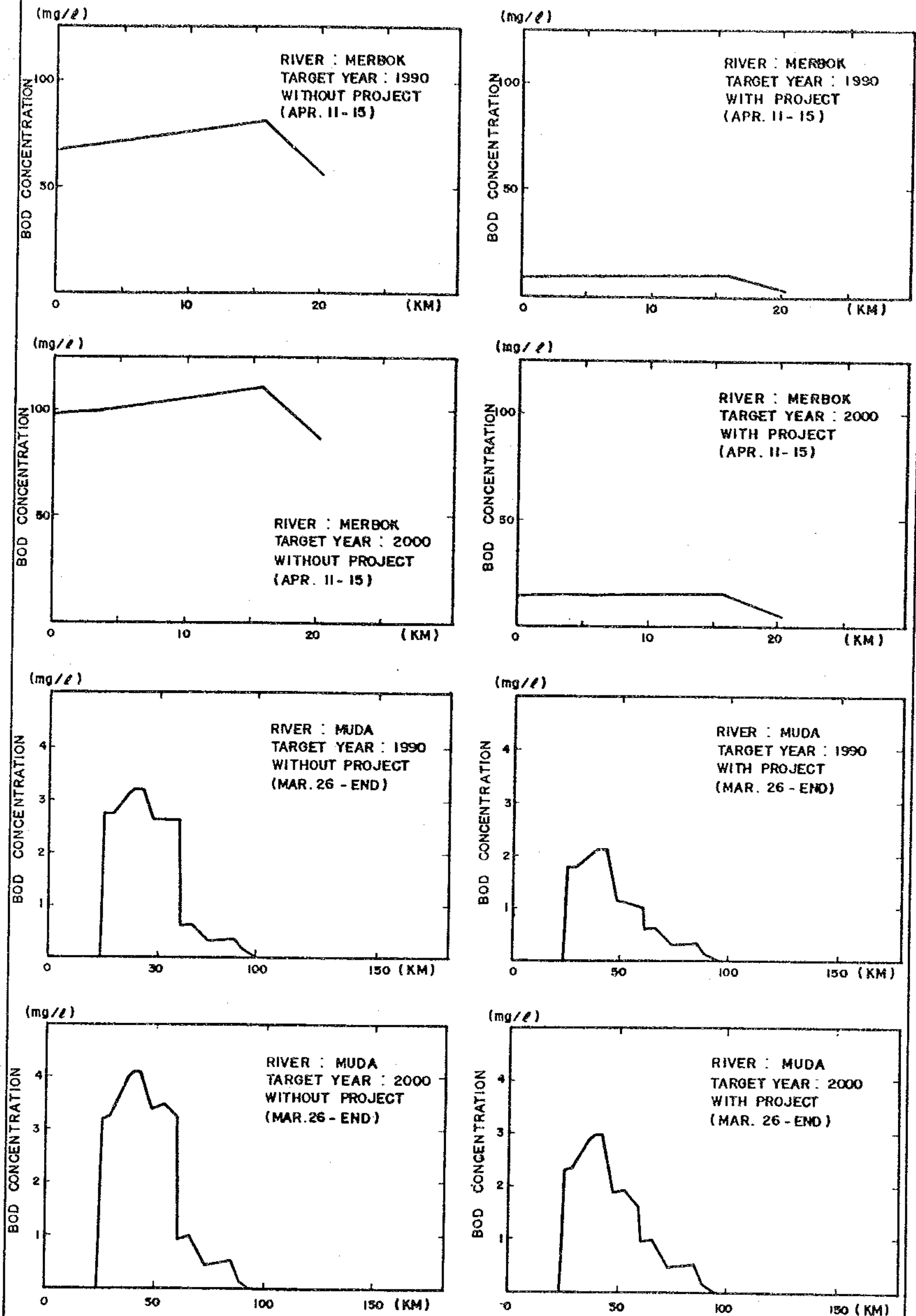

Fig. 13 Distribution of Projected BOD Concentration in 1990 and 2000 Under the Condition of 4MP (2/3)

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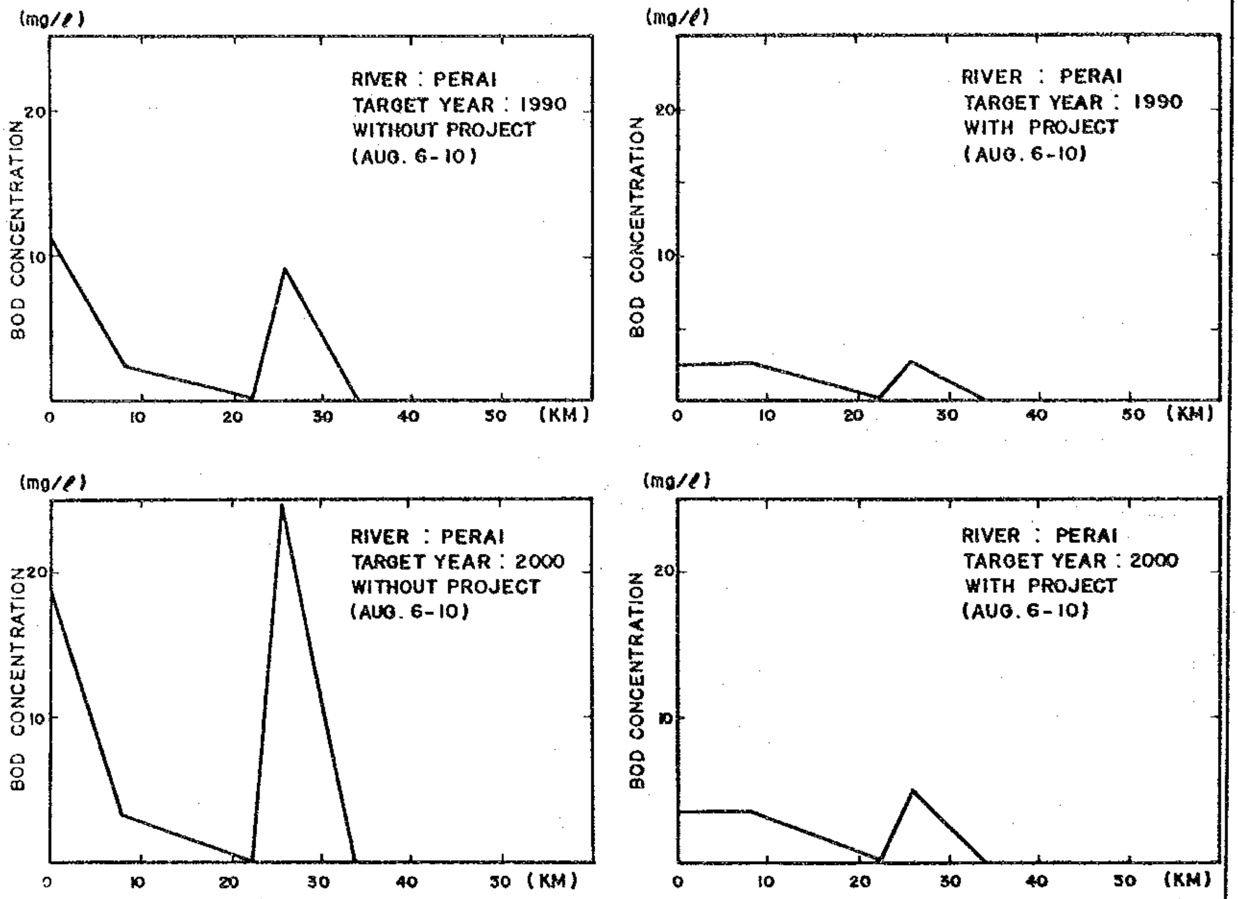

Fig. 14 Distribution of Projected BOD Concentration in 1990 and 2000 Under the Condition of 4MP (3/3)

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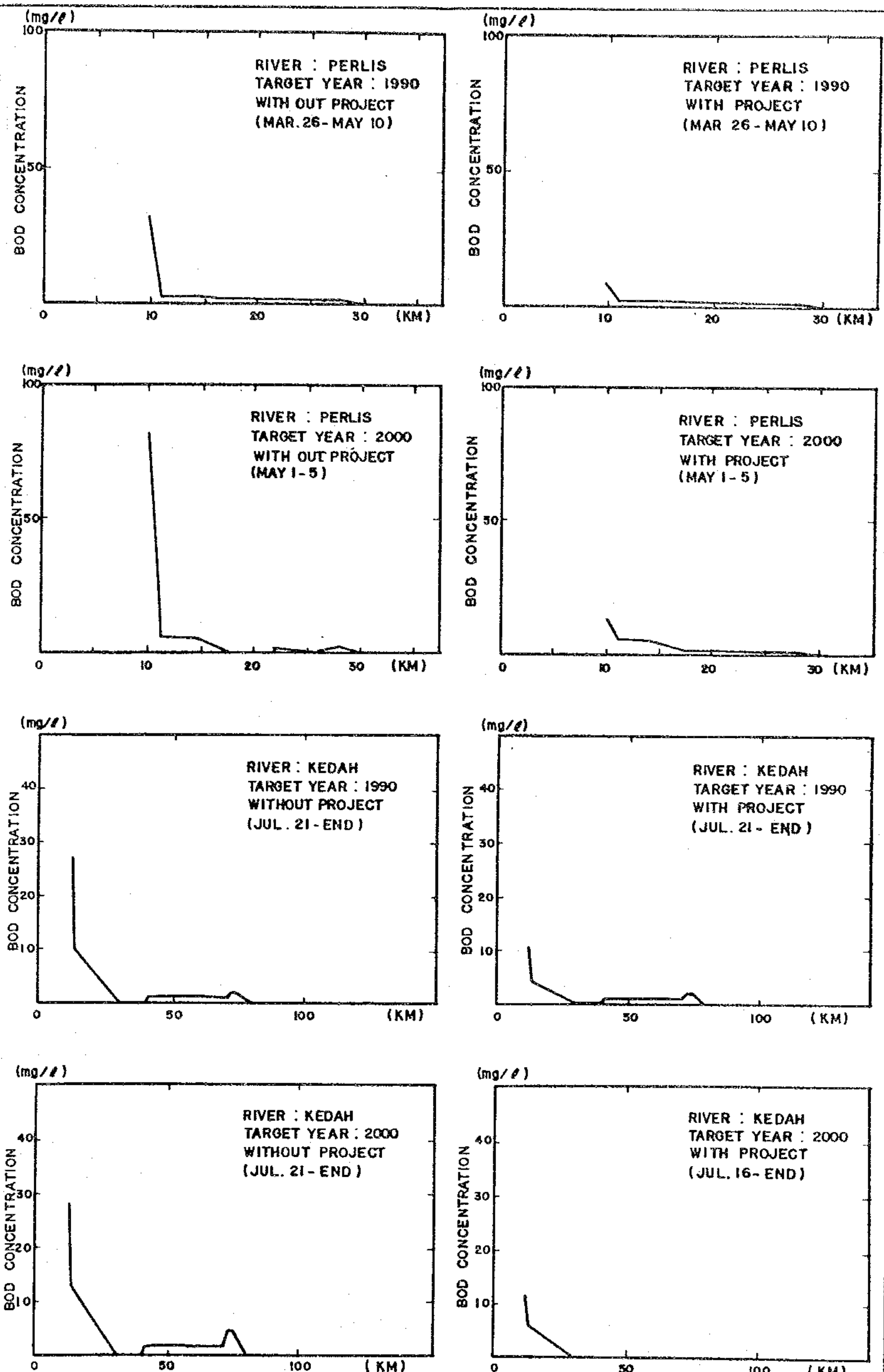

Fig. 15 Distribution of Projected BOD Concentration in 1990 and 2000 Under the Condition of Lower Economic Growth (1/3)

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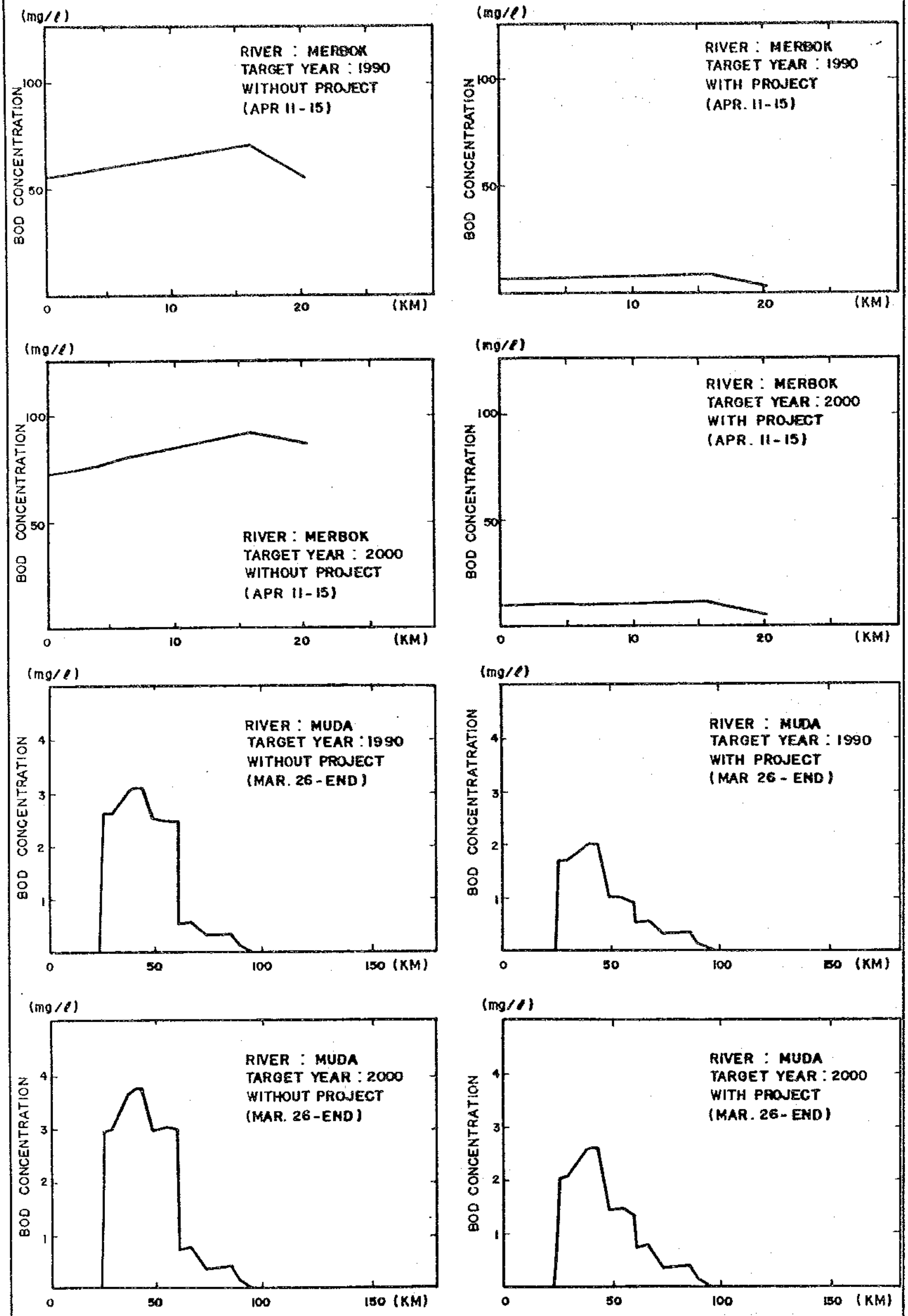

Fig. 16 Distribution of Projected BOD Concentration in 1990 and 2000 Under the Condition of Lower Economic Growth (2/3)

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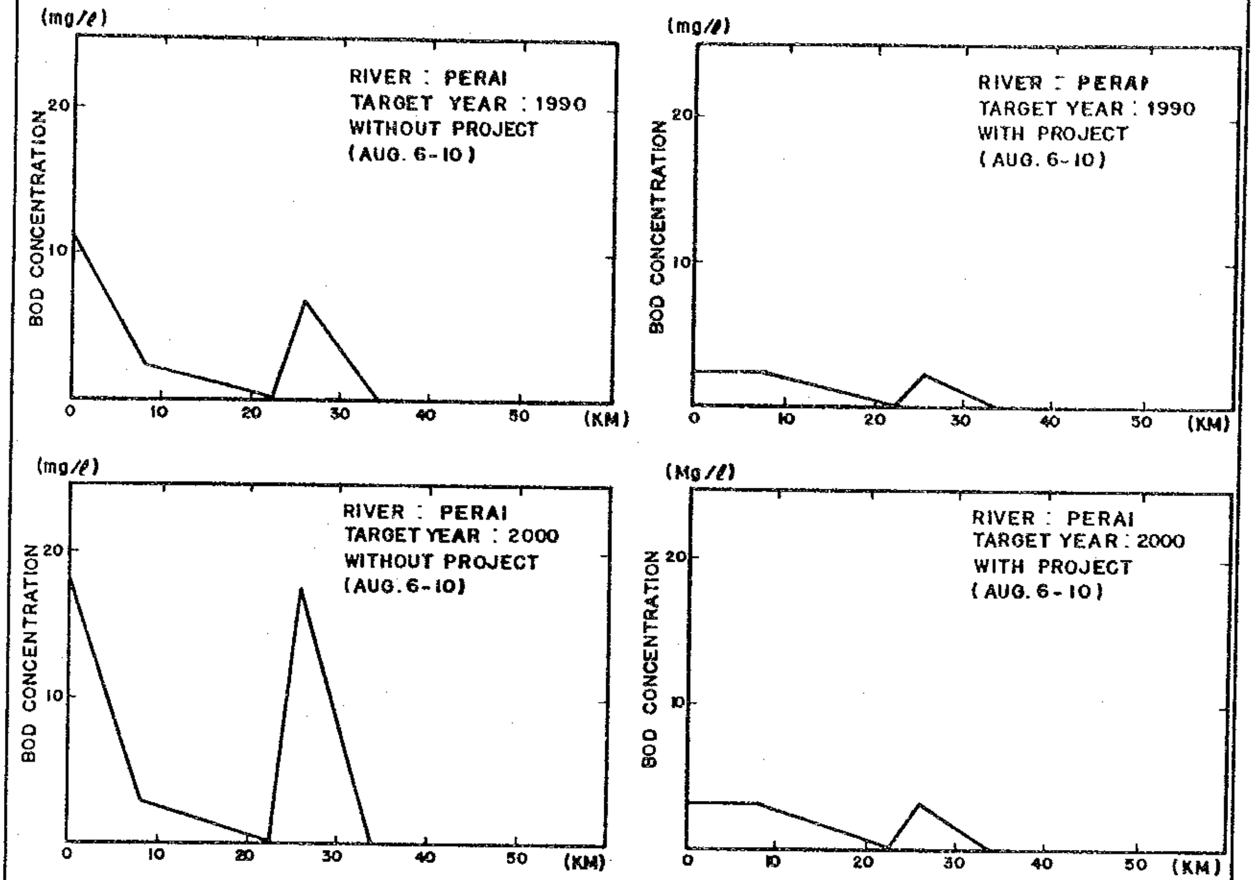

Fig. 17 Distribution of Projected BOD Concentration in 1990 and 2000 Under the Condition of Lower Economic Growth (3/3)

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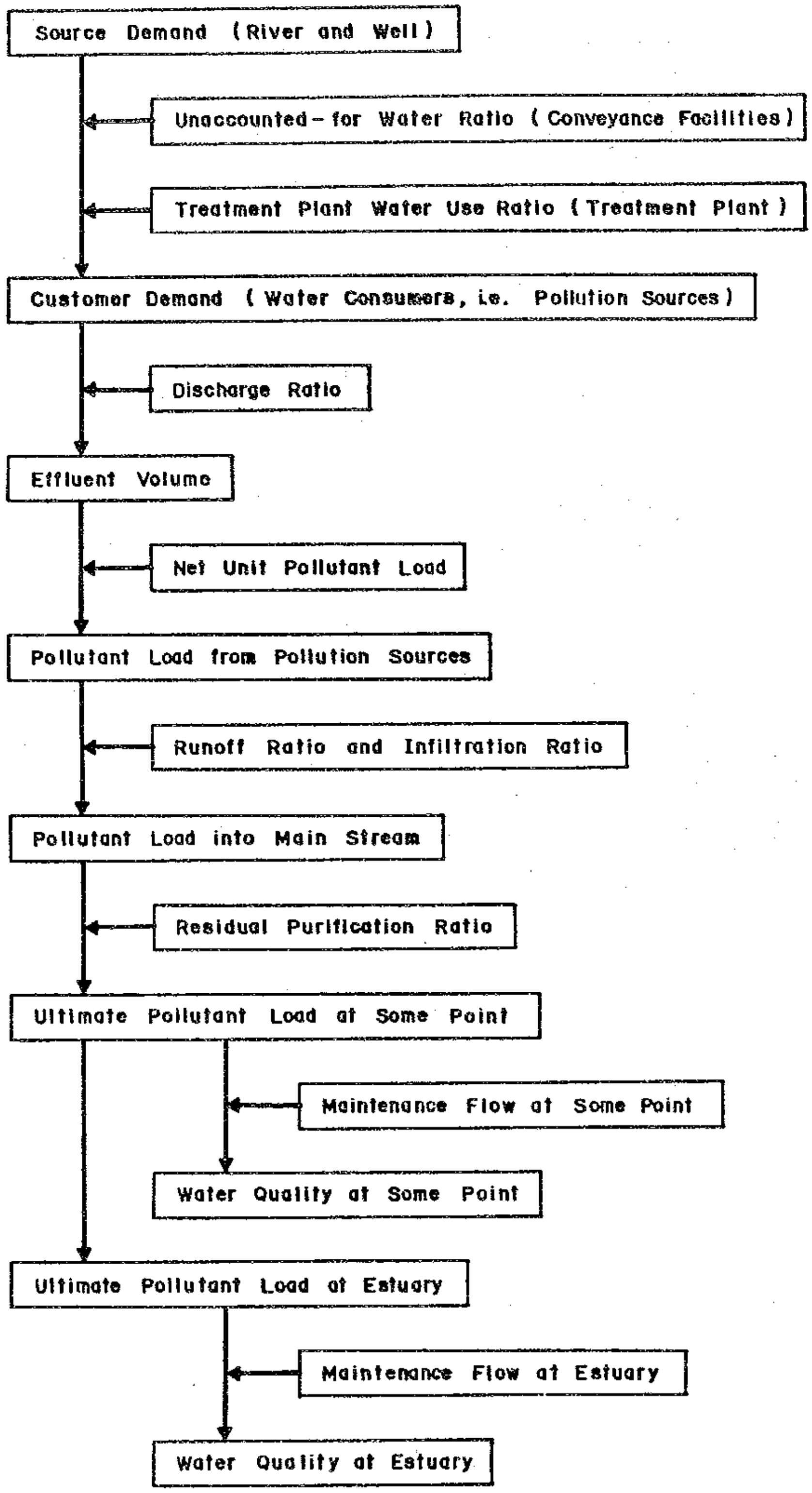

Fig. 18 Water Quality Projection Flow Chart

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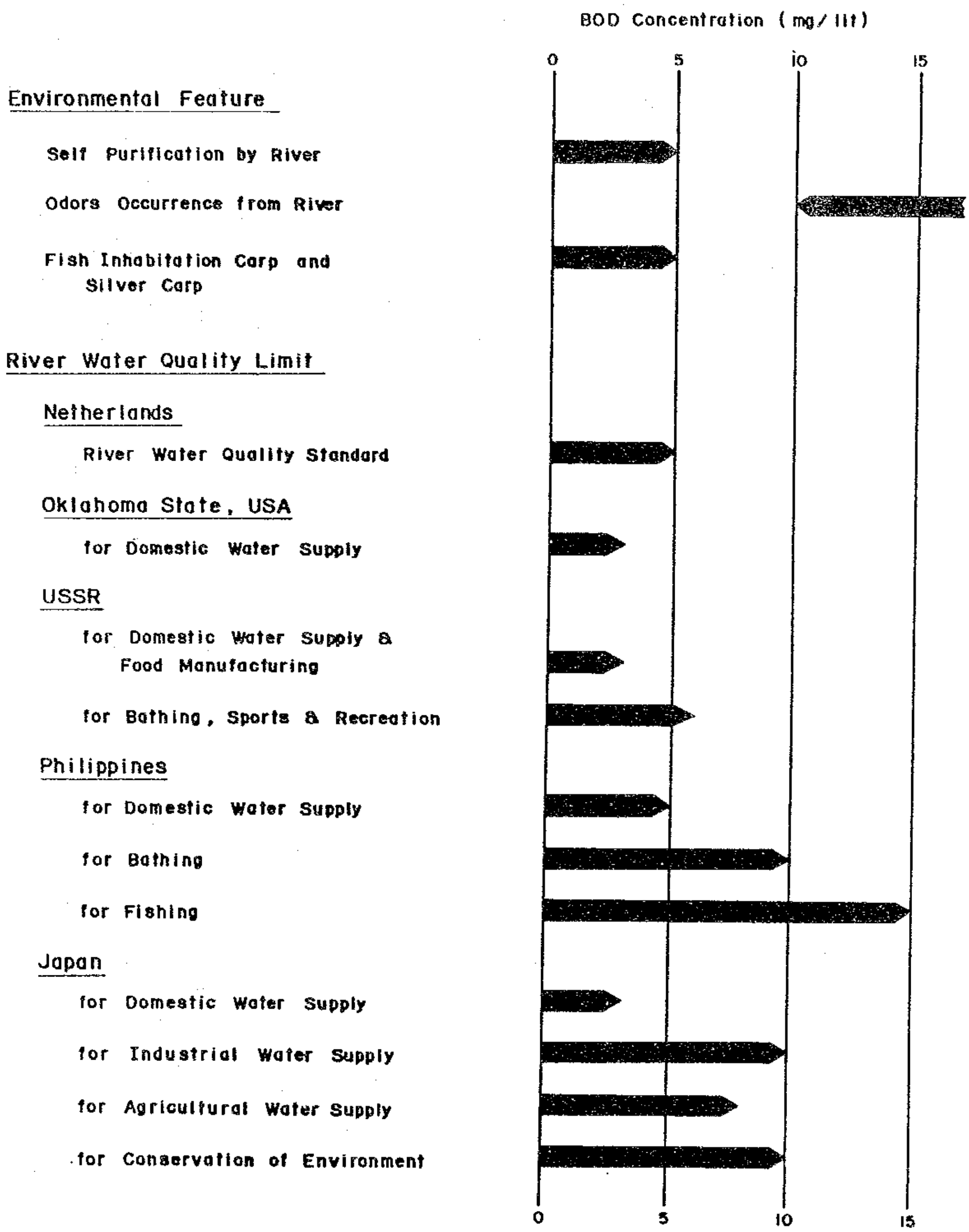

Fig. 19 Relationships Between BOD Concentration and Environmental Feature, and River Water Quality Limit

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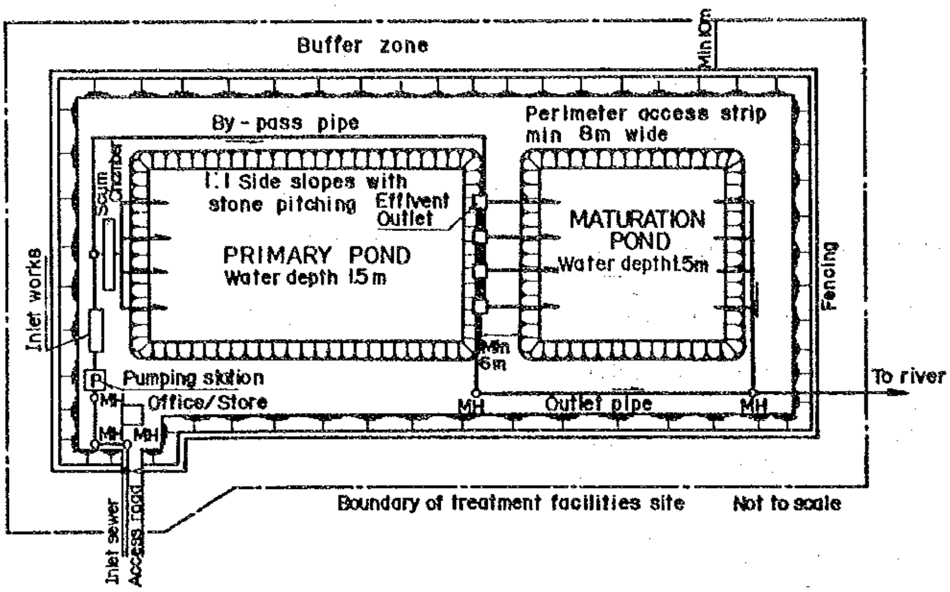

Fig. 20 Typical Layout of Stabilization Pond Process

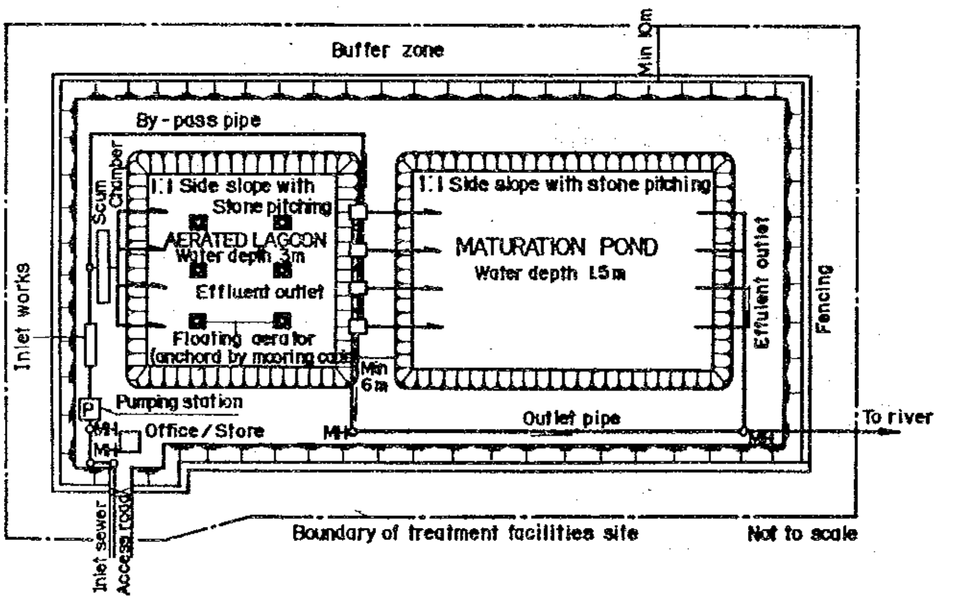

Fig. 21 Typical Layout of Aerated Lagoon Process

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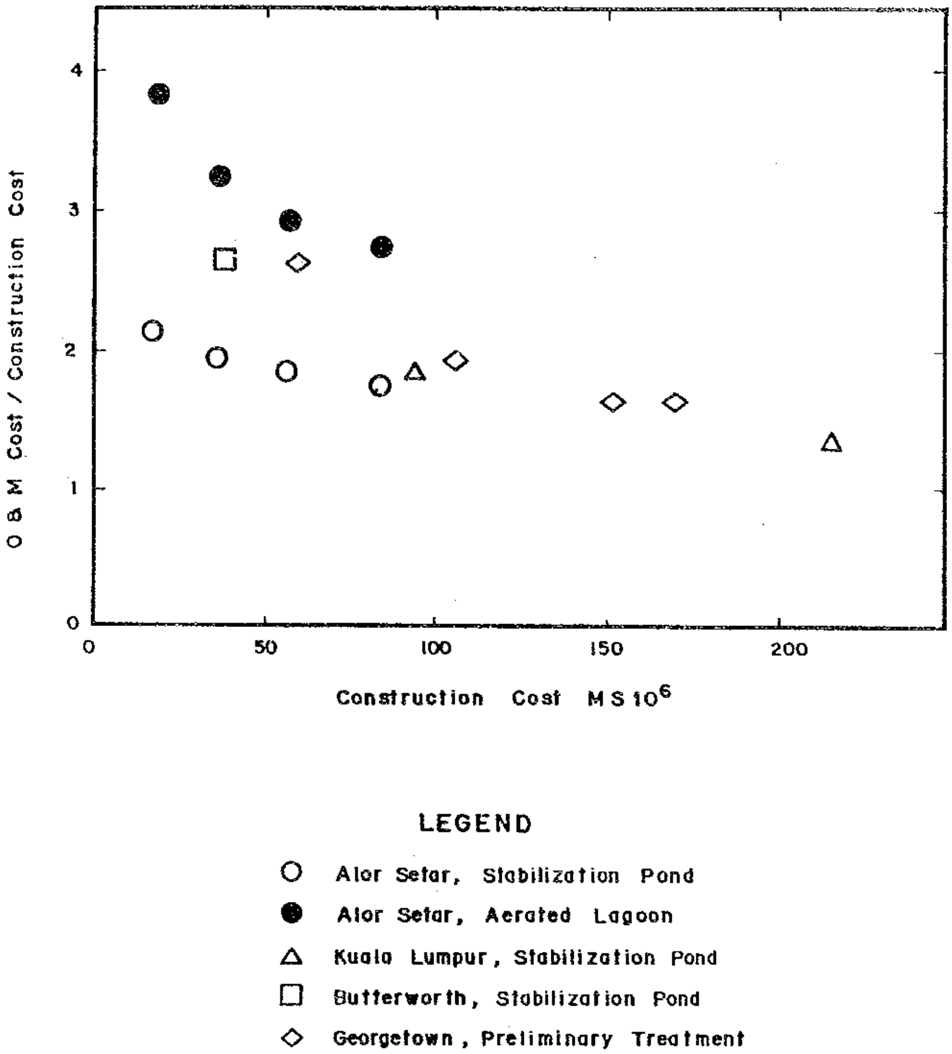

Fig. 22 Relationships Between O&M Cost and Construction Cost

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