FEASIBILITY STUDY
FOR
SEWERAGE AND DRAINAGE PROJECT
BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA
MALAYSIA

VOLUME II

SEWERAGE SYSTEM

FEBRUARY 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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VOLUME II

SEWERAGE SYSTEM

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LIST OF ABBREVIATIONS

Organization

- EHEU - Environmental Health and Engineering Unit
- DE - Department of Environment
- EPU - Economic Planning Unit, Penang State Government
- ED - Engineering Department
- PWD - Public Works Department
- DID - Drainage and Irrigation Department
- PDC - Penang Development Corporation
- PWA - Penang Water Authority
- TCP - Town and Country Planning
- MPSP - Majlis Perbandaran Seberang Perai (Municipal Council Province Wellesley)
- MPPP - Majlis Perbandaran Pulau Pinang (Municipal Council Penang Island)
- WHO - World Health Organization
- IBRD - International Bank for Reconstruction and Development
- ADB - Asian Development Bank
- OECF - Overseas Economic Cooperation Fund

Unit

mm	-	Millimetre
cm	-	Centimetre
m	-	Metre
km	-	Kilometre
m^2	-	Square metre
ha	-	Hectare
hr	-	Hour
m^3	-	Cubic metre
MG	-	Million Imperial gallon
mg	-	Milligramme
g	-	Gramme
kg	-	Kilogramme
l	-	Litre
kl	-	Kilolitre
gal	-	Gallon (Imperial)
sec	-	Second
min	-	Minute
d	-	Day
m/sec	-	Metres per second
m^3/sec	-	Cubic metres per second
m^3/d	-	Cubic metres per day
l/day	-	Litres per day
gpd	-	Imperial gallons per day
g/cap	-	Grammes per capita
g/day	-	Grammes per day
mg/l	-	Milligrammes per litre

l/day·cap	-	Litres per day per capita
kWh	-	Kilowatt hour
°C	-	Degree Centigrade
yr	-	Years

Others

BOD	-	Biochemical oxygen demand (5-day, 20°C)
COD	-	Chemical oxygen demand
CPI	-	Consumer price index
DO	-	Dissolved oxygen
GNP	-	Gross National Product
M$	-	Malaysian Dollars
NEP	-	New Economic Policy
pH	-	The reciprocal of logarithm of the hydrogen ion concentration, in grammes per litre of solution
PMP	-	Preventive Master Plan
RCP	-	Reinforced concrete pipe
RL	-	Reduced Level
SMP	-	Second Malaysia Plan
SOD	-	Survey Ordnance Datum
SS	-	Suspended solids
TMP	-	Third Malaysia Plan
VCP	-	Vitrified clay pipe
ACP	-	Asbestos cement pipe
PRCP	-	Precast reinforced concrete pipe

CONVERSION

Length (1)

m	cm	yd	ft	in.
1	100	1.0936	3.2808	39.370
0.01	1	0.0109	0.0328	0.3937
0.9144	91.440	1	3	36
0.3048	30.480	0.3333	1	12
0.0254	2.540	0.0278	0.0833	1

Length (2)

km	yd	mi
1	1,093.61	0.62137
0.00091	1	-
1.60934	1,760	1

Area

ha	km^2	acre	sq mi	m^2	sq ft
1	0.0100	2.471	0.00386	10,000	107.640
100	1	247.10	0.3861	-	-
0.4047	0.004047	1	0.00156	-	-
259	2.590	640	1	-	-
-	-	-	-	1	10.764
-	-	-	-	0.09290	1

1 sq ft = 144 sq in. 1 sq in. = 0.006946 sq ft

CONVERSION (Continued)

Volume

l	m^3	cu ft	Imp.gal
1	0.001	0.03531	0.220
1,000	1	35.31	220
28.317	0.02832	1	6.231
4.546	0.004546	0.1605	1

Weight

Kg	t	ounce	lb
1	0.001	35.27	2.2046
1,000	1	3.257×10^4	2,204.6
0.02835	2.835×10^{-5}	1	0.06250
0.4536	4.536×10^{-3}	16	1

Velocity

m/sec	km/hr	ft/sec	mile/hr
1	3.600	3.2808	2.237
0.2778	1	0.9113	0.6214
0.3048	1.0973	1	0.6818
0.4470	1.6093	1.4667	1

CONVERSION (Continued)

Rate of Flow (1)

l/sec	m^3/hr	m^3/sec	Imp.gal/min
1	3.6	0.001	13.198
0.2778	1	2.778×10^{-4}	3.666
1,000	3,600	1	1.3198×10^{4}
0.07578	0.2728	7.577×10^{-5}	1
7.866×10^{-3}	0.02832	7.866×10^{-6}	0.10381
28.32	101.94	0.02832	373.7
52.61	189.41	0.05261	694.4
0.01157	$4,167 \times 10^{-2}$	0.1157×10^{-4}	0.1528

Rate of Flow (2)

cu ft/hr	cu ft/sec	Imp. MGD	m^3/day
127.13	0.03531	0.01901	86.4
35.31	9.810×10^{-3}	5.279×10^{-3}	24
1.2713×10^{5}	35.31	19.01	86,400
9.632	0.002676	1.440×10^{-3}	6.547
1	2.778×10^{-4}	1.495×10^{-4}	0.6796
3,600	1	0.5383	2,447
6,688.2	1.858	1	4,546
1.471	4.087×10^{-4}	2.200×10^{-4}	1

CHAPTER 1

INTRODUCTION

1.1 Purpose and Scope of Work

Volume II as presented herein describes the results of the preliminary engineering design of sewerage system covering the entire Study Area and the financial feasibility study of the sewerage system to be implemented in the first stage programme.

Basic concepts of the preliminary engineering design and financial study have been developed on the basis of the Terms of Reference for Feasibility Study prepared by the Government of Malaysia in 1977 and also through review of the Master Plan Report, with the results of various investigations, surveys and technical analyses conducted under this project.

1.2 Studies Carried Out Under the Project

The studies carried out under the project include the following:

(a) Delineation of the Study Area for the preliminary engineering and feasibility study.

(b) Evaluation of existing public services.

(c) Projection of population and land use pattern.

(d) Estimation of wastewater quantities and qualities.

(e) Development of design bases and standards for structures.

(f) Layout planning for sewerage facilities, including various alternative schemes.

(g) Preliminary engineering design of facilities covering the entire Study Area.

(h) Cost estimations and construction programmes of the facilities.

(i) Evaluation of existing organization, management and legislation arrangement.

(j) Financial planning for the first stage programme.

(k) Evaluation of benefits.

For the studies, the Master Plan was reviewed and evaluated on the basis of the latest available information and data obtained during the course of the project and was updated and modified where necessary, so that the most realistic sewerage planning can be developed.

CHAPTER 2

STUDY AREA

For the purpose of master planning of the sewerage system, the entire Metropolitan Area was divided into four sewerage districts, namely (1) Butterworth, (2) Seberang Jaya, (3) Prai, and (4) Bukit Mertajam. These sewerage districts were further divided into 20 sewerage zones taking into account the characteristics of the districts such as population density, land use pattern, administrative boundary, extent of urbanization, topographic condition, and public facilities.

These sewerage zones were rated for priority of implementation in the Master Plan Report (refer to Appendix H, Volume II of the Master Plan Report), and a four-stage construction programme was proposed for the sewerage system up to the year 2000.

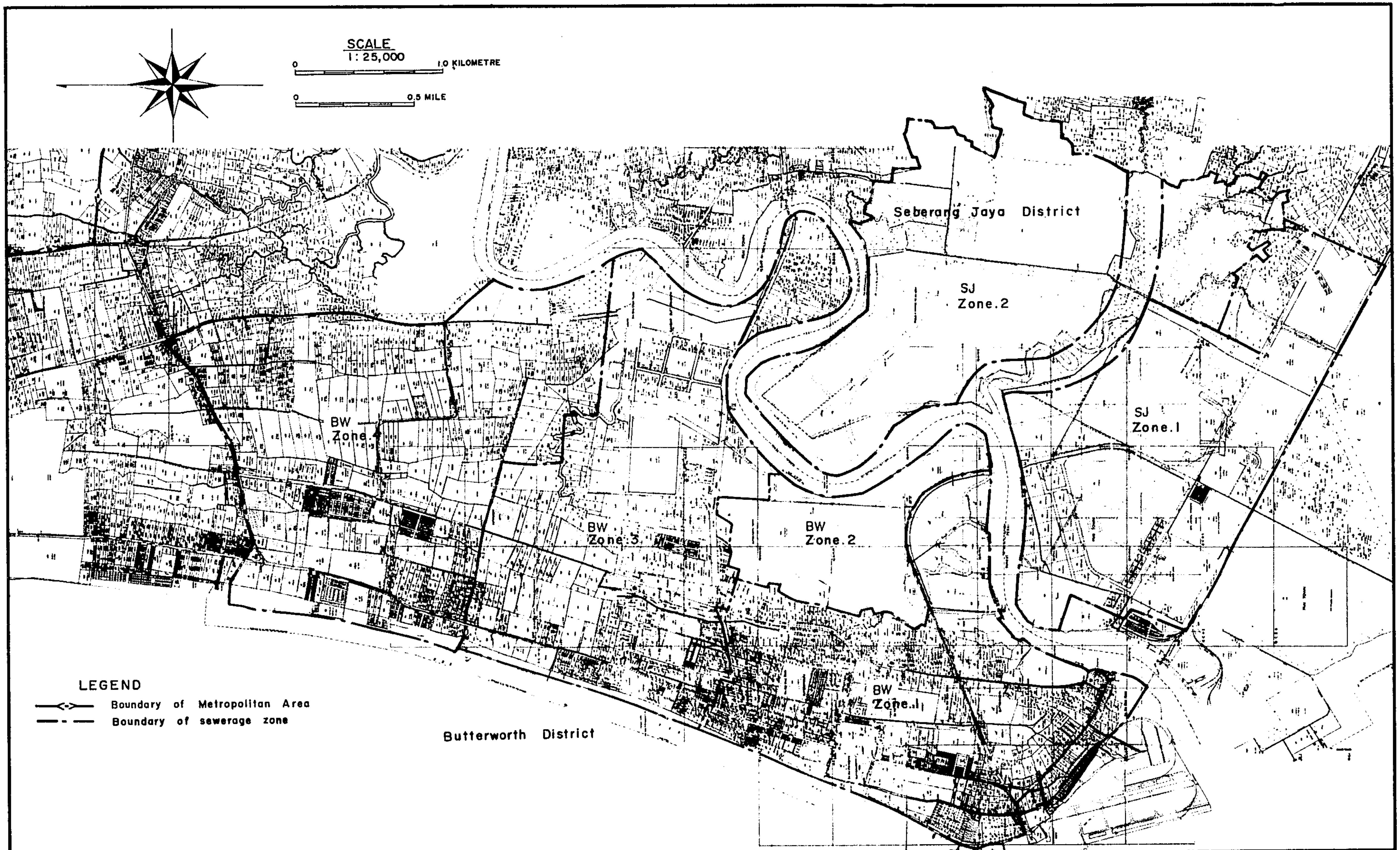
On the basis of the proposed implementation schedule and discussions with the Government of Malaysia, seven sewerage zones are finally selected for the preliminary engineering design and feasibility study, as described in the Inception Report prepared by JICA for this project. The selected seven sewerage zones are (1) Butterworth zones Nos. 1, 2, 3 and 4, (2) Seberang Jaya zones Nos. 1 and 2, and (3) Bukit Mertajam zone 3, which are conveniently defined hereafter as the Study Area.

While the area of each sewerage zone is maintained in the Feasibility Study as defined by the Master Plan Report, review of the existing condition of each zone has been made for the preliminary engineering purpose because of the changes in local situation after the Master Plan was prepared. Based on the latest available information on land use, topographic and economic conditions of the area, routes of sewers and locations of pumping stations and treatment works previously proposed have been reviewed for further assurance. The boundaries of sewerage zones in the area as identified in the Master Plan are slightly revised so that the most realistic system can be planned.

The net area of the seven sewerage zones is 3,255 ha (8,040 acres), in which the surface area occupied by the Prai, Juru and Derhaka rivers is not included. The area of each sewerage zone is shown in Table 2.1 and location is illustrated in Figures 1 and 2.

Table 2.1 Study Area by Sewerage Zone

Sewerage	Zone No.	Area (ha)
1. Butterworth (BW)	1	380
- " -	2	120
- " -	3	445
- " -	4	475
2. Seberang Jaya (SJ)	1	385
- " -	2	400
3. Bukit Mertajam (BM)	3	1,050
Total	16	3,255 ha (8,040 acres)



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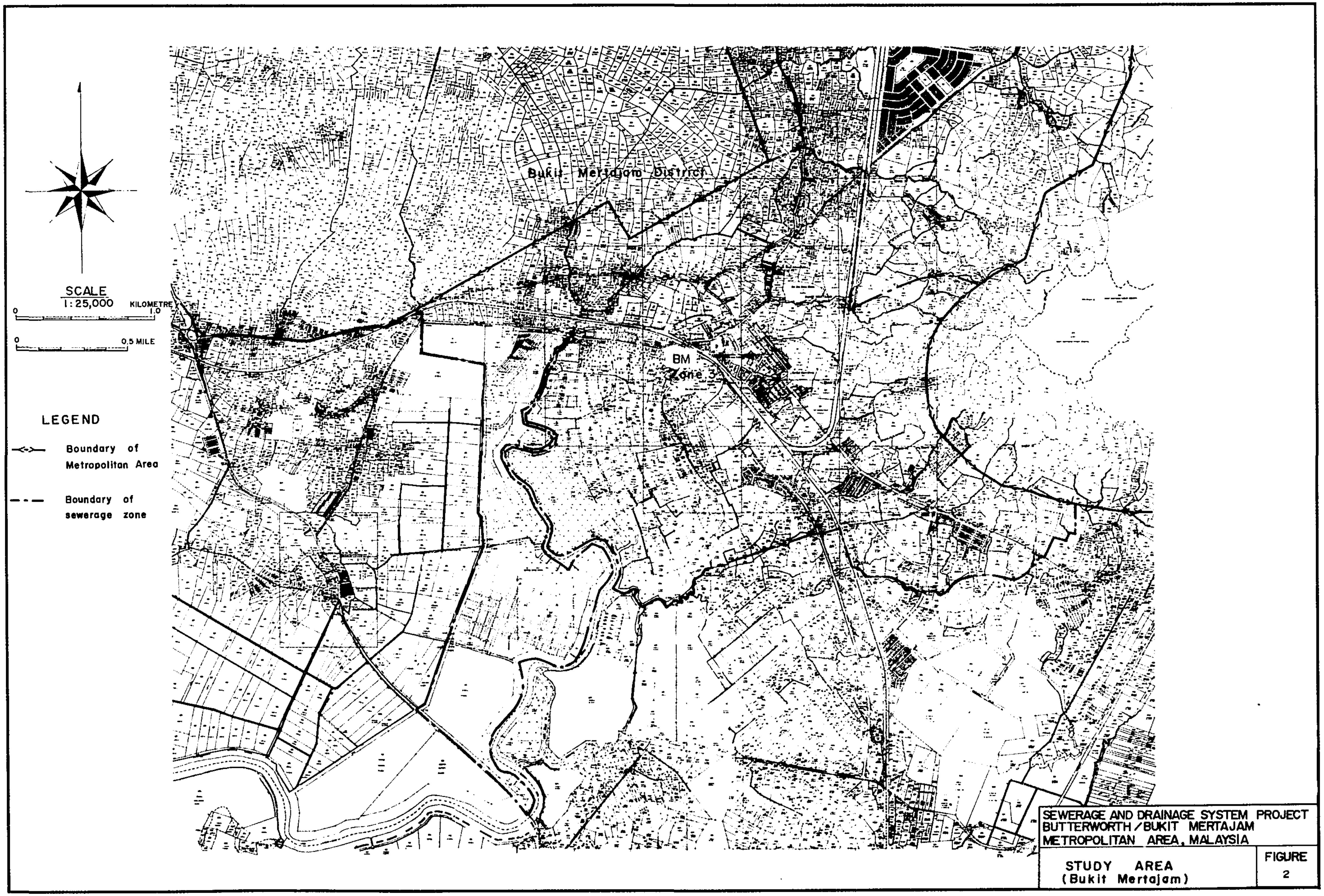
METROPOLITAN AREA, MALAYSIA

STUDY AREA
(Butterworth & Seberang Jaya)

FIGURE 1



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METROPOLITAN AREA, MALAYSIA

STUDY AREA
(Bukit Mertajam)

FIGURE 2

CHAPTER 3

EXISTING SERVICES

3.1 Domestic Wastewater Disposal Systems

3.1.1 Sullage Water

Within the Study Area, there is at present only one community served by a modern sewerage system which collects and treats both sullage and toilet flush water. This system is provided in zone 2 of Seberang Jaya wherein PDC has undertaken the development programme. In the rest of the Study Area, there is no adequate sewerage system to cater for both sullage water and night soil. Sullage water from these areas, including both kampung and urbanized zones, is discharged directly into the nearby waterways without any treatment.

In urbanized areas, most of households are served by concrete open drains provided around the house blocks, which are connected to monsoon drains or directly to rivers or the sea. Maintenance of these drains is carried out by MPSP; however, the maintenance has not been satisfactory to solve the problems and various phenomena, such as silting, anaerobic decomposition and mud accumulation, have been often observed at the sites where the flow is blocked by garbage and other obstacles.

In kampung areas, most of the drains are of earthern channel. As compared with the urbanized areas, maintenance of the drains is not well performed. During the dry weather season, the flow is small and the water becomes stagnant. Once a storm occurs, the surface runoff mixed with sullage water flows out of the drains to the streets and ground surface, and houses in low-lying area are often flooded, creating unsanitary conditions especially in kampung areas.

3.1.2 Night Soil

Current practice of night soil disposal in the Metropolitan Area, including the Study Area, is generally classified into three categories; namely (1) septic/Imhoff tank system, (2) bucket system, and (3) pit privy/over-river latrine system. Areas served by these systems are illustrated in Figures SD-3 and SD-4 of Volume V.

(a) Septic Tank System

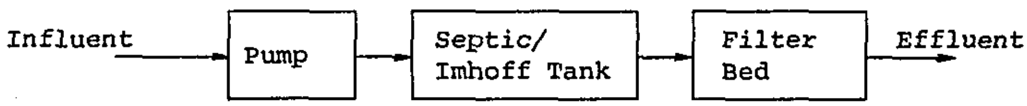
In view of the existing septic tank system, it may be conveniently classified into two categories, one is the system covering the community and the other individual households. Some of the existing septic tank systems are provided with filter bed. Septic tank system does not receive sullage water and the effluent is discharged into open drains.

Communal Septic Tank

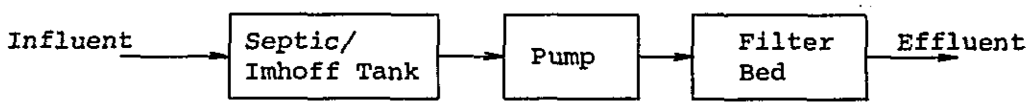
Generally, housing areas recently developed have their own communal night soil treatment and disposal system by means of septic tank or Imhoff tank. These facilities are constructed by private developers and then transferred to MPSP for their operation and maintenance. As of 1977, 49 communal systems (of which one is provided with a stabilization pond) are under the control of MPSP. Out of the 49 systems, 37 systems including one stabilization pond are managed by MPSP's head quarter in Butterworth, whereas the remaining 12 systems are under the control of MPSP's branch office in Bukit Mertajam.

The communal system has three different types depending upon the conditions, as shown below.

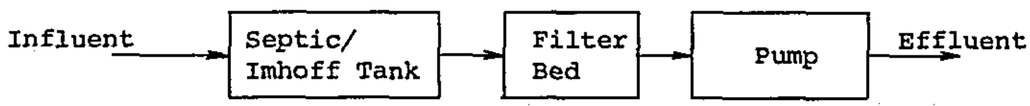
Type A



Type B



Type C



Normally, pumps in the systems are operated manually at least once every day except Sundays. These pumps are often out of order due mainly to poor maintenance caused by the lack of manpower and insufficient pump capacity to lift the inflowing wastewater. Subsequently, many complaint to the operation and maintenance of the systems have been made so far to MPSP. Particularly, in Type-A system, the wastewater overflows out of the pump pit and manhole when the pump stops its operation. As compared with Type-A system, Types-B and C have less problems in operation and maintenance because they have larger space before the pump and can store the inflow for a certain time after the pump becomes out of order. When pump stops, the inflowing wastewater is sucked out either by vacuum truck or portable submersible pump.

In Types A and B, the filter bed is dried up in most of the day, since in many cases inflowing rate of the wastewater is so small that the pump is operated intermittently. Thus the condition affects adversly to the growth of microbial population and the filter efficiency is lowered. Furthermore, washing of micro-organisms by the intermittent pump operation causes occasionally undesirably high level of suspended solids in the effluent. In Type-C system, however, such phenomena have not been observed because the wastewater is supplied continuously to the bed.

Since 1974, construction of the communal septic tank systems has been subject to prior approval of MPSP so that the system is properly designed and constructed to avoid any troubles with regard to operation and maintenance of the system. As the guideline for the approval of the plan, MPSP has proposed the design criteria, as abstracted in Table 3.1. Pipe system designed and constructed conforming to the criteria can be incorporated in the new sewerage system after modifying house connection pipes to receive sullage and night soil.

There are at present 20 plans of septic/Imhoff tank systems designed in accordance with the criteria and submitted to MPSP for approval. Also, a total of 30 septic/Imhoff tank systems have been already approved by MPSP and are either under construction or completed, but not transferred yet to MPSP for operation and maintenance. These are summarized in Table 3.2.

Table 3.1 Guidelines for Approval of Plans for Sanitary Installation

Item	Unit	Value	Remarks
1. House Connection			
Minimum diameter	mm	102 (4 in.)	
2. Public Sewer			
Minimum diameter	mm	152 (6 in.)	
Minimum gradient	-	1:150	For pipe dia. of 152 mm (6 in.).
- " -	-	1:200	For pipe dia. of 229 mm (9 in.) or more.
3. Manhole			
Interval	m	57.9 (190 ft)	Maximum
Diameter of manhole cover	mm	533 (21 in.)	Minimum

Source: MPSP

Table 3.2 Communal Septic/Imhoff Tank Systems to be Transferred to MPSP

Item	Butterworth	Bukit Mertajam	Total
Proposed	16	4	20
Under construction	12	2	14
Completed but not yet transferred	7	9	16
Total	35	15	50

Source: MPSP

Individual Septic Tank

There are two categories in this system, one for private and the other for public uses. The private septic tank systems are provided in individual houses, hotels and factories, while the public systems are provided for institutions such as government offices, hospitals and schools, as well as for houses of government employees. Operation and maintenance of the private septic tanks are performed by house owners, but cleaning and de-sludging are carried out by MPSP on the request of the owners. The costs for the cleaning and desludging are charged to house owners by MPSP.

It was found during the site investigations that many of the private septic tanks not well maintained discharged low quality effluent and indigested sludge to open drains. All public septic tank systems, except those of MPSP office, have been constructed and maintained by PWD, but cleaning work of both public and private systems has been done by MPSP. Operation and maintenance of the public systems are not sufficiently enough and there have been a number of complaint against odour and other maintenance problems.

The existing internal reticulation sewers could be used as a part of the new public sewerage after modification of connection pipes to carry domestic sewage and effluent from communal septic tank systems.

Operation and Maintenance of Septic Tank System

The current MPSP manpowers for operation and maintenance of the systems, including de-sludging, consist of the following:

1) Engineering Work	
Engineer	1 person(s)
Technical assistant	1 "
Technician	1 "
Overseer	3 "
Sub-total	6 persons
2) Supervisory Work	
Driver	8 persons
Pump operator	6 "
Attendant for vehicle	12 "
Labourer	13 "
Others	4 "
Sub-total	43 persons
Total	49 persons

In addition to the above manpowers, three fitters are assigned to the central work shop of MPSP for mainly repairing pumps. They also work for general services for MPSP as mechanical technician. Generally, operation and maintenance of the systems are carried out by MPSP's own staff, but in some cases maintenance are provided by private firms depending upon the degree of repairing required.

Operation and maintenance of the communal septic tank systems under the control of MPSP have been carried out periodically by the staff according to the routine schedule of MPSP. Only de-sludging is performed by MPSP for individual systems on the request of house owners. At present, 48 communal septic tank systems under the control of MPSP have been maintained by six pump operators and 13 labourers mainly for manual operation of pumps provided in the systems. For de-sludging, totally six tank lorries are used, of which four lorries serve the areas of Butterworth, Prai and Seberang Jaya, whereas the remaining two lorries cover Bukit Mertajam area. Frequency of de-sludging for communal systems varies from once in every three to six months. The frequency is however, seems to be not sufficient to remove all the sludge produced in the systems. The sludge removed from the systems is disposed of on the designated areas at Bagan Ajan and Telok Wang located outside the Study Area. The costs for operation and maintenance of the system under the control of MPSP expended in 1974 through 1976 are shown in Table 3.3.

Table 3.3 Operation and Maintenance Costs Expended for Septic Tanks Controlled by MPSP

(unit: M$ per year)

	Component of Expenditure	1974	1975	1976 (*)
1.	Manpower			
	Wage for engineer	19,200	20,400	21,600
	Wage for technical assistant	13,440	13,920	14,400
	Wage for technician	8,280	8,640	9,000
	Wage for overseer	13,500	14,040	14,580
	Wage for labourer	61,530	81,630	83,790
	Sub-total	115,950	138,630	143,370

Table 3.3 Operation and Maintenance Costs Expended for Septic Tanks Controlled by MPSP (continued)

Component of Expenditure	1974	1975	1976 (*)
2. Materials and Equipment			
Electricity for pump operation	8,500	4,000	4,500
Fuel for portable de-sludging pump	8,600	8,600	9,200
Repairing of system	15,000	28,400	47,000
Operation of de-sludging vehicle	3,500	3,500	3,800
Repairing of vehicle	6,560	7,590	8,900
Sub-total	37,160	52,090	73,400
3. Depreciation Cost for Vehicle	12,660	12,660	17,310
Grand-total	165,770	203,380	234,080

Note: (*) up to November.

Source: MPSP

(b) Bucket System

Presently, a total of 7,784 bucket systems are controlled by MPSP. Other bucket systems are maintained by owners themselves. The numbers of bucket toilet and collection charges by district are shown in Table 3.4.

Table 3.4 Number of Bucket Toilets and Collection Charges

District	Number of Bucket	Collection Charge
Butterworth	5,331	M$2.5/month/unit
Bukit Mertajam	2,320	M$1.95/month/unit
Seberang Jaya	133	M$2.5/month/unit
Total	7,784	

Source: MPSP

For disposal of the night soil from the system controlled by MPSP, four private firms have been granted a franchise by MPSP. Three of the firms are serving the Metropolitan Area and one for the areas outside the area. They collect the night soil from individual houses by collection buckets provided by house owners. The buckets are first carried either by carts or on shoulders to bucket stations and then transferred by trucks to the designated dumping sites and buried. There are seven bucket stations within the Metropolitan Area, six in Butterworth, three in Bukit Mertajam and one in Seberang Jaya. The area of the night soil dumping sites, as of 1977, is 9.7 ha. It is planned that additional 17.3 ha area will be acquired in the near future to meet the increased demand for night soil dumping.

For operation and maintenance of the bucket systems, MPSP has expended approximately M$31,500 monthly, including charges for contract services and supervisory work, as shown in Table 3.5.

Table 3.5 Operation and Maintenance Costs for Bucket System Controlled by MPSP

(unit: M$ per month)

Item	Expenditure
1. Contract Service Charge	21,830
2. Charge for Supervisory Work	
Public health inspector	2,600
Overseer	1,200
Driver	1,200
Labourer	1,750
3. Charge for Material & Equipment	
Including Depreciation Cost for Lorries	2,900
Total	31,480

Source: MPSP

In addition to the costs spent by MPSP, significant amount of money has been expended for the operation and maintenance of the bucket systems managed privately. Although sufficient information is not available as to the costs for the private bucket system, an attempt is made to estimate the costs that would have been spent for managing the systems. For the estimation, it is assumed that the average family member is six and the percentages of households served by both MPSP and private systems are 60, 60 and 69 per cents to the total households for Butterworth, Seberang Jaya and Bukit Mertajam respectively. Then the numbers of household maintained by the owners themselves are estimated as shown in Table 3.6.

Table 3.6 Household Numbers Served by Private Bucket System

Area	(1) Pop. of Area	(2) Household No.	(3) Percentage of Served Household	(4) No. of House by MPSP System	(5) No. of House by Private System
BW	89,500	14,900	60	5,331	3,609
BM	47,400	7,900	69	2,320	3,131
SJ	19,500	3,240	60	133	1,811
Total	156,400	26,040	-	7,784	8,551

Note: (1) See Table 4.6
(2) = (1) ÷ 6
(3) See Part II "Background", Master Plan Report
(5) = (2) x (3) - (4)

Source: MPSP

As shown in Table 3.6, the total number of households served by the private bucket system is estimated to be 8,551 within the Study Area. The average operation and maintenance cost for MPSP bucket system is estimated at M$4.05 per month per unit (see Table 3.5). Assuming that the cost for private system is same as that for MPSP system, the total cost required for private system will be M$34,600 per month.

Recently, the use of the bucket system has tended to decline because of the shortage of labour. Currently, the improvement plan for the night soil collection and disposal system is under consideration by MPSP and the existing bucket system in kampung area will be modified to receive the flow from flush toilets so that the liquid can infiltrate into the ground. An alternative to be considered may be the introduction of septic tank system to the new development areas and application of new sewerage system by use of stabilization pond to the Study Area.

3.2 Industrial Wastewater Disposal System

Most of large scale factories in the area are concentrated in Mak Mandin industrial estate and its surrounding areas. Other factories are located along the Prai River and also near the port area whereas small scale (family size) factories are scattered in town and kampung areas.

There is no communal system for industrial wastewater collection and disposal in the area. The wastewater is generally discharged into open drains or directly into rivers or sea, with only limited treatment system as described in Annex 1. Toilet wastes produced by the factory workers are treated by septic/Imhoff tank system provided in each of factories and the effluent is discharged into open drains.

The Butterworth drain C (refer to Chapter 4, Volume III), which receives all of the industrial wastewater discharged from Mak Mandin area, empties the wastewater to the Prai River. Having been provided with a tide gate, the Butterworth drain acts as a sedimentation basin for industrial wastewater when the gate is closed as the river water surface elevation rises by high tide. During low tide, water flows out to the Prai River with abundant precipitants and creates unaesthetic condition in the river water near the tide gate.

3.3 Public Utility Services

The site investigation and information obtained from various agencies indicate that there are many public utility services in the area such as water supply pipes, electric power cables and telephone cables. These structures are laid under the public roads and also under the private roads at some places. Locations of water pipe lines, electric power cables and telephone cables are shown in Figures SD-5 and SD-6 of Volume V.

CHAPTER 4

POPULATION AND LAND USE

4.1 General

Review of the land use and population distribution in the Study Area, as estimated in the Master Plan Report, is necessary to ascertain the existing conditions of the Area and to project the realistic future population and its distribution with a possible land use pattern.

The Master Plan estimated the population distribution in the Project Area, up to the year 2000 on the basis of the past and present land use development patterns, covering the entire Butterworth/Bukit Mertajam Metropolitan Area of 11,600 ha (28,660 acres). For the purpose of the Feasibility Study, however, further investigations and surveys were carried out to obtain the latest information, and thus certain modifications on the population projection have been made as enumerated in the following sections.

4.2 Present Land Use Pattern

In order to estimate the realistic population distribution in the Study Area, it is found appropriate to set up six categories of land use pattern, namely (1) commercial, (2) institutional, (3) urbanized residential, (4) kampung, (5) industrial, and (6) others, as identified in the following:

(a) Commercial Area

This area is occupied mainly by shops, stores, restaurants and markets, including small industries such as motor vehicle repairing shops scattering throughout the area.

(b) Institutional Area

This area comprises mainly social and public administrative buildings, including government offices, hospitals, schools, courts, churches, etc.

(c) Urbanized Residential Area

The areas wherein housing schemes have been undertaken by the government agencies, i.e., PDC and PWD, and private developers, are covered under this category including small stores and shops scattered in the area.

(d) Kampung Area

Both undeveloped residential and low population density areas are included in this category.

(e) Industrial Area

Industrial estates under the control of PDC fall in this category. Also, industrial estates of individual factories and groups of small factories are included in this category.

(f) Others

Both agricultural and waste lands come under this category, including rice fields, coconut gardens, etc. Rivers also fall in this category.

On the basis of the definitions above, each sewerage zone of the Study Area is identified for its land use pattern. The results of the study are summarized in Table 4.1 and also illustrated in Figures SD-8 and SD-9 of Volume V.

Table 4.1 Present Land Use Pattern of Sewerage Zone (1976 condition)

Land Use / Sewerage Zone	Commercial area (ha)	Institutional area (ha)	Urbanized residential area (ha)	Kampung area (ha)	Industrial area (ha)	Others (ha)	Total (ha)
BW1	39	25	26	167	53	70	380
BW2	-	-	-	-	-	120	120
BW3	-	13	55	134	131	112	445
BW4	4	-	52	359	3	57	475
SJ1	10	7	103	24	8	233	385
SJ2	-	-	13	-	17	370	400
BM3	22	56	62	496	-	414	1,050
Total	75	101	311	1,180	212	1,376	3,255

4.3 Future Land Use Pattern

For projecting the future land use pattern in the Study Area up to the year 2000, the following elements are taken into account:

(a) Identification of the development plan as to land uses such as residential, institutional, industrial and commercial areas; vacant lands; planned roads; etc., in accordance with the zoning maps and new housing schemes prepared by TCP.

(b) New housing schemes by private developers which have been submitted to MPSP for approval.

(c) New housing schemes for Seberang Jaya by PDC's development plan.

(d) Seberang Jaya and Mak Mandin industrial areas development plan by PDC.

Various information have been gathered during the course of the present project; however, the available information are not sufficiently enough to draw clear picture of the conditions in the year 2000, especially the data with regard to the present pattern of land use on which the future projections can be projected.

Due mainly to the uncertainties involved in undertaking the long-term projection for land use pattern, it is considered that the broader identification is appropriate than the six categories applied previously. For this reason, the land use pattern applied for the Feasibility Study are adjusted to three categories of (1) commercial, (2) residential, and (3) industrial.

The estimated future land use pattern according to the three categories and population density in each of the sewerage zones are presented in Table 4.2 and Figures SD-12 and SD-13 of Volume V.

Table 4.2 Land Use Projection for the Year 2000

(unit: ha)

Land Use / Population Density (persons/ha) (1) / Sewerage Zone	Commercial area		Residential area					Industrial Area	Total
	200	120	200	120	85.7	50	40	0	
BW 1	56	17	94	141	-	16	-	56	380
BW 2	-	-	-	120	-	-	-	-	120
BW 3	-	1	-	270	-	24	-	150	445
BW 4	-	7	-	267	-	198	-	3	475
SJ 1	-	12	-	298	-	67	-	-	385
SJ 2	-	28	-	279	-	5	-	88	400
BM 3	26	4	-	349	175 (2)	-	496	-	1,050
Total	82	480	94	1,724	175	310	496	305	3,255

Note: (1) Ref. Section 4.5, "Population Distribution in the year 2000."

(2) Figure shows the area of new housing schemes on the west side of Sungai Rambai.

4.4 Present Populations and Their Distribution

The Master Plan Report estimated the population of the entire Metropolitan Area for the year 1976 to be 238,000 based on the information including the 1970 National Census data, Penang Master Plan Report 1970 and WHO Assignment Report 1973.

Under the present project, a study has been carried out to estimate more precisely the population distribution for each of the sewerage zones of the Study Area. For the study, a total of 60 representative areas for commercial, urbanized residential and kampung districts, ranging from 1 to 10 ha in area, have been selected and analyzed in their characteristics and the relationship between population density and extent of area. The number of households and the area of each selected area have been obtained from the available maps, and then the population densities are calculated assuming that the average member of a family is six. For those areas for which accurate maps are not available, field survey was conducted to identify the type of houses, density of houses and characteristics, and then population densities are estimated and the results were compared with those estimated by using the maps.

On the basis of the results of the above study, present population density for each land use pattern is estimated as follows:

(a)	Commercial area	120 - 200	persons/ha
(b)	Institutional area	0 - 120	- " -
(c)	Urbanized residential area	100 - 200	- " -
(d)	Kampung area	40 - 200	- " -
(e)	Industrial area	0	
(f)	Others	0	

The population densities and the populations in the year 1976 in the sewerage zones are then calculated as shown in Table 4.3 and in Figures SD-10 and SD-11 of Volume V. The component areas in each sewerage zone by population density are also presented in Table 4.4.

Table 4.3 Present Population Distribution (1976)

(unit: persons)

Sewerage Zone (1)	Population Density (persons/ha)					
	200	150	100	50	40	Total
BW 1	14,200	10,350	10,800	850	-	36,200
BW 2	-	-	-	-	-	-
BW 3	15,600	2,250	4,400	3,250	-	25,500
BW 4	4,200	3,900	2,500	17,150	-	27,750
SJ 1	-	7,500	5,500	2,850	-	15,850
SJ 2	3,600	-	-	-	-	3,600
BM 3	10,000	5,250	16,500	-	15,640	47,390
Total	47,600	29,250	39,700	24,100	15,640	156,290

Note: (1) For locations of Sewerage Zone, See Figures 1 and 2.

Table 4.4 Area by Population Density (1976)

(unit: ha)

Land Use / Population Density / Sewerage Zone (1)	Residential Area						Industrial Area	Total
	200	150	100	50	40	0	0	
BW 1	71	69	108	17	-	62	53	380
BW 2	-	-	-	-	-	120	-	120
BW 3	78	15	44	65	-	112	131	445
BW 4	21	26	25	343	-	57	3	475
SJ 1	-	50	55	57	-	215	8	385
SJ 2	18	-	-	-	-	365	17	400
BM 3	50	35	165	-	391	409	-	1,050
Total	238	195	397	482	391	1,340	212	3,255

Note: (1) For locations of Sewerage Zone, See Figures 1 and 2.

4.5 Population Distribution in the Year 2000

In the Master Plan Report, the population of the Metropolitan Area up to the year 2000 was projected on the assumption that the annual population growth rates would be 5.5 per cent for the period from 1976 to 1985 and 3.5 per cent from 1986 through 2000. However, for the estimation of future population distribution in each sewerage zone of the Study Area, it is necessary to analyze in depth taking various factors of the area into account.

Since the entire Study Area is classified into three land use patterns for the year 2000, each of the sewerage zones is identified and classified into commercial, residential and industrial areas, then the population of each zone is estimated using the following population densities for the land use patterns:

(a)	Commercial area	- high density	200 persons/ha
		low density	120 - " -
(b)	Residential area	- high density	200 - " -
		medium density	120 or 85.7 - " -
		low density	50 or 40 - " -
(c)	Industrial area		0

Population distributions of the sewerage zones for the year 2000 have been estimated according to the land use pattern as presented in Table 4.5 and illustrated in Figures SD-12 and SD-13 of Volume V. The population distributions for the years 1985 and 1990 have also been estimated using the interpolation method based on the estimated population distributions for the years 1976 and 2000. These are presented in Table 4.6.

Table 4.5 Projected Population Distribution in 2000

(unit: persons)

Land Use / Population/Density (persons/ha) / Sewerage Zone	Commercial Area		Residential Area					Total
	200	120	200	120	85.7	50	40	
BW 1	11,200	2,040	18,800	16,920	-	800	-	49,760
BW 2	-	-	-	14,400	-	-	-	14,400
BW 3	-	120	-	32,400	-	1,200	-	33,720
BW 4	-	840	-	32,040	-	9,900	-	42,780
SJ 1	-	1,440	-	35,760	-	3,350	-	40,550
SJ 2	-	3,360	-	33,480	-	250	-	37,090
BM 3	5,200	480	-	41,880	15,000(*)	-	19,840	82,400
Total	16,400	8,280	18,800	206,880	15,000	15,500	19,840	300,700

Note: (*) This figure shows the population of new housing schemes on the west side of Sungai Rambai. The population density according to the development plan is assumed to be 85.7 persons/ha.

Table 4.6 Projected Population Distribution by Zone by Key Years (1976-2000)

(Unit: persons)

Sewerage Zone	Year 1976	Year 1985	Year 1990	Year 2000
BW1	36,200	41,066	43,483	49,760
BW2	0(*)	5,160	7,728	14,400
BW3	25,500	28,444	29,914	33,720
BW4	27,750	33,136	35,820	42,780
SJ1	15,850	24,701	29,104	40,550
SJ2	3,600	15,600	21,573	37,090
BM3	47,390	59,932	66,178	82,400
Total	156,290	208,039	233,800	300,700

Note: (*) As of 1976, Zone BW2 is a vacant land used for landfill for the large scale housing development scheme.

CHAPTER 5

SEWAGE FLOW QUANTITIES AND QUALITIES

This chapter describes the study results on sewage flows in the Study Area and estimates the sewage flow rates and characteristics of both domestic and industrial wastewaters for the preliminary engineering design purpose. Allowance to be included in the sewerage design capacity is also described. Commercial and other wastewaters are included in the domestic sewage, because they are similar both in quantity and quality.

5.1 Domestic Sewage

5.1.1 Water Consumption

More than 95 per cent of the total population of the Metropolitan Area are served by piped water supply system. In the Master Plan Report, average per capita water consumption rate in the Metropolitan Area in 1976 was estimated to be approximately 180 l/day. This value is about 20 per cent lower than the rate (200 l/day.cap) proposed for urbanized area by Binnie and Partners in 1967, but about 40 per cent higher than the average water consumption rate of 126 l/day.cap for the Province of Wellesley by PWA in 1976.

The difference between the two is considered reasonable, because in the first case, the widely existing rural areas in the Metropolitan Area have made the water consumption lower, while in the second case the high consumption rate has probably been caused by the fact that the Metropolitan Area is highly urbanized in comparison with other areas in the Penang State.

According to the Binnie and Partners projection, estimated per capita water consumption rate in the year 2000 is 227 l/day for urbanized area, which is based on the projection that the water demand will increase at a rate of 0.5 per cent per year. In the Master Plan Report by JICA, the average water consumption rate for the year 2000 was estimated at 230 l/day.cap based on the increase rate of 1 per cent per annum. These values are nearly equal.

As rapid urbanization is expected in the Metropolitan Area, it is assumed that the pattern of water consumption will also rapidly change from the rural type to urban type, i.e., from low to relatively high water consumption. For this reason, the higher increase rate in water consumption, i.e., 1 per cent per annum, is justified to be reasonable for the entire area; however, for the Study Area wherein urbanized districts are predominant, the lower increase rate is more reasonable. Thus, 0.5 per cent increase is applied in the feasibility study.

5.1.2 Per Capita Wastewater Production in 1976

(a) Residential Area

In accordance with the Master Plan Report, per capita wastewater production in residential area was estimated at 170 l/day with the average per capita BOD of 37 g/day, based on the result of field survey conducted at a typical housing complex served by communal septic tank system receiving no sullage water.

Since the above data were obtained for master planning purpose under somewhat general conditions including the present Study Area, a further sampling of wastewater is carried out at the new housing estate in Seberang Jaya during the course of this study. The results of 24-hour measurements of the sewage flow rate and characteristics, conducted twice, indicate that the average per capita wastewater productions are 150 l/day and 194 l/day with the average per capita BOD load of 36 g/day.

For the purpose of the preliminary engineering design, the average per capita wastewater production from residential area is assumed to be 180 l/day for the condition in 1976. With respect to BOD and SS, the same figures as assumed in the Master Plan Report are considered reasonable for the preliminary engineering purpose. These are summarized in Table 5.1.

(b) Commercial Area

A house-to-house visit wastewater sampling has been made during the period of the study at a selected "Enlarged Market Area" representative for typical commercial area. The result indicated that the average per capita water consumption was 415 l/day in the average commercial area, with the average per capita BOD load of 85 g/day.

It was also found in the sampling that the amount of water lost for drinking, cooking, lawn sprinkling, etc. in the commercial area was generally quite low as compared with that in residential area. Thus it is considered reasonable to assume that 100 per cent of the supplied water will be discharged as the wastewater from commercial area. The results are summarized in Table 5.1.

Table 5.1 Estimated Per Capita Waste Productions with Qualities in 1976

Area	Per Cap. Flow Rate (l/d/c)	Per Cap. Waste Load (g/d/c)		Concentration of Waste (mg/l)	
Residential	180	BOD 37	SS 37	BOD 200	SS 200
Commercial	415	" 85	" 85	" 200	" 200

5.1.3 Per Capita Wastewater Production in 2000

Average per capita waste production of domestic wastewater is derived from the previously mentioned studies by various agencies and consultants and also from the field surveys. The factors and assumptions considered for the estimation are as follows:

(a) Present per capita BOD productions for both residential and commercial areas are 37 g/day and 85 g/day respectively (see Table 5.1).

(b) Approximately 0.5 per cent per annum increase in per capita water consumption rates.

(c) Entire Study Area will be urbanized by the year 2000.

(d) The residential sewage flow will be 90 per cent of the average water consumption and 100 per cent for the commercial water.

The projected per capita wastewater production for the year 2000 are shown in Table 5.2.

Table 5.2 Projected Domestic Wastewater Productions with Qualities for the Year 2000

Area	Per Cap. Flow Rate (l/d/c)	Per Cap.Waste Load (g/d/c)		Concentration of Waste (mg/l)	
		BOD	SS	BOD	SS
Residential	230 (1)	46	46	200	200
Commercial	460 (2)	92	92	200	200

Note: (1) ÷ 225 ℓ/d/c x $(1.005)^{24}$ x 0.9
(2) ÷ 415 ℓ/d/c x $(1.005)^{24}$ x 1.0

5.2 Industrial Wastewater

Most of the major factories in the Study Area are concentrated in/around the Mak Mandin industrial estate in BW-3 and the rest are located in the areas near the Ferry Port of Butterworth and along the Prai River in BW-1 and BW-4 of the sewerage zones. The other smaller scale factories are scattered throughout the entire Study Area. In Seberang Jaya, 88 hectares of land for light industries are reserved in the sewerage zone SJ-2.

In the Master Plan Report, both present and future industrial wastewater productions were estimated based on the surveys carried out in Mak Mandin, Prai and Seberang Jaya as well as the data provided by MPSP and the Ministry of Science, Technology and Environment.

Under the present study, a similar survey is carried out covering 104 factories in the Study Area, to obtain more accurate and updated data on industrial wastewater production and characteristics. During the course of the survey, questionnaires are delivered to the factories and 52 per cent of the questionnaires are recovered. In addition, 86 factories are also visited for interview by engineers, and data and information concerning the wastewater production, characteristics, etc. are gathered.

The collected data are analyzed as to pH, BOD, heavy metals, etc., and their effects on the stabilization pond process are studied. Based on the results of the analysis, the wastewater productions and BOD loads in the sewerage zones both for the years 1976 and 2000 are estimated as summarized in Table 5.3.

Table 5.3 Industrial Wastewater Productions and BOD Loadings for 1976 and 2000 by Sewerage Zone

Zone	Year 1976		Year 2000	
	Waste Flow (m^3/day)	BOD Production (kg/day)	Waste Flow (m^3/day)	BOD Productions (kg/day)
BW-1	759	126	953	190
BW-2	0	0	0	0
BW-3	4,002	599	8,332	1,183
BW-4	947	397	947	397
SJ-1	223	17	370	28
SJ-2	53	5	5,044	603
BM-1	295	23	394	32
Total	6,279	1,167	16,040	2,433

5.3 Extraneous Water

For the preliminary engineering designs, an extraneous water allowance is considered. Since not enough data are available within the Study Area for reasonable estimation of the allowance to the sewers, a study is made to estimate the amount of infiltration, considering the specific physical characters of the Study Area, type of joints and pipe materials.

A field survey was conducted at a selected existing sewerage system to obtain the actual infiltration into the sewers. The survey result indicated that the average of 8.2 m^3/day.ha was inflowing to the system, which maintains the medium range among other similar towns and cities elsewhere in the world as shown in Table 5.4.

Table 5.4 Extraneous Flow Allowances in the U.S.A.

City	Allowance	
	m^3/day/ha (1)	m^3/day/m of pipe length (2)
Seattle, Wash.	10.4	0.052
Bay City, Tex.	9.5	0.047
Lorain, Ohio	28.4	0.142
Marion, Ohio	7.1	0.036
Ottumwa, Iowa	5.7	0.028
West Springfield, Mass.	19.0	0.095
Alma, Mich.	1.3	0.007

Note: (1) Source; "Design and Construction of Sanitary and Storm Sewers," WPCF, U.S.A., 1974, p32.

(2) Calculated assuming that the pipe length is 200 m/ha of service area.

On the basis of the survey results and other available data, 9.0 m^3/day/ha for urbanized areas and 5.0 m^3/day/ha for low density areas are considered to be the fair estimate for the extraneous flows to sewers. Extraneous flow allowances to be applied to the preliminary engineering design are summarized in Table 5.5.

Table 5.5 Design Extraneous Flow Allowances

Type of Area	Allowance (m^3/day/ha)	Allowance (m^3/day/m of pipe length)
High density residential	9.0	0.045
Low density residential	5.0 (*)	0.045
Commercial	9.0	0.045
Industrial	5.0 (*)	0.045

Note: (*) Calculated assuming that the total pipe length is 100 m/ha of service area.

CHAPTER 6

DESIGN CRITERIA

Since various detailed studies and discussions as to design criteria have already been made in the Master Plan Report, this chapter summarizes the elements of the criteria recommended for the preliminary engineering design, with supplementary explanations where necessary.

6.1 Design Flow Rates

Design flow rates to be used in the preliminary engineering designs are summarized in Table 6.1.

Table 6.1 Design Flow Rates

Item		Year, 1990	Year, 2000
Domestic Wastewater	Residential area	208 l/d·cap	230 l/d·cap
	Commercial area	441 l/d·cap	460 l/d·cap
Industrial Wastewater	BW 1	15.76 m^3/d·ha	17.02 m^3/d·ha
	BW 2 (1)	-	-
	BW 3	43.23 m^3/d·ha	55.55 m^3/d·ha
	BW 4	315.67 m^3/d·ha	315.67 m^3/d·ha
	SJ 1	37.50 m^3/d·ha	46.25 m^3/d·ha
	SJ 2	56.58 m^3/d·ha	57.32 m^3/d·ha
	BM 3 (2)	349 m^3/d	394 m^3/d
Extraneous Water	High population density area (ranging from 85.7 to 200 persons per hectare)	9 m^3/d·ha	
	Low population density area including industrial area	5 m^3/d·ha	

Note: (1) Since this zone is under a large scale housing development plan, no industrial area is expected to be established.
(2) Estimated to be discharged from a single factory.

6.2 Sewers

The proposed separate sewers are designed on the basis of the design criteria, as summarized in the following:

6.2.1 Flow Friction Formula

The Manning's equation is applied for the design of sewers and channels, in the form:

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

where

V = velocity of flow, in m/sec

n = coefficient of roughness, 0.013 for new sewers and 0.015 for existing sewers

R = hydraulic radius, in m

S = slope

6.2.2 Sewer Materials

Among the pipe materials available on the local market, the following pipes have been selected for the sewerage system:

- VCP for the sizes up to 300 mm in dia.
- RCP for the sizes 375 mm in dia. or more.
- ACP for the pressure pipe up to 600 mm in dia.
- Steel pipe for the pressure pipe of 700 mm or more.

6.2.3 Peak Flow Rate

The ratio of the peak flow rate to the average for the day is given in the following formula:

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

where

M = ratio of peak flow to average flow

P = design population, in thousand

Then the design sewage flow rate for sewer design is expressed in the form:

$$Q = P' \times q \times M$$

where

Q = design flow rate, m^3/day

P'= population served, persons

q = daily average flow rate, m^3/day.cap

6.2.4 Velocity of Flow

All sewers shall be designed to maintain a mean flow velocity, when flowing full or half full, of not less than 0.6 m/sec (2 ft/sec) for VCP, based on the Manning's equation using an 'n' value of 0.013. However, for centrifugally cast reinforced concrete pipe or any other cement-bonded pipe materials, a minimum design flow velocity of 0.75 m/sec (2.5 ft/sec) shall be applied using the 'n' value of 0.013.

Velocity should not exceed 3.0 m/sec (10 ft/sec) in any type of sewer, to protect sewer erosion. Where the ground surface slope is steep and velocity of more than 3.0 m/sec may result, special consideration should be given on the protection of pipes against erosion and shock.

6.2.5 Sewer Slope

All sewers shall be so designed and constructed that mean velocities of flow will not be less than 0.6 m/sec for VCP and 0.75 m/sec for RCP or cement-bonded pipes.

6.2.6 Design Depth of Flow

All circular pipes shall be designed on the basis of 100 per cent full capacity for the peak flow rate, except for the case when the flowing condition may cause sulfide problems in the pipe.

6.2.7 Minimum Size of Sewer

No sewer shall be less than 150 mm (6 in.) in dia. For sanitary sewers, a minimum size of 225 mm (9 in.) in dia. is recommended to facilitate good maintenance.

6.2.8 Manhole

For the preliminary engineering design purpose, the following maximum manhole spacings are proposed:

Pipe diameter	Maximum spacing
600 mm (24 in.) or less	100 m (328 ft)
675 mm (27 in.) or more	150 m (492 ft)

The spacings mentioned above are slightly different from those recommended in the Master Plan Report. These are revised on the basis of the field investigations and evaluation of the types of sewer cleaning equipment such as rod type widely in use in the sewerage system in Georgetown of Penang. The rod type cleaning equipment, which normally has a cleaning performance up to 150 m of pipe length per day, may be used as a major cleaning device for the new sewerage system, instead of highly mechanized equipment such as hydraulic sand ejectors. This is because the rods are generally far lower in cost and easy to handle as compared with the mechanized equipment.

Except for very shallow sewers, all manholes are planned to have adequate dimensions for entry and for operation of the cleaning rods. The minimum diameters of manholes shall be as follows:

Pipe diameter	Minimum manhole diameter
Less than 900 mm	1,200 mm (47 in.)
900 - 1,200 mm	1,500 mm (59 in.)
More than 1,200 mm	1,800 mm (71 in.)

Watertight manhole covers of either cast iron or concrete are to be used wherever the manhole tops may be flooded by street run-off or high water. Manholes of brick or segmented block should be waterproofed on the exterior wall with plaster coatings where necessary. Manhole steps are to be a sulfide corrosion resistant material such as cast iron or equivalent provided at 30 cm intervals and embeded to reach the dome wall. Typical manholes are shown in Figure SD-40, Volume V.

6.2.9 Depth

The external crown of public sewers shall be at least one metre (3.3 ft) below the ground surface, with an exception for specific situations that prove shallower depths are preferable. Main and submain sewers shall be sufficiently deep so as to receive sewage from branch and lateral sewers.

6.2.10 Construction

(a) Excavation

In general, all sewers shall be laid under existing and/or planned roads except in the case that the conditions may allow the pipe laying inside private house plot.

Excavation shall generally be made by trench method with sheetings depending upon soil conditions and depth to be excavated.

The width of trench excavated shall be kept minimum with due considerations of the pipe diameter for installation, trench bracing and working spaces required for placing, jointing and backfilling, based on the available mechanical equipment for excavation.

In the light of the soil data obtained in the Study Area, typical forms of trench excavation by trench depth and pipe size are studied and suggested as illustrated in Figure SD-40, Volume V.

(b) Sewer Bedding

Sewer bedding shall be designed and constructed taking into account the type of loading condition, type and weight of soil encountered, groundwater conditions, superimposed loads, type of pavement cover and strength of pipes to be used.

For preliminary engineering designs, boring tests were carried out at the selected points in the Study Area, where sewer pipes will be laid, in order to obtain geotechnical information on the subsoil conditions. The results of the test boring are shown in Figure SD-7, Volume V, indicating that the soil is soft and groundwater elevation is generally high. Consequently, properly designed beddings with either well-compacted gravel base or concrete cradle is suggested.

Types of sewer bedding recommended both for VCP and RCP are shown in Figure SD-40, Volume V.

(c) Sewer Joints

Sewer joints shall be designed to minimize infiltration and to prevent the entrance of roots. As discussed in the Master Plan Report, rubber ring gasket joint will be the best joint material for sewers to meet the above requirements.

The rubber gasket joint for RCP and compression type joint for VCP are presently not available in Malaysia. However, various propriety forms of flexible joints are available on international market and can be imported at reasonable costs.

In view of the above mentioned conditions, it is recommended that the rubber ring gasket joint be used for all concrete pipes and compression type joint for VCP.

6.3 Pumping Station

For the provision of pumping stations, basic considerations on location, layout, type of equipment and structure, and external appearance shall be given. Following are the major elements to be considered for the proper design of pumping station.

6.3.1 Design Flow

The design of pumping station shall be based on the peak flow of the sewage, unless lower rate of flow for design is justified. All pipes and conduits shall also be designed to carry the expected peak flow plus some allowance for abnormal flow increase.

Enough storage capacity shall be provided in wells, where automatic controls and variable speed drives are not furnished to match pumping rates exactly with inflow rates.

6.3.2 Type and Structure

In view of the local availability of circular caisson for small structures, it is recommended that the circular type be used for small capacity stations and rectangular type for large capacity stations.

6.3.3 Grit Removal Units and Screening Devices

For sanitary sewage pumping stations, no grit removal units are recommended. Coarse bar screens (100 mm clearance between the screen bars) manually cleaned shall be provided prior to the pump well, to prevent large objects from entering the wet well.

6.3.4 Ventilation and Prevention of Odour and Noise

Pumping stations shall be enclosed in a concrete structure to prevent the diffusion of odour and noise to the nearby residences. However, a suitable ventilation shall be provided for all stations to ventilate the screening room or any other portion requiring maintenance or inspection.

6.3.5 Pumps

Pump capacity shall be increased according to the stages of implementation of the system, although the structure shall be designed for the year 2000.

In the preliminary engineering design, initial capacity of pumps shall be adequate to meet the condition of the year 1990 so that excessive pre-investment can be avoided. At least two pumps shall be provided initially, then additional pumps shall be installed at latter stages according to the increase of flow.

For the selection of type of pumps, care is given on alternative types including screw, centrifugal and submersible pumps. In view of the present conditions of the area and also easiness in installation and operation, submersible non-clogging pumps are recommended. Advantages and disadvantages for the adoption of submersible pump are discussed in detail in Annex 17.

6.3.6 Pump Drives

In selecting a type of pump drives, careful considerations are given on the frequency of electrical power suspension and its duration as well as on cost comparison between electric motor and engine. The study indicates that generally the use of electricity is more economical and dependable than engine or other source of power. Further, electricity has been used for years in Malaysia without much trouble, therefore, it is recommended that pump drives in all pumping stations be of electric motor.

6.4 Treatment and Disposal System

6.4.1 Process Design

Various types of treatment processes have been evaluated from both technical and economic viewpoints, and stabilization pond system has been recommended in the Master Plan Report as the most desirable process for treating the sewage in the area.

Basically, the treatment system as proposed consists of primary facultative ponds and maturation ponds in series. Further, at the inlet of each primary facultative pond, a sedimentation cell is provided to remove scum and sludge prior to biological reaction in the succeeding facilities.

6.4.2 Design Capacity and Loading

In general, the design of treatment units shall be based on the average rate of sewage flow per 24-hour except where significant deviation from normal diurnal flow patterns are expected. For pipes and conduits, peak flow rate shall be considered in determining the capacity.

Standard design factors for each of the facilities are summarized in Table 6.2.

Table 6.2 Design Basis for Stabilization Pond

Item	Design Loading	
1. Sedimentation Cell		
Detention time	3 hr	(max.)
Depth	3 m	(max.)
2. Primary Facultative Pond		
Surface BOD loading	300 kg/day.ha (268 lb/day.acre)	
Depth	1.5 m (5 ft)	
3. Maturation Pond		
Detention time	3 days	
Depth	1.5 m	
4. Expected Effluent Quality		
BOD5	50 mg/l (max.)	
Coliforms	1,000 N/ml	

6.4.3 Construction Details

Despite of its simplicity in nature, the stabilization pond shall be constructed properly in order to ensure economy and durability as well as good performance. Some general considerations to be given on the design of pond structures are described in the following, and the proposed systems are illustrated in Figures SD-36 through SD-39, Volume V.

(a) Shape of Pond

The shape of ponds shall have no narrow or elongated portions. In principle, rectangular pond with a length not exceeding three times the width is proposed to be most desirable. Also, corners of the pond shall be rounded to minimize accumulation of floating materials.

(b) Embankment

Vegetation and debris shall be completely removed from the area where the embankments are to be constructed. Embankments shall be constructed of impervious materials to the extent possible and compacted sufficiently to form a stable structure. The embankment top width is to be 6 to 8 m (19.7 to 26.2 ft) to permit access of maintenance vehicles. The inner and outer slopes of the embankment should not be steeper than one horizontal to one vertical. The embankment is pitched with rubble stones from the top of the embankment down to the bottom of the pond. Also, vinyl sheet lining may be used depending on soil conditions. The top width of the dike shall also be paved to ensure the access and passage of maintenance vehicles. Minimum freeboard is considered to be 0.5 m.

(c) Pond Bottom

The pond bottom shall be made level to the extent possible. The soil formation at the bottom shall be relatively impervious to avoid percolation or seepage. Therefore, although the removal of porous topsoil and compacted subsoil at the bottom increase the water-holding capacity to some extent, the pond bottom shall be replaced by well compacted clay or other suitable materials. A thickness proposed throughout the pond bottom for replacement is 0.3 m. Furthermore, depending upon soil conditions, vinyl sheet may be used to cover the bank and a part of the pond bottom extended about 10 m from the bottom edge.

(d) Inlet and Outlet Arrangement

Multiple inlets and outlets shall be provided to the ponds. The inlets shall always be submerged so as to allow the incoming sewage flow towards the bottom rather than the surface to avoid odour nuisance and ensure better mixing of the incoming flow with the pond contents. The important precaution to be taken in providing the inlet arrangement is to ensure that the incoming sewage is not discharged in the direction of the outlet, thus avoiding short circuiting. Therefore, the relative location of the inlet and outlet is important. The intervals between the inlet and outlet shall be 10 m (33 ft) or more.

(e) Miscellaneous

The pond area shall be enclosed with a suitable fence to preclude livestock and discourage trespassing. A vehicle access gate of sufficient width to accommodate the maintenance and operational equipment shall be provided. Open space around the pond is seeded by a low perennial spreading grass which is most satisfactory for growing at stabilization pond sites. Care should be given to landscaping treatment site, providing buffer zone between the facilities and site boundary, to prevent noise or odour problems.

6.5 Monitoring

As discussed in Chapter 9, the proposed first stage sewerage system comprises wastewater stabilization pond facilities, for which effluent quality monitoring programme should be formulated. This includes obtaining information on a continued basis of pond effluents and waterways affected by waste discharges.

The guideline for surface water quality prepared by the *Ministry of Health classifies water courses into nine categories* for beneficial water uses and further sets ten parameters of water quality for each beneficial water use, including coliforms, pH, dissolved oxygen, etc. (see Annex 2 "Water Quality Standards").

The tentative effluent quality standards suggested under the present study (see Section 2.2, Annex 2) include eight major parameters for waste stabilization pond system effluent to be monitored. They are (1) temperature, (2) pH, (3) DO, (4) BOD, (5) COD, (6) SS, (7) coliforms, and (8) heavy metals if necessary. Minimum sampling frequencies may be daily for temperature, pH and DO; weekly test for BOD (both total and filtrate), SS and COD; and monthly or seasonally test for coliforms, oil/grease and heavy metals. A suggested minimum monitoring programme for stabilization pond system is summarized in Table 6.3.

Table 6.3 Suggested Minimum Monitoring Programme for Stabilization Pond

Parameter	Frequency of Test or Measurement		
	Daily	Weekly	Monthly or Seasonally
Quantity of flow	●		
Quality of flow			
Temperature	●		
pH	●		
DO	●		
BOD (total)		●	
BOD (filtrate)		●	
SS		●	
Coliforms (fecal)			●
Oil/grease			●

The sampling programme established for treatment facilities must include (1) location of sample, (2) analyses to be made, (3) information as to whether the samples to be tested are to be based on grab or 2-, 8-, or 24-hour composites, and (4) information as to whether the composite is to be based on samples taken at 15-minute, 30-minute, or 1-hour intervals.

Decisions as to which characteristics are essential for satisfactory pond operation, or are required for control, should be made during the design stages before the pond system is constructed. The suggested parameters and frequencies for pond system in Table 6.3 are considered to be a minimum requirement and that additional samplings may be needed depending upon the specific conditions of pond system.

6.6 Laboratory Facilities

For carrying out the monitoring programme, laboratory facilities will be needed; however, in view of the current shortage of skilled analysts for the programme and also lack of the laboratory equipment in the organization, it is suggested that the laboratory services be provided by renting outside facilities for the first stage programme by a minimum MPSP personnel required. When analyses and testings become more complicated as the system expands and the personnel gain experience in proper operation of the system, their own central laboratory should be provided to carry out routine analyses for assessing the efficiency of pond performance together with industrial wastewater.

The facilities should include, as a minimum requirement, laboratory testing facilities to analyze wastewater samples for BOD, SS, settleable solids, pH, COD, DO, fecal coliform and oil/grease, but nutrients (N,P) and heavy metals tests may be added as required. A list of laboratory equipment required to conduct the suggested minimum monitoring programme is presented in Table 6.4.

Table 6.4 Minimum Laboratory Equipment Needed for Small Wastewater Stabilization Pond

	Name of Equipment	Quantity
1.	Analytical Balance	1
2.	Centrifuge	1
3.	Flow Meter with Totalizer/indicator	1
4.	Fume Hood	1
5.	Hot Plate	1
6.	Incubator (BOD)	1
7.	Incubator (microbiological)	1
8.	Microscope	1
9.	Oven	1
10.	pH Meter	1
11.	Pump (vacuum-pressure)	1
12.	Refrigerator (large and small)	2
13.	Sterilizer	1
14.	Still	1
15.	Thermometer (registering)	2
16.	Water Bath	1

CHAPTER 7

SEWERAGE SYSTEM LAYOUT PLANNING

7.1 General

Although the layout of the sewerage system covering the entire Project Area has been established in the Master Plan Report, it is necessary to carry out more detailed studies for preliminary engineering purposes in order to reflect the latest local conditions in the Study Area. The basic approach and major items considered in the study for selecting the most desirable layout of the sewerage system for the high priority zones are described in the following:

- The layout of the sewerage system has been developed on the basis of the delineation of the sewerage zones. The layout is carefully reviewed and more detailed analysis is made on the possible sewer routes and locations of pumping stations and treatment facilities, using the updated information and data as to developement programmes and topographic conditions in each of the zones.

- Each of the sewerage zones is further divided into subzones for the convenience of the planning, taking into account of the latest available information. Slight adjustment is made for sewerage zone boundaries as determined in Master Plan to reflect the actual conditions of the area.

- All sewer routes are re-examined in detail. The alternative routes for sewers are prepared on the basis of the site reconnaissances and investigations conducted under the present study as required, using the available maps in the scales of 1 : 1,584 (1 in. to 2 chains), 1 : 3,168 (1 in. to 4 chains), and 1 : 6,336 (1 in. to 8 chains), obtained from the Government. The sewer routes are drawn on either existing roads, planned roads or house plot boundaries.

- After the preliminary layout of the sewerage system is provided, further analyses are made on the major sewer routes and locations of pumping station and waste stabilization pond in each of the sewerage zone, including cost effectiveness and operation and maintenance problems.

The analyses of sewer routes and locations of pumping station are described in detail in the following sections.

7.2 Zoning of Sewerage System

7.2.1 Sewerage Zone

In deciding sewerage zones in the area, the governing factor is the selection of suitable site for stabilization pond with enough space. Site reconnaissances, surveys and investigations indicate that sufficient space for the pond system is found available in each sewerage zone except in some areas where unexpected rapid development has taken place. Consequently, slight adjustment is made for the boundaries of the sewerage zones originally proposed in the Master Plan Report so that the realistic conditions are to be reflected in the preliminary engineering design. The modifications made under the present study are as follows:

- The Port Area originally included in the sewerage zone No. 1 of Butterworth sewerage district is excluded from the Study Area in accordance with the decision made by the Government.

- The boundary between zones 1 and 2 of the Butterworth sewerage district is slightly modified to make the boundary coincide with the line of Sungai Nyor and Siram roads, because the entire area of zone 2 is expected to be developed by private developers in the near future according to the development plans submitted to the Government. Within the development area, branch and lateral sewers will be provided by the developers with some temporary sewage treatment facilities i.e., septic tank or Imhoff tank. In the latter stage, when the public sewers become available, these sewers will be connected to the public sewers.

- The boundary between zones 2 and 3 of Butterworth sewerage district is slightly modified on the basis of the actual topographic conditions and the progress of the development in the zones.

- The commercial area located north of Telaga Ayer road and along the jetty, originally included in zone 3 of Butterworth district, is shifted to zone 1 of Butterworth sewerage district. The advantage of the alteration is that the rapidly urbanizing commercial area can be accommodated with the sewer system at earlier stage of sewerage implementation.

- Since part of the sewerage zones 1 and 2 of Seberang Jaya sewerage district has been urbanized and is scheduled to be extended by PDC's development plans with the provision of a new sewerage system consisting of sewers and waste stabilization pond, the boundary between zones 1 and 2 is delineated to conform to the PDC's development plans. Thus, the southern part of the PDC's development areas located south of the Darhaka River is added to zone 2, and the eastern boundary of zone 2, originally drawn along Datuk Ussein Onn road, is adjusted to conform to the PDC's development plan areas.

- The boundary of zone 3 in the Bukit Mertajam sewerage district is modified to include urbanized and development areas close to Kampung Baharu road located at the southeast of zone 3.

The modified sewerage zones are illustrated in Figures 3 and 4, and their area and population are shown in Table 7.1.

7.2.2 Sewerage Sub-zone

For the purpose of the preliminary engineering design, each of the sewerage zones is further divided into sub-zones, taking various factors into account such as local conditions of development, existing rural areas and actual topographic conditions.

By dividing the sewerage zones into smaller units, it is more likely to reflect in designing sewerage facilities of each sub-zone. It also enables the sewerage construction schedule to be more flexible to meet the degree of the requirement and availability of financial support for the staged investment, thus preventing premature investment for rural areas where development programme is yet to be prepared.

On the basis of the field reconnaissances and investigations on each of the sub-zones and also in consultation with the Government, the Study Area is divided into 20 sewerage sub-zones. Population and tributary area of each sub-zone are presented in Table 7.1 and locations are illustrated in Figures 3 and 4.

7.3 Stabilization Pond

The site investigations and discussions with various agencies concerned indicate that enough space is available for the stabilization ponds for the conditions in 1990, but not sufficient in some zones for the conditions in 2000. It is, therefore, necessary to consider in the future the modified treatment processes such as aerated lagoon or other similar methods to overcome the land

Table 7.1 Area and Population by Sub-zone

Sewerage Zone	Sub-zone	Area(ha)	Population Year 1976	Population Year 2000
BW 1	BW1-A	164	21,800	26,400
	BW1-B	42	1,200	3,200
	BW1-C	160	13,200	20,160
	Sub-total	366	36,200	49,760
BW 2	BW2	120	0	14,400
BW 3	BW3-A	116	10,300	13,920
	BW3-B	221	6,850	8,880
	BW3-C	95	8,350	10,920
	Sub-total	432	25,500	33,720
BW 4	BW4-A	172	14,150	20,280
	BW4-B	279	13,600	22,500
	Sub-total	451	27,750	42,780
SJ 1	SJ1-A	243	14,450	27,720
	SJ1-B	76	800	9,360
	SJ1-C	54	600	3,470
	Sub-total	373	15,850	40,550
SJ 2	SJ 2	400	3,600	37,090
BM 3	BM3-A	172	17,300	19,977
	BM3-B	292	14,610	30,320
	BM3-C	96	2,740	5,120
	BM3-D	57	400	2,280
	BM3-E	249	12,340	11,674
	BM3-F	107	0	9,172
	BM3-G	45	0	3,857
	Sub-total	1,018	47,390	82,400
	Total	3,160	156,290	300,700

Note: Area required for the all stabilization ponds (estimated to be 95 ha) is not included.

shortage. Conditions in each sewerage zone are described in the following:

(a) Butterworth District, Zone 1 (BW 1)

The site for treatment facilities (Sungai Nyor Waste Stabilization Pond) is proposed in the undeveloped swampy area surrounded by the Chain Ferry Road, Prai River and Nyor River, as proposed in the Master Plan Report.

The available land space for stabilization pond in this zone is estimated to be about 14 ha, which can accommodate the pond facilities to treat the sewage of 11,500 m^3/day, but not sufficient enough for the amount of 18,580 m^3/day to be expected in the year 2000. Therefore, consideration should be given on the possible modification in the future by means of other process such as aerated lagoon.

(b) Butterworth District, Zone 3 (BW 3)

In the Master Plan Report, the site for the pond is recommended within kampung area wherein a considerable number of houses are scattered in the north of Mak Mandin industrial estate. This condition may create problems as to amount to be compensated for the houses to be replaced and also for the negotiation for the timing to be replaced. For these reasons, the area along the Prai River, which is presently a swampy area, is studied as an alternative site for the pond. This area, owned by the State Government, is situated near the proposed site of stabilization pond for Butterworth zone 4, and has enough land space to accommodate the treatment facilities to treat the sewage from both zones 3 and 4. The available land area in the swamp is 37 ha which is enough to provide the facilities to treat the sewage flow estimated for the year 2000.'

(c) Butterworth District, Zone 4 (BW 4)

As discussed above, the site for the pond in this zone is recommended to be selected close to the pond site of zone 3.

(d) Seberang Jaya District, Zone 1 (SJ 1)

About a half of the proposed site area recommended in the Master Plan Report has already been occupied by houses, and the housing area is still expanding rapidly. A possible alternative site for the pond is, therefore, within the swampy area along the Prai River at the southeast corner of the zone.

Of the three sub-zones in this zone, the sub-zone 1-B is to be covered by the stabilization pond by private developers. However, since the planned site for this pond being located far from the proposed pond site for the zone, and in the light of the easiness of operation and maintenance work, as well as the availability of land space for the pond for entire zone, it is proposed that the sewage from the sub-zone 1-B be treated jointly at the proposed site for the zone. Accordingly, the developer's plan should be revised.

The proposed site for the entire zone has enough space for the pond to cater for the condition in 2000.

(e) Bukit Mertajam District, Zone 3 (BM 3)

The proposed site for the treatment facilities (Sungai Rambai Stabilization Pond) by the Master Plan is considered to be reasonable from the viewpoints of its location, space and city planning. The proposed site is situated at the east of the Rambai River and within the swampy area. A total of 32 ha area available at the site is sufficient enough for the stabilization pond to treat the sewage expected in the year 2000.

7.4 Alternative Study for Sewage Conveyance Facilities

To select the most cost effective system among reasonable alternative sewage conveyance systems including main, and submain sewers and pumping stations, network models of sewerage system are developed for each of the sewerage zones in the Study Area. Using these models, studies are made with respect to their capital, operation and maintenance costs to identify the most economical systems. Due to both development programmes being underway in BW 2, SJ 2 and BM 3 and difficulty in assuming precisely the future conditions in such areas at this stage, these zones are separately analyzed in Section 7.5.

The capital costs of sewers, pumping stations, force mains, waste stabilization ponds and land acquisitions are estimated on the basis of the costs developed in Chapter 9. Annual operation and maintenance costs for these facilities are also estimated using the basic operation and maintenance costs for each sewerage component as described in Chapter 9. All costs are at 1977 price levels, but no consideration is given to cost escalation for purposes of economic comparison among the alternatives. The estimated costs including capital and operation and maintenance are summarized in Annex 4, from Tables (1) through (5).

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

- Sewers, including force mains:	50 years
- Pumping stations and treatment facilities:	25 years
- Land:	full salvage value

These overall useful lives are estimated on the basis of these component facilities, i.e., 50 years for civil works and 15 years for equipment. It is assumed that money is borrowed at 8 per cent interest and that annual depreciation payments into the sinking fund would grow at the same rate. The estimated annual costs of alternative sewerage systems by sewerage zone are summarized in Tables (6) in Annex 4. Descriptions of these practical alternatives are presented in the following paragraphs with simplified diagrams:

(a) Butterworth District, Zone 1 (BW 1)

This zone is generally flat and ground elevation is low with an average ground elevation of 2 metres above the mean sea level. All sewers are planned on the existing main roads. The possible routes for main sewers will be:

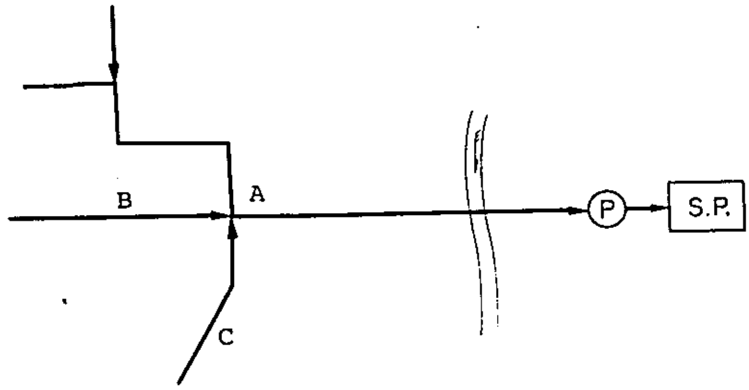
Trunk sewer A - Laid along Heng Choon Thian and Sungai Nyor roads, collecting sewage from northern part of the zone and joining to other two trunk sewers at the junction of Chain Ferry, Assumption and Sungai Nyor roads.

Trunk sewer B - Laid along Chain Ferry road up to the junction, receiving the sewage from the industrial area at jetty and from commercial areas located along the Chain Ferry road.

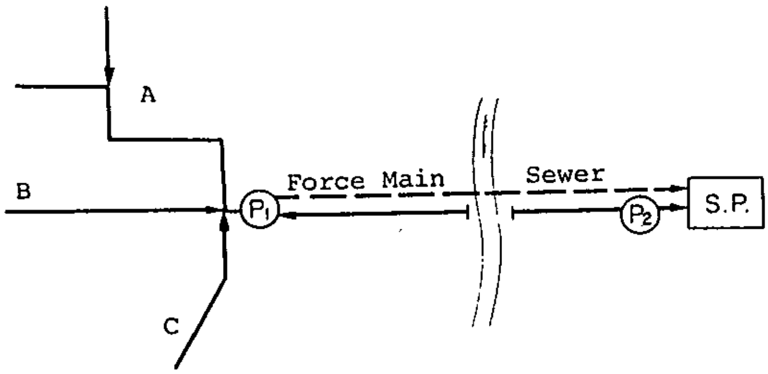
Trunk sewer C - Laid through Assumption road and joins to other trunk sewers at the junction, collecting the sewage from Kampung Bagan Dalan and industrial area along Assumption road.

If the sewage collected by these sewers is conveyed down to the disposal point by gravity, the depth of sewers will be tremendous and the construction cost will be significant. In view of the conditions of the zone, four practicable alternative combinations of gravity sewers and pumping stations are analyzed so as to be able to select the most cost effective layout plan among them:

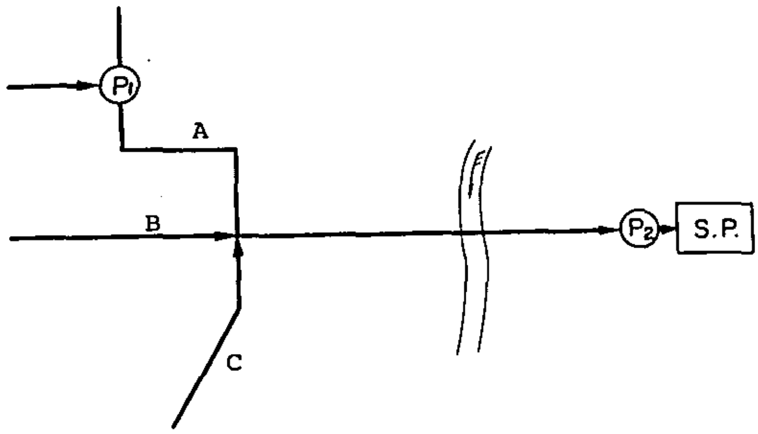
Alternative I: Convey all the sewage by gravity to the final disposal site.



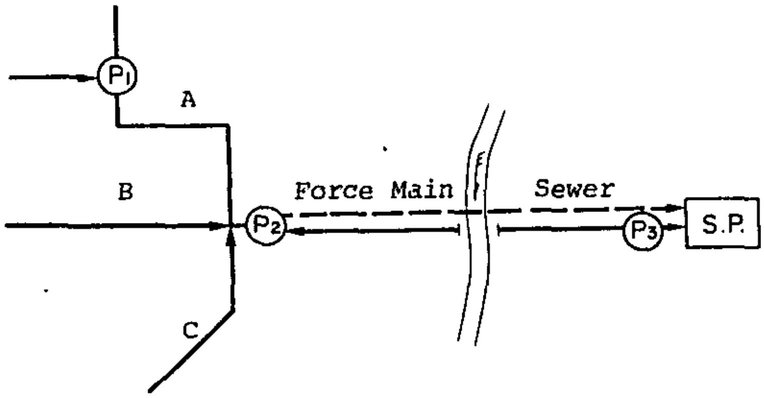
Alternative II: Convey most sewage by force main from the junction to the disposal site after collecting the sewage upstream and downstream of the junction by gravity, with partial pumping area downstream of the river.



Alternative III: Convey all the sewage by gravity to the final disposal site, except for a partial pumping on the line of Trunk sewer A.



Alternative IV: Convey the sewage by the system of a combination of Alternatives II and III.



The estimated total annual costs for Alternatives I, II, III and IV are M$216,100, M$168,400, M$206,400 and M$168,700 respectively as shown in Table (6) of Annex 4. The results of the economic analysis indicate that Alternatives II and IV are superior to other alternatives.

Since the difference between these two alternatives is not so significant in terms of cost, other factors dominate in selecting the best suitable local system. It is obvious that the sewer for Alternative IV with the pumping station P1 can be laid shallower than that in Alternative II. Further, the Heng Choon, Thian and Sungai Nyor roads have heavy traffic, and shallower sewer is more preferable to avoid the inconvenience to be created to the community as a result of deep excavation and disruption of traffic. In view of the above considerations, Alternative IV is recommended as the most suitable local sewerage system in this zone.

(b) Butterworth District, Zone 3 (BW 3)

As described previously, this sewerage zone comprises three sub-zones namely, 3-A, 3-B and 3-C. The sub-zones 3-A and 3-C are situated along the shore and the west of this zone, whereas sub-zone 3-B is located to the east of this zone and close to the stabilization pond site.

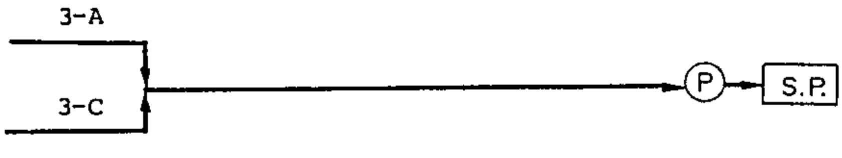
According to the projected future land use pattern, this zone is classified mainly into two different categories, i.e., residential and industrial areas. The residential area is for zones 3-A and 3-C, while the industrial area is for sub-zone 3-B comprising Mak Mandin industrial estate.

In view of the above conditions and also available existing road networks, two possible routes of main sewers which collect the sewage from these areas are defined. For sub-zones 3-A and 3-C, the sewer is to be laid from the west to east, and then finally reaching the stabilization pond planned along the Prai River. Consequently, a long sewer line is required. Since the ground surface of this zone is generally flat, the sewer will become deep, so that a study of alternatives is necessary to compare the cost between the provision of pumping station and deeper sewer for economical system selection.

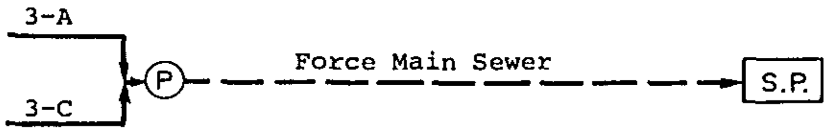
On the other hand, the sewer route in sub-zone 3-B may be provided separately from sub-zones 3-A and 3-C, because this subzone is located close to the site of the proposed stabilization pond and cost effective sewer route can be selected without alternative analysis.

For the reasons mentioned above, sewers in sub-zones 3-A and 3-C and sewers for industrial area in sub-zone 3-B are studied separately. For selection of the most suitable sewerage system for sub-zones 3-A and 3-C, the following two alternative combinations are analyzed in their costs:

Alternative I: Convey the sewage by gravity with a pumping station prior to the stabilization pond.



Alternative II: Convey the sewage by a force main with a pumping station at the junction of the two sewers upstream



The estimated total annual costs of Alternatives I and II are M$170,100 and M$97,200 respectively, as shown in Table (6) of Annex 4. It is recommended therefore that Alternative II be adopted for this zone.

For the collection system in sub-zone 3-B, two main sewers are routed along the existing roads, one starts from the junction of the Permatang Pauh and Rja Uda roads and then runs down to the waste stabilization pond passing through the Permatang Pauh and Mak Mandin roads, and the other starts from the eastern side of this sub-zone and flows down to the waste stabilization pond running through the Permatang and Mak Mandin roads.

(c) Butterworth District, Zone 4 (BW 4)

Many housing schemes are either completed or underway in sub-zone 4-A, while sub-zone 4-B comprises kampung areas and has no comprehensive development plan which covers the entire sub-zone. Therefore, the sewerage provision should be scheduled separately for each of the two sub-zones at the different construction stages.

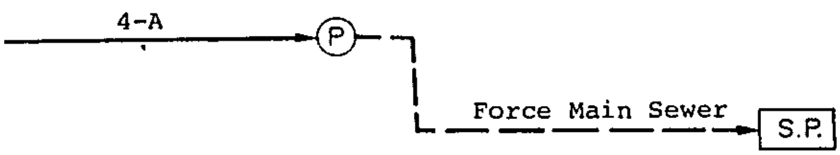
The possible routes for main sewer for both sub-zones 4-A and 4-B include two runs. For sub-zone 4-A, the sewer is planned from northwestern part of this sub-zone to the waste stabilization pond, running along the Began Ajam, Tamly Kechl and Bangan Lalang roads. For sub-zone 4-B, the sewer is routed from northern part of this sub-zone down to the waste stabilization pond, along planned road prepared by TCP.

Since this zone is located in low-lying area, studies on the balance of the costs for pumping station and deep sewer are necessary. However, the study is not required for sub-zone 4-B because the sewage from this sub-zone can be conveyed by gravity flow with relatively shallow sewers.

For sub-zone 4-A, following alternative plans are studied:

Alternative I: Convey the sewage by gravity with a pumping station prior to the stabilization pond.

Alternative II: Convey the sewage through a force main with a pumping station en route to the stabilization pond.



As shown in Table (6) of Annex 4, the estimated annual costs for Alternatives I and II are M$157,600 and M$91,700 respectively. Thus Alternative II is recommended for sub-zone 4-A.

(d) Seberang Jaya District Zone 1 (SJ 1)

This zone covers three sub-zones, namely 1-A, 1-B and 1-C. In sub-zone 1-B a sewerage plan had already been prepared by private developer and the plan was submitted to the Government for approval. When the sewerage system by the private developer is completed, it will be easily integrated to the public sewerage system by the Government. For this reason, sub-zone 1-B is excluded from the sewerage planning under this study.

In view of the above situation, the route for main sewer to collect the sewage from sub-zones 1-A and 1-C is proposed to be laid along the Prai road. Since the sewer will be long and deep, a lift station will be needed to raise the sewage and reduce the construction cost, as is in the case of BW 4.

(3) Bukit Mertajam District, Zone 3 (BM 3)

In view of the topographic conditions and existing road networks in this zone, sewer routes are planned in three runs. One is routed along the Beljaya road to collect the sewage from the new housing estates and commercial areas both located along the eastern side of the Kulim road. The sewer further crosses the railway and goes through the planned road by TCP, collecting the sewage from kampung areas. The sewer is finally led to the waste stabilization pond. The service area of the sewer covers sub-zones 3-B, 3-D and a part of 3-C. As the sewage from these sub-zones can be drained by gravity with reasonable depth, no lift station will be required.

Another sewer is proposed for sub-zones 3-A, 3-E and a part of 3-C. This sewer starts from the northern part of the zone and runs down to the stabilization pond, passing through the planned road by TCP after crossing the railway. Since the ground slope of sub-zone 3-E is against the sewer direction, sewer will become deeper and a lift station will be required near the Ara River. The sewage collected from sub-zone 3-E is to be conveyed to the junction of the Sai Jin road through the force main.

The third sewer is proposed for sub-zones 3-F and 3-G to serve the large scale housing development scheme at the west of the Rambai River, but this sewer may be constructed by private developer because these sub-zones are under the housing development plan by private developer.

7.5 Study on Sewerage System in Large Scale Development Area

In the Study Area, large scale housing development schemes are now underway by PDC and private developers. These schemes are planned in Butterworth zone 2, Seberang Jaya zone 2 and Bukit Mertajam sub-zones 3-F and 3-G, which are excluded from the previous studies.

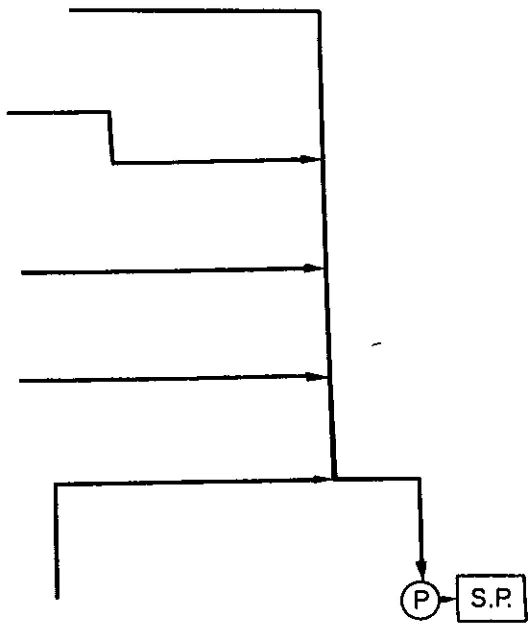
Although sewerage schemes in these development areas are excluded from the present sewerage study, provisional technical comments are given in the following with the hope that such will be found useful for PDC and private developers in planning sewerage schemes in each of the zones.

(a) Butterworth District, Zone 2 (BW 2)

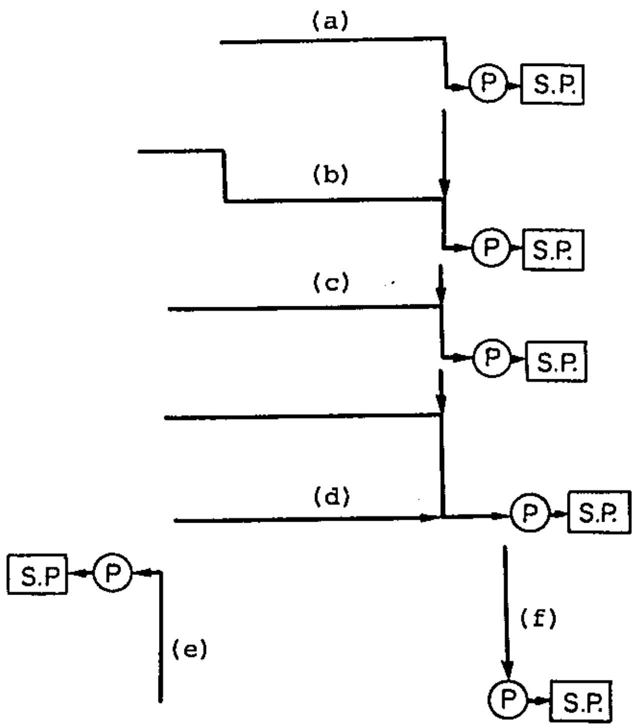
In this zone a housing development programme covering a total area of 120 ha is under consideration. The housing area of this zone has already been reclaimed even though the construction schedule has not yet been finalized. It is expected that the implementation of sewerage system will be based on a staged construction according to the requirement.

In view of the above, and with due regard to the scale and progress of the development programme, the basic approach for the provision of the sewerage system up to the year 2000 is to consider whether a single or plural number of the system is appropriate under such circumstance. Therefore, reasonable alternative considerations are made as follows:

Alternative I: Centralized collection system with one waste stabilization pond



Alternative II: Decentralized collection system with six waste stabilization ponds .



Note; Letters in parentheses show the name of sewerage sub-zone.

In Alternative I, a stabilization pond can be provided at the south of this zone, surrounded by the Chain Ferry road and Prai River, which is the same as that proposed in the Master Plan.

For Alternative II, it is planned that the entire sewerage area is divided into six sub-zones and a stabilization pond is set up for each sub-zone close to the Prai River. Sewerage service area and estimated population by sub-zone are shown in Table 7.2.

As shown in Table (4), Annex 4, costs accruing to these alternatives have been estimated and, on the basis of the estimated costs, annual costs are estimated as summarized in Table (6) of Annex 4. The result of the cost analysis indicates that the centralized collection system with a single stabilization pond of Alternative I is superior to Alternative II.

It is also suggested that a consideration has to be given to the construction schedule of the housing scheme. Because this zone is located in the development area by private developers, the provision of adequate sewerage system shall be made parallel to the housing construction schedule which is expected to be over in a ten-year period according to the agency concerned.

Table 7.2 Area dnd Population by Sub-zone in Butterworth District, Zone 2

Sewerage Sub-Zone	Area (ha)	Population in 2000
(a)	15.5	1,860
(b)	23.8	2,856
(c)	19.5	2,340
(d)	31.4	3,768
(e)	7.4	888
(f)	22.4	2,688
Total	120.0	14,400

The above two alternatives are further considered with situations assumed as follows:

Case I: To construct sewerage facilities based on Alternative I. - The sewerage system will consist of main sewer, pumping station (if necessary), stabilization pond, and branch and lateral sewers to accommodate the expected sewage flow during the progress of the housing construction.

Case II: To provide sewerage facilities as an interim measure based on Alternative II. - Temporary treatment facilities in each six sub-zones will be provided in accordance with the implementation schedule of the development programme. After completion of the development programme, the facilities in the entire area of this zone are combined as a centralized collection system for easier operation and maintenance. Accordingly, a small scale pumping station and treatment facilities will be constructed for each sub-zone as temporary facilities, but branch and lateral sewers constructed in each sub-zone can be considered as permanent facilities. The specification of the design criteria for the temporary treatment facilities is shown in Annex 5.

In Case II above, an assumption is further made that the construction schedule for the housing scheme is to be completed in a ten-year period, and provision of the sewerage system in each sub-zone is scheduled in conformity with the construction of the housing as shown in Table 7.3.

On the basis of the above, a cost comparison is made, and the estimated construction cost with present worth discounted to 1977 price level at 8 percent per annum, are shown in Annexes 6 and 7 respectively. In the estimation of the construction costs, land costs for the temporary sewerage facilities are excluded because land for such facilities will be included in the housing areas. The results of the cost comparison indicate that case II is more economical than Case I.

From the above study it is concluded that the sewerage facilities be constructed in stages according to the progress of the development programme on the basis of decentralized system as stated earlier. The developers should undertake the construction of branch and lateral sewers, together with temporary facilities such as pumping station and stabilization pond, but the construction of main sewers to connect each of the sub-zones may be undertaken by the Government.

Table 7.3 Tentative Construction Schedule for Housing Development Programme in Butterworth District Zone 2

Stage	Implementation Area (*) (ha)	Years of Construction
I	15.5	1st - 2nd
II	23.8	3rd - 4th
III	19.5	5th - 6th
IV	31.4	7th - 8th
V	29.8	9th - 10th

Note: (*) Area for Stage V is the combination of (e) & (f) sub-zones shown in Table 7.2.

(b) Seberang Jaya District, Zone 2 (SJ 2)

This zone covers PDC's development area with a total area of 400 ha which is the largest development one within the Study Area. According to the PDC's development plan obtained during the course of the present study, the area to be developed comprises various land use patterns such as commercial, institutional, residential and industrial areas. The implementation programme for the development plan is scheduled to be completed in the year 1983.

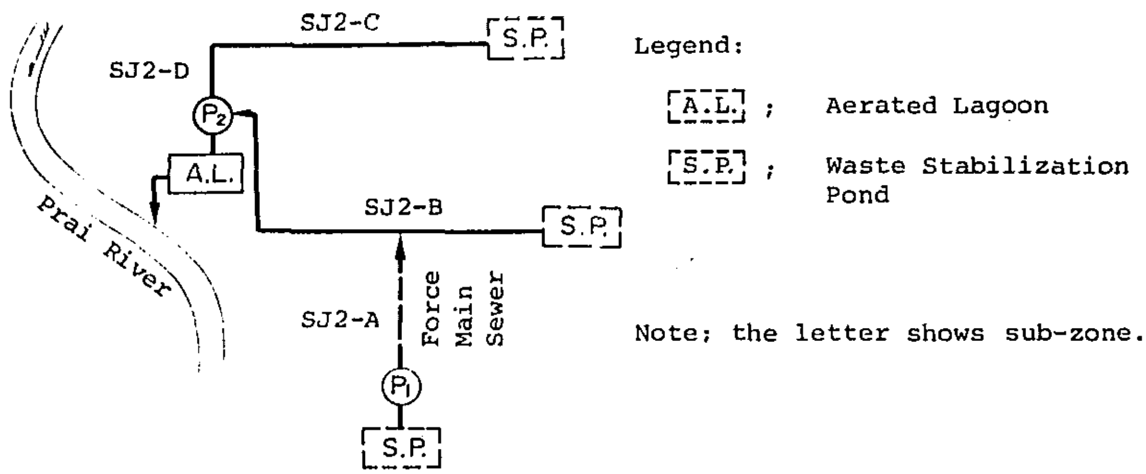
Sewerage system is already developed by PDC in accordance with the implementation schedule of the development programme. The network for the sewerage system prepared is to divide the area into four sewerage sub-zones covering the area from 60 to 180 ha, and each of the sub-zones is to have an independent stabilization pond which can treat both sullage and night soil. A part of the area has already been served by the sewerage system consisted of sanitary sewer, pumping station and stabilization pond. Although such facilities are presently capable of handling the sewage discharged from the area, it may be useful to evaluate the proposed PDC's sewerage plan as to the adequacy of the proposed system to cover the entire area of this zone. The factors considered for evaluation of the PDC's planning area; (1) proposed sewerage sub-zones, (2) construction schedule, (3) type and process of treatment, and (4) site and available land space for the treatment facilities.

The results of evaluation indicate that (1) the served area, ranging from 60 to 180 ha in each sub-zone, is appropriate as a unit sewerage area in comparison with the areas of other proposed zones, (2) with the development schedule within a short period up to the year 1983, a construction shall be undertaken by stages for each of the sub-zones, and a suitable sewerage system is required at the time of different stage of construction for each sub-zone, (3) the treatment plant envisaged by PDC is the same as the proposed treatment system under this study, namely, stabilization pond system, and (4) PDC has already confirmed the available land space for the stabilization ponds.

The plan as envisaged by PDC. therefore, is adequate and sufficient to meet the needs of sewerage provision for zone 2, provided the design of the treatment plant is based on the design criteria proposed under this study.

Another factor which is worthy to be considered is that the stabilization pond as planned for the zone requires wider land space than other biological treatment system such as aerated lagoon. The provision of four stabilization ponds should be thoroughly justified in the area where land price is significant.

A study is, therefore, made based on the centralized collection system wherein aerated lagoon process is applied. Following diagram shows a tentative plan for the centralized collection system, including site of the aerated lagoon. One of the four stabilization ponds can be used for the aerated lagoon, as shown below.



One of the advantages expected from the centralized collection system will be that land space for the three stabilization ponds can be used as residential, commercial, institutional and industrial purposes. Thus the significant benefit from effective land use can be expected, as the present land value of the three waste stabilization ponds of 8.87 ha is estimated to be approximately M$4.8 million (see Annex 12). Also, a reduction in the number of treatment facilities will have an advantage in terms of water pollution control and reduced operation and maintenance costs.

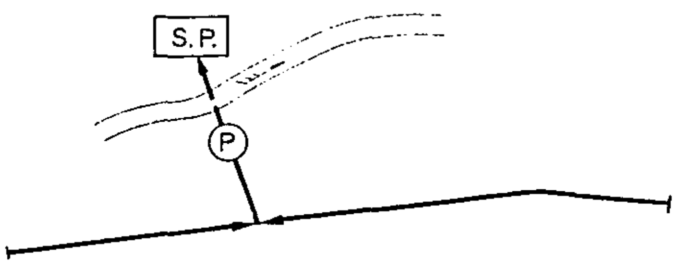
The estimated provisional construction cost of the centralized collection system at 1977 price level is M$5.5 million as shown in Annex 8. In view of the above discussions, it is suggested that centralized collection system with other biological treatment process may be worth-while to consider in the future, although the decentralized collection system prepared by PDC is adequate for this zone.

(c) Sub-zones 3-F and 3-G within Zone 3 of Bukit Mertajam District (BM3-F & BM3-G)

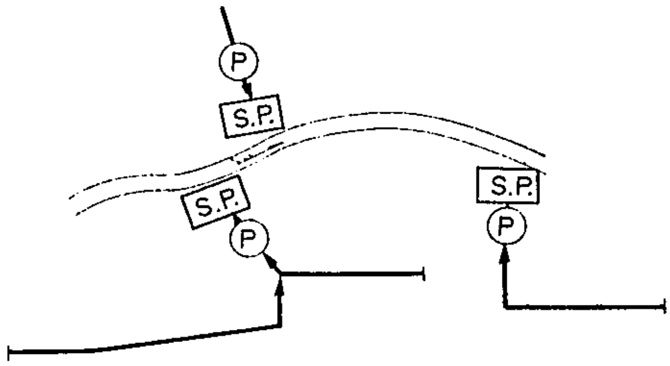
As referred in Section 7.4, item (e), these sub-zones are involved within sewerage zone 3 of Bukit Mertajam District, and are also defined as a large housing development area with a total area of 107 ha for BM3-F and 52 ha for BM3-G.

A suitable location of stabilization pond which can accommodate the sewage from all the area of zone 3, including development area of BM3 and 3-G, is set up within the swampy land at east side of the Rambai River. However, the development plan in BM3-F and 3-G shall provide sewer facilities and, if necessary, treatment facilities by developer. An additional study of alternatives is, therefore, required for overall sewerage system to cover whole area of zone 3, as follows:

Alternative I: Centralized collection system with one waste stabilization pond. The sewage from the development area of BM3-F and 3-G is conveyed by a main sewer crossing the Rambai River to the Sungai Rambai stabilization pond which can also accommodate the sewage from all the area of zone 3, so that a centralized collection system is established in zone 3.



Alternative II: Decentralized collection system with three waste stabilization ponds to provide three separate systems for zone 3, including one pond for each of the sub-zones 3-F and 3-G.



The estimated costs for the sewerage facilities of the both alternatives are summarized in Table (5), Annex 4, and the annual costs in Table (6), Annex 4. The estimated annual costs are M$119,500 for Alternative I and M$156,000 for Alternative II, which suggest that Alternative I is superior to Alternative II in terms of cost. Another advantage of Alternative I is that the centralized stabilization pond is easier than three ponds in controlling the facilities.

Since the sewerage facilities in the development area is to be provided by developers according to their construction schedule, it is suggested that the sewerage facilities in sub-zones 3-F and 3-G be provided as a temporary basis according to their develoo-ment plan, which will be integrated in the sewerage system for the rest of zone 3 at the final stage. The provision of the connecting pipe from the interim treatment facilities to the stabilization pond for zone 3 will be undertaken by MPSP.

7.6 Recommended Layout Planning for Sewerage System

On the basis of the various studies as discussed previously, the layout planning for sewerage system in each of the sewerage zone is developed for the preliminary engineering purpose, as shown in Figures 3 and 4. Also, available land space for treatment facilities in each sewerage zone is presented in Annex 9.

CHAPTER 8

PRELIMINARY ENGINEERING DESIGN

8.1 Scope and Purpose of Design

The purpose of the design is to define the magnitude and scope of the final design, including the selection of the most favourable alternative with respect to layout, design criteria and capacity of the system, and to supplement the financial and management studies. The nature and the magnitude of the design are therefore to be such that it is possible to select the best solution for the first stage programme with reasonable certainty.

As discussed previously, the sewerage system in the development areas will be provided by private developers according to the development schemes approved by the Government. Therefore, design of sewerage system for the development areas is excluded from this study, but will be designed and financed by private developers under the Government's control.

In view of the above considerations, the preliminary engineering design is confined to the design of sewerage system to be provided by the Government. For the development areas, the Government will provide only major sewers which will receive the sewage flow from these areas.

8.2 Maps and Drawings

The avenue maps are available from the Government in the scales of both 1:3168 (1 inch to 4 chains) and 1:6336 (1 inch to 8 chains). These maps do not necessarily indicate topographic features or location of scattered buildings.

New maps in the scale of 1:5000 are therefore prepared based on the avenue maps, showing both existing and planned road network and ground elevations at the major points. The ground elevations indicated on the maps are obtained from the field surveys carried out during the course of the present study. Ground elevation in low-lying areas is assumed to be 2.25 metres (7.5 feet) according to the land reclamation plan prepared by DID.

8.3 Sewers

The designated sewerage is the separate system which collects and conveys all wastewater from residential, commercial and industrial areas to waste stabilization ponds to be provided at the terminal of the system.

The design sewage flows are calculated for the conditions in the year 2000, including extraneous flows such as groundwater infiltration. For industrial areas, wastewater flows are estimated using the unit flow rate per hectare plus some extraneous inflow.

Sewer capacity has been determined using the design criteria as discussed in Chapter 6. The proposed routes of sewers, with diameters, slopes and lengths, as well as the locations of appurtenances, are presented in Figures SD-14 through SD-19 of Volume V, and the facilities are listed in Table 8.1. Hydraulic computations and sewer profiles are also shown in Figures SD-43 through 47 and SD-20 through SD-30, Volume V.

The above designs do not include the sewerage system in the development areas; however, when new development plans are submitted to the Government for approval, MPSP is expected to review the developers' plan as to sewer size, slope and invert elevation, in accordance with the design criteria developed under the present study.

8.4 Pumping Stations

A total of 13 pumping stations are required for the sewerage system covering the entire Study Area. Each of these pumping stations has been designed on the basis of the design criteria discussed in Chapter 6. All pumping stations are designed to meet the conditions in the year 2000, but pumps will be provided with the capacity to handle the sewage flow rate expected in 1990, in order to avoid the excessive pre-investment of capital cost.

The proposed shapes for pump well are both circular and rectangular; circular type for small capacity and rectangular type for large capacity stations (refer to Figures SD-31 to SD-35, Volume V). The investigations and surveys indicate that the ground conditions in the area are generally favourable for well sinking (caisson) construction. However, local contractors have not enough experience in such construction, and this method is suggested only for small scale stations with the capacity of 2 m^3/min or less.

For the pumping stations, no grit chamber is provided, but with the provision of coarse bar screens of 100 mm (4 in.) clearance between the screen bars. The screenings will be removed manually and carried away by buckets or carts for disposal.

Both for large and small scale stations submersible non-clog pump is suggested. Advantages of the submersible pump are (1) easiness in inspection, operation and maintenance, (2) requirements for smaller floor space than conventional pump, and (3) lower operation cost than other types. Also, a wide range of the size is available in market from less than 100 mm up to 500 mm in diameter, with long experience in operation in the area. In view of the above considerations, it is considered appropriate to apply submersible pump for all stations of the sewerage system. A study as to the selection of pump type is described in Annex 17.

Number of pumps in a station should be at least two, including one stand-by for the initial stage. Because of the efficiency of pump and availability in market, the maximum capacity of a pump is limited to 8 m^3/min, and the number of pumps is determined considering the staged sewer construction programme and the availability of pump size and capacity. The design flow rates and specifications of the pumps are summarized in Table 8.3. Plans and sections of the proposed pumping stations are presented in Figures SD-31 through 35 of Volume V.

8.5 Waste Stabilization Ponds

Waste stabilization ponds consist of sedimentation cells, primary ponds and maturation ponds. These are located close to the waterways such as the Prai and Rambai rivers and the effluent from the ponds is discharged to these rivers.

Under the preliminary engineering study, each waste stabilization pond has been designed to cater for the sewage inflow estimated for the year 2000, using the design criteria developed in Chapter 6. Each pond will be provided with multiple units for the convenience of operation and maintenance of the facilities.

The required pond surface areas for primary and maturation ponds, design flow rates and BOD loadings are shown in Table 8.4. Plans of the pond are illustrated in Figures SD-36 through SD-39 of Volume V.

The available land space for the waste stabilization ponds in BW zone 1 is estimated to be 8.62 ha, while the required minimum land space for the conditions in 2000 is 14.01 ha (Table

8.4). Hence, a further study is made as to the application of aerated lagoon process. The study results suggest that the primary pond unit No. 2 should be changed to aerated lagoon at the later stage when the sewage inflow rate increases. The sewage inflow to the ponds from BW1-A and BW1-B by the end of the first stage programme is estimated at 10,100 m^3/day, which is about half as much that for the year 2000, and the pond will have no problem to treat the sewage during the first stage programme.

For the BW zones 3 and 4, the proposed stabilization pond system has 12 units as shown in Figure SD-37 of Volume V, which is large enough to cater for the design flow rate of 33,870 m^3/day for the year 2000 and will have no problem as to land space. The sewage discharged from BW3-A and BW3-B, to be included in the first stage programme, is estimated at 12,680 m^3/day. This amount of inflow can be treated by units of Nos. 2, 3 and 4 of the pond as shown in Figure SD-37 of Volume V.

In SJ-1, sub-zone SJ 1-B is now under the development scheme by private developer including the construction of a waste stabilization pond. This scheme will be implemented before the public sewerage system is provided, thus this pond will be utilized independently to treat the sewage from the scheme area. However, the site of the stabilization pond by the developer is suggested to be re-located close to the proposed site for stabilization pond under the study. The estimated design flow rates for the year 2000 are 2,860 m^3/day for SJ 1-B and 10,340 m^3/day for SJ 1-A and SJ 1-C. Enough land space is available for the pond system to treat the estimated sewage inflows.

The sewage flow from the first stage programme area covering BM 3-A and BM 3-B, Bukit Mertajam district, is estimated to be 14,020 m^3/day. A stabilization pond (Sungai Rambai) consisting of 8 units, is proposed for the zone as shown in Figure SD-38, Volume V. Enough land space is available for the conditions in the year 2000. For the first stage programme area, the sewage flow will be treated by the units of Nos. 1, 2, 3 and 4.

Table 8.1 (1) Proposed Sewer System for Butterworth Zone 1 (Government Contribution)

Pipe Diameter (mm)	Average Sewer Depth (m)	Pipe Length (m)	Number of Manhole
225	2.0	5,575	81
	3.0	2,355	29
	4.0	375	4
300	3.0	1,635	23
	4.0	2,010	30
	5.0	245	3
375	3.0	425	6
	4.0	185	6
	5.0	475	5
	6.0	430	5
450	3.0	375	5
	4.0	400	7
525	4.0	150	2
	5.0	335	4
	6.0	340	4
600	5.0	65	1
675	5.0	100	1
	6.0	705	5
900	6.0	50	1
	7.0	30	1
600*	2.0	1,300	-
Total	-	17,560	223

Note: (*) force main .

Table 8.1 (2) Proposed Sewer System for Butterworth Zone 3 (Government Contribution)

Pipe Diameter (mm)	Average Sewer Depth (m)	Pipe Length (m)	Number of Manhole
225	2.0	6,415	85
	3.0	3,420	37
	4.0	2,190	30
	5.0	255	4
300	3.0	695	8
	4.0	1,880	26
	5.0	355	4
375	4.0	410	5
	5.0	1,320	17
	6.0	460	5
450	5.0	410	5
	6.0	585	8
	7.0	220	3
525	6.0	350	5
	7.0	165	2
600	6.0	250	3
	7.0	280	3
675	7.0	555	8
750	7.0	30	1
525*	2.0	1,740	-
Total	-	21,985	259

Note: (*) force main

Table 8.1 (3) Proposed Sewer System for Butterworth Zone 4
(Government Contribution)

Pipe Diameter (mm)	Average Sewer Depth (m)	Pipe Length (m)	Number of Manhole
225	2.0	2,385	63
	3.0	4,250	36
	4.0	3,130	32
	5.0	220	4
	6.0	740	9
300	4.0	2,625	32
	5.0	535	6
	6.0	890	10
375	5.0	480	6
	6.0	1,090	13
	7.0	715	8
450	6.0	170	2
	7.0	250	3
	8.0	250	3
525	7.0	200	4
	8.0	270	3
600	8.0	300	6
450*	2.0	1,650	-
Total	-	20,150	240

Note: (*) force main

Table 8.1 (4) Proposed Sewer System for Seberang Jaya Zone 1 (Government Contribution)

Pipe Diameter (mm)	Average Sewer Depth (m)	Pipe Length (m)	Number of Manhole
225	2.0	450	7
	3.0	1,485	18
	4.0	505	8
300	2.0	370	5
	3.0	1,285	16
	5.0	560	7
375	3.0	1,440	17
	4.0	565	6
	5.0	160	2
	6.0	245	4
450	5.0	375	5
	7.0	240	4
600	2.0	270	4
675	4.0	490	4
	5.0	475	4
	6.0	850	7
750	6.0	30	1
Total	-	9,795	119

Table 8.1 (5) Proposed Sewer System for Bukit Mertajam Zone 3 (Government Contribution)

Pipe Diameter (mm)	Average Sewer Depth (m)	Pipe Length (m)	Number of Manhole
225	2.0	16,570	228
	3.0	6,525	94
	4.0	1,755	36
	5.0	540	12
300	2.0	460	6
	3.0	1,730	24
	4.0	1,165	17
	5.0	2,060	29
	6.0	570	8
375	2.0	720	15
	3.0	140	2
	4.0	1,685	23
	5.0	650	6
450	4.0	230	4
	6.0	105	2
525	3.0	390	4
600	3.0	550	6
	5.0	210	3
675	6.0	620	8
750	4.0	110	1
	5.0	1,945	15
900	6.0	40	1
225*	1.6	680	-
Total	-	39,450	544

Note: (*) force main

Table 8.2 Design Flow Rates for Pumping Station
(1990 and 2000)

(1) Butterworth Zone 1

Name	1990		2000
	Daily Average Flow (m^3/day)	Peak Flow (m^3/min)	Peak Flow (m^3/min)
Kampung Bengali	1,712	4.1	4.8
Chain Ferry	9,395*	21.3*	30.7
Sungai Nyor	709*	1.6*	2.0

(2) Butterworth Zone 3

Name	1990		2000
	Daily Average Flow (m^3/day)	Peak Flow (m^3/min)	Peak Flow (m^3/min)
Permatang Tengah	3,456	6.6	14.2
Mak Mandin	9,086*	13.6*	17.4
Soon Corporation	401*	1.1*	1.1

(3) Butterworth Zone 4

Name	1990		2000
	Daily Average Flow (m^3/day)	Peak Flow (m^3/min)	Peak Flow (m^3/min)
Kampung Simpah	6,482	10.7	13.2
Bagan Lalang	5,513	9.7	12.8

(4) Seberang Jaya Zone 1

Name	1990		2000
	Daily Average Flow (m^3/day)	Peak Flow (m^3/min)	Peak Flow (m^3/min)
Chai Leng Park	4,696	8.8	11.0
Kampung Selut	8,342	14.5	18.9
Kim Sar Garden	377	0.8	1.9

(to be continued)

(5) Bukit Mertajam Zone 3 (continued)

Name	1990		2000
	Daily Average Flow (m^3/day)	Peak Flow (m^3/min)	Peak Flow (m^3/min)
Sungai Ara	1,708	3.4	3.6
Betek	316*	0.7*	2.5
Sungai Rambai	14,023*	23.1*	37.4

Note: (*) These indicate the sewage flow rates only from the first stage programme area as discussed in Chapter 9.

Table 8.3 Specifications for Pump

(1) Butterworth Zone 1

Name of Pumping Station	Total Head (m)	Pump Capacity Per Unit (m^3/min)	Number of Pumps Required(*)		Pump Type
			Initial Stage (1990)	Later Stage (2000)	
Kampung Bengali	3	2.4	3	3	Submersible
Chain Ferry (with force main)	22	7.7	4	5	Submersible
Sungai Nyor	5	2.0	2	2	Submersible

(2) Butterworth Zone 3

Name of Pumping Station	Total Head (m)	Pump Capacity Per Unit (m^3/min)	Number of Pumps Required(*)		Pump Type
			Initial Stage (1990)	Later Stage (2000)	
Permatang Tengah (with force main)	16.5	7.1	2	3	Submersible
Mak Mandin	9.0	6.8	3	4	Submersible
Soon Corporation	3.5	1.1	2	2	Submersible

(3) Butterworth Zone 4

Name of Pumping Station	Total Head (m)	Pump Capacity Per Unit (m^3/min)	Number of Pumps Required(*)		Pump Type
			Initial Stage (1990)	Later Stage (2000)	
Kampung Simpah	10	5.3	3	4	Submersible
Bagan Lalang (with force main)	21	4.9	3	4	Submersible

(to be continued)

(4) Seberang Jaya Zone 1 (continued)

Name of Pumping Station	Total Head (m)	Pump Capacity Per Unit (m^3/min)	Number of Pumps Required(*)		Pump Type
			Initial Stage (1990)	Later Stage (2000)	
Chai Leng Park	7.0	4.4	3	4	Submersible
Kampung Selut	7.0	7.3	3	4	Submersible
Kim Sar Garden	4.0	1.9		2	Submersible

(5) Bukit Mergajan Zone 3

Name of Pumping Station	Total Head (m)	Pump Capacity Per Unit (m^3/min)	Number of Pumps Required(*)		Pump Type
			Initial Stage (1990)	Later Stage (2000)	
Sungai Ara (with force main)	15.0	1.8	3	3	Submersible
Betek (with force main)	5.0	0.7	2	3	Submersible
Sungai Rambai	7.5	7.7	4	6	Submersible

Note: (*) Including one stand-by.

Table 8.4 Required Surface Areas for Waste Stabilization Pond

(1) Butterworth Zone 1 (Sungai Nyor)

Item	Unit	Value
Design Flow (Daily average flow)	m^3/day	18,575
Applied BOD Loading	kg/day	3,088
Required Surface Area of Primary Pond	ha	10.29
Required Surface Area of Maturation Pond	ha	3.72

(2) Butterworth Zones 3 & 4 (Mak Mandin)

Item	Unit	Value		Total
		BW 3	BW 4	
Design Flow (Daily average flow)	m^3/day	19,424	14,450	33,874
Applied BOD Loading	kg/day	2,741	2,403	5,144
Required Surface Area of Primary Pond	ha	9.14	8.01	17.15
Required Surface Area of Maturation Pond	ha	3.88	2.89	6.77

(3) Seberang Jaya Zone 1 (Kampung Selut)

Item	Unit	Value		Total
		SJ1-B	SJ1-A&1-C	
Design Flow (Daily average flow)	m^3/day	2,855	10,337	13,192
Applied BOD Loading	kg/day	431	1,528	1,959
Required Surface Area of Primary Pond	ha	1.44	5.09	6.53
Required Surface Area of Maturation Pond	ha	0.57	2.07	2.64

(4) Bukit Mertajam Zone 3 (Sungai Rambai)

Item	Unit	Value
Design Flow (Daily average flow)	m^3/day	28,119
Applied BOD Loading	kg/day	4,083
Required Surface Area of Primary Pond	ha	13.61
Required Surface Area of Maturation Pond	ha	5.65

CHAPTER 9

COST ESTIMATES AND CAPITAL INVESTMENT PROGRAMME

9.1 General

This chapter describes cost estimating procedures of sewerage system, including construction methods to cope with the different conditions in soil, depth and width of trench, size, etc., together with the evaluation of implementation priority, magnitude of investment and selection of the most desirable sewerage system for the first stage programme.

9.2 Cost Estimates

9.2.1 Basis for Construction Cost Estimates

For estimating the construction costs of the proposed sewerage facilities, unit prices for labour, materials, equipment, power and transportation, both locally available and imported, have been collected and checked during the course of the present project.

Using the data obtained from various sources in Malaysia, the basic construction costs are identified in three categories, namely (1) labour costs, (2) basic materials, and (3) unit costs for construction including both labour and materials, as described in detail in Annex 11. All costs are expressed in 1977 price levels in Malaysia.

Materials for structures of pipe bedding, pumping station and treatment facility are generally available in Malaysia, except mechanical equipment for pumping station and treatment system. Most of the materials, including reinforcing bars, timber, sand and gravel for concrete, vitrified clay pipe and centrifugally cast reinforced concrete pipe of 1,800 mm (71 in.) in diameter or less, are available in local market.

Construction for the facilities may be defined basically as the sum of all expenditures required to bring the project to completion. The expenditures for the civil works, installation of the equipment, contractor's profits and overhead, and all related construction works are divided into direct items and indirect items.

Values of the land covered under the project are also estimated on the basis of the information obtained from the Valuation Department of MPSP. The information is grouped into three categories; (1) land with potential for residential development including local stores, (2) land with potential for commercial development for stores, shopping centre and hotel, and (3) land with potential for industrial development. The market values of these unit lands are estimated on the basis of their potential land uses and related frontages of paved or unpaved roads. Then the current market values of the lands for the proposed sites of stabilization pond facilities are estimated as shown in Annex 12.

(a) Average Construction Costs for Sewers

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

Since the trench excavation method is proposed for all sewer constructions as discussed in Chapter 6, sheet piling may be needed depending on the soil conditions and sewer depth. In the majority of the locations, the soil will be primarily soft clay and sand and the high ground water table will be encountered, as indicated in Figure SD-7 of Volume V. In those areas of primarily silty soil, tight sheeting and bracing will be normally required with a depth of 2.0 metres or deeper. However, for the safety of men and equipment, sheeting and bracing are included for all cost estimations of sewer construction, as shown in Annex 11.

Based on the standard bedding, size and depth of sewer, and their unit prices, the average sewer construction costs in terms of per metre have been estimated. These costs include excavation, sheeting and bracing, dewatering, pipe bedding, concrete placing, forming, reinforcing, restoration of paving as needed, and contractor's profits and overhead. These costs are based on normal situation excluding for rock excavation, relocation of underground utilities, and dewatering for which special techniques are required. Average construction costs of sewer by size and depth both for gravity and pressure pipes are summarized in Tables 9.1 and 9.2. Construction costs for manhole are also summarized in Table 9.3.

(b) Pumping Station and Treatment Facilities

Both pumping stations and stabilization ponds are to be constructed generally by open cut, while it is possible to construct small scale pumping stations by well sinking method.

The construction costs are estimated on the basis of unit prices for materials and equipment including overhead for contractors. Major part of the electrical and mechanical equipment is assumed to be imported from foreign countries such as Japan, America, Australia and Singapore. These costs are estimated based on reasonable assumptions and also quotations obtained from reliable manufacturers.

9.2.2 Miscellaneous Items

(a) Foreign Exchange

In estimating the costs for foreign components, it is assumed that all items that are not manufactured in Malaysia will be imported. The items include pumps, engines, valves, metering and controlling devices, and other equipment required for pumping stations and treatment facilities. It is also assumed that the materials needed for producing the centrifugally cast reinforced concrete pipes such as steel bars will be imported.

(b) Import Duties

Since the project is undertaken by the Government, it is assumed that no import duties will be assessed against the imported materials and equipment. However, proper administrative procedures will be required to have agreement from the Government agencies concerned.

(c) Engineering Costs

Engineering costs for the construction include the costs both for detailed engineering design and construction supervision services. It is assumed that 10 per cent of the escalated construction costs will be needed for the engineering services. About 50 per cent of the total engineering costs is considered to be needed for the construction supervision services during the 5-year period of implementation.

(d) Contingencies

As contingency allowances, 20 per cent of the estimated construction cost is added to all construction costs, to represent the best estimate of expected costs for the completion of the project. This percentage is estimated on the basis of the similar international projects experienced elsewhere in Asian countries and also taking various factors in the project area into account.

9.2.3 Basis for Operation and Maintenance Costs

The operation and maintenance for sewers, pumping stations and treatment facilities is the responsibility of the Government. The Government should finance annual expenditures required for operation and maintenance of the facilities, including administrative expenses, operating costs, i.e., fuel and salary for operators and labourers, and maintenance services such as repairs and inspection. For estimation of the costs, comparable information obtained from other similar cities in Malaysia and Japan have been reviewed, and the results are used as the basis for reasonable cost estimations.

(a) Sewer

Small sewers of 150 mm (6 in.) in diameter or less and house connection pipes should be cleaned either by rodding equipment or hydraulically-propelled tools. For sewers 225 mm (9 in.) in diameter or larger, power bucket machines consisted of truck loaded bucket and pull-in bucket machine should be used. The annual repairing cost for sewers is assumed to be 0.25 per cent of the construction cost on the basis of the experience obtained in the similar cities both in Malaysia and other countries. Using the above cleaning equipment and also considering the staged construction programme of the sewers, the overall operation and maintenance cost has been estimated for the first stage programme. The assumptions made for the estimations are as follows:

Frequency of Cleaning

Public sewers	- once every four years
House connections	- once every ten years

Cleaning capacity

Public sewers	- 200 m/day (660 ft/day)
House connections	- 2.5 hr/connection

Crew number

Public sewers	- six persons
House connections	- three persons

Useful life span of equipment

Ten years

Cost for spare parts, repairing, overhauling of equipment

Five per cent of equipment cost (per annum)

Work days and hours

Work days	- 300 days per year
Work hours	- 6 hours per day

Wage of crew

M$8.5 per day

(b) Pumping Station

Operation and maintenance costs for these facilities are derived from the current labour and material costs in the area, including power, fuel, water for cooling and sealing, lubrication, screenings removal, and major repairing of equipment.

Inspection and cleaning of pumps and removal of screenings will be made three times a week by at least two workers. A team of two workers can take care of two stations in a day.

Annual cost for repairing of civil works and buildings is assumed to be 0.25 per cent of the construction cost and 2 per cent for electrical and mechanical equipment.

(c) Treatment Facilities

Operation and maintenance required for stabilization ponds are mainly supervisory work. By visual observation, the operator is able to know the general condition of the pond with particular attention to odour and colour of sewage. In addition, accumulation of floating algae and scum of organic materials will be checked periodically along with the growth of aquatic plants in the pond. The operator should also inspect the access road, fencing and embankment, and keep them in good condition.

In view of the above conditions, the operation and maintenance of the ponds should be made by only the limited number of workers with the plant supervisor, thus reducing the costs significantly. The number of staff required for each stabilization pond is assumed to be three. After implementation of the first stage programme, the existing septic tanks will be phased out, and it will be possible to transfer the staff for septic tank cleansing to the stabilization pond operation and maintenance teams. Wage for each worker is estimated at M$8.5 per day. Annual cost for repairing of civil works and others is assumed to be 0.25 per cent of the construction cost of the pond.

Table 9.1 Construction Costs of Gravity Sewers

(M$/m of pipe length, at 1977 price)

Pipe Dia. (mm)	Depth of Excavation (m)							
	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
150	59	83	165	183	-	-	-	-
225	104	128	152	228	305	-	-	-
300	128	151	176	251	330	380	-	-
375	158	181	207	281	360	432	510	-
450	190	216	241	319	400	480	560	-
525	211	237	263	342	489	530	570	-
600	240	270	297	383	536	580	625	670
675	290	323	353	444	604	652	749	845
750	-	346	376	471	632	682	783	-
900	-	423	455	558	728	782	895	-
1,050	-	513	548	658	838	896	1,020	-
1,200	-	587	624	744	932	995	1,130	-
1,350	-	706	745	870	1,066	1,131	1,274	-
1,500	-	810	852	986	1,190	1,260	1,415	-

Table 9.2 Construction Costs of Pressure Sewers

(1) Force Main

(M$/m of pipe length, at 1977 price)

Pipe Dia. (mm)	150	225	300	375	450	525	600	700	800	900
Earth covering of sewer (m)										
1.0	74	88	109	115	157	185	219	512	641	771

(2) Inverted Siphon

(M$/m of pipe length, at 1977 price)

Pipe Dia. (mm)	225	300	375	450	525	600
Depth of excavation (m)						
5.0	293	312	319	367	400	451
6.0	475	494	501	550	584	640
7.0	585	605	611	666	703	770
8.0	708	729	732	792	834	914
9.0	753	773	780	841	885	974

Table 9.3 Construction Costs of Manholes

(M$/unit at 1977 Price Levels)

Internal Size(1) (mm)	Depth (m)							
	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
1,200(2)	1,600	1,770	1,954	2,296	2,464	2,617	2,787	3,375
1,500(3)	-	-	2,549	2,734	2,885	3,038	3,202	-
1,800(4)	-	-	3,267	3,432	3,583	3,756	-	-

Note: (1) Internal size of manholes is decided by that of sewers connected to the manholes.

(2) less than 900 mm of sewers connected.

(3) 900 - 1,200 mm of sewers connected.

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

9.3 Evaluation of Investment Requirement for the First Stage Programme

Discussions were made with Technical and Steering Committees of the Government in December 1977 as to the evaluation of investment requirement for the first stage programme of the project. In the meetings it was tentatively agreed that the preliminary engineering design should include the entire Study Area, covering Butterworth zones 1, 2, 3 and 4, Seberang Jaya zones 1 and 2, and Bukit Mertajam zone 3.

According to the discussions, the preliminary engineering design has been prepared for the Study Area and the costs for the sewerage system are estimated for each of the sewerage zone. Then the priority for sewerage implementation and reasonable scale of the investment programme for the first stage programme have been determined.

In the study, each of the sewerage sub-zone is evaluated in its urgency for the sewerage requirements, using a reasonable rating system similar to that applied for the Master Plan. All the sewerage sub-zones are rated for their priority so that the results can be utilized as the basis for determining the order of priority for implementation and of magnitude of investment for the first stage programme. Procedures for these studies are described briefly in the following:

9.3.1 Priority for Sewerage System Implementation

Priority for providing sewerage system to the 20 sub-zones is determined on the basis of the assessment and rating on five key elements, including (1) population density, (2) progress of urbanization, (3) waste loadings, (4) sewage production, and (5) condition of existing excreta disposal system.

As the first step for the evaluation, basic data are prepared for each of the sewerage sub-zone, covering the five elements both at present and in the future, as summarized in Annex 13. Then, the magnitude of each sub-zone is calculated for each of the five assessment elements using the obtained basic data, as summarized in Annex 14. For example, all figures indicated in the column for 1976 population in Annex 14 are the ratio of population density in each sub-zone to that of Butterworth sub-zone 1-A. Figures in other columns also indicate the ratios of figure for each sub-zone to the highest value in the same column.

For rating of the sewerage sub-zones, each ratio as indicated in Annex 14 is multiplied by the weighted points given to both present and future conditions. Sixty points are equally assigned to each element. In order to make the evaluation more realistic, four alternative combinations of weighted points are considered as shown in Table 9.4. The results of the rating system are summarized in Table 9.5.

The results of the rating indicate that eight sub-zones namely; Butterworth 1-A, 1-B, 3-A, 3-B and 4-A; Seberang Jaya 1-A; and Bukit Mertajam 3-A and 3-B; are gained higher points than other zones. In accordance with the results of the above studies and discussions with the government agencies concerned, it is concluded that these eight sub-zones should be considered as the maximum areas for the first stage programme.

Table 9.4 Assigned Weighted Points for Evaluation of Implementation Priority

Element	Parameter	Basic Point	Weighted Point Alternative 1	Alternative 2	Alternative 3	Alternative 4
i) Population	in 1976	60	30	40	20	40
	in 1985		30	20	40	20
ii) Urbanization	Existing Condition	60	30	40	20	40
	Future Condition		30	20	40	20
iii) Waste Loading	BOD	60	30	40	40	40
	Coliforum		30	20	20	20
iv) Sewage Flows Produced		60	60	60	60	60
v) Excreta Disposal System	Existing Communal Septic Tank	60	15	10	10	20
	Proposed Communal Septic Tank		15	10	10	20
	Individual Septic Tank		15	20	20	10
	Bucket System		15	20	20	10
Total		300	300	300	300	300

Note: Alternative 1: To be assigned the same weighted points to each of the parameters in the elements selected.

Alternative 2: To be assigned higher weighted points to the existing situations.

Alternative 3: To be assigned higher weighted points to future situations.

Alternative 4: To be assigned higher weighted points to existing situations including communal septic tank.

Table 9.5 Results of Rating by Sub-Zone

Sewerage Zone	Subzone	Total Number of Points gained by the Five Elements				Priority			
		Alternative							
		1	2	3	4	1	2	3	4
Butterworth Zone 1	1-A	259.20	267.40	264.00	254.40	1	1	1	1
	1-B	128.10	126.20	125.40	135.40	7	7	7	7
	1-C	113.85	123.20	122.60	115.30	9	9	9	8
Butterworth Zone 2	-	51.00	38.40	62.20	39.80	14	15	14	15
Butterworth Zone 3	3-A	181.35	177.40	176.80	183.70	2	3	3	2
	3-B	134.55	135.60	127.80	137.50	6	6	6	6
	3-C	115.05	124.40	124.20	115.10	8	8	8	9
Butterworth Zone 4	4-A	172.80	160.60	159.60	173.40	4	4	4	4
	4-B	76.05	75.60	76.80	76.50	11	11	13	11
Seberang Jaya Zone 1	1-A	142.50	141.40	139.00	147.20	5	5	5	5
	1-B	63.99	53.10	76.90	54.10	13	14	12	13
	1-C	22.05	20.60	20.80	19.30	18	18	18	18
Seberang Jaya Zone 2	-	72.15	61.65	81.50	63.00	12	12	11	12
Bukit Mertajam Zone 3	3-A	173.85	182.40	180.00	177.50	3	2	2	3
	3-B	109.35	109.30	109.90	111.60	10	10	10	10
	3-C	30.75	34.80	33.40	31.30	17	16	17	17
	3-D	4.20	5.60	4.60	4.80	20	20	20	20
	3-E	49.80	57.20	54.20	51.60	15	13	16	14
	3-F	47.40	34.80	56.80	38.00	16	16	15	16
	3-G	12.60	11.60	13.60	11.60	19	19	19	19

9.3.2 Alternative Magnitudes of Investment

Prior to the detailed planning of the first stage programme, a reasonable magnitude of capital investment for the first stage programme should be determined considering the availability of fund for the project. For that purpose, a study is made to select the most appropriate sewerage system among the possible alternative plans, covering the likely sources of financing, sewer service charges and cost effectiveness of each plan, as discussed in the following:

(a) Financial Resources

The financial viability for the project is dependent, among others, on the adequate magnitude of capital investment which is determined mainly by financial capability of the local authority who will undertake the project, and economic background of the community such as income level or ability to pay of local users relevant to potential revenue projection. Although there is no accepted standard formula to determine the adequate magnitude of the investment, a review of the exemplified practices of comparable existing projects with identical local conditions will contribute to make the estimation reasonable.

The present financial capability of MPSP represented by the annual revenue projection is, therefore, compared with that of the city of Kuala Lumpur which has recently initiated the first five-year sewerage project on a financially viable basis at a total capital cost of approximately M$120 million at 1977 price levels. The present magnitude of annual revenue of MPSP is approximately M$7 million (see Table 10.1, Chapter 10), which is equivalent to about one fourth of annual revenue of Kuala Lumpur amounting to M$28 million.

Since the sewerage project of Kuala Lumpur is the only comparable project in Malaysia and more or less identical to the proposed project in Butterworth and Bukit Mertajam area in every aspects, including income level of the prospective users of the system, the reasonable magnitude of the investment for sewerage project of MPSP is to be approximately M$30 million at 1977 price levels.

(b) Possible Alternative Plans for the First Stage Programme

On the basis of the study results as mentioned in the previous sections, seven alternative combinations of sewerage zones are prepared for further analyses. The basic considerations given to select the possible alternative plans include:

- Avoidance of unrealistically minimized magnitude of the programme which does not necessarily achieve any meaningful contribution for improvement of local conditions.

- Inclusion of the central portion of Butterworth and Bukit Mertajam sewerage districts, such as BW 1-A, BW 1-B, BW 3-A, and BM 3-B, in the first stage programme because of the urgent needs for sanitation improvement in these zones and also the expected high contribution to the revenue from Mak Mandin industrial estate in BW 3-B.

Each of the selected alternative plans are summarized in the following:

Alternative 1

This alternative covers all the eight high priority sewerage sub-zones, namely BW 1-A, BW 1-B, BW 3-A, BW 3-B, BW 4-A, BM 3-A, BM 3-B and SJ 1-A, and is the largest in the magnitude of the construction scale among other alternative plans.

Alternative 2

This alternative excludes sub-zones SJ 1-A from Alternative 1, since SJ 1-A has been developed with septic tank system and the public sewerage system is likely to be less needed.

Alternative 3

This alternative covers the sewerage sub-zones BW 1-A, BW 1-B, BW 3-A, BW 3-B, BW 4-A and BM 3-A, excluding sub-zone BM 3-B from Alternative 2.

Alternative 4

Sub-zones BW 1-A, BW 1-B, BW 3-A, BW 3-B, BW 4-A and BM 3-B are included in this alternative.

Alternative 5

This alternative includes sub-zones BW 1-A, BW 1-B, BW 3-A, BW 3-B, BM 3-A and BM 3-B.

Alternative 6

This alternative is the smallest in the scale, covering BW 1-A, BW 1-B, BW 3-A, BW 3-B and BM 3-A.

Alternative 7

This alternative includes BW 1-A, BW 1-B, BW 3-A, BW 3-B and BM 3-B.

(c) Cost Analysis

On the basis of the above study and the results of preliminary engineering design, comparative analysis has been made for each of the seven alternatives, including estimates for construction costs and possible revenues expected from the system. For estimating the construction costs, the entire sewerage area is classified into two categories depending upon the local conditions, one is as the built-up urbanized areas wherein branch and lateral sewers together with main sewers can readily be provided, and the other as areas sparsely inhabited where the provision of branch and lateral sewers may not be feasible at this stage. Hence the latter category includes the costs only for main sewers running on the existing roads but excludes costs for branch and lateral sewers.

In some of the built-up urbanized areas, the large scale housing development schemes have been underway by private developers with the provision of sewers and septic tanks or Imhoff tanks. These sewers will be incorporated in the new sewerage system as branch and lateral sewers. Thus only main sewers are considered for cost estimation for these areas.

The construction costs are estimated at 1977 price levels, but no consideration is given for cost escalation. It is to be emphasized that these cost estimates are of the order-of-magnitude level and are satisfactory only for planning purposes and for comparison of alternatives.

The results of the cost estimation for each of the seven alternative plans are summarized in Table 9.6.

Table 9.6 Comparative Study for Magnitude of Investment for the First Stage Programme by Alternatives

	Alt. 1 (1)	Alt. 2 (2)	Alt. 3 (3)	Alt. 4 (4)	Alt. 5 (5)	Alt. 6 (6)	Alt. 7 (7)
Served Area (ha)	1,420	1,177	885	1,005	1,005	713	833
Served Population	119,000	100,000	80,000	82,000	84,000	64,000	66,000
Construction Cost 8) (1,000M$)	41,727	34,312	29,685	29,934	28,676	24,049	24,298
Wastewater Quantity							
Domestic (1,000 m^3/yr)	8,590	7,207	5,751	5,897	6,033	4,577	4,718
Domestic (MG/yr)	(1,888)	(1,584)	(1,264)	(1,296)	(1,326)	(1,006)	(1,037)
Trade (1,000 m^3/yr)	4,050	3,822	3,790	3,335	3,781	3,749	3,294
Trade (MG/yr)	(890)	(840)	(833)	(733)	(831)	(824)	(724)
Annual Sewerage Fee 9) (1,000M$)	2,061	1,839	1,658	1,558	1,688	1,507	1,407
Annual Sewerage Fee/ Construction Cost	0.049	0.054	0.056	0.052	0.059	0.063	0.058
Construction Cost per Hectare (1,000M$/ha)	29	29	34	28	29	33	29
Construction Cost per Capita (1,000M$/cap)	0.35	0.34	0.37	0.37	0.34	0.38	0.37

Note:
(1) Areas: BW 1-A, 1-B, 3-A, 3-B, 4-A, SJ1-A, BM3-A, 3-B
(2) Areas: BW 1-A, 1-B, 3-A, 3-B, 4-A, BM3-A, 3-B
(3) Areas: BW 1-A, 1-B, 3-A, 3-B, 4-A, BM3-A
(4) Areas: BW 1-A, 1-B, 3-A, 3-B, 4-A, BM3-B
(5) Areas: BW 1-A, 1-B, 3-A, 3-B, BM3-A, 3-B
(6) Areas: BW 1-A, 1-B, 3-A, 3-B, BM3-A
(7) Areas: BW 1-A, 1-B, 3-A, 3-B, BM3-B
(8) *Total construction cost from* 1980 *to* 1985 at 1977 prices
(9) Assumed to be collected from all prospective users connected to sewers

9.3.3 Evaluation of Alternative Plans for the First Stage Programme

Using the results of the previous studies as presented in Table 9.6, each alternative plan has been evaluated for its cost effectiveness and then the most feasible alternative plan is selected for further detail financial analyses. Followings are the brief descriptions of the evaluation results.

(a) Per Hectare Cost

With respect to per hectare construction cost, Alternatives 4 and 5 are superior to other alternative plans although the demonstrating the cost effective investments for the population to be served by the system.

(b) Per Capita Cost

Alternatives 2 and 5 are superior to other alternative plans, demonstrat the cost effective investments for the population to be served by the system.

(c) Revenue Per Cost

In terms of revenue per construction cost, Alternative 6 is the most competent one followed by Alternatives 5 and 7.

It is apparent from the foregoing analyses of the alternative plans that Alternative 5 is comparatively superior to other alternatives in general aspects such as revenue, cost effectiveness and magnitude of the initial capital requirement for the first stage programme. In view of the above study results and also in consultation with the Government agencies concerned, alternative 5 is finally selected as the most appropriate system for the first stage programme. The selected sewerage system will cover a total area of 1,066 ha and serve an estimated total population of 84,000 in the year 1985.

9.4 Construction and Disbursement Programme

Implementation of the first stage programme, including detailed design and construction, is to start from 1980 and ending by 1985. Detailed design and preparation of tender documents, together with land acquisition for stabilization ponds, are to be performed in 1980 and the construction from 1981.

9.4.1 Construction Schedule for the First Stage Programme

Because Butterworth zones 1 and 3, and Bukit Mertajam zone 3 have their own independent stabilization pond system, construction schedule has been established for each of the zones separately. By doing so, time lag among the construction of the sewerage components can be minimized, and thus the system can start its service in a relatively short time.

The implementation schedule for each of the sewerage zones has been decided taking various factors into consideration, including degree of requirements for sewerage service, benefits and revenues expected by the system, and engineering aspects. Brief description as to the setting of construction schedule for each sewerage zone is given in the following. The proposed sewerage implementation schedule and facilities are presented in Tables 9.7 and 9.8 respectively.

(a) Butterworth Zone 1 (Sub-zones 1-A and 1-B)

In view of the urgent requirement for sanitation facilities in this zone, the construction of sewers and pumping stations is scheduled to complete in 1981, and then a stabilization pond system will be provided at Sungai Nyor in 1982. House connections will be provided simultaneously as the sewer construction progresses.

At the beginning of 1983, it is anticipated that the sewerage system will be functioning and services will cover the entire zone 1 area.

(b) Bukit Mertajam Zone 3 (Sub-zones 3-A and 3-B)

Construction of sewers and pumping stations will start in 1982 and complete by the end of the same year for sub-zone 3-A, but for zone 3-B the construction is scheduled in 1983, while the stabilization pond is to be constructed in 1983. House connections is scheduled in 1983 for sub-zone 3-A and in 1984 for sub-zone 3-B.

At the beginning of 1984, sub-zone 3-A is expected to start services and sub-zone 3-B from the beginning of 1985.

(c) Butterworth Zone 3 (Sub-zones 3-A and 3-B)

For sub-zone 3-A, the provision of sewers and pumping stations is expected to complete by the end of 1984, followed by the construction for sub-zone 3-B in 1985. A stabilization pond at Mak Mandin will be constructed by the end of 1985 to cover both zones 3-A and 3-B. House connections are scheduled to complete by the end of 1985 for sub-zone 3-A and 1986 for sub-zone 3-B.

Although the sewers, pumping stations and stabilization pond in this zone are expected to complete by the end of 1985, the house connections to be provided by private sectors will continue their construction until the end of 1986. Therefore, the sewerage services are anticipated to start from 1986 for sub-zone 3-A and from 1987 for sub-zone 3-B.

9.4.2 Operation and Maintenance Equipment

In accordance with the above mentioned construction schedule, equipment for operation and maintenance for the sewerage system will be needed as the system extends. Purchase of sewer cleaning machines and trucks is scheduled in both 1983 and 1985.

9.4.3 Estimated Construction Costs for the First Stage Programme

As previously discussed, there exist many housing development schemes, which have been provided or will be provided with sewerage facilities, septic tanks or Imhoff tanks by private developers. These facilities generally serve at present only for night soil collection and disposal, however, when the public sewers become available for these areas, these private sewers can be integrated in the new sewerage system as branch and lateral sewers to collect and convey both excreta and sullage water from these areas to the new system. In the light of the situation, no branch and lateral sewers construction within the areas are included in the first stage programme but only main and submain sewers will be provided by the Government.

On the other hand, the construction of all sewerage facilities in other areas wherein no sewerage system exist will be the Government's responsibility. Thus the first stage programme includes only the facilities to be provided by the Government.

The construction costs of the facilities proposed for the first stage programme are estimated on the basis of the preliminary engineering design and the basic costs developed previously. All the costs are expressed at 1977 price levels in Malaysia, including contingency allowances and engineering costs for detailed design and supervision services, as shown in Table 9.9.

Allocation of the costs over the six-year span of the first stage programme has been made according to the construction programme. The first year of the programme (1980) will be for the detailed design work and land acquisition for stabilization ponds, and the following five years from 1981 through 1985 will be the construction phase. The construction costs disbursement schedule for the six-year period from 1980 through 1985 is shown in Table 9.10.

9.4.4 Annual Cost for Operation and Maintenance

As discussed in Paragraph 9.2.3, Chapter 9, the basic assumptions have been made for operation and maintenance of the sewerage system. Based on these assumptions and also the required manpower for the administrative work as shown in Table 4.2, Volume IV, annual operation and maintenance costs for the years from 1980 through 1990 have been estimated as summarized in Table 9.11.

Table 9.7 Implementation Schedule for the Proposed Sewerage Facilities in the First Stage Programme

Items	1980	1981	1982	1983	1984	1985
I) Sewage Collection System						
1. BW1-A and 1-B (including Kampung Bengali, Chain Ferry, and Sungai Nyor pumping stations)	D	C				
2. BM3-A (including Detek pumping station)	D		C			
3. BM3-B (including Sungai Rambai pumping station)	D			C		
4. BW3-A (including Permatang Tengah pumping station)	D				C	
5. BW3-B (including Soon Corporation and Mak Mandin pumping station)	D					C
II) Waste Stabilization Pond						
6. BW1 (Sungai Nyor treatment system)	D		C			
7. BM3 (Sungai Rambai treatment system)	D			C		
8. BW3 (Mak Mandin treatment system)	D					C
III) Other Activities						
9. Land Acquisition	A					
10. Others (cleaning equipment)				A		A

Note: D: Detailed design
C: Construction
A: Other activities

Table 9.8 Proposed Sewerage Facilities by the Government Contribution for the First Stage Programme

Sewerage Zone / Component	BW Zone 1 (BW1-A & BW1-B)	BW Zone 3 (BW3-A & BW3-B)	BM Zone 3 (BM3-A & BM3-B)
1. Sewer			
a. Total length of sewer	11,905 m (7.4 miles)	16,795 m (10.4 miles)	26,440 m (16.4 miles)
b. Size of sewer	225 to 900 mm dia.	225 to 750 mm dia.	225 to 900 mm dia.
2. Pumping Station	a) Kampung Bengali Capacity 4.1 m^3/min 3 pumps	a) Permatang Tengah Capacity 6.6 m^3/min 2 pumps	a) Betek 0.7 m^3/min 2 pumps
	b) Chain Ferry 21.3 m^3/min 4 pumps	b) Mak Mandin 13.6 m^3/min 3 pumps	b) Sungai Rambai 23.1 m^3/min 4 pumps
	c) Sungai Nyor 1.6 m^3/min 2 pumps	c) Soon Corporation 1.1 m^3/min 2 pumps	
3. Waste Stabilization Pond			
a. Design flow (daily average flow)	10,103 m^3/d (2.2 MGD)	12,677 m^3/d (2.8 MGD)	14,023 m^3/d (3.1 MGD)
b. Area required for pond(*)	14 ha (35 acres)	37 ha (91 acres)	32 ha (79 acres)
c. Number required of pond unit	2 units	3 units	4 units

Note: (*) Required land space for the conditions in the year 2000.

Table 9.9 Estimated Construction Costs for Proposed Sewerage Facilities in the First Stage Programme (1980-1985)

(1) Butterworth Zone 1 (BW 1-A and BW 1-B)

(Unit: M$1,000 at 1977 price)

Facility	Cost for Civil & Architectural Works	Cost for Electrical & Mechanical Equipment	Cost for Land Acquisition	Total
1) Sewer facilities	2,520	-	-	2,520
2) Pumping station				
a) Kampung Bengali	87	74	97 (*)	258
b) Chain Ferry	470 (a)	198	21 (*)	689
c) Sungai Nyor	87	74	- (b)	161
3) Waste stabilization pond (Sungai Nyor)	1,216	-	2,632 (*)	3,848
Total	4,380	346	2,750	7,476

Note: (a) Including force main

(b) Included in the cost of waste stabilization pond

(*) Costs are estimated as follows:

For pumping station
Kampung Bengali: 430 (m^2) x 226 M$/$m^2$

Chain Ferry: 600 (m^2) x 35 M$/$m^2$

For waste stabilization pond
Sungai Nyor: 140,000 (m^2) x 18.8 M$/$m^2$

(2) Butterworth Zone (BW 3-A and BW 3-B)

(Unit: M$1,000 at 1977 price)

Facility	Cost for Civil & Architectural Works	Cost for Electrical & Mechanical Equipment	Cost for Land Acquisition	Total
1) Sewer facility	3,647	-	-	3,647
2) Pumping station				
a) Permatang Tengah	491 (a)	174	10 (*)	675
b) Soon Corporation	31	38	- (b)	69
c) Mak Mandin	181	171	- (c)	355
3) Waste stabilization pond (Mak Mandin)	1,216	-	- (d)	1,216
Total	5,569	383	10	5,962

Note: (a) Including force main

(b) Located within the site of existing septic tank

(c) Located within the site of waste stabilization pond

(d) State land

(*) 540 (m^2) x 18.8 M$/$m^2$

(3) Bukit Mertajam Zone 3 (BM3-A and BM3-B)

(M$1,000 at 1977 price)

Facility	Cost for Civil & Architectural Works	Cost for Electrical & Mechanical Equipment	Cost for Land Acquisition	Total
1) Sewer facilities	5,449	-	-	5,449
2) Pumping station				
a) Betek	101	63	- (a)	164
b) Sungai Rambai	212	228	- (b)	440
3) Waste stabilization pond (Sungai Rambai)	1,645	-	1,363 (*)	3,008
Total	7,407	291	1,363	9,061

Note: (a) Located within the site of existing septic tank

(b) Included in the cost of waste stabilization pond

(*) 317,000 m^2 x 4.3 M$/$m^2$

Table 9.10 Disbursement Schedule for the First Stage Programme

(M$ 1,000 at 1977 price)

Description	Local Currency							Foreign Currency							
	1980	1981	1982	1983	1984	1985	Sub-Total	1980	1981	1982	1983	1984	1985	Sub-Total	Total
(1) Sewers	-	2,142	2,213	2,419	1,120	1,980	9,874	-	378	390	427	198	349	1,742	11,616
(2) Pumping Station															
•Mech. and Electrical Equipment	-	104	19	68	52	63	306	-	242	44	160	122	146	714	1,020
•Civil works	-	515	81	170	393	172	1,331	-	129	20	42	98	43	332	1,663
(3) Waste Stabilization Pond															
•Civil Works	-	-	973	1,316	-	1,007	3,296	-	-	243	329	-	252	824	4,120
(4) Cleaning Machine	-	-	-	-	-	-	-	-	-	-	232	-	102	334	334
Sub-total	-	2,761	3,286	3,973	1,565	3,222	14,807	-	749	697	1,190	418	892	3,946	18,753
(5) Consulting Services															
•Engineering design	469	-	-	-	-	-	469	469	-	-	-	-	-	469	938
•Supervision	-	70	80	103	40	82	375	-	105	120	155	60	123	563	938
(6) Contingencies	94	566	673	815	321	661	3,130	94	171	163	269	96	203	996	4,126
(7) Land Acquisition	4,123	-	-	-	-	-	4,123	-	-	-	-	-	-	-	4,123
Total	4,686	3,397	4,039	4,891	1,296	3,965	22,904	563	1,025	980	1,614	574	1,218	5,974	28,878

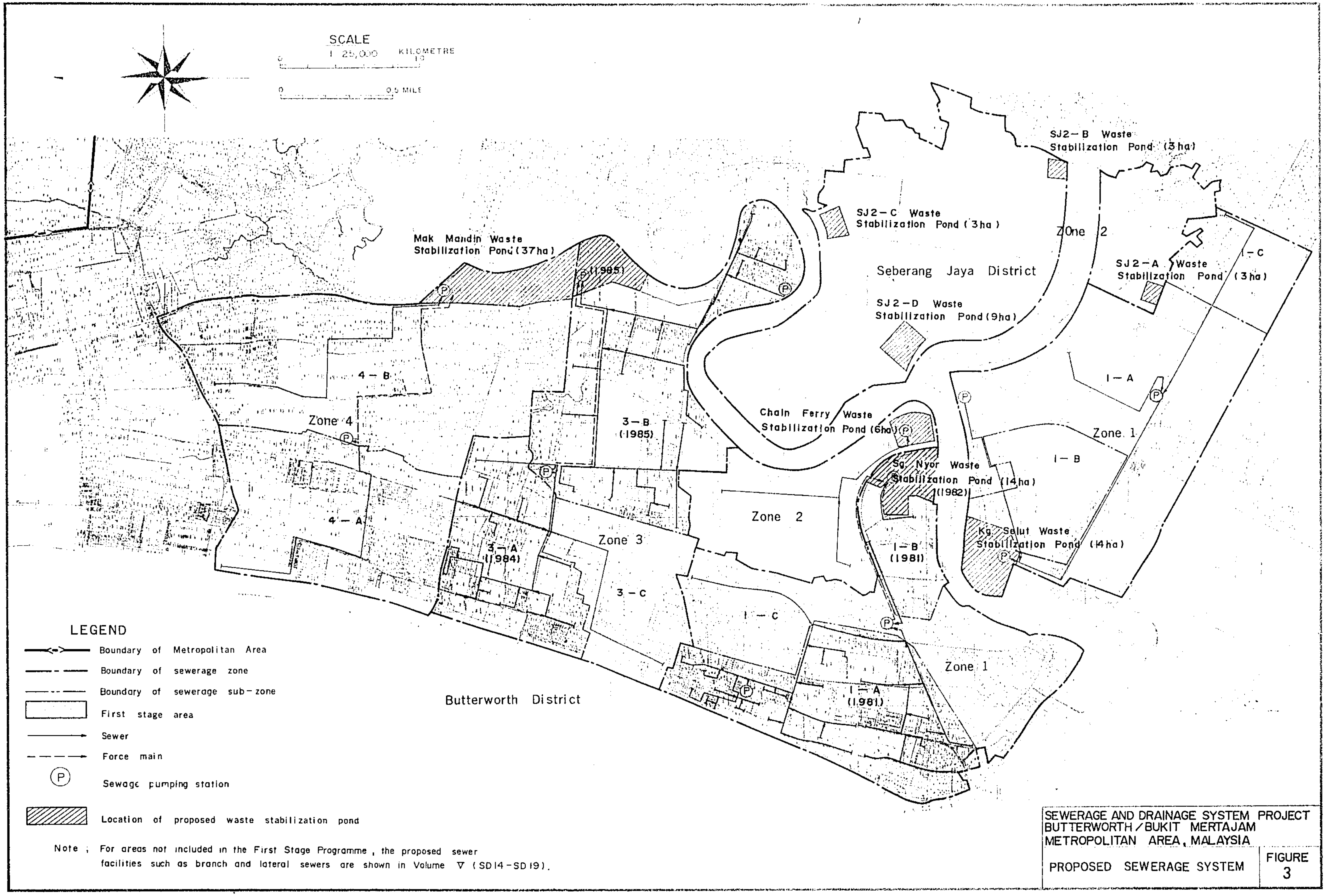
Table 9.11 Annual Operation and Maintenance Costs

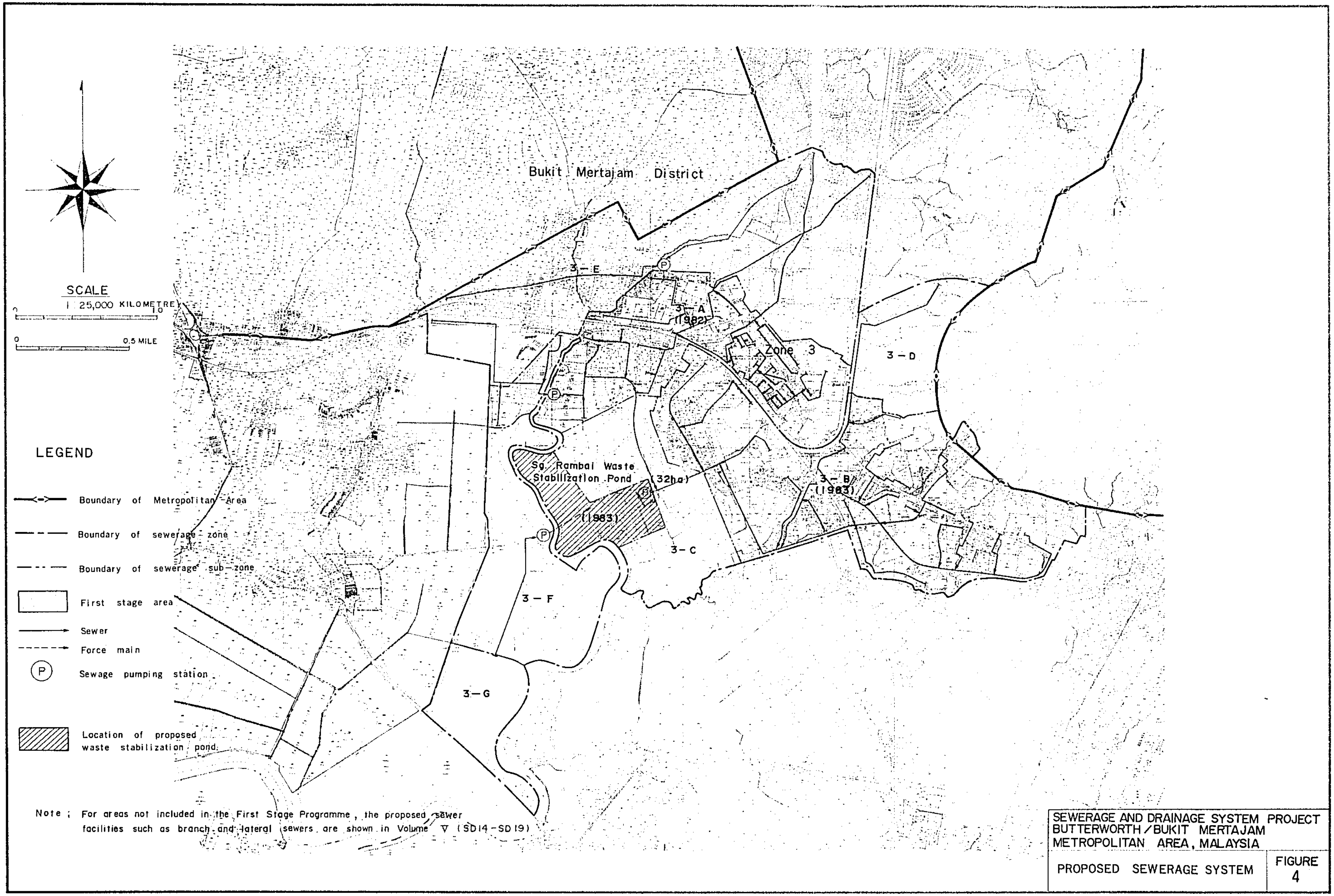
(M$1,000 at 1977 prices)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Payroll (a)	86	153	153	284	355	397	410	410	410	410	410
Maintenance	-	-	-	43	64	101	119	134	134	134	134
Power	-	-	-	26	35	43	53	68	69	70	71
Administration (b)	9	15	15	28	36	40	41	41	41	41	41
Total	95	168	168	381	490	581	623	653	654	655	656

Note: (a) Wages and salaries for the personnel to be employed for the sewage works.

(b) Miscellaneous expenses including those for office supplies and personnel temporarily employed.


SCALE
1 : 25,000
KILOMETRE
0.5 MILE
Mak Mandin Waste
Stabilization Pond (37ha)
(1985)
SJ2-C Waste
Stabilization Pond (3ha)
SJ2-B Waste
Stabilization Pond (3ha)
Zone 2
Seberang Jaya District
SJ2-A Waste
Stabilization Pond (3ha)
1-C
SJ2-D Waste
Stabilization Pond (9ha)
1-A
4-B
Zone 4
3-B
(1985)
Chain Ferry Waste
Stabilization Pond (6ha)
Zone 1
1-B
Sg. Nyor Waste
Stabilization Pond (14ha)
(1982)
Zone 2
4-A
3-A
(1984)
Zone 3
Kg. Selut Waste
Stabilization Pond (14ha)
1-B
(1981)
3-C
1-C
Zone 1
1-A
(1981)
Butterworth District
LEGEND
Boundary of Metropolitan Area
Boundary of sewerage zone
Boundary of sewerage sub-zone
First stage area
Sewer
Force main
Sewage pumping station
Location of proposed waste stabilization pond
Note ; For areas not included in the First Stage Programme, the proposed sewer facilities such as branch and lateral sewers are shown in Volume V (SD14-SD19).
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
PROPOSED SEWERAGE SYSTEM
FIGURE
3


Bukit Mertajam District
SCALE
1 : 25,000 KILOMETRE
0 1.0
0 0.5 MILE
3 - E
3 - A
(1982)
Zone 3
3 - D
Sg. Rambai Waste
Stabilization Pond (32ha)
(1983)
3 - B
(1983)
3 - C
3 - F
3 - G
LEGEND
Boundary of Metropolitan Area
Boundary of sewerage zone
Boundary of sewerage sub-zone
First stage area
Sewer
Force main
Sewage pumping station
Location of proposed waste stabilization pond
Note ; For areas not included in the First Stage Programme , the proposed sewer facilities such as branch and lateral sewers are shown in Volume V (SD14-SD19)
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
PROPOSED SEWERAGE SYSTEM
FIGURE
4

CHAPTER 10

FINANCIAL PLANNING

10.1 Introduction

The financial implications are highlighted in this chapter for the ultimate objective to develop a programme by which the project of the investment magnitude of M$28,878,000 can be implemented on the sound financial bases. Such financial implications include the current financial situation of the agency which will be directly involved in the execution of the project, the financing for the required initial capital and recurrent costs with due consideration on the equitable financial contributions from the beneficiaries of the services. The sewerage service charge expected to be collected from the potential users of the services has direct bearings on income of each user or capacity of the user to pay the charge which is also commented in this chapter.

10.2 Current Financial Situation of Majlis Perbandaran, Seberang Perai (Municipal Council, Province Wellesley)

Prior to the amalgamation of the three district councils of North, Central and South in 1975, three separate accounting activities had been undertaken in the three councils under the administration of Penang State Treasury. In 1975, the major reorganization was performed to unify those councils and accounting functions were transferred back from State Treasury to the present MPSP. In the wake of above restructure and reshuffle the Municipal Council, Province Wellesley has turned to be financially autonomous body under the Local Government Act, 1974, which is currently enacted to supersede the outmoding Municipal Ordinance.

As there is presently no normal sewage works undertaken by MPSP except rudimental public sanitary services as night soil collection and disposal as well as desludging of septic tank, it is considered not possible to present information normally required for financial analysis of agency responsible for sewage works. The following description refers, therefore, to general views of revenues and expenditures of the public services provided by MPSP. Table 10.1 shows the summary of the revenues and expenditures of MPSP for the past three years. The major revenue source for MPSP is the general rates including contribution in lieu of rates representing approximately 70 percent of total revenue as of the

Table 10.1 General Revenue and Expenditure Accounts for 1975 - 1977 (M$), MPSP

REVENUE	1975	1976	1977
Rates	3,701,165	4,291,400	6,641,900
Contribution in lieu of Rates (1)	934,430	575,430	1,204,000
Miscellaneous Tax	17,590	4,000	1,700
Government Subsidy & Special Revenue	1,793,000	2,093,000	1,480,020
Other Non-rate Income	1,293,000	1,085,852	1,394,120
Total Revenue	7,739,185	8,049,682	10,721,740
EXPENDITURE			
Secretariat (Administration):	1,582,603	1,775,405	1,644,892
Health Division:			
Refuse Collection & Disposal	1,727,654	1,886,240	2,167,004
Desludging & Maintenance of Septic Tank	272,132	267,808	314,062
Other Health Service	1,221,890	1,303,309	1,339,209
Engineering Division:	951,109	1,054,215	1,136,397
Building Division:	460,737	471,405	478,436
Town Planning Division:	50	11,811	37,139
Finance Division:	535,797	545,378	587,257
Valuation Division:	169,777	178,960	322,310
Special Expenditure:			
Procurements	320,350	648,330	494,290
Market Construction & Extension	1,470,000	1,762,020	1,382,010
Drainage Construction & Improvement	493,010	413,010	100,020
Other Development Works	265,050	997,050	269,790
Evaluation Works	10	20,000	737,800
Subtotal	9,470,169	11,334,941	11,010,616
Surplus(Deficit) to General Reserve Fund	(1,730,984)	(3,285,259)	(288,876)
Total Expenditure	7,739,185	8,049,682	10,721,740

Note: (1) Contribution equivalent to rates due from the government and quasi governmental agencies including State and Federal Government, Army/Air Force, Penang Port Commission, National Electricity Board, Malayan Railways, Penang Water Authority and National Padi(Rice) Board.

year 1977. The rates are levied on the basis of annual rental value of the property within the boundary of the council.

These rates are varied in respective areas and categories as follows:

Rates	Ratable Properties	Areas
21%	Households, Buildings & Lands	Town Areas
16%	Buildings and Lands	Industrial Areas
16%	Households and Buildings with flush toilets & bucket systems	Outside Town Areas
13%	Households and Buildings without flush toilets or bucket systems	Outside Town Areas
7.5%	Lands	Outside Town Areas

Since the last evaluation of properties which took place approximately 20 years ago, no new valuation has been performed except for newly developed housing and building estates which are evaluated by current market price. The new revaluation is now being attempted, to establish a realistic valuation and to adjust the anomaly between the property values assessed in 20 years ago and those new properties assessed by recent market price.

Such revaluations have also been contemplated in other cities and municipalities in Malaysia to ameliorate obsolete evaluations. They are, however, expected to be confronted with public resistance to the revaluations which would result in net increase of rate due from property owners. The authorities are, therefore, considering reduction of existing ratios of rates as against the increase of property value as a result of the revaluation in order to mitigate the public resistance. While it may be politically undesirable to give rise to public discontent, such revaluation is considered to be vital to the reasonable increase of rate revenue. MPSP is, therefore, recommended to take a necessary step to increase the rate revenue in a justifiable manner reflecting the revaluation to be implemented around the year 1980.

The major expenditures of the MPSP are those related to public sanitary services, i.e., refuse collection and disposal and special development works such as construction and improvement of market place and public amenity facilities. The capital expenditure for the major development works has been financed by State Government loans at low interest rates of 5 per cent per annum with 10 years repayment period. The outstanding loans as of December 31, 1977 are insignificant and totally amounted to M$147,800. Among the past three years, the statements of the accounts of 1976 indicates the highest deficit due mainly to increased development expenditure and modest increase of rates revenue. The financial situation in 1977 has been expected, however, to be significantly ameliorated by sharp increase of rates revenue and moderate amount of expenditures for the development works. The rates revenue is expected to increase further in accordance with increasing annual assessment value (equivalent to annual rental value of property) in development area where new housing and industrial developments are in progress.

10.3 Financial Situation of Water Supply Agency (PWA)

Penang Water Authority (PWA) was established on 1st January, 1973 as a fully autonomous body authorized by Federal Legislation amalgamating the former City Water Department of the City Council of Georgetown which provided the water supply in the City and adjacent areas, and the former Water Supply Section of the State Public Works Department which provided water supply in Province Wellesley and in certain parts of Penang Island. The newly established PWA has been providing water supply in the whole area of the State of Penang since the date of formation. The financial situation of PWA has been in good position since its formation owing to annual increase of revenue at constant rate of over 10 per cent. The annual surplus derived from recurrent revenues and expenditures has been applied to the investment on capital works such as construction and improvement of the facilities and systems. Table 10.2 indicates revenue and expenditures of the PWA since its formation in 1973.

The water billing rates established at the formation of PWA in 1973 are still valid. Billing rate for domestic supply is M$0.6 per 4,550 litres (1,000 gallons) for the first 22,750 litres (5,000 gallons) and M$0.95 per 4,550 litres (1,000 gallons) over 22,750 litres (5,000 gallons). The trade charge is M$1.30 per 4,550 litres (1,000 gallons) for the first 22,750 cubic metres (5 million gallons). PWA is well organized by the competent staff and computerized billing and collection systems. PWA is undertaking billing of other public utility charges on commission basis which is subject to an agreement with an agency requesting such billing.

PWA has recently completed water supply project under ADB loan finance to ensure an adequate supply of water from the Muda River which is at present a main source of water supply to whole Penang State area. Under the Third Malaysia Plan, water supply programmes are proposed to be implemented by PWA under Federal Government financial contribution, as described in the following:

Table 10.2 Penang Water Authority Revenue, Expenditure and Capital Works

Number of Consumers	1973	1974	1975	1976
Domestic	79,626	83,018	89,580	84,025
Trade				5,618
Total Quantity of Water Supplied (million gal/year)	11,464.93	11,877.56	13,434.05	14,491.87
REVENUE				
(1) from metered supplies	$9,408,792	$11,185,770	$12,440,505	$13,690,257
(2) from other sources	327,668	338,082	742,988	835,667
Total Revenue	$9,736,460	$11,523,852	$13,183,493	$14,525,924
EXPENDITURE - RECURRENT				
(1) Production & Distribution	4,030,304	4,366,755	4,955,790	4,965,845
(2) Management & General	1,088,439	1,390,814	1,764,355	1,758,114
(3) Depreciation	-	2,491,940	2,656,365	2,767,565
(4) Interest	2,850,411	3,048,855	3,041,008	2,975,089
Total Recurrent Expenditure	$7,969,154	$11,298,364	$12,417,518	$12,466,613
EXPENDITURE - CAPITAL				
(1) New Capital Works (including renewal)	6,811,224	2,362,474	1,839,224	2,011,417
(2) New Meters	153,576	270,155	330,091	97,660
Total Capital Expenditure	$6,964,800	$2,632,629	$2,169,315	$2,109,077

(a) River Muda Water Scheme

- Purchase of new pumps and renovation of the filtration plant at River Dua waterworks, Seberang Perai, at the estimated cost of M$1 million (1978-1979).

- Laying of approx. 4.9 km (16,000 ft.) of 1,220 mm (48") steel pipeline from Weld Quay to Bukit Dumbar, Penang Island, at the estimated cost of M$2.5 million (1977-1979).

- Construction of a 10 million-gallon service reservoir at Bukit Dumbar at the estimated cost of M$5 million (1977-1979).

- Laying of approximately 6.1 km (20,000 ft.) of 533 mm (21") A.C. pipeline from Bukit Indera Muda Reservoir to Bukit/Mertajam at the estimated cost of M$0.8 million (1978-1979).

- Rural Water Supply Projects at the estimated cost of approximately M$1.5 million (1976-1980).

10.4 Sources of Finance

10.4.1 Sources for Capital Costs

The financial viability of the project would ultimately be ensured by adequate magnitude of the construction and well schemed funding for the required costs. The determination of investment magnitude of the sewerage construction programme is partly dependent on the political judgement on the need of such public sanitary system. If there is an urgent need for the pollution control and public health protection in a certain community, the sewerage project will be given high priority and significant amount of construction from the government sources can be expected. In such a case, the magnitude of the sewerage construction can be enlarged in proportion to such a contribution provided.

The magnitude of investment to meet the required construction costs for the initial 5 years is considered to be totally M$28,878,000 as discussed in Section 9.3.3 on the understanding that the sewerage system for Butterworth and Bukit/Mertajam area will be self-supporting to the extent possible. The financial feasibility of the project is, therefore, dependent on the minimized investment cost for meaningful construction programme and stable revenue projection.

As the means to help minimize the capital cost, MPSP is contemplating the sewerage system construction within housing development areas by private developers and the cost of the sewerage system is reimbursed by the household owners. The loans from the international lending agencies such as International Bank for Reconstruction and Development (IBRD), the Asian Development Bank (ADB), or bilateral fund sources as Overseas Economic Cooperation Fund (OECF), Japanese Government, are assumed to finance mainly the foreign portion of the required cost of the construction. The remaining part of the construction cost is assumed to be financed by the Federal Government loan. The terms and conditions of the loans are considered on the basis of current loan practices of IBRD, ADB and OECF as well as Federal Government as described in the subsequent Financial Projection.

Although it is a basic desire to expect self-supporting operation of the project; such a project as sewerage development programme entails a significant amount of capital cost with relatively less remunerative nature. The government contribution to a certain part of the cost for the sewerage system, in any form of financial assistance, is found necessary under the present magnitude of investment in order to help reduce the loan amount and alleviate the difficulty of the debt service payment for placing the project on a sound and viable financial basis.

10.4.2 Sources for Operating Revenue

The sufficient revenues have to be raised for the satisfactory operation and maintenance of the sewerage system. The revenues to be generated in whatever methods would be required to compensate not only the cost related to physical maintenance of the system but also the financial cost as debt service payments. The methods to raise such revenue should be designed to satisfy, to the possible extent, the simple practicable and equitable operation.

The "benefit-received" principle is normally employed in the selection of revenue sources to meet the required cost. There are two methods in a broader concept to meet such principle, one is to impose a charge on the users of the wastewater system in proportion to the use they make of the system, and the other is to levy the charges on the whole community both for users and nonusers of the system in accordance with the overall community benefits derived from the sewerage services.

The former is more directly related to the individual users of the system and normally takes a form to collect the charges based on waste water flow contribution. The latter is normally considered to supplement the revenue sources taking a form of assessment on properties based on the justification that each property, occupied or unoccupied, and each person, user or nonuser, receives benefits. The following alternative charging method currently practiced elsewhere in the world are therefore considered to be of help to select the feasible method for this project.

(a) Pedestal Charge

The flat rate is multiplied by the number of water closet (WC) pedestals in the household to calculate the charges on the theory that the waste volume is linked with the pedestals. Collection of the charges is administratively easy and has been practiced in Georgetown, but it does not appear that the waste discharge is closely related to the pedestals, and more reasonable method that directly reflects the actual water use should be considered.

(b) Fixture-unit Charge

The number of water fixtures, such as faucets, water heaters, air coolers and flush toilets, is multiplied by a flat rate to estimate the charge based on the theory that the volume of waste discharge is related to the volume of water consumption, hence to the number of fixtures. However, the households which have many fixtures do not necessarily consume much water for the number of fixtures.

(c) Per Capita Charge

The charge is calculated multiplying the number of residents or employees in a household or commercial property by a flat rate fee based on the theory that volume of waste discharge is proportionate to the number of residents. This method is more logical than the above two methods in estimating the quantity of waste discharge, however, it has a significant disadvantage in practicability as there is no registration system to confirm the number of residents in the Study Area.

(d) Surcharge on Water Consumption

The water rate surcharge is a service charge related to water use which is calculated by adding a fixed rate to metered water consumption. This method would appear to be the best alternative satisfying the required adequacy for recommendable method because the volume of waste discharge is closely related to water consumption which is accurately metered. Although there will be certain cases that water consumption is difficult to measure where consumers take water from private sources (wells), most water in the Study

Area is supplied by pipe, hence this surcharge rate system seems to be the best alternative.

Another benefit of this method would be that the collection of charges can be made without difficulty in combination of billing procedure for water supply already in existence. In discussion with the official of PWA, it has been assured that the collection of the charge can be made with reasonable billing commission and that the agency is well arranged physically and administratively in carrying out such procedures by the computer billing system.

(e) Sewerage Benefit Assessment

Special rate can also be levied in addition to the existing assessment on properties in the area provided with the sewerage services. Such a specific rate can be more justifiable in that revenue can be obtained from the area receiving direct or indirect benefits from the systems while general rate revenue is derived from the wider area including the area with no connection to the sewerage services. The Local Government Act, 1976 empowers the local municipality in its Sections 128, 130 and 131 to impose sewerage improvement rate at a maximum of 5 per cent per annum of the annual value of the property served or to be served by sewerage system, to meet the costs for construction and maintenance of such sewerage system.

(f) Surcharge on Industrial Wastewater

There has been a theory maintained in recent years in many countries of the world that the industry should be charged to defray the cost additionally incurred to treat the industrial wastewater containing certain types of materials which substantially exceed in quality found in normal domestic wastewater. Such charge is frequently referred to as surcharge and is charged for each unit weight of BOD and SS or other measurement of wastewater strength in excess of a concentration in normal domestic wastewater. The regulations or bylaws are required in this instance to establish level of BOD and SS concentration for additional charges in addition to prohibited constituents of wastewater. The industry can be exempted from the surcharge by providing pre-treatment facilities which reduce the waste strength to the level comparable with that of domestic wastewater.

The surcharge system has the advantage of encouraging the industry to reduce the pollution load of its waste and examine its process critically from the point of view of efficient and examine its process critically from the point of view of efficient use of raw materials including water. Although such advantage is of a significant importance, there is a disadvantage of enormous administrative complexity in this system. It requires, however, additional cost, trained personnel and time-consuming procedures as sampling, analyzing and flow measuring.

10.5 Recommended Charging Systems

Studies on the selection of the revenue sources to meet the required annual cost, including the operating expenditure and debt service payment, are undertaken based on the principle that the individuals should contribute toward meeting cost in relation to the benefits they receive from the use of the sewerage services. Those who receive the benefits are not necessarily direct users connected to the sewer but include the owners of properties receiving general benefits of health protection, nuisance elimination, aesthetic enjoyment of waterways and increase of market value of properties. Both the property owners and the users should, therefore, contribute fair share of the cost associated with the construction of the system as represented in a form of annual repayment of loan required for such construction, and operation and maintenance costs to ensure continued satisfactory service.

The most appropriate charging method from the direct users shall be to collect surcharge on water consumption of the individual users. This method is particularly considered adequate in the Study Area where all water used is metered. The water rate surcharge will be billed and collected by PWA through combined water and sewerage bills, and the proceeds of the surcharge will be remitted to the agency responsible for the sewerage system operation after deduction of an agreed fee for PWA's service. A legislative arrangement will be required to add stipulations qualifying the joint billing of water and sewerage charges and cutting off the water supply in case of non-payment of sewerage charge in the existing Penang Water Authority Enactment, 1972.

As the supplementary revenue to be contributed from residents who will receive general benefits of sewerage services, sewerage benefit assessment is considered logical, but a great deal of difficulties are anticipated from the past experience of MPSP in identifying property owners who will benefit from sewerage system construction, and in billing and collecting additional rate of fees from them.

Uncollected revenue may be accumulated to a degree that the projected revenue plan would result in complete failure at the implementation stage and therefore this is not recommended.

General rates revenue among the items of revenue of the Municipality is the major source of revenue, as stated earlier, on the rental value of the properties. The nature of the revenue being levies on property values, it may be permissible to consider the use of a part of such revenue for sewerage system service in order to make the financial planning viable, even though it may be less equitable as the revenue is obtained from whole municipal area while the benefits of such revenue accrue to only limited area provided with sewerage services. However, such provision of fund derived from the general rates may be justified, on the basis of social investment for improvement of general health and sanitation of the community as a whole.

The combination of the above two financing sources, namely, surcharge on users and financial assistance from general rates is therefore considered to ensure the best means on the basis of equitable and practicable consideration between the user and non-user beneficiaries.

As for the surcharge on industrial wastewater, it is concluded that such charging system cannot be practiced in the immediate future because it is obvious that a considerable period of time is required for further technical studies and legislative arrangement to introduce such system of charges. While studies on industrial waste tariff should be undertaken at the earliest possible convenient time, its immediate application should be avoided. Although the industries will not be charged a higher surcharge associated with the quality of the wastewater, they will be charged a higher rate than domestic sewerage rate per unit water consumption since such rates have been computed on the basis of uniform percentage of the existing water rates of which the rate for industrial water is higher than that for domestic water.

In order to ensure revenue from the direct users, which will constitute main source of financial support, serious consideration should be given to enact regulation in effect to make connection mandatory whenever services are made available within 100 ft from property. Moreover, the sewerage charge should be collected regardless whether the households are connected to the sewer or not. Such arrangement for enforced payment will likely to overcome customers' initial reluctance to avail them of the sewerage services, and expedite the connections, thus making the financial plan workable.

10.6 Financial Projection

On the basis of the recommended charging systems and estimated annual construction programme, four alternative financial plans are developed based on various loan components with varid interests and terms as follows:

Alternative - I : Combined loans from IBRD or ADB for foreign currency portion of M$7,918,000 which is approximately 21 per cent of the total project cost and from Federal Government for loan currency portion of M$29,831,000 or approximately 79 per cent of total project cost.

Alternative - II : Combined loans from OECF for foreign currency portion of M$7,918,000 approximately 21 per cent of the total project cost and from Federal Government for local currency portion of M$29,831,000 or approximately 79 per cent of the total project cost.

Alternative - III : Combined loans from IBRD or ADB for M$15,100,000 or approximately 40 per cent of the total project cost and from Federal Goverment for M$22,649,000 or approximately 60 per cent of the total project cost.

Alternative - IV : Combined loans from OECF for M$15,100,000 or approximately 40 per cent of the total project cost and from Federal Government for M$22,649,000 or approximately 60 per cent of the total project cost.

The following components are assumed as the basis of the alternative financial plans. The projected financial statements for four sets of alternative plans are shown in Tables 10.7 through 10.18.

(a) Fund Requirements

The capital cost for the first stage programme from 1980 to 1985 and operation cost from 1980 to 1990 only, for the purpose of funding indication of general trend of financial condition, are summarised in Tables 10.3 to 10.5. These costs include the allowance for price escalation of 5 per cent per annum on the costs estimated at 1977 prices.

(b) Loans

The loans from the multilateral lending agency such as IBRD and ADB as well as bilateral lending agency such as OECF are assumed to provide funds for foreign currency portion of the project cost. As the foreign currency component of the project cost is significantly small equivalent to only 21 per cent of total cost, the alternative financial projections are attempted on the assumption that above international lending agencies would not limit the loan to the foreign currency portion only but extend a loan to a part of local currency portion when local currency is not sufficiently available and particularly when local procurement is done for those of foreign origin. The alternative financial projections, therefore, incorporate the foreign exhcnage component equivalent arbitralily to approximately 40 per cent of total project costs.

The terms of above international loans are assumed from the current lending practice of each lending agency for the development project in South East Asian regions including Malaysia. The loan from IBRD or ADB is assumed to be made at 8 per cent per annum, 20 equal annual repayments after 6 years grace period. The loan from OECF is assumed to be made at 4 per cent interest per annum, 14 equal annual repayments after 6 years grace period. The above terms of loans are relatively hard as they are normally applied for the development project. It is expected, therefore, that softer terms of loan can be made for such less remunerative development project as sewerage works, subject, however, to lending policy of the agencies concerned. The Federal Government loan is assumed to be made at 6 per cent interest per annum and 30 equal annual repayments after 6 years grace period. The disbursement of loans is assumed dictated by annual capital requirements.

The deferred payment of interest in addition to deferred payment of principal during the grace period (construction period) is assumed to reduce the significant financial burden which the agency would otherwise be required to assume. Such interest is recommended to be charged to operation after the grace period when construction is completed and sufficient revenue is generated.

(c) Depreciation

Depreciation allowances are estimated by applying the composite depreciation rate of 2.4 per cent to the completed fixed assets in service.

The above depreciation rate is calculated based on the estimated life and the estimated investment for each category of the sewerage system as follows:

Category	Estimated life	Depreciation rate (a)	Share of investment (b)	(a)x(b)
Sewers, ponds and structures	50 years	2%	93%	1.9%
Equipment and machine	15 years	6.7%	7%	0.5%
		Composite Rate		2.4%

(d) Revnue Projection

From the year 1983 to 1985, the sewerage unit rate is assumed to be M$0.53 per 1,000 Imperial gallons for domestic wastewater (equivalent to 70% of average unit rate for domestic water). The average unit rate for trade wastewater for the same period is assumed to be M$0.9 per 1,000 Imperial gallons (equivalent to 70% of existing average unit rate for trade water).

The average monthly water bill per household in the project area is M$7 and the sewerage rate equivalent to 70 per cent of water bill will be approximately M$5, which is equivalent to approximately 0.8 per cent of the average monthly household income of M$610. The rate of 0.8 per cent can be considered to be within the ability of the residents to pay for the sewerage charge as indicated in detail in subsequent Section 10.6. The projected sewerage charges by year are summarized in Table 10.6. The collection of the sewerage charge is entrusted to PWA and the collection fee of 2 per cent of the sewerage charge is assumed to be paid to PWA.

The unit rate of surcharge is assumed to increase to M$0.67 and M$1.18 for domestic and trade wastewater respectively (each represents 90% of respective water rate presently employed) from 1986 to meet the allowance for assumed escalated prices. Such increase of rate is assumed to be justifiable as the ability of the customers to pay would increase in accordance with the general trend of increased wage level in the continuing favourable economic climate of the State and the country at large.

The above sewerage rates for the initial three years (1983 - 1985) are almost equivalent to sewerage tariff of Kuala Lumpur city where unit rates of M$0.4 for domestic, M$1.00 for commercial and M$0.7 for partly trade and partly domestic wastewater are employed at each unit volume of 1,000 Imperial gallons.

The general rate is assumed to be allocated from MPSP's general rate fund to supplement the sewerage charge revenue. The amount of such allocation is assumed to meet the minimum requirements to enable the financial plan of each alternative to be at least viable on cashflow base.

(e) Minimum Requirements for Financial Feasibility

In comparison with other public utility system works, the sewerage works normally entails large capital investment and cost for subsequent operation and maintenance of the completed facilities, while user's contribution will be less substantial in amount. For these reasons, it is difficult to expect a net profit as required normally for the remunerative enterprises.

The revenue should be projected, however, at least to cover operation expenses and debt service payment as the minimum requirement for the feasibility of the sewerage project; otherwise the project operation would be suspended due to shortage of cash available. In this context, the cash balance at the end of each year during the implementation of the project is projected to cover at least four months' operation expenses of the following years in a projected cash flow statements of the alternative plans.

(f) Other Supporting Requirements

The connections of public sewers with all domestic, commercial and industrial properties are assumed to be made as soon as public sewers are made available within 100 ft of the properties. The cost for such connections, pertinent plumbing and replumbing would be borne by the property owners and such a cost is not included in the financial projections.

The cost for construction of local sewers as well as connections including plumbing and replumbing in the development areas is assumed to be borne by developers and such a cost is excluded from the financial projections.

A revolving fund is recommended to be set up to provide loan assistance for customers who would face financial difficulties to pay for the cost of connection, plumbing and replumbing. The loans from such fund are recommended to be made repayable over six years at an interest of 5 per cent per annum. The required amount of such fund will be assessed only after sewers are extended, and therefore, it is not included in the financial projections.

Table 10.3 Project Cost Estimates

(M$1,000)

	1980		1981		1982		1983		1984		1985		Total	
	L	F	L	F	L	F	L	F	L	F	L	F	L	F
Sewers			2,142	378	2,213	390	2,419	427	1,120	198	1,980	349	9,784	1,742
Pumping Station:														
Mech. & Electrical Equipment			104	242	19	44	68	160	52	122	63	146	306	714
Civil Works			515	129	81	20	170	42	393	98	172	43	1,331	332
Waste Stabilization Pond:														
Civil Works	-	-	-	-	973	243	1,316	329	-	-	1,007	252	3,296	824
Cleaning Machine	-	-	-	-	-	-	-	232	-	-	-	102		334
Land	4,123	-	-	-	-	-	-	-	-	-	-	-	4,123	
Sub-Total	4,123	-	2,761	749	3,286	697	3,973	1,190	1,565	418	3,222	892	18,930	3,946
Consulting Services:														
Engineering Design	469	469	-	-	-	-	-	-	-	-	-	-	469	469
Supervision	-	-	70	105	80	120	103	155	40	60	82	123	375	563
Physical Contingencies	94	94	566	171	673	163	815	269	321	96	661	203	3,130	996
Total Project Cost (End, 1977 price)	4,686	563	3,397	1,025	4,039	980	4,891	1,614	1,926	574	3,965	1,218	22,904	5,974
Escalation Factors (a)	1.158		1.216		1.276		1.34		1.407		1.477			
Total Project Cost	5,426	652	4,131	1,246	5,154	1,250	6,554	2,163	2,710	808	5,856	1,799	29,831	7,918
(Escalated Price)	6,078		5,377		6,404		8,717		3,518		7,655		37,749	

Note: L : Local Currency
F : Foreign Currency
(a): 5% per annum for total cost

Table 10.4 Operation and Maintenance Costs at Escalated Prices (a)

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Payrol (b)	100	186	195	375	499	586	636	668	701	736	773
Maintenance				58	90	149	185	218	229	240	253
Power				35	49	64	82	111	118	126	134
Administration (c)	10	18	19	38	51	59	64	67	70	74	77
Total	110	204	214	506	689	858	967	1,064	1,118	1,176	1,237

(a) Escalated at 5% per annum on End 1977 price.
(b) Wages and salaries for the personnel to be employed for the sewerage works.
(c) Miscellaneous expenses including expenses for office supplies and personnel temporarily employed.

Table 10.5 Construction and Operation and Maintenance Costs by Year at Escalated Prices

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Construction	6,078	5,377	6,404	8,717	3,518	7,655	-	-	-	-	-
Operation & Maintenance	110	204	214	506	689	858	967	1,064	1,118	1,176	1,237
Total	6,188	5,581	6,618	9,223	4,207	8,513	967	1,064	1,118	1,176	1,237

Table 10.6 Projected Sewerage Charges (1981 - 1990)

M$

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
A. Total Population Butterworth/ Bukit Mertajam Metropolitan Area	310,670	327,785	345,844	364,897	385,000	398,616	412,713	427,308	442,420	458,000
B. Estimated Connected Population			24,740	43,176	63,871	76,411	85,104	86,201	87,335	88,503
C. % of Population Connected			7.2	11.8	16.1	19.2	20.6	20.2	19.7	19.3
D. Estimated Households Connected			4,333	7,615	11,345	13,694	15,361	15,673	15,995	16,329
E. Estimated Water Consumption-Connected Customers in liters (Ig)/cap/day	189 (4.15)	191 (42)	193 (42.4)	195 (42.9)	197 (43.3)	199 (43.7)	201 (44.2)	203 (44.6)	206 (45.3)	208 (45.7)
F. Annual Domestic Water Consumption-Connected Customer (B x E x 365) in 1,000 m^3 (IMg)			1,743 (383)	3,076 (676)	4,591 (1,009)	5,551 (1,220)	6,247 (1,373)	6,384 (1,403)	6,570 (1,444)	6,716 (1,476)
G. Average Domestic Sewerage Rate in M$/4,550 liters (1,000 Ig)			0.53	0.53	0.53	0.67	0.67	0.67	0.67	0.67
H. Annual Domestic Sewerage Charge (M$1,000)			202	358	534	817	919	939	967	988
I. Annual Trade Water Consumption-Connected Customers in 1,000 M^3 (IMg)			956 (210)	1,479 (325)	1,552 (341)	1,579 (347)	4,004 (880)	4,113 (904)	4,195 (922)	4,313 (948)
J. Average Rate for Trade Wastewater in M$/4,550 liters (1,000 Ig)			0.9	0.9	0.9	1.18	1.18	1.18	1.18	1.18
K. Annual Charge for Trade Wastewater (M$1,000)			190	293	306	412	1,038	1,065	1,087	1,117
L. Estimated Total Sewerage Charge per annum (M$1,000)			392	651	840	1,229	1,957	2,004	2,054	2,105

Note: Ig = Imperial gallon or 4.55 liters
IMg = million Imperial gallon
G : 70% (1983 - 1985) and 90% (1986 - 1990) of existing domestic water rate
J : 70% (1983 - 1985) and 90% (1986 - 1990) of existing trade water rate

Table 10.7 Projected Income Statement (1980 - 1990)

Alternative - I

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Operating Revenues											
Sewerage Charge	-	-	-	392	651	840	1,229	1,957	2,004	2,054	2,105
General Rates	171	201	315	203	125	89	2,811	2,211	2,169	2,177	2,190
Total Operating Revenue	171	201	315	595	776	929	4,040	4,168	4,173	4,231	4,295
Operating Expenses											
Billing and Collection Fees (a)	-	-	-	8	13	17	25	39	40	41	42
Provision for Bad Debits (b)	-	-	-	4	7	8	12	20	20	21	21
Payroll	100	186	195	375	499	586	636	668	701	736	773
Power	-	-	-	35	49	64	82	111	118	126	134
Maintenance	-	-	-	58	90	149	185	218	229	240	253
Administration	10	18	19	38	51	59	64	67	70	74	77
Total Operating Expenses	110	204	214	518	709	883	1,004	1,123	1,178	1,238	1,300
Net Operating Income	61	(3)	101	77	67	46	3,036	3,045	2,995	2,993	2,995
Depreciation (c)	-	-	-	314	523	608	791	791	791	791	791
Interest	-	-	-	-	-	-	2,423	2,387	2,348	2,307	2,262
Net Income (Deficit)	61	(3)	101	(237)	(456)	(562)	(178)	(133)	(144)	(105)	(58)

(a) : Estimated at 2% of Sewerage Charge

(b) : Estimated at 1% of Sewerage Charge

(c) : Composite rate of 2.4% for Assets in Service

Table 10.8 Projected Cash Flow Statement (1980 - 1990)

Alternative - I

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Sources of Funds											
Net Operating Income	61	(3)	101	77	67	46	3,036	3,045	2,995	2,993	2,995
Increase in Account Payable	9	8	1	25	16	15	10	10	4	5	5
Decrease in Current Assets (less cash)	-	-	-	-	-	-	-	-	-	-	-
Foreign Loan	652	1,246	1,250	2,163	808	1,799	-	-	-	-	-
Government Loan	5,426	4,131	5,154	6,554	2,710	5,856	-	-	-	-	-
Government Subsidy	-	-	-	-	-	-	-	-	-	-	-
Total Sources	6,148	5,382	6,506	8,819	3,601	7,716	3,046	3,055	2,999	2,998	3,000
Application of Funds											
Capital Expenditure	6,078	5,377	6,404	8,717	3,518	7,655	-	-	-	-	-
Interest:											
Foreign Loan:	-	-	-	-	-	-	633	620	605	589	571
Government Loan	-	-	-	-	-	-	1,790	1,767	1,743	1,718	1,691
Amortization of Principal											
Foreign Loan	-	-	-	-	-	-	173	186	201	217	235
Government Loan	-	-	-	-	-	-	377	400	424	449	476
Total Debt Service	-	-	-	-	-	-	2,973	2,973	2,973	2,973	2,973
Increase in Current Assets (less cash)	2	2	-	39	25	20	34	63	6	5	5
Decrease in Current Liabilities	-	-	-	-	-	-	-	-	-	-	-
Total Applications	6,080	5,379	6,404	8,756	3,543	7,675	3,007	3,036	2,979	2,978	2,978
Net Cash Increase (Decrease)	68	3	102	63	58	41	39	19	20	20	22
Cash Available at End of Year	68	71	173	236	294	335	374	393	413	433	455

Table 10.9 Projected Balance Sheet (1980 - 1990)

Alternative -1

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Assets											
Fixed Asses:											
Land	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774
Utility Plant in Service	-	-	-	13,085	21,802	25,320	32,975	32,975	32,975	32,975	32,975
Less Accumulative Depreciation	-	-	-	314	837	1,445	2,236	3,027	3,818	4,609	5,400
Net Fixed Assets in Service	-	-	-	17,545	25,739	28,649	35,513	34,722	33,931	33,140	32,349
Construction in Progress	1,304	6,681	13,085	8,717	3,518	7,655	-	-	-	-	-
Total Fixed Assets	6,078	11,455	17,859	26,262	29,257	36,304	35,513	34,722	33,931	33,140	32,349
Current Assets:											
Cash	68	71	173	236	294	335	374	393	413	433	455
Account Receivable (a)	-	-	-	33	54	70	102	163	167	171	175
Inventory (b)	2	4	4	10	14	18	20	22	24	25	26
Total Current Assets	70	75	177	279	362	423	496	578	604	629	656
Total Assets	6,148	11,530	18,036	26,541	29,619	36,727	36,009	35,300	34,535	37,769	33,005
Liabilities and Equity											
Long Term Dept:											
Foreign Loan	652	1,898	3,148	5,311	6,119	7,745	7,559	7,358	7,141	6,906	6,652
Government Loan	5,426	9,557	14,711	21,265	23,975	29,454	29,054	28,630	28,181	27,705	27,200
Total Long Term Debt	6,078	11,455	17,859	26,576	30,094	37,199	36,613	35,988	35,322	34,611	33,852
Current Liabilities:											
Accounts Payable (c)	9	17	18	43	59	74	84	94	98	103	108
Current Debt Maturities	-	-	-	-	-	550	586	625	666	711	759
Total Current Liabilities	99	17	18	43	59	624	670	719	764	814	867
Equity											
Government Capital Contribution	-	-	-	-	-	-	-	-	-	-	-
Retained Earnings	61	58	159	(78)	(534)	(1,096)	(1,274)	(1,407)	(1,551)	(1,656)	(1,714)
Total Equity	61	58	159	(78)	(534)	(1,096)	(1,274)	(1,407)	(1,551)	(1,656)	(1,714)
Total Liabilities and Equity	6,148	11,530	18,036	26,541	29,619	36,727	36,009	35,300	34,535	33,769	33,005

(a) Estimated at 1/12 of Operating Revenues (b) Estimated at 2% of Operating Expenses (c) Estimated at 1/12 of Operating Expenses

Table 10.10 Projected Income Statement (1980 - 1990)

Alternative-II

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Operating Revenues											
Sewerage Charge	-	-	-	392	651	840	1,229	1,957	2,004	2,054	2,105
General Rates	171	201	315	203	125	89	2,755	2,155	2,113	2,121	2,134
Total Operating Revenue	171	201	315	595	776	929	3,984	4,112	4,117	4,175	4,239
Operating Expenses											
Billing and Collection Fee (a)	-	-	-	8	13	17	25	39	40	41	42
Provision for Bad Debts (b)	-	-	-	4	7	8	12	20	20	21	21
Payroll	100	186	195	375	499	586	636	668	701	736	773
Power	-	-	-	35	49	64	82	111	118	126	134
Maintenance	-	-	-	58	90	149	185	218	229	240	253
Administration	10	18	19	38	51	59	64	67	70	74	77
Total Operating Expenses	110	204	214	518	709	883	1,004	1,123	1,178	1,238	1,300
Net Operating Income	61	(3)	101	77	67	46	2,980	2,989	2,939	2,937	2,939
Depreciation (c)	-	-	-	314	523	608	791	791	791	791	791
Interest	-	-	-	-	-	-	2,107	2,066	2,024	1,981	1,934
Net Income (Deficit)	61	(3)	101	(237)	(456)	(562)	82	132	124	165	214

(a) : Estimated at 2% of Sewerage Charge

(b) : Estimated at 1% of Sewerage Charge

(c) : Composite rate of 2.4% for Assets in Service

Table 10.11 Projected Cash Flow Statement (1980 - 1990)

Alternative - II

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Sources of Funds											
Net Operating Income	61	(3)	101	77	67	46	2,980	2,989	2,939	2,937	2,939
Increase in Account Payable	9	8	1	25	16	15	10	10	4	5	5
Decrease in Current Assets (less cash)	-	-	-	-	-	-	-	-	-	-	-
Foreign Loan	652	1,246	1,250	2,163	808	1,799	-	-	-	-	-
Government Loan	5,426	4,131	5,154	6,554	2,710	5,856	-	-	-	-	-
Government Subsidy	-	-	-	-	-	-	-	-	-	-	-
Total Sources	6,148	5,382	6,506	8,819	3,601	7,716	2,990	2,999	2,943	2,942	2,944
Application of Funds											
Capital Expenditure	6,078	5,377	6,404	8,717	3,518	7,655	-	-	-	-	-
Interest:											
Foreign Loan	-	-	-	-	-	-	317	299	281	263	243
Government Loan	-	-	-	-	-	-	1,790	1,767	1,743	1,718	1,691
Amortization of Principal:											
Foreign Loan	-	-	-	-	-	-	433	451	469	487	507
Government Loan	-	-	-	-	-	-	377	400	424	449	476
Total Debt Service	-	-	-	-	-	-	2,917	2,917	2,917	2,917	2,917
Increase in Current Assets (less cash)	2	2	-	39	25	20	34	63	6	5	5
Decrease in Current Liabilities	-	-	-	-	-	-	-	-	-	-	-
Total Applications	6,080	5,379	6,404	8,756	3,543	7,675	2,951	2,980	2,923	2,922	2,922
Net Cash Increase (Decrease)	68	3	102	63	58	41	39	19	20	20	22
Cash Available at End of Year	68	71	173	236	294	335	374	393	413	433	455

Table 10.12 Projected Balance Sheet (1980 - 1990)

Alternative - II (M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Assets											
Fixed Assets:											
Land	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774
Unility Plant in Service	-	-	-	13,085	21,802	25,320	32,975	32,975	32,975	32,975	32,975
Less Accumulative Depreciation	-	-	-	314	837	1,445	2,236	3,027	3,818	4,609	5,400
Net Fixed Assets in Sercice	-	-	-	17,545	25,739	28,649	35,513	34,722	33,931	33,140	32,349
Construction in Progress	1,304	6,681	13,085	8,717	3,518	7,655	-	-	-	-	-
Total Fixed Assets	6,078	11,455	17,859	26,262	29,257	36,304	35,513	34,722	33,931	33,140	32,349
Current Assets											
Cash	68	71	173	236	294	335	374	393	413	433	455
Account Receivable (a)	-	-	-	33	54	70	102	163	167	171	175
Inventory (b)	2	4	4	10	14	18	20	22	24	25	26
Total Current Assets	70	75	177	279	362	423	496	578	604	629	656
Total Assets	6,148	11,530	18,036	26,541	29,619	36,727	36,009	35,300	34,535	33,769	33,005
Liabilities and Equity											
Long Term Dept:											
Foreign Loan	652	1,898	3,148	5,311	6.119	7,485	7,034	6,565	6,078	5,571	5,044
Government Loan	5,426	9,557	14,711	21,265	23,975	29,454	29,054	28,630	28,181	27,705	27,200
Total Long Term Debt	6,078	11,455	17,859	26,576	30,094	36,939	36,088	35,195	34,259	33,276	32,244
Current Liabilities:											
Accounts Payable (c)	9	17	18	43	59	74	84	94	98	103	108
Current Debt Maturities	-	-	-	-	-	810	851	893	936	936	1,032
Total Current Liabilities	9	17	18	43	59	884	935	987	1,034	1,086	1,140
Equity:											
Government Capital Contribution	-	-	-	-	-	-	-	-	-	-	-
Retained Earnings:	61	58	159	(78)	(534)	(1,096)	(1,014)	(882)	(758)	(593)	(379)
Total Equity	61	58	159	(78)	(534)	(1,096)	(1,014)	(882)	(785)	(593)	(379)
Total Liabilities and Equity	6,148	11,530	18,036	26,541	29,619	36,727	36,009	35,300	34,535	33,769	33,005

(a) Estimated at 1/12 of Operating Revenues (b) Estimated at 2% of Operating Expenses (c) Estimated at 1/12 of Operating Expenses

Table 10.13 Projected Income Statement (1980 - 1990)

Alternative - III (M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Operating Revenues											
Sewerage Charge	-	-	-	392	651	840	1,229	1,957	2,004	2,054	2,105
General Rates	171	201	315	203	125	89	2,951	2,421	2,379	2,387	2,400
Total Operating Revenue	171	201	315	595	776	929	4,250	4,378	4,383	4,441	4,505
Operating Expenses											
Billing and Collection Fees (a)	-	-	-	8	13	17	25	39	40	41	42
Provision for Bad Debts (b)	-	-	-	4	7	8	12	20	20	21	21
Payroll	100	186	195	375	499	586	636	668	701	736	773
Power	-	-	-	35	49	64	82	111	118	126	134
Maintenance	-	-	-	58	90	149	185	218	229	240	253
Administration	10	18	19	38	51	59	64	67	70	74	77
Total Operating Expenses	110	204	214	518	709	883	1,004	1,123	1,178	1,238	1,300
Net Operating Income	61	(3)	101	77	67	46	3,246	3,255	3,205	3,203	3,205
Depreciation (c)	-	-	-	314	523	608	791	791	791	791	791
Interest	-	-	-	-	-	-	2,567	2,524	2,477	2,426	2,373
Net Income (Deficit)	61	(3)	101	(237)	(456)	(562)	(112)	(60)	(63)	(14)	41

(a) : Estimated at 2% of Sewerage Charge

(b) : Estimated at 1% of Sewerage Charge

(c) : Composite rate of 2.4% for Assets in Service

Table 10.14 Projected Cash Flow Statement (1980 - 1990)

Alternative - III

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Sources of Funds											
Net Operating Income	61	(3)	101	77	67	46	3,246	3,255	3,205	3,203	3,205
Increase in Account Payable	9	8	1	25	16	15	10	10	4	5	5
Decrease in Current Assets (less cash)	-	-	-	-	-	-	-	-	-	-	-
Foreign Loan	2,431	2,151	2,562	3,487	1,407	3,062	-	-	-	-	-
Government Loan	3,647	3,226	3,842	5,230	2,111	4,593	-	-	-	-	-
Government Subsidy	-	-	-	-	-	-	-	-	-	-	-
Total Sources:	6,148	5,382	6,506	8,819	3,601	7,716	3,256	3,265	3,209	3,208	3,210
Application of Funds											
Capital Expenditure	6,078	5,377	6,404	8,717	3,518	7,655	-	-	-	-	-
Interest:											
Foreign Loan	-	-	-	-	-	-	1,208	1,182	1,153	1,122	1,089
Government Loan	-	-	-	-	-	-	1,359	1,342	1,324	1,304	1,284
Amortization of Principal:											
Foreign Loan	-	-	-	-	-	-	330	356	385	416	449
Government Loan	-	-	-	-	-	-	286	303	321	341	361
Total Debt Service	-	-	-	-	-	-	3,183	3,183	3,183	3,183	3,183
Increase in Current Assets (less cash)	2	2	-	39	25	20	34	63	6	5	5
Decrease in Current Liabilities	-	-	-	-	-	-	-	-	-	-	-
Total Applications	6,080	5,379	6,404	8,756	3,543	7,675	3,217	3,246	3,189	3,188	3,188
Net Cash Increase (Decrease)	68	3	102	63	58	41	39	19	20	20	22
Cash Available at End of Year	68	71	173	236	294	335	374	393	413	433	455

Table 10.15 Projected Balance Sheet (1980 - 1990)

Alternative - III

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Assets											
Fixed Assets:											
Land	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774
Utility Plant in Service	-	-	-	13,085	21,802	25,320	32,975	32,975	32,975	32,975	32,975
Less Accumulative Depreciation	-	-	-	314	837	1,445	2,236	3,027	3,818	4,609	5,400
Net Fixed Assets in Service	-	-	-	17,545	25,739	28,649	35,513	34,722	33,931	33,140	32,349
Construction in Progress	1,304	6,681	13,085	8,717	3,518	7,655	-	-	-	-	-
Total Fixed Asses	6,078	11,455	17,859	26,262	29,257	36,304	35,513	34,722	33,931	33,140	32,349
Current Assets:											
Cash	68	71	173	236	294	335	374	393	413	433	455
Account Receivable (a)	-	-	-	33	54	70	102	163	167	171	175
Inventory (b)	2	4	4	10	14	18	20	22	24	25	26
Total Current Assets	70	75	177	279	362	423	496	578	604	629	656
Total Assets	6,148	11,530	18,036	26,541	29,619	36,727	36,009	35,300	34,535	33,769	33,005
Liabilities and Equity											
Long Term Dept:											
Foreign Loan	2,431	4,582	7,144	10,631	12,038	14,770	14,414	14,029	13,613	13,164	12,679
Government Loan	3,647	6,873	10,715	15,945	18,056	22,363	22,060	21,739	21,398	21,037	20,654
Total Long Term Debt	6,078	11,455	17,859	26,576	30,094	37,133	36,474	35,768	35,011	34,201	33,333
Current Liabilities:											
Accounts Payable (c)	9	17	18	43	59	74	84	94	98	103	108
Current Debt Maturities	-	-	-	-	-	616	659	706	757	810	868
Total Current Liabilities	9	17	18	43	59	690	743	800	855	913	976
Equity:											
Government Capital Contribution	-	-	-	-	-	-	-	-	-	-	-
Retained Earnings	61	58	159	(78)	(534)	(1,096)	(1,208)	(1,268)	(1,331)	(1,345)	(1,304)
Total Equity	61	58	159	(78)	(534)	(1,096)	(1,208)	(1,268)	(1,331)	(1,345)	(1,304)
Total Liabilities and Equity	6,148	11,530	18,036	26,541	29,619	36,727	36,009	35,300	34,535	33,769	33,005

(a) Estimated at 1/12 of Operating Revenues (b) Estimated at 2% of Operating Expenses (c) Estimated at 1/12 of Operating Expenses

Table 10.16 Projected Income Statement (1980 - 1990)

Alternative - IV

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Operating Revenues											
Sewerage Charge	-	-	-	392	651	840	1,229	1,957	2,004	2,054	2,105
General Rates	171	201	315	203	125	89	2,913	2,313	2,271	2,279	2,292
Total Operating Revenue	171	201	315	595	776	929	4,142	4,270	4,275	4,333	4,379
Operating Expenses											
Billing and Collection Fees (a)	-	-	-	8	13	17	25	39	40	41	42
Provision for Bad Debts (b)	-	-	-	4	7	8	12	20	20	21	21
Payroll	100	186	195	375	499	586	636	668	701	736	773
Power	-	-	-	35	49	64	82	111	118	126	134
Maintenance	-	-	-	58	90	149	185	218	229	240	253
Administration	10	18	19	38	51	59	64	67	70	74	77
Total Operating Expenses	110	204	214	518	709	883	1,004	1,123	1,178	1,238	1,300
Net Operating Income	61	(3)	101	77	67	46	3,138	3,147	3,097	3,095	3,097
Depreciation (c)	-	-	-	314	523	608	791	791	791	791	791
Interest	-	-	-	-	-	-	1,963	1,913	1,861	1,805	1,748
Net Income (Deficit)	61	(3)	101	(237)	(456)	(562)	384	443	445	499	558

(a) : Estimated at 2% of Sewerage Charge

(b) : Estimated at 1% of Sewerage Charge

(c) : Composite rate of 2.4% for Assets in Service

Table 10.17 Projected Cash Flow Statement (1980 - 1990)

Alternative - IV

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Sources of Funds											
Net Operating Income	61	(3)	101	77	67	46	3,138	3,147	3,097	3,095	3,097
Increase in Account Payable	9	8	1	25	16	15	10	10	4	5	5
Decrease in Current Assets (less cash)	-	-	-	-	-	-	-	-	-	-	-
Foreign Loan	2,431	2,151	2,562	3,487	1,407	3,062	-	-	-	-	-
Government Loan	3,647	3,226	3,842	5,230	2,111	4,593	-	-	-	-	-
Government Subsidy	-	-	-	-	-	-	-	-	-	-	-
Total Sources:	6,148	5,382	6,506	8,819	3,601	7,716	3,148	3,157	3,101	3,100	3,102
Application of Funds											
Capital Expenditure	6,078	5,377	6,404	8,717	3,518	7,655	-	-	-	-	-
Interest:											
Foreign Loan	-	-	-	-	-	-	604	571	537	501	464
Government Loan	-	-	-	-	-	-	1,359	1,342	1,324	1,304	1,284
Amortization of Principal:											
Foreign Loan	-	-	-	-	-	-	826	859	893	929	966
Government Loan	-	-	-	-	-	-	286	303	321	341	361
Total Debt Service	-	-	-	-	-	-	3,075	3,075	3,075	3,075	3,075
Increase in Current Assets (less cash)	2	2	-	39	25	20	34	63	6	5	5
Decrease in Current Liabilities	-	-	-	-	-	-	-	-	-	-	-
Total Applications	6,080	5,379	6,404	8,756	3,543	7,675	3,109	3,138	3,081	3,080	3,080
Net Cash Increase (Decrease)	68	3	102	63	58	41	39	19	20	20	22
Cash Available at End of Year	68	71	173	236	294	335	374	393	413	433	455

Table 10.18 Projected Balance Sheet (1980 - 1990)

Alternative-IV

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Aseets											
Fixed Assets:											
Land	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774	4,774
Utility Plant in Service	-	-	-	13,805	21,802	25,320	32,975	32,975	32,975	32,975	32,975
Less Accumulative Depreciation	-	-	-	314	837	1,445	2,236	3,027	3,818	4,609	5,400
Net Fixed Assets in Service	-	-	-	17,545	25,739	28,649	35,513	34,722	33,931	33,140	32,349
Construction in Progress	1,304	6,681	13,085	8,717	3,518	7,655	-	-	-	-	-
Total Fixed Assets	6,078	11,455	17,859	26,262	29,257	36,304	35,513	34,722	33,931	33,140	32,349
Current Assets:											
Cash	68	71	173	236	294	335	374	393	413	433	455
Account Receivable (a)	-	-	-	33	54	70	102	163	167	171	175
Inventory (b)	2	4	4	10	14	18	20	22	24	25	26
Total Current Assets	70	75	177	279	362	423	496	578	604	629	656
Total Assets	6,148	11,530	18,036	26,541	29,619	36,727	36,009	35,300	34,535	33,769	33,005
Liabilities and Equity											
Long Term Dept:											
Foreign Loan	2,431	4,582	7,144	10,631	12,038	14,274	13,415	12,522	11,593	10,627	9,622
Government Loan	3,647	6,873	10,715	15,945	18,056	22,363	22,060	21,739	21,398	21,037	20,654
Total Long Term Debt	6,078	11,455	17,859	26,576	30,094	36,637	35,475	34,261	32,991	31,664	30,276
Current Liabilities:											
Accounts Payable (c)	9	17	18	43	59	74	84	94	98	103	108
Current Debt Maturities	-	-	-	-	-	1,112	1,162	1,214	1,270	1,327	1,388
Total Current Liabilities	9	17	18	43	59	1,186	1,246	1,308	1,368	1,430	1,496
Equipty:											
Government Capital Contribution	-	-	-	-	-	-	-	-	-	-	-
Retained Earnings	61	58	159	(78)	(534)	(1,096)	(712)	(269)	176	675	1,233
Total Equity	61	58	159	(78)	(534)	(1,096)	(712)	(269)	176	675	1,233
Total Liabilities and Equity	6,148	11,530	18,036	26,541	29,619	36,727	36,009	35,300	34,535	33,769	33,005

(a) Estimated at 1/12 of Operating Revenues (b) Estimated at 2% of Operating Expenses (c) Estimated at 1/12 of Operating Expenses

10.7 Ability and Willingness to Pay

The ability and willingness of the potential customers to pay for the benefits of sewerage services are measures to gauge the feasibility of the financial independency. The ability to pay is measured by the ratio of the service charge to the total available income of the potential customers. If the ratio is smaller, the potential ability to pay is greater and maximum limit of the rates commonly employed for sewerage charge in developing countries is approximately 2 per cent. If proposed charge is under 2 per cent of total household income, the owners of such household are considered capable of paying the proposed charge.

The willingness to pay is not necessarily consistent with the ability to pay as it depends mainly on the individual's awareness and evaluation of the benefits derived from the sewerage services, and further individuals have common desire to underestimate their capability to pay the charges. The willingness of the individuals to pay for the sewerage services may not be as explicit as their willingness to pay for other utility services including water supply which provide more visual and evident benefits, while benefits of sewerage services are more intangible as represented by general sanitation and aesthetic improvements. The public guidance will be necessary to make the individuals aware and recognize of such benefits as one of the solutions to enhance their willingness to pay.

Two field surveys were conducted separately in December, 1976 and in December 1977 to gauge the ability to pay of potential users of the sewerage services and their awareness of the benefits to be derived from the proposed sewerage system. Various types of houses representing varied income groups were located in the Study Area. The objects of the surveys included not only to collect information/ data for household incomes but also other relevant matters such as existing disposal systems, numbers of residents in the house, and expenditures for water supply and others. Tables 10.19 and 10.20 indicate the results of the surveys.

In both surveys, various types of house representing different income levels were selected from various parts of the Study Area to ascertain realistic income situation. Among various utilities charges each household is presently paying including property assessment, the water charges only are listed so that they can be conveniently compared with possible sewerage charges. While the surveys were based on the sampling approach, the results are considered sufficient to provide a general guideline for reasonable financial strategies. The increase of income after one year time lag is significant as indicated by the average income of M$530 and M$610 in 1976 and 1977 respecrively. The ability of residents to pay the required service charges in the Study Area is in general evidently recognized while the willingness to pay has not been so

Table 10.19 Household Economic Survey (December, 1976)

Items	Numbers of Selected Households by House Type Total	A	B	C	D	E	F	G
M$/Month								
101-200	12	11	1					
201-300	12	6	5	1				
301-400	12	1	7	1	3			
401-500	11	1	2	2	5	1		
501-600	7		3	2	1	1		
601-700	4			1	2		1	
701-800	3			2			1	
801-900	1						1	
901-1000	4		2					2
1001-2000	5		1	1		1	1	1
more than 2000	2					1		1
Total	73	19	21	10	11	4	4	4
Average Income (M$)	530	210	470	630	470	1,130	940	1,350
Average Nos. of Residents	6	5	6	6	6	7	6	6
Average Water Bill(M$)	6	5	6	7	6	12	8	7
Max. Service Charge within Ability to Pay(M$)	10	4	9	12	9	22	18	27
Existing Waste Disposal System		BS or PL	CST	CST	CST	SCT	PST	CST

Note: A: Wooden house in kampung area
B: One-storied attached terrace house
C: Two-storied attached terrace house
D: Multi-storied apartment house
E: Commercial house
F: Semi-detached house
G: Terrace house located in newly developed low density residential area

BS: Bucket system
PL: Pit latrine
CST: Communal septic tank
PST: Private septic tank

Table 10.20 Household Economic Survey (December, 1977)

Items	Numbers of Households Selected by House Type Total	A	B	C	F(1)	F(2)
Income (M$/Month) Less than 100	3	3				
101-200	13	11	2			
201-300	7	5	1			1
301-400	8	2	1	3	1	1
401-500	7	2	4			1
501-600	2				2	
601-700						
701-800	2	1		1		
801-900	1	1				
901-1000	6			4	1	1
1001-2000	12		2	2	7	1
Total	61	25	10	10	11	5
Average Income (M$)	610	260	570	860	1,170	700
Average Nos. of Residents	6	6	5	6	5	6
Average Water Bill (M$)	7	7	7	8	6	8
Max. Service Charge within Ability to Pay (M$)	12	5	11	17	23	14
Existing Waste Disposal System	BS or PL	CST	CST	CST	CST	PST

Note:
A: Wooden house in kampung area
B: One-storied attached terrace house
C: Two-storied attached terrace house
F(1): One-storied attached terrace house
F(2): Two-storied semi-detached house
BS: Bucket system
PL: Pit latrine
CST: Communal septic tank
PST: Private septic tank

explicit. The residents provided with septic tank systems have shown generally less willingness to pay, since they are presently not disturbed by evident inconveniences and also are not aware of benefits to be derived from the future sewerage services, while residents with bucket systems and pit latrines have shown their keen interests in the complete sanitary system and some of them indicated willingness to pay as much as M$5.00 per month. It is evident that those households in the income bracket over M$400 have sufficient capabilities to pay the potential sewerage charges. The lower income households appear to encounter some difficulties in paying the charges. However, the water consumption of such households are normally less than the average and their associated sewerage charges are assumed to be less substantial. If the specific minimum charge for a certain basic volume of consumption is set up to enable the low income households to pay the economic rates, the more evident subsidiary effect can be expected from the higher income groups whose abilities to pay are much greater.

Because the septic tank users have been receiving municipal service for septic tank operation and maintenance as one of the public services provided for municipal tax payers, they may express initially reluctancy to use sewers when they find the obligation to pay the sewerage charges in addition to the existing tax payments.

More emphatic demonstration will, therefore, be necessary to make them aware of the intangible benefits of the sewerage services as general sanitation and aesthetic improvement as well as the physical superiority of sewerage systems to septic tank system which are susceptible to malfunction. Such public guidance alone, however, will not be sufficient to ensure the collection of sewerage charges, and a public legislation empowered to levy the sewerage charges will be required.

10.8 Evaluation of Alternative Financial Plans

As indicated in the financial statements, four alternative schemes are developed to be on the financially viable base. The amount of required operating revenue in each financial scheme is estimated to provide annual cash surplus sufficient, if accumulated, to cover at least four months' operating expenses of the following years. The required amount of such operating revenue is affected by the debt service requirements (payment of interest and principal of loan), and the required allocation from the government general rate fund is different in amount in respective alternatives due to the different loan condition as shown in the financial statements. Such required allocation from the government may be the vital factor to select an acceptable alternative scheme since the assumed allocation will determine the extent of financial responsibility on the part of the government.

There are other factors to assess adequacy of the financial scheme of the project such as net income and retained earnings (accumulated net income). The estimated figures of net income indicate that the operating revenues are sufficient enough to cover operating expenses, amortization of loan interest and principal, and even the depreciation cost of the plant and facilities. The net loss of income is mainly derived from the coverage of depreciation cost and should not be construed to invalidate the demonstrated financial feasibility since the annual operating expenses and debt service payment are met by annual operating revenues. The summarized comparison of the alternative schemes, as shown in Table 10.21, has been attempted to help illuminate the most acceptable alternative.

10.9 Conclusions

As shown in Table 10.21, Financial Comparison of Alternative schemes, Alternative II is found to be requiring the least financial contribution from MPSP's general rate fund while project net incomes are less than those of Alternative IV with the highest income projection among four Alternatives. Assuming that the project implementation is dictated mainly by MPSP's financial capacity and the least financial burden on MPSP is desirable, Alternative II is considered most recommendable.

Under the financial plan of Alternative II, the combined loans of foreign currency amounting to M$7,918,000 from OECF and local currency amounting to M$29,831,000 from Federal Government have been assumed to cover the total capital cost of M$37,749,000 (including price escalation). The sewerage charge and the allocation from MPSP's general rate fund are assumed to be two major revenue sources to cover to operating and debt service expenses.

The proposed sewerage charges to be levied from 1983 to 1985 is M$0.53 per 1,000 Imperial gallons of water consumed equivalent to approximately 70% of existing water supply charge and M$0.67 from 1986 thereafter. The annual allotments of general rate fund required during the construction period of initial 5 years are less substantial. From the year 1986 the allotment equivalent to approximately 5% of annual value of property will be required. The sewer connections are assumed to be mandatory as laterals are made available within 100 ft. from each individual household and such connections will be made at the expense of each household owner.

Table 10.21 Financial Comparison of Alternative Plans

(M$1,000)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
A. Allocation from General Rates											
Alternative - 1	171	201	315	203	125	89	2,811	2,211	2,169	2,177	2,190
- II	171	201	315	203	125	89	2,755	2,155	2,113	2,121	2,134
- III	171	201	315	203	125	89	2,951	2,421	2,379	2,387	2,400
- IV	171	201	315	203	125	89	2,913	2,313	2,271	2,279	2,292
B. Net Income(loss)											
Alternative - 1	61	(3)	101	(237)	(456)	(562)	(178)	(133)	(144)	(105)	(58)
- II	61	(3)	101	(237)	(456)	(562)	82	132	124	165	214
- III	61	(3)	101	(237)	(456)	(562)	(112)	(60)	(63)	(14)	41
- IV	61	(3)	101	(237)	(456)	(562)	384	443	445	499	558
C. Retained Earnings (*Deficit*)											
Alternative - I	61	58	159	(78)	(534)	(1,096)	(1,274)	(1,407)	(1,551)	(1,656)	(1,714)
- II	61	58	159	(78)	(534)	(1,096)	(1,014)	(882)	(758)	(593)	(379)
- III	61	58	159	(78)	(534)	(1,096)	(1,208)	(1,268)	(1,331)	(1,345)	(1,304)
- IV	61	58	159	(78)	(534)	(1,096)	(712)	(269)	176	675	1,233

CHAPTER 11

BENEFITS

11.1 General

As already discussed in the Master Plan Report, various types of benefits derived from the sewerage system can be expected, including those from health and sanitation improvement, water population control, values added to land and other various economic benefits.

Since the benefits are mostly unquantifiable in nature, no attempt is made to indicate the results of the analysis in the form of Benefit/Cost Ratio.

11.2 Health and Sanitation Benefits

The average annual number of waterborne diseases occurred per 1,000 persons was 0.41 on the basis of the information over six years from 1970 through 1975 (see Chapter 3, PART II, Master Plan Report). Also, the cost for the treatment of the diseases was about M$27 per person per day for an average two weeks time.

In estimating the benefits from the first stage programme, it is assumed that if a half of the diseases occurred is attributable to poor excreta disposal and if this can be eliminated by the provision of sewerage system, then the reduction of the rate of incidence of the diseases per year would be 0.205 per 1,000 persons within the area. The projected incremental population and reduction of the incidences in the first stage programme area during the project period are summarized below:

Item	First Stage Implementation Period							
	1983	1984	1985	1986	1987	1988	1989	1990
(1) Population Served (1,000 persons)	24.7	43.2	63.9	76.4	85.1	86.2	87.3	88.5
(2) Reduction in No. of Incidences	5	9	13	16	17	18	18	18

Note: (2) = (1) x 0.205

On the basis of the above projection, the reduction of direct costs for illness expected in the years 1983 to 1990 has been estimated and discounted to 1977 price levels at a rate of 8 per cent per annum. The benefits are estimated at approximately M$20,000 for the years from 1983 through 1990, as shown in Table 11.1.

A main element of indirect cost is calculated assuming that the average income of labour participating group is M$250 per person per month and 47 per cent of the total affected populations are caused wage losses for over two weeks off from the work. The loss is estimated at M$3,000 discounted to 1977 price levels as calculated in Table 11.2.

Other benefits expected from the sewerage system include; (1) reduction of discomfort and distress, (2) improvement in environmental aesthetics, and (3) reduction of groundwater contamination; however, these are mostly unquantifiable in nature and the benefits evaluation in terms of money has not been made under the present study.

11.3 Water Pollution Control Benefits

As discussed in the Master Plan Report, most of the drains in urbanized areas have been polluted and are expected to become much worse in the near future unless the sewerage system is provided.

The proposed first stage programme could keep the total BOD loadings to drains and rivers to the level lower than that of present until 1990, as described in Annex 16. The effect of the sewerage system is therefore significant especially in waterways receiving waste loads from high population density areas. The unpolluted river waters will in turn become new water resources for various uses.

11.4 Benefits by Reduced Expenditure for Sanitary Facilities

As described in Chapter 3, the existing excreta disposal systems in the Study Area are generally represented by two systems namely, by septic tank and bucket. For operation and maintenance of these facilities, MPSP expended in 1976 the money of approximately M$21,300 monthly for the septic tank system (see Table 3.3) and about M$31,500 monthly for the bucket system (see Table 3.5), covering 48 communal septic tank systems and 7,784 bucket systems. Also, the costs for cleaning of individual septic tanks are included in MPSP's expenditures.

In addition to the above mentioned systems, there exist many other individual septic tank and bucket systems in the area, which are not managed by MPSP for their operation and maintenance work. Although accurate information are not available as to these privately managed systems, it is evident that considerable amount of costs would have been spent privately for operation and maintenance of these systems. If the public sewerage system is provided and these expenditures are eliminated, significant benefits can be expected both in terms of money and sanitation conditions of the area.

In the first stage programme area, a total of 72,000 population resided in 1976, of which approximately 31,500 persons are covered by 41 communal systems and many individual systems. Also, the bucket systems managed by MPSP and private houses serve about 40,500 persons. The operation and maintenance costs for these facilities are M$12.2 per person per year for septic tank and M$48.5 for bucket at 1976 price levels. Using these cost data, a comparative analysis is made between the costs of the existing sanitary facilities and modern public sewerage system, as presented in Table 11.3. The result of the analysis indicate that the cost required for sewerage system is lower than those required for the existing sanitary facilities, in terms of both annual and per capita costs.

The benefits expected from the reduction of operation and maintenance cost of the existing night soil disposal systems by the provision of the proposed sewerage system for the first stage programme have been estimated for the years from 1983 through 1990 discounted to 1977 price levels, as shown in Table 11.4. The result of the estimation indicates that the total benefits to be derived until the year 1990 will be M$2,160,000, at 1977 price.

Furthermore, if the planned development programmes within the first stage areas start their construction during the first stage period, it will be possible to save considerable amount of costs for septic tank construction by the provision of the proposed sewerage system. The cost comparison between septic tank and stabilization pond systems (see Table III. 30, Part III, Master Plan Report) suggests that the cost for the former is significantly higher than that for the latter, even though the septic tank system has a big handicap with respect to the treatment of sullage and industrial wastewater.

11.5 Other Benefits

The sewerage system will raise the land value significantly. The additional land value will constitute a major economic benefit by the sewerage project in that, not only eliminating unsanitary conditions but an additional source of taxation for the revenue in favour of the Government.

Although the benefit is not estimated in money terms under the present study, the significant increase of land value will be anticipated by the implementation of the sewerage system.

11.6 Benefits Justification

On the basis of the results of the evaluation of benefits by the development of the proposed sewerage system in the first stage programme area, it is concluded that the project is definitely justifiable. If no sewerage system is provided in the area, sanitary conditions, which are already deplorable in many areas of the city, will become progressively worse. Moreover, if this project is not undertaken at this time, the cost for the implementation at later stage will be increasingly higher.

Table 11.1 Reduction in Direct Costs Due to Elimination of Waterborne Diseases (At 1977 price levels)

Year	Population Served (1,000 persons) (1)	Reduction in Number of Incidence (persons) (2)	Saving in Direct Costs (M$) (3)	Discount Factor (4)	Discounted Benefits to 1977 (M$) (5)
1981	-	-	-	-	-
82	-	-	-	-	-
83	24.7	5	1890	0.630	1,191
84	43.2	9	3402	0.583	1,983
1985	63.9	13	4914	0.540	2,654
86	76.4	16	6048	0.500	3,024
87	85.1	17	6426	0.463	2,975
88	86.2	18	6804	0.429	2,919
89	87.3	18	6804	0.397	2,701
1990	88.5	18	6804	0.368	2,504
Total	-	114	43092	-	19,951

Note: (2) = (1) x 0.205
(3) = (2) x 27 M$/d·cap x 14 days

$$(4) = \frac{1}{(1+0.08)^{(x-1977)}} \qquad (x;\ \text{year})$$

(5) = (3) x (4)

Table 11.2 Reduction of Wage Loss Due to Disability (At 1977 price levels)

Year	Reduction in Nos. of Incidence (persons) (1)	Affected Populatinon by the Incidence of Diseases (persons) (2)	Saving in Indirect Costs for Wage Loss (M$) (3)	Discount Factor (4)	Discounted Benefits to 1977 (M$) (5)
1981	-	-	-	-	-
82	-	-	-	-	-
83	5	2	233	0.630	147
84	9	4	467	0.583	272
1985	13	6	700	0.540	378
86	16	8	933	0.500	467
87	17	8	933	0.463	432
88	18	9	1,050	0.429	450
89	18	9	1,050	0.397	417
1990	18	9	1,050	0.368	386
Total	114	55	6,416	-	2,949

Note:

(2) = (1) x 0.47

(3) = (2) x 250M$/month·cap x $\frac{14}{30}$

(4) = $\frac{1}{(1+0.08)^{(x-1076)}}$ (x; year)

(5) = (3) x (4)

Table 11.3 Operation and Maintenance Cost Comparison Between Existing Sanitary System and Proposed Sewerage System

(M$ at 1977 price levels)

	Septic Tank	Bucket System	Total	Sewerage System
Served population (persons)	31,522	40,538	72,060	85,104
O and M Cost/year cap (M$/year.cap)	12.2	8.1 (1)	-	-
Cost/year (M$1000/year)	385	328	713	612 (3)
Cost/year.cap (M$/year.cap)	-	-	9.9	7.2

Note: (1) = M$48.5/year ÷ 6 persons/household

(2) Population served is estimated for the year 1977, because the proposed sewerage system in the first stage programme covering the entire area will be in operation from the year 1977.

(3) The annual cost of operation and maintenance estimated for the year 1977 for the proposed sewerage system does not include the administration cost (M$653,000-M$41,000; refer to Table 9.11).

Table 11.4 Reduction of Operation and Maintenance Costs Due to Elimination of Existing Sanitary Facilities

	Population Served by Septic Tank System (1)	Population Served by Bucket System (2)	O&M Costs for Septic Tank System (M$1,000) (3)	O&M Costs per year for Bucket System (M$1,000) (4)	Total Costs for S.T. Bucket (5)	Discounting Factor	Benefits Discounted to the year 1977 (M$1,000)
1981	-	-	-	-	-	-	-
82	-	-	-	-	-	-	-
83	9,546	13,454	116	109	225	0.630	142
84	14,904	25,396	182	206	388	0.583	226
1985	22,252	32,658	271	265	536	0.540	289
86	27,932	37,278	341	302	643	0.500	322
87	31,522	40,538	385	328	713	0.463	330
88	31,522	40,538	385	328	713	0.429	306
89	31,522	40,538	385	328	713	0.397	283
1990	31,522	40,538	385	328	713	0.368	262
TOTAL:	200,722	270,938	2,450	2,194	4,644		2,160

Note: (3) = (1)x12.2 M$/cap.year
(4) = (2)x8.1 M$/cap.year
(5) = (3) + (4)

ANNEXES

ANNEX 1

TREATMENT OF INDUSTRIAL WASTEWATER

1.1 Characteristics of Industrial Wastewater

Industrial wastewater surveys have been conducted at the selected major factories in the Study Area during the course of the feasibility study, covering enquiry by questionnaire, interview, and sampling and analysis of industrial wastewater. The characteristics of process wastewater of some specified industries in the area are described below:

(a) Seafoods

Seafood factories in the area do not discharge harmful matter in terms of pH, temperature, and chemical characteristics. However, high BOD wastes (more than 2,000 mg/l), which consist of settlable BOD such as prawn debris, are occasionally discharged from some processes. The average BOD value of all wastewaters from seafood factories surveyed, on the other hand, is 460 mg/l since the high BOD wastes are diluted with much lower BOD wastes discharged from other processes.

Some seafood factories recover the settlables by installing settling pit, and the settlings are reused as animal feed. The discharge of such high settlable BODs to sewer could be prevented by the use of this kind of facility.

(b) Vegetable Oil

There exists no primary oil mill in the Study Area. Most of the oil factories in the area are of the kind of kernel oil extraction/refining with oil traps for recovering spilled oil. The oil traps are often malfunctional, and the concentrated oilly floatables break through the traps.

The COD values of the effluents discharged from the oil factories are very high (sometimes more than 100,000 mg/l), while the average BOD value is estimated at about 640 mg/l because of the small reaction coefficient for biological decomposition of spilled oil, which may be, therefore, difficult to treat in a stabilization pond process, and may accumulate on sewer walls as a mixture with other suspended solids.

Another specific characteristic of the waste from the chemical refining process of the oil factories is low pH value (less than 2).

During the survey, it was observed that the concrete open drain had been severely corroded by the low pH effluent.

(c) Food and Soft Drinks

Food processing factories discharge intermittently quite high BOD effluents but the volume is small. Soft drink bottlers on the other hand discharge high pH wastewater of about 10 because they use caustic soda for bottle washing.

(d) Dyeing Textile

Textile factories in the area use mainly cotton as raw material. The wastewater from dyeing factories is mainly from the processes of bleaching and dyeing, both of which are processed by batch method. The bleaching process comprises sub-processes of desizing, boiling, bleaching, and mercerizing. The wastewater from this process is characterized by the contents of high BOD and suspended solids, and high pH value. About 60 to 70% of wet wastes of dyeing textile are produced by this process. The dyeing process is composed of dyeing and washing. High BOD concentration, high pH value and made-colour dye stuff (sometimes including heavy metals) are characteristics of the dyeing process. Printing process generally does not discharge wastewater.

Semi-in-situ tests on photosynthetic activity in existing stabilization pond, carried out under the survey, indicate that influence of the dyeing effluent to the treatment system is negligible if the effluent is diluted to 1,000 to 10,000 times by other wastewater.

(e) Rubber

In the area, rubber industries handle only scrap rubber. Their main process is washing and rolling of scrap rubber with large volume of water. The wastewater includes high contents of settlables and suspended solids. They install many traps arranged in series for physical treatment of the wastewater and the treated water is recycled for reuse, while a portion of which is discharged into the nearby monsoon drain. The effluent BOD is in a range of 100 to 500 mg/l that is lower than that from latex rubber factory. Groundwater is used for washing.

(f) Metal Works (Excluding Plating/Galvanizing)

Most of metal work factories are small in scale and in amount of process water, or in some cases, no water. Their waste mineral and oil are discharged into open drains.

(g) Plating/Galvanization

Plating/galvanization factories in the area may be divided into two groups, one is those of comparatively large scale and the other of small family scale factories. The former generally have a simple pH control device, consisting of waste container and lime injector, but are not always effective. The effluent is discharged into open drains or directly to the Prai River sometimes with the pH values as low as 2 or 3. The latter are the industry making small metalic household utensil, cycle parts, etc., and are scattered throughout the town and kampung areas. Electroplating of chromium, nickel and zinc is their main process. Washed water is in many cases spilled on the floor and flows into open drains. The effluent is characterized by low pH values (3 to 4) and high heavy metal concentrations, but not large volume.

1.2 Treatment of Sewage Dominated by Industrial Wastes

In principle, industrial wastewater produced in the area can be treated jointly with domestic wastewater as mentioned in the Sewerage Master Plan Report. However, in case industrial wastewater becomes a far dominant component of the sewage, for example, BW-3 Zone where wastewater collection pipes are designed independently to collect the dominant industrial wastes from Sub-zone BW-3B centering around Mak Mandin Industrial Estate, it may be necessary to consider a possibility of independent treatment of the wastewater, or the necessity of mixing it with domestic sewage from other Sub-zones to supply nutrients for the biological treatment processes.

Considerations to be made for biological treatability of sewage are: (1) nutrient balance, (2) decomposition factor (reaction rate constant), and (3) presence of harmful matter, as briefly mentioned below:

(a) Nutrient Balance

As the balance of nutrients required for biological treatment, the ratio BOD:N:P should be about 100:5:1. If N and/or P are lower than the above ratio, the sewage would be undesirable for the biota in the treatment system. Consequently, BOD removal efficiency would decrease.

Based on the estimation of wastewater characteristics such as

BOD, N and P, produced by industries and residents in Sub-zone BW-3B, the ratio BOD:N:P is estimated at 173:11:1, indicating that the component of phosphorous will be slightly insufficient.

(b) Decompsition Factor (Reaction Rate Constant)

Table 1.1 shows BOD decomposition factors as experimentally estimated for major industrial wastewaters in the area. The factors are comparable to those of the sullage water excluding vegetable oil refining waste.

(c) Harmful Matter

It is assumed that no influence will be found in the proposed sewers and stabilization ponds, based on the components in the estimated wastewaters.

On the basis of the results of the above considerations, it is proposed that the industrial wastewaters collected from Sub-zone BW-3B be mixed with the sewage from other sub-zones for treatment.

Table 1.1 Estimated Reaction Constant 'k' of Decomposition of BOD Wastes

Type of Effluent	'k' Value
Seafood	0.3
Vegetable Oil	0.07
Textile (*)	0.4
Rubber (**)	0.9
Sullage Water	0.4 - 0.6

Note: (*) Desizing waste

(**) Scrap rubber waste

ANNEX 2

WATER QUALITY STANDARDS

2.1 Present Activity on Water Quality Regulation in Malaysia

Surface waters in Malaysia have been polluted as a result of the rapid developments, including agricultural, industrial, residential, etc. For the pollution control, the Environmental Quality Act was established in 1974 by the Federal Government of Malaysia. Following the Act, several regulations/guidelines of water quality are being prepared by the Federal Government to restore the waters to a tolerable level for beneficial uses by the people.

The strategy for the pollution control by the Government comprises a double-sided approach by: (1) setting-up surface water quality standards for various water uses, and (2) controlling effluent water quality for conservation or restoration of the quality by standard set up to each type of beneficial use of receiving water. However, the enactments have not been sufficiently enforced, and most of them are still considered only as a guideline.

The Ministry of Health has proposed a guideline for surface water quality, in which Malaysian waters are classified into nine categories of beneficial uses, and 10 parameters of water quality are described for each beneficial use. The description of the parameters are, however, not clear except coliforms, pH, and dissolved oxygen.

As a reference, the surface water quality criteria applied in several countries are shown in Table 2.1.

The Ministry of Science, Technology and Environment is preparing the effluent quality criteria for sewage and industrial wastewater. The effluent is classified into three types according to their sources:

(1) Primary plam oil mill wastes,

(2) Rubber factory wastes, and

(3) Other factory, commercial and domestic wastes

The effluent quality of palm oil and rubber factories, which discharge wastes containing high BOD (some have thousands milligram per liter) will be regulated step by step following the special yearly plan established by the Government. For primary palm oil mill wastes, the effluent standards and yearly plan have been established in 1977.

The effluent quality criteria for the other factories will be regulated by both setting up the objectives for water quality of receiving water and establishing the permissible concentration of pollution parameters in the effleunt. This is still under draft preparation. The Ministry of Health, Federal Industrial Development Authority, and others are intimately involved in these draft preparation.

2.2 Tentative Effluent Quality Criteria

(a) Treatment Plant Effluent

The effluent from the proposed treatment plants would be discharged into water bodies which have many different beneficial uses such as agriculture, fisheries, recreation, and other possible uses in future. Therefore, the effluent from the treatment plants must be controlled to protect these uses.

The parameters of water quality to be measured are classified into two categories by the objectives for:

(1) Operation and surveillance of the treatment plant: Water temperature, pH value, dissolved oxygen, BOD, COD, suspended solids, and coliforms

(2) Special purpose: heavy metals (mercury, cadmium, lead, chromium, etc.), arsenic, and other harmful chemicals

Taking into consideration the existing water quality regulations of Malaysia as mentioned in the previous section, especially the environmental quality regulations for sewerage and industrial effluent currently being drafted, tentative effluent quality criteria are proposed as shown in Table 2.2. These criteria are used in designing the proposed treatment plants.

Such elements as water temperature, pH, and DO in stabilization ponds are mainly governed by solar radiation intensity and photosynthetic activity of phytoplankton. Therefore, the temperature, pH, and DO of pond effluent will reflect in the condition of the biological process.

BOD, COD, and SS are the most important parameters to check the treatment efficiency. The values for the parameters prepared by the Government are applied to the tentative effluent criteria. Data accumulated during long term operation should be used for improvement of treatment plant operation and future design.

Coliform bacteria themselves are not harmful to human health, but commonly used as an index parameter of potential contamination of human excreta and, consequently, of enteric disease bacteria. According to the effluent quality criteria prepared by the Ministry of Health as a guideline, for the same beneficial uses, as those of the receiving water of the proposed sewage treatment plant effluent, coliforms of the effluent is regulated to be a maximum of 20 N/ml. This value may be too conservative because coliforms must be highly diluted and majority portion die off. As a tentative criterion, therefore, 1,000 N/ml are proposed as shown in Table 2.2.

As heavy metals adversely affect human health, if the receiving waters are expected to be used for agriculture and/or fisheries, the permissible concentration should be determined with special considerations on ability of bio-concentration of the matter in natural ecosystem after discharge of wastewater. The value tentatively proposed in Table 2.2 should be reconsidered and amended if necessary after effluent standards are set by the Government, including arsenic and other harmful chemicals. The data on these parameters to be obtained by long term periodical measurements should be used to prevent pollution or deterioration of the receiving waters.

(b) Discharge Regulation of Industrial Wastes to the Sewers

At present, there is no industry controlled under the effluent quality regulations established by the Federal Government in the Study Area. However, steps are being taken by the Federal Government to exercise the discharge control to most of the industries. Penang Pollution Control Committee has already made an effluent quality guideline based on the regulation drafted by the Federal Government.

When the new effluent quality regulation is enforced, each factory has to make some measures for the discharging waste; however, if the proposed sewerage system is provided and the industrial wastes are allowed into the system, the responsibility of each factory would not be as great as the case treated individually. Whatever the case may be, minimum criteria on effluent quality should be established and applied for industrial waste effluents into the sewer.

Table 2.3 shows tentatively recommended effluent quality criteria for industrial wastes discharging into the sewer. This proposal is made on the basis of the draft effluent quality regulation prepared by the Federal Government and the guideline of industrial effluent control prepared by the Penang Pollution Control Committee. The provision is made to regulate quantity and to assess the impact to the sewerage system and the ability of small factories to install their own treatment system.

Table 2.1 Receiving Water Quality Criteria Being Applied in Various Countries

	Coliforms (N/ml)	BOD (mg/l)	SS (mg/l)	pH	DO (mg/l)
Malaysia	10.20(*)	-	-	6 - 9	3
Japan	10/50(*)	3/5/10(*)	5/25(*)	6.5 - 8.5	7.5/5(*)
Philippines	10	-	10	6.5 - 8.5	5
Great Britain	-	20	30	-	10%-40%
Netherland	20/50	3/5	25/80	6.5 - 8.5	50%-120%
USA	10/20/50/100	-	-	-	-
Brazil	100	-	-	-	-
Uruguai	40	-	-	-	-
Ghana	10	-	-	-	-
WHO	0.5/2	-	-	5.9	-

Note: (*) value varies according to type of water uses

Table 2.2 Tentatively Recommended Effluent Quality Criteria for Sewage Treatment Plant

Parameter	Unit	Value	Remarks
Temperature	°C	24 - 37	natural value
pH	-	6 - 10	natural value
DO	mg/l	present	-
BOD	mg/l	50	5 days at 20°C
COD	mg/l	100	-
SS	mg/l	100	-
Coliforms	N/ml	1,000	-
Heavy Metals	mg/l	0.1	Total heavy metals (Hg, Cd, Pb)

Table 2.3 Tentatively Recommended Effluent Quality Criteria before Discharging into the Sewerage System

Parameter	Unit	Effluent Quality		Remarks
		Less than 10 m^3/day	more than 10 m^3/day	
Temperature	°C	60	45	max.
pH	-	5 - 10	5 - 10	
BOD	mg/l	600	400	max.
COD	mg/l	1,000	1,000	max.
SS	mg/l	600	400	max.
Heavy Metals	mg/l	-	10(*)	max.

Note: (*) Specified by the municipality

ANNEX 3

Waste Stabilization Pond

3.1 Sedimentation Cell

A sedimentation cell should be designed to remove both settlables and floatables. A part of the settlables precipitated in the sedimentation cell will be converted into scum, and accumulate in the cell as floatables. The floatables carried into the pond by the flow will create an unaesthetic condition with the difficult maintenance problem to remove out of the pond. The sedimentation cell, therefore, should trap and accumulate these floatables, and thereby they are easily and properly removed and buried in selected locations.

This facility could remarkably reduce the operation and maintenance efforts for floatables removal as compared to fine screen facility. The sludge accumulated in the cell will be gradually pumped to primary ponds. It is presumed that the sludge will not cause aesthetic problem since the primary pond is large enough to accept it. Therefore, it is not necessary to provide any special disposal system for the sludge. As for the removal of sludge from the cell, it will be sufficient once in every 3 to 5 years. The cell is proposed to have a detention time of 3 hours with a depth of 3 metres. The depth includes the space for accumulating sludge and floatables.

3.2 Primary Facultative Pond

Major factors affecting the primary facultative pond process are areal organic loading, pond depth, detention time, temperature, solar radiation intensity, and the quantity and quality of influent waste.

The pond system has been studied referring to the work of Shaw et al. (1962), Marais and Shaw (1961), and Gloyna (1965). Although a reference has been given to the effects of detention time and temperature developed by Gloyna et al., the rational theory has not yet been applied to other factors.

The material balance in a facultative pond is performed as follows:

$$Ce/Ci = \frac{1}{1 + kD} \quad \text{..................... (1)}$$

where

- Ce = concentration of effluent BOD, mg/l
- Ci = concentration of influent BOD, mg/l
- k = reaction rate constant, day^{-1}
- D = detention time, day

The rate constant 'k' is a gross measure of bacterial activity and, in common with most parameters for biological growth process, its value is strongly temperature dependent. Its variation with temperature is usually described by the Arrhenius equation as follows:

$$k_T = k_{20}\theta^{T-20} \quad \text{.................... (2)}$$

where,

- k_T = k value at T°C
- k_{20}= k value at 20°C
- θ = temperature coefficient

Typical 'θ' values for representative sewage treatment processes are:

Waste stabilization ponds	1.05 - 1.09
Aerated Lagoons	1.35
Trickling filters	1.040
Activated sludge processes	1.005 - 1.030

'θ' values are themselves a function of temperature, decreasing with increasing temperature. Caution must, therefore, be exercised in adopting 'θ' values found in temperate climates (Mara 1976).

According to McGarry and Pescod (1970), the analysis of pond operation data in tropical and temperate zones has indicated that the BOD removal in facultative ponds is independent of pond depth, detention time and influent waste concentration, and that the areal BOD removal, 'Lr" (in kg/day·ha), in primary facultative ponds is estimated through knowledge of areal BOD loading, "Li" (in kg/day·ha), by the formula:

$$Lr = 0.725\ Li + 10.35 \quad \text{...................... (3)}$$

Recently, the areal BOD loading rate has come into widespread use as one of the most reliable design parameters.

In this report, the McGarry and Pescod formula is used for the process design. Assuming 300 kg/day·ha as BOD areal loading, the BOD removal rate is computed to be 76 per cent based on Equation (3).

On the other hand, the design BOD concentration of influent and effluent are assumed to be 200 mg/l and 50 mg/l respectively. The latter is culculated expecting 75 per cent BOD removal in the proposed facultative pond. The result of analysis of the data obtained from the Wardieburn Pond operation, which is the most reliable experience of waste stabilization pond systems in Malaysia, indicate that 300 kg/day·ha of surface BOD load will be successful to operate a waste stabilization pond without problem. Thus, the figure, which is considered to be on the safety side, is applied as a design criterion for the pond design.

Pond depth should be decided not only to keep detention period but also to prevent both emergent vegetation and mosquito breeding in the pond. Although the minimum depth of a facultative pond is ideally 1 metre, the design depth should be modified on case-by-case basis as follows (Gloyna 1976):

Case	Depth	Related condition
1	1 metre	Very uniform temperature, tropical to subtropical climate, minimum settlable solids in sewage.
2	1.25 metres	Same as above but with modest amount of settlable solids, 0.25 metre is used for reserve volume for settlables.
3	1.5 metres	Same as in Case 2 except for significant seasonal variation in temperature and major fluctuations in daily flow.
4	2 metres or greater	Wastewater containing soluable matter with low biodegradability, requiring longer detention time.

Under the weather conditions in this area, 1 metre depth of pond will be sufficient to prevent objectionable vegetation and mosquito breeding. It is, however, that the design depth of pond be 1.5 metres for the reasons mentioned below.

(1) Some portion of the settable solids not trapped in a sedimentation cell will inflow to a primary pond. Thus some allowance should be provided in the pond capacity for easy operation and sludge disposal.

(2) Longer detention period is better for coliform reduction in the pond.

(3) Ground water level is high at the proposed sites for the pond.

3.3 Maturation Pond

The primary purpose of a maturation pond is to provide a high quality effluent in terms of its chemical, biochemical, bacteriological and potential eutrophication parameters. It is evident that several parameters will govern the design, depending on the type of disposal or reuse of effluent. With respect to public health and environmental pollution control in urbanization areas, the parameters of BOD and coliforms are used for evaluation of final effluent quality.

Although minimum requirement of effluent BOD can be almost achieved at the primary pond, the concentration of coliform at the primary pond effluent may still remain on the order of some thousands per millilitre. An appropriate detention time should be, therefore, provided by a maturation pond for reducing the number of coliforms in the final effluent to less than the number of effluent criteria.

The reduction of faecal bacteria in a pond has been found to follow first order kineties. On the model of continuous flow of n ponds in series and complete mixing in each pond, final effluent coliforms could be estimated by following equation:

$$Ne = \frac{Ni}{(1+Kb \cdot D_1)(1+Kb \cdot D_2) \; \cdots\cdots \; (1+Kb \cdot D_n)} \quad \cdots\cdots\cdots \quad (4)$$

where

Ne = effluent coliforms, N/ml

Ni = influent coliforms, N/ml

Kb = first order rate constant, day^{-1}

Dn = detention time in nth pond, day

The value of 'Kb' is extremely temperature sensitive as given by the Marais equation (Marais 1974):

$$K_T = 2.6\ (1.19)^{T-20} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (5)$$

where

K_T = the value of 'Kb' at T°C

The treatment system proposed in the Master Plan Report is composed of three major parts in series, i.e., sedimentation cell, primary facultative pond, and maturation pond, whose mean detention periods are 3 hours, 10 days and 3 days respectively. The water temperature of the ponds is considered to be approximately 28°C. Assuming that 5 x 10^6 coliforms per ml are contained in the inflow, the effluent coliforms are calculated to be about 400 (N/ml), which satisfy the design criteria shown in Table 6.1. Therefore, a 3-day detention time is recommended for designing the maturation pond. The pond depth is recommended to be 1.5 metres. The depth of the primary pond is also recommended to be 1.5 metres because the high groundwater level gives a disadvantage to the construction of a deeper pond.

ANNEX 4

Basic Data for Comparative Study and Cost Comparison Among Alternatives

(1) Butterworth Zone 1

(at 1977 price levels)

Alternatives	Facility	Specification	Construction Cost (M$)	Operation & Maintenance Cost (M$/yr)	Land Acquisition Cost for Pumping Station (M$)
Alternative I	Sewer (including manhole)	ø450mm - ø900mm L = 2,840m	1,942,000		-
	Lift station ; P	Qp = 33 m^3/min. H = 10m	394,000		-
	Total		2,336,000	20,400	-
Alternative II	Sewer (including manhole)	ø225mm - ø675mm L = 2,740m	1,043,000		
	Pumping station ; P_1	Qp = 31 m^3/min. H = 20m	427,000		21,000
	Pumping station ; P_2	Qp = 20 m^3/min. H = 5m	66,000		-
	Force main	ø600mm, A.C.P. L = 1,300m	285,000		-
	Total		1,821,000	12,000	21,000
Alternative III	Sewer (including manhole)	ø450mm - ø900mm L = 2,840m	1,554,000		-
	Pumping station ; P_1	Qp = 4.9 m^3/min. H = 3m	161,000		97,000
	" ; P_2	Qp = 33 m^3/min. H = 9m	372,000		-
	Total		2,087,000	21,700	97,000

(to be continued)

(continued)

Alternatives	Facility	Specification	Construction Cost (M$)	Operation & Maintenance Cost (M$/yr)	Land Acquisition Cost for Pumping Station (M$)
Alternative IV	Sewer (including manhole)	ø225mm - ø675mm L = 2,840m	764,000		-
	Pumping station P_1	Qp = 4.9 m^3/min. H = 3m	161,000		118,000
	Pumping station P_2	Qp = 31 m^3/min. H = 22m	416,000		
	Pumping station P_3	Qp = 2 m^3/min. H = 5m	66,000		-
	Force main	ø600mm (A.C.P.) L = 1,300m	285,000		-
	Total		1,692,000	13,300	118,000

Note:
ø : sewer diameter
L : sewer length
Qp : peak flow
H : total head
A.C.P. : asbestos cement pipe

All costs are indicated at 1977 prices

(2) Butterworth Zone 3

(at 1977 price levels)

Alternatives	Facility	Specification	Construction Cost (M$)	Operation & Maintenance Cost (M$/yr)	Land Acquisition Cost for Pumping Station (M$)
Alternative I	Sewer	ø675mm L = 1,740m	1,300,000		-
	Pumping station; P	Qp = 14 m^3/min. H = 10m	454,000		-
	Total		1,754,000	21,300	-
Alternative II	Pumping station; P	Qp = 14 m^3/min. H = 16.5m	370,000		10,000
	Force main	ø525 (A.C.P.) L = 1,740m	322,000		-
	Total		692,000	35,300	10,000

Note: ø : sewer diameter
L : sewer length
Qp : peak flow
H : total head
A.C.P.: asbestos cement pipe

All costs are indicated at 1977 prices

(3) Butterworth Zone 4

(at 1977 price levels)

Alternatives	Facility	Specification	Construction Cost (M$)	Operation & Maintenance Cost (M$/yr)	Land Acquisition Cost for Pumping Station (M$)
Alternative I	Sewer	ø600mm L = 1,650m	1,208,000		-
	Pumping station; P	Qp = 13 m^3/min. H = 11m	440,000		-
	Total		1,648,000	17,700	-
Alternative II	Pumping station; P	Qp = 13 m^3/min. H = 21m	420,000		8,000
	Force main	ø = 450mm A.C.P. L = 1,650m	260,000		-
	Total		680,000	30,500	8,000

Note: ø : sewer diameter
L : sewer length
Qp : peak flow
H : total head
A.C.P.: asbestos cement pipe

All costs are indicated at 1977 prices

(4) Butterworth Zone 2

(at 1977 price levels)

Alternatives	Facility	Specification	Construction Cost (M$)	Operation & Maintenance Cost (M$/yr)	Land Acquisition Cost for Pumping Station (M$)
Alternative I	Sewer (including Manhole)	ø225 - ø525mm L = 4,640m	1,102,000		—
	Pumping station	Qp = 8.6 m^3/min. H = 8.0m	288,000		—
	Waste stabilization pond	Q = 4,392 m^3/d	650,000		1,130,000
	Total		2,040,000	12,500	1,130,000
Alternative II	Sewer (including Manhole)	ø225 - ø300mm L = 4,690m	678,000		—
	Pumping station	Qp = 0.8-2.1 m^3/min. H = 3.7 - 5.5m	362,000		—
	Waste stabilization pond	Q = 204 - 867 m^3/d	1,226,000		2,659,000
	Total		2,266,000	10,000	2,659,000

Note: ø : sewer diameter
L : sewer length
Qp : peak flow
H : total head

All costs are indicated at 1977 prices

(5) Sub-zones 3-F and 3-G within zone 3 of Bukit Mertajam District

(at 1977 price levels)

Alternatives	Facility	Specification	Construction Cost (M$)	Operation & Maintenance Cost (M$/yr)	Land Acquisition Cost for Pumping Station (M$)
Alternative I	Sewer (including manhole)	ø225mm - ø450mm L = 2,670m	643,000		-
	Pumping station	Qp = 8.2 m^3/min. H = 5.5m	140,000		155,000
	Waste stabilization pond	Q = 3,073 m^3/d	322,000		-
	Total		1,105,000	11,300	155,000
Alternative II	Sewer (including manhole)	ø225mm - ø450mm L = 3,625m	821,000		-
	Pumping station	Qp = 6 m^3/min. H=7m Qp = 2.6m^3/min. H=4m	211,000		-
	Waste stabilization pond	Q = 1,292 m^3/day	321,000		357,000
	Total		1,353,000	10,500	357,000

Note: ø : sewer diameter
L : sewer length
Qp : peak flow
H : total head

All costs are indicated at 1977 prices

(6) Total Annual Costs for Alternative Sewerage Systems

1. Butterworth Zone 1

(at 1977 price levels)
(M$1,000 per year)

Item	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Interest at 8%	186.9	147.4	174.7	144.8
Depreciation				
Sewers	3.4	2.3	2.7	1.8
Pump stations	5.4	6.7	7.3	8.8
O & M	20.4	12.0	21.7	13.3
Total annual cost	216.1	168.4	206.4	168.7

2. Butterworth Zone 3

Item	Alt. I	Alt. II
Interest at 8%	140.3	56.2
Depreciation		
Sewers	2.3	0.6
Pump stations	6.2	5.1
O & M	21.3	35.3
Total annual cost	170.1	97.2

3. Butterworth Zone 4

Item	Alt. I	Alt. II
Interest at 8%	131.8	55.0
Depreciation		
Sewers	2.1	0.5
Pump stations	6.0	5.7
O & M	17.7	30.5
Total annual cost	157.6	91.7

(to be continued)

4. Butterworth Zone 2

(continued)

Item	Alt. I	Alt. II
Interest at 8%	253.6	394.0
Depreciation		
Sewers	1.9	1.2
Pump stations and stabilization ponds	12.8	21.7
O & M	12.5	10.0
Total annual cost	280.8	426.9

5. Bukit Mertajam Zone 3, Sub-zone 3-F and 3-G

Item	Alt. I	Alt. II
Interest at 8%	100.8	136.8
Depreciation		
Sewers	1.1	1.4
Pump stations and stabilization ponds	6.3	7.3
O & M	11.3	10.5
Total annual cost	119.5	156.0

ANNEX 5

Criteria for Temporary Treatment
Facilities of Stabilization Pond

Item	Description	Criteria
Sedimentation Cell	Unit	None
Stabilization Pond	Unit	One
Maturation Pond	Unit	None
Bank	Height	0.6 m
	Embankment top width	3 m
	Pond slope	1:1
	Dike shelter	Spreading grass
	Seating for pond	None
Fencing	Height	2 m

ANNEX 6

Estimated Construction Cost by Stage for the Two Cases in Zone 2 of Butterworth District

(at 1977 price levels)

(1) Case 1 (unit:M$)

Stage	Sewer (Including Manhole)	Pumping Station	Treatment facility	Total
I	680,400	248,000	402,900	1,331,300
II	90,500	-	-	90,500
III	87,400	39,500	270,000	396,900
IV	189,700	-	-	189,700
V	53,700	-	-	53,700
Total	1,107,700	287,500	672,900	2,062,100

(2) Case II (unit:M$)

Stage	Sewer (Including Manhole)	Pumping Station	Treatment facility	Total
I	80,500	67,800	31,300	179,600
II	164,700	53,800	41,200	259,700
III	164,600	52,800	36,600	254,000
IV	369,100	53,800	49,800	472,700
V	322,700	287,600	654,900	1,265,200
Total	1,101,600	515,800	813,800	2,431,200

ANNEX 7

Cost Comparison Between the Two Cases by Discounted Cash Flow Method for Zone 2 of Butterworth District

(at 1977 price levels)

Case	Stage	Capital Cost (M$)	Discount Factor	Discounted to 1977 at 8% (M$)
	I	1,331,300	0.857	1,140,900
	II	90,500	0.735	66,500
I	III	396,900	0.630	250,000
	IV	189,700	0.540	102,400
	V	53,700	0.463	24,900
Total				1,584,700
	I	179,600	0.857	153,900
	II	259,700	0.735	190,900
II	III	254,000	0.630	160,000
	IV	472,700	0.540	255,300
	V	1,265,200	0.463	585,800
Total				1,345,900

ANNEX 8

Basic Data for Application of Centralized Collection System in Seberang Jaya Zone 2

Facilily	Specification	Construction Cost (M$)	Total Cost. (M$)
Sewer (including Manhole)	ø225mm - ø525mm L = 4,090m	994,350	
Pumping Station P_1	Qp = 4.2 m^3/min H = 22 m	184,000	5,486,750
Pumping Station P_2	Qp = 17.7 m^3/min. H = 6 m	348,600	
Aerated Lagoon	Q = 17,602 m^3/d	4,009,800*	

Note: ø : Sewer diameter

L : Sewer Length

Qp : Peak flow

Q : Daily average flow

H : Total head

(*) estimated based on cost function of $0.2323Q^{0.998}$ x 1,000 as developed in the Master Plan Report.

ANNEX 9

Available Land Space for Treatment Facility and
Area to be Sewered by Sewerage Zone

(Unit: ha)

Sewerage Zone	Available Land Area for Treatment Facility	Area to by sewered	Total
Butterworth Zone 1	14	366	380
Butterworth Zone 2	6	114	120
Butterworth Zone 3	13	432	455
Butterworth Zine 4	24	451	475
Seberang Jaya Zone 1	14	371	385
Seberang Jaya Zone 2	18	382	400
Bukit Mertajam Zone 3	32	1,018	1,050
Total	121 ha	3,134 ha	3,255 ha

ANNEX 10

Preliminary Engineering Design for Sewerage System in the Large Scale Development Area

In the Study Area, large scale development schemes are underway by both PDC and private developers within the sewerage zone 2 of Butterworth, zone 2 of Seberang Jaya, and sub-zones 3-F and 3-G of Bukit Mertajam.

Based on the study results, as discussed in Chapter 7, preliminary engineering design is made for the sewerage facilities required to be contributed by the Government. Especially, for zone 2 of Seberang Jaya District, it is noted that although PDC has planned to provide sewerage facilities by decentralized collection system, providing a stabilization pond for each four sub-zones, the centralized collection system is applied under this study for the sewerage zone, considering future situation.

The waste stabilization pond is the only sewerage facility designed under the present study, and the remaining major facilities of this system are worked out by PDC. The pond design suggests to PDC only for the land acquired for the waste stabilization pond.

In the large scale development area, the proposed sewerage system and facilities which will be undertaken by the Government are a tentative plan. However, these can be used as a suggestion to both the Government and developers.

The results of the study include for sewer capacity, design flow rates and design specification for pumping station and required pond surface area for waste stabilization pond as indicated in the following tables. Also, these designed sewerage facilities are shown in plans as presented in Figures SD-14 through SD-39, and SD-43 through SD-47, Volume V.

10.1 Estimated Sewer Capacities by the Government Contribution

(1) Butterworth Zone 2

Pipe Diameter (m)	Average Depth of Sewer Laying (m)	Pipe Length (m)	Number of Monholes Required
225	4.0	20	2
	6.0	50	2
300	4.0	710	6
375	5.0	415	5
450	6.0	175	2
525	6.0	600	9
	7.0	50	2
Total		2,020	28

(2) Seberang Jaya Zone 2

450	2.0	780	11
	3.0	920	13
525	4.0	1,720	20
225(*)	1.6	670	—
Total		4,090	44

Note: (*) force main

(continued)

(3) Bukit Mertajam Sub-Zones 3-F and 3-G

Pipe Diameter (m)	Average Depth of Sewer Laying (m)	Pipe Length (m)	Number of Monholes Required
375	6.0	870	10
450	7.0	150	3
525	7.0	70	2
375(*)	1.8	375	—
Total		1,465	15

Note: (*) force main

10.2 Design Flow Rates for Proposed Pumping Stations

(1) Butterworth Zone 2

Name of Pumping Station	Daily Average Flow (m^3/d)	Peak Flow (m^3/min)
BW 2	4,392	8.6

(2) Seberang Jaya Zone 2

Name of Pumping Station	Daily Average Flow (m^3/d)	Peak Flow (m^3/min)
SJ 2-A	2,132	4.2
SJ 2-D	7,748	17.7

(3) Bukit Mertajam Sub-zones 3-F and 3-G

Name of Pumping Station	Daily Average Flow (m^3/d)	Peak Flow (m^3/min)
Golden Grove	4,565	8.5

10.3 Specification for Pumping Stations

(1) Butterworth Zone 2

Name of Pumping Station	Total Head (m)	Pump Capacity per unit (m^3/min)	Number of Pumps Required(*)	Pump Type
BW 2	8	4.4	3	Submersible

(2) Seberang Jaya Zone 2

Name of Pumping Station	Total Head (m)	Pump Capacity per unit (m^3/min)	Number of Pumps Required(*)	Pump Type
SJ 2-A (with force main)	22	2.1	3	Submersible
SJ 2-D	6	5.9	4	Submersible

(3) Bukit Mertajam Sub-zones 3-F and 3-G

Name of Pumping Station	Total Head (m)	Pump Capacity per unit (m^3/min)	Number of Pumps Required	Pump Type
Golden Grove	105	4.3	3	Submersible

Note: (*) including one standby

10.4 Estimated Pond Surface Area for Proposed Waste Stabilization Ponds

(1) Butterworth Zone 2

Item	Units	Value
Design Flow (Daily Average Flow)	m^3/day	4,392
Applied BOD	kg/day	662
Required Primary Pond Surface Area	ha	2.21
Required Maturation Pond Surface Area	ha	0.88

(2) Seberang Jaya Zone 2

Item	Units	Value			
		2-A	2-B	2-C	2-D
Design Flow (Daily Average Flow)	m^3/day	2,158	2,599	3,074	9,771
Applied BOD	kg/day	321	392	464	1,288
Required Primary Pond Surface Area	ha	1.07*	1.31	1.55	4.29
Required Maturation Pond Surface Area	ha	0.43	0.52	0.61	1.95

(*) including existing pond surface area of 0.60 ha.

ANNEX 11

Basic Data of Unit Construction Costs (at 1977 prices)

(1) Labour Cost

Type of Labour	M$/day(8 hr)
Common Worker	8.50
Skilled Worker	14.00
Carpenter	14.00
Stone Masonry	14.00
Plumber	14.50
Foreman	20.00

(2) Price of Basic Materials

Item	Unit	Price(M$)
Cement	t	148.00
Sand	m^3	7.80
Crushed Stone	m^3	19.00
Gravel	m^3	20.90
Steel Bar	t	815.60
Timber	t	10.00
Vitrified Clay Pipe		
ø 150 (6")	m	13.10
ø 225 (9")	m	16.40
ø 300 (12")	m	29.50
Centrifugally Cast Reinforced Concrete Pipe		
ø 150 (6")	m	19.00
ø 225 (9")	m	28.40
ø 300 (12")	m	35.40
ø 375 (15")	m	49.40
ø 450 (18")	m	64.80
ø 525 (21")	m	74.40
ø 600 (24")	m	84.80
ø 675 (27")	m	104.10
ø 750 (30")	m	114.90
ø 900 (36")	m	149.50
ø 1,050 (42")	m	188.50
ø 1,200 (48")	m	217.50
ø 1,350 (54")	m	275.60
ø 1,500 (60")	m	326.10
ø 1,800 (72")	m	435.40

(3) Unit Cost of Construction (including labour and materials)

Item	Description	Unit	Cost (M$)
Concrete	Structural concrete Mix 1:2:4	m^3	99.40
Concrete	Non Structural Concrete Mix 1:3:6	m^3	81.00
Reinforced Concrete	Reinforced Concrete Including Steel and Forming	m^3	250.00
Mortor Works	1:2	m^3	122.50
Mortor Works	1:3	m^3	92.80
Excavation	Bulk Excavation (by hand)	m^3	3.00
Excavation	Bulk Excavation (by Machinery)	m^3	1.80
Excavation	Trench Excavation (depth 0 - 1.5m)	m^3	3.60
Excavation	Trench Excavation (depth 1.5 - 3.0m)	m^3	5.40
Excavation	Trench Excavation (depth 3.0 - 4.5m)	m^3	9.20
Excavation	Trench Excavation (depth 4.5 - 6.0m)	m^3	13.80
Excavation	Trench Excavation (depth 6.0 - 7.5m)	m^3	17.20
Excavation	Trench Excavation (depth 7.5 or more)	m^3	20.50
Backfilling and Compaction		m^3	2.60
Forming		m^3	7.60
Restoration of Paving		m^3	15.60
Dewarering		hr	3.00
Sheeting	Excavation depth (1 - 2 m)	m	6.30
Sheeting	Excavation depth (2 - 3 m)	m	9.00
Sheeting	Excavation depth (3 - 4 m)	m	18.00
Sheeting	Excavation depth (4 - 5 m)	m	40.50
Sheeting	Excavation depth (6 m)	m	112.00
Sheeting	Excavation depth (7 m)	m	123.00
Sheeting	Excavation depth (8 m or more)	m	133.00

ANNEX 12

Estimated Market Value of Land

(at 1977 prices levels)

(Unit: M$/$m^2$)

Category	Butterworth and Seberang Jaya	Bukit Mertajam
Urbanized Residential Area	30 - 50	20 - 30
Urbanized Commercial Area	75 - 80	-
Development Residential Area	5 - 60	3 - 28
Development Industrial Area	30 - 40	-
Area of Town Centre	180 - 450	160 - 200

ANNEX 13

Basic Data for Application of the Rating System (1)

Sewerage Zone	Subzone	(1) Population: Year 1976 (Person)	(1) Population: Year 1985 (Person)	(2) Urbanization: Existing Area (ha)	(2) Urbanization: Foreseeable Area (ha)	(3) Waste Loading: BOD (kg/d)	(3) Waste Loading: Average Coliform Number in Existing Drain (Nos/ml)	(4) Sewage Flow in 1985 (m^3/d)	(5) Excreta Disposal System: Existing Communal Septic Tank (Unit)	(5) Proposed Communal Septic Tank (Unit)	(5) Area Served by Individual Septic Tank (ha)	(5) Population Served by Bucket System (Person)
Butterworth Zone 1	1-A	21,800	23,453	82.4	94.0	590	184,200	7,956	4	4	58.8	13,454
	1-B	1,200	1,916	28.2	39.9	38	3,000	1,327	2	1	0	0
	1-C	13,200	15,697	18.5	20.1	319	7,000	4,777	1	1	0.4	12,990
Butterworth Zone 2	-	0	5,160	0	120.0	0	100	2,097	0	1	0	0
Butterworth Zone 3	3-A	10,300	11,596	41.7	60.3	293	150,000	3,329	8	5	15.4	4,620
	3-B	6,850	7,576	150.2	158.4	193	8,500	8,111	6	2	5.5	3,260
	3-C	8,350	9,272	4.9	7.7	202	24,700	2,752	0	1	3.9	7,978
Butterworth Zone 4	4-A	14,150	16,345	57.2	77.3	105	14,750	5,803	16	10	18.1	6,224
	4-B	13,600	16,791	1.4	31.7	327	5,000	5,243	1	10	0.5	13,432
Seberang Jaya Zone 1	1-A	14,450	19,205	124.6	144.1	427	80,000	6,548	15	4	13.3	4,462
	1-B	800	3,868	0	74.0	19	100	1,464	0	1	0	800
	1-C	600	1,628	0	0	14	5,000	635	0	0	0	600
Seberang Jaya Zone 2	-	3,600	15,600	30.0	382.0	17	100	10,807	0	3	0	0
Bukit Mertajam Zone 3	3-A	17,300	18,262	54.1	69.2	458	45,250	6,391	8	3	29.0	11,942
	3-B	14,610	20,240	74.6	114.2	409	45,250	6,465	13	7	37.5	7,262
	3-C	2,740	3,591	0	0	66	5,400	1,347	0	0	0	2,740
	3-D	400	1,072	0	0	10	100	496	0	0	0	400
	3-E	12,340	12,100	5.4	5.4	299	4,300	3,738	1	0	2.8	12,022
	3-F	0	3,285	0	107.0	0	100	1,610	0	2	0	0
	3-G	0	1,382	0	0	0	100	677	0	0	0	0

Basic Data for Application of the Rating System (2)*

Sewerage Zone	Subzone	(1) Population Density: Year 1976 (Person/ha)	(1) Population Density: Year 1985 (Person/ha)	(2) Urbanization: Existing Area (ha/ha)	(2) Urbanization: Foreseeable Area (ha/ha)	(3) Waste Loading: BOD (kg/d/ha)	(3) Waste Loading: Average Coliform Number in Existing Drain (Nos/ml)	(4) Sewage Flow in 1985 (m^3/d·ha)	(5) Excreta Disposal System: Existing Communal Septic Tank (Unit/ha)	(5) Excreta Disposal System: Proposed Communal Septic Tank (Unit/ha)	(5) Excreta Disposal System: Area Served by Individual Septic Tank (ha/ha)	(5) Excreta Disposal System: Population Served by Bucket System (Person/ha)
Butterworth Zone 1	1-A	133	143	0.50	0.57	3.60	184,200	48.5	0.0244	0.0244	0.3585	82
	1-B	29	46	0.67	0.95	0.90	3,000	31.6	0.0476	0.0238	0	0
	1-C	83	98	0.12	0.13	1.99	7,000	29.9	0.0063	0.0063	0.0025	81
Butterworth Zone 2	-	0	43	0	1.00	0	100	17.5	0	0.0083	0	0
Butterworth Zone 3	3-A	89	100	0.36	0.57	2.53	150,000	28.7	0.0690	0.0431	0.1328	40
	3-B	31	34	0.68	0.72	0.87	78,500	36.7	0.0271	0.0090	0.0249	15
	3-C	88	98	0.05	0.08	2.13	24,700	29.0	0	0.0105	0.0411	84
Butterworth Zone 4	4-A	82	95	0.33	0.45	0.61	147,500	33.7	0.0930	0.0581	0.1052	36
	4-B	49	60	0.01	0.11	1.17	5,000	18.8	0.0036	0.0358	0.0018	48
Seberang Jaja Zone 1	1-A	59	79	0.51	0.57	1.76	80,000	26.9	0.0617	0.0165	0.0547	18
	1-B	11	52	0	1.00	0.25	100	19.8	0	0.0135	0	11
	1-C	11	30	0	0	0.26	5,000	11.8	0	0	0	11
Severang Jaya Zone 2	-	9	41	0.08	1.00	0.04	100	28.0	0	0.0078	0	0
Bukit Mertajam Zone 3	3-A	101	106	0.31	0.40	2.66	45,250	37.2	0.0465	0.0174	0.1686	69
	3-B	50	69	0.26	0.39	1.40	45,250	22.1	0.0445	0.0240	0.1284	25
	3-C	29	37	0	0	0.69	5,400	14.0	0	0	0	29
	3-D	7	19	0	0	0.18	100	8.7	0	0	0	7
	3-E	50	49	0.02	0.02	1.20	4,300	15.0	0.0040	0	0.0112	48
	3-F	0	31	0	1.00	0	100	15.0	0	0.0187	0	0
	3-G	0	31	0	0	0	100	15.0	0	0	0	0

* based on unit area

ANNEX 14

Evaluation Points by Sewerage Sub-Zone

Sewerage Zone	Subzone	(1) Population Year 1976 (Person/ha)	(1) Population Year 1985 (Person/ha)	(2) Urbanization Existing Area (ha/ha)	(2) Urbanization Foreseeable Area (ha/ha)	(3) Waste Loading BOD (kg/d/ha)	(3) Waste Loading Average Coliform Number in Existing Drain (Nos/ml)	(4) Sewage Flow in 1985 ($m^3/d \cdot ha$)	(5) Excreta Disposal System Existing Communal Septic Tank (Unit/ha)	(5) Proposed Communal Septic Tank (Unit/ha)	(5) Area Served by Individual Septic Tank (ha/ha)	(5) Population Served by Bucket System (Person/ha)
Butterworth Zone 1	1-A	1.00	1.00	0.74	0.57	1.00	1.00	1.00	0.26	0.42	1.00	0.98
	1-B	0.22	0.22	0.99	0.95	0.25	0.02	0.58	0.51	0.41	0	0
	1-C	0.62	0.64	0.18	0.13	0.55	0.04	0.53	0.07	0.11	0.01	0.96
Butterworth Zone 2	-	0	0.19	0	1.00	0	0	0.22	0	0.14	0	0
Butterworth Zone 3	3-A	0.67	0.65	0.53	0.52	0.70	0.81	0.50	0.74	0.74	0.37	0.48
	3-B	0.23	0.12	1.00	0.72	0.24	0.43	0.70	0.29	0.15	0.07	0.18
	3-C	0.66	0.64	0.07	0.08	0.59	0.13	0.51	0	0.18	0.11	1.00
Butterworth Zone 4	4-A	0.62	0.61	0.49	0.45	0.17	0.80	0.63	1.00	1.00	0.29	0.43
	4-B	0.37	0.33	0.01	0.11	0.33	0.27	0.25	0.04	0.62	0	0.57
Seberang Jaya Zone 1	1-A	0.44	0.48	0.75	0.59	0.49	0.43	0.46	0.66	0.28	0.15	0.21
	1-B	0.08	0.27	0	1.00	0.07	0	0.28	0	0.23	0	0.13
	1-C	0.08	0.09	0	0	0.07	0.27	0.08	0	0	0	0.13
Severang Jaya Zone 2	-	0.07	0.18	0.12	1.00	0.01	0	0.48	0	0.13	0	0
Bukit Mertajam Zone 3	3-A	0.76	0.70	0.46	0.40	0.74	0.25	0.72	0.50	0.30	0.47	0.82
	3-B	0.38	0.40	0.38	0.39	0.39	0.25	0.34	0.48	0.41	0.36	0.30
	3-C	0.22	0.15	0	0	0.19	0.03	0.13	0	0	0	0.35
	3-D	0.05	0	0	0	0.05	0	0	0	0	0	0.08
	3-E	0.38	0.24	0.03	0.02	0.33	0.02	0.16	0.04	0	0.03	0.57
	3-F	0	0.10	0	1.00	0	0	0.16	0	0.32	0	0
	3-G	0	0.10	0	0	0	0	0.16	0	0	0	0

* based on unit area

ANNEX 15

Sewers by the Government Contribution For the First Stage Programme

(1) Butterworth Zone 1 (BW1-A & BW1-B)

Pipe Dia. (m)	Average Depth of Excavation (m)	Pipe Length (m)	Number of Manholes
225	2.0	4,200	65
	3.0	920	8
	4.0	315	4
300	3.0	960	13
	4.0	810	12
	5.0	235	3
375	4.0	185	6
	6.0	430	5
450	3.0	375	5
	4.0	400	7
525	4.0	150	2
	5.0	335	4
	6.0	340	4
600	5.0	65	1
675	5.0	100	1
	6.0	705	5
900	6.0	50	1
	7.0	30	1
600*	2.0	1,300	
Total		11,905	147

* force main

(2) Butterworth Zone 3

a) BW 3-A

Pipe Dia. (mm)	Average Depth of Excavation (m)	Pipe Length (m)	Number of Manholes
225	2.0	850	14
	3.0	1,215	14
	4.0	1,380	18
300	4.0	280	4
	5.0	355	4
375	5.0	390	4
	6.0	260	3
450	6.0	210	4
600	6.0	250	3
675	7.0	255	3
750	7.0	30	1
525*	2.0	1,740	
Total		7,215	72

*force main

b) BW 3-B

225	2.0	4,000	50
	3.0	615	8
	4.0	810	12
	5.0	255	4
300	4.0	940	13
375	4.0	240	3
	5.0	830	11
	6.0	200	2
450	6.0	375	4
	7.0	220	3
525	6.0	350	5
	7.0	165	2
600	7.0	280	3
675	7.0	300	5
Total		9,580	125

(3) Bukit Mertajam Zone 3

a) BM 3-A

Pipe Dia. (mm)	Average Depth of Excavation (m)	Pipe Length (m)	Number of Manholes
225	2.0	5,100	33
	3.0	1,650	23
	4.0	30	4
	5.0	30	4
300	2.0	460	6
	3.0	885	13
	4.0	15	2
	5.0	505	7
375	2.0	720	15
	3.0	140	2
	4.0	855	13
450	6.0	105	2
525	3.0	390	4
675	6.0	620	8
750	5.0	730	6
900	6.0	40	1
Total		12,275	189

b) BM 3-B

225	2.0	4,955	70
	3.0	2,710	40
	4.0	750	14
	5.0	15	2
300	4.0	1,150	15
	5.0	790	13
375	4.0	830	10
	5.0	650	6
450	4.0	230	4
600	3.0	550	6
	5.0	210	3
750	4.0	110	1
	5.0	1,215	9
			193

ANNEX 16

BOD Loadings to Drains and Streams

As mentioned in the Master Plan Report, the major drains in the Butterworth town area have been polluted by municipal wastes such as sullage, thus anaerobic conditions have been prevailing throughout the drains. In the Bukit Martajam town area, heavily polluted conditions are observed only in downstream where the drain slope is gentle. On the other hand, the Rambai River has almost become anaerobic, and this condition is observed down to the tide gate of the Juru River.

It is apparent that the pollution is mainly attributable to the discharge of sullage waters from town areas, and unless some measures are taken the pollution problems will become worse in the near future.

Table 16.1 shows BOD loadings estimated according to contributing areas to individual major drains and streams in Butterworth and Bukit Mertajam. The estimation has been made on the basis of "Present and Projected Population" described in Chapter 4, Part III, "Per Capita Waste Production" mentioned in Chapter 5, Part III, assuming 40% BOD removal efficiency of septic/Imhoff tank systems.

As shown in Table 16.1, the BOD loadings on the individual drains and streams would be markedly decreased by the proposed first stage sewerage systems. It is expected that in the year 1990, the BOD loadings on the three major drains in Butterworth could be decreased to 50 to 60% of the present value (as of 1976). Even in the year 2000, the BOD loading could be maintained in the range of 80 to 90% of the present value notwithstanding in the steady increase in the number of total population. In Bukit Mertajam, further high reduction rates of loadings are seen in Table 4.1. However, the effluent of the proposed stabilization ponds would be discharged into the Rambai River, and approximately 600 and 700 kg/day of BOD, which correspond to about 30% of the present loading value (1976), would be additionally loaded in 1990 and 2000 respectively.

If the First Stage programme were not completely implemented by 1990, BOD loadings on the drains and streams would increase up to 120 to 180% of the present values, and reach to 150 to 250% by the year 2000.

Table 16.1 BOD Loading to Drains and Streams (1)

(kg/day)

	Drains/Streams	Total Sewage BOD 1976	Total Sewage BOD 1990	Total Sewage BOD 2000	First Stage Sewege BOD 1990	First Stage Sewege BOD 2000
Butterworth	Drain A	1,168	1,622	2,052	1,107	1,242
	Drain B	403	619	841	218	245
	Drain C	314	1,619	2,437	1,216	1,757
	Sub-Total	1,885	3,860	5,330	2,541	3,244
Bukit Mertajam	Sg. Ara	487	621	784	85	102
	BM Town	1,070	967	1,164	952	1,146
	Rambai L	111	186	224	77	93
	Sg. Pasir	606	1,041	1,254	949	1,143
	Sub-Total	2,633	3,198	3,887	2,376	2,861

Notes:
1. Total sewage BOD is the total BOD to be discharged into the proposed sewerage systems.
2. First stage sewage BOD is the value to be collected by the First Stage Sewerage systems.

Table 16.1 BOD Loadings to Drains and Streams (2)

(kg/day)

	Drains/ Streams	1976 BOD Loadings	1990 First Stage BOD Loading 30%	60%	80%	100%	1990 BOD Loadings 30%	60%	80%	100%
Butterworth	Drain A	888	389	417	435	453	1306	1376	1422	1468
	Drain B	299	308	328	342	356	475	507	528	549
	Drain C	821	310	330	344	357	1487	1576	1535	1555
	Sub-Total	2008	1007 (50)	1075 (54)	1121 (56)	1166 (58)	3268 (163)	3399 (169)	3485 (174)	3572 (173)
Bukit Mertajam	Sg. Ara	326	435	464	483	502	500	534	556	578
	BM Town	1025	12	13	13	14	926	935	941	947
	Rambai L	258	53	57	59	62	294	313	326	339
	Rambai R	76	84	89	92	97	143	152	159	165
	Sg.Pasir	455	71	76	79	82	800	853	888	924
	Sub-Total	2140	655 (31)	699 (33)	727 (34)	757 (38)	2663 (124)	2787 (130)	2870 (134)	2953 (147)

Notes:

1. First stage BOD loadings and BOD loadings are computed assuming that 30, 60, 80 and 100% populations be served by septic tank systems.
2. First stage BOD loadings are the values to be discharged into individual tributary areas outside of the First Stage area proposed.
3. BOD loadings are the values discharged or to be discharged into individual tributary areas in case of no sewerage system.
4. Figures in parentheses mean the percentage cut-off rates of BOD loadings for the drains/streams to the present (1976) BOD loadings.

Table 16.1 BOD Loadings to Drains and Streams (3)

(kg/day)

	Drains/Streams	2000							
		First Stage BOD Loadings				BOD Loadings			
		30%	60%	80%	100%	30%	60%	80%	100%
Butterworth	Drain A	623	664	692	719	1652	1740	1798	1857
	Drain B	458	488	508	529	646	689	717	746
	Drain C	523	557	580	604	2237	2281	2310	2339
	Sub-Total	1604 (80)	1709 (85)	1780 (89)	1852 (92)	4535 (226)	4710 (235)	4825 (240)	4942 (246)
Bukit Mertajam	Sq. Ara	524	559	582	605	602	642	669	696
	BM Town	14	15	16	16	1115	1126	1133	1140
	Rambai L	64	69	71	74	354	377	393	409
	Rambai R	101	108	112	116	172	184	191	199
	Sq. Pasir	86	91	95	99	963	1027	1070	1112
	Sub-Total	789 (37)	842 (39)	876 (41)	910 (43)	3206 (150)	3356 (157)	3456 (161)	3556 (166)

Note: See Table 16.1(2).

ANNEX 17

SELECTION OF PUMP TYPE FOR SEWAGE PUMPING STATIONS

17.1 Alternatives Considered

In order to select the most suitable pumping station for the proposed sewerage system, a comprehensive study has been made on the alternative pump types, including submersible pump, screw pump and vertical centrifugal pump.

For the study, typical pumping stations, namely Sungai Nyor and Sungai Rambai, are selected each representing for small and large scale station respectively. These stations are estimated for their capital and operation and maintenance costs (for details of the stations, see Figures SD-31 and SD-36, Volume V). Specifications of the stations are as follows:

Name of Stations	(1) Capacity (m^3/sec) Daily Ave.	Peak	(2) Pump No.	Total Dynamic Head (m)
Sungai Nyor	0.013	0.033	2	5
Sungai Rambai	0.053	0.142	4	8

Note: (1) flow rates estimated for 2000 conditions.
(2) required pump numbers for 1990 conditions.

17.2 Estimated Capital Costs

Capital costs for the alternatives have been estimated on the basis of the unit costs developed in Chapter 9. It should be emphasized, however, that the cost estimates are for order-of-magnitude, or reconnaissance study only, and these are satisfactory for comparative study purposes. The estimated costs are summarized below:

(unit: M$1,000)

Item	Structure	Equipment	Land Cost	Total Cost
1. Sungai Nyor				
Submersible	87	74	1	162
Centrifugal	96	78	1.5	175.5

(to be continued)

(continued)

Item	Structures	Equipment	Land Cost	Total Cost
Screw	104	72	2.4	178.4
2. Sungai Rambai				
Submersible	212	228	1.5	441.5
Centrifugal	233	239	2.0	474.0
Screw	254	220	2.5	476.5

Note: All costs are at 1977 price levels. Land cost for Sungai Nyor is M$20/m^2 and for Sungai Rambai M$5/m^2.

17.3 Estimated Annual Operation and Maintenance Costs

The operation and maintenance costs for the alternatives are estimated on the basis of the procedures described in Chapter 9, as summarized in the following:

	Total Dinamic Head (m)	Electricity, Water, Manpower, Spare Part, etc. (M$/yr)
1. Sungai Nyor		
Submersible	5	3.6
Centrifugal	5	3.9
Screw	5	4.1
2. Sungai Rambai		
Submersible	8	9.7
Centrifugal	8	10.4
Screw	8	11.0

Note: All costs are at 1977 price levels.

17.4 Total Annual Costs

For cost comparison, all costs of the facilities are expressed on annual basis using the average lives of the components, i.e., 50 years for civil and building works and 15 years for equipment. It is also assumed that annual depreciation payments into the sinking fund would grow at 8 per cent per annum. The estimated total annual costs for the alternatives by type are summarized in the following:

(1) Sungai Anyor Station

(unit: M$1,000/yr)

Item	Submersible	Centrifugal	Screw
Interest at 8%	13.0	14.0	14.3
Depreciation			
Structures	0.2	0.2	0.2
Equipment	2.7	2.1	2.7
O and M costs	3.6	3.9	4.1
Total annual costs	19.5	20.2	21.3

(2) Sungai Rambai Station

(unit: M$1,000/yr)

Item	Submersible	Centrifugal	Screw
Interest at 8%	35.3	37.9	38.1
Depreciation			
Structures	0.4	0.4	0.4
Equipment	8.4	8.8	8.1
O and M costs	9.7	10.4	11.0
Total annual costs	53.8	57.5	57.6

Note: For land costs full salvage value is considered.

17.5 Evaluation of the Alternatives

As shown in the tables above, the pumping stations with submersible pumps are superior to other types in terms of the total annual cost, as well as other various advantages. Advantages and disadvantages of the submersible type are summarized as follows:

- Since submersible pumps are installed directly in wet well, dry well can be eliminated thus the costs for land, superstructure and substructure can be significantly reduced.

- Because of its structure, submersible pumping station has less problems with respect to flooding which is expected in other types.

- As the motor is directly connected to the pump, submersible pump does not have long shaft and the lubrication to the intermediate bearing box is not required. This makes the overall pump efficiency higher than other types of pump.

- Because of its lighter and compact construction without suction hose, submersible pump may require less maintenance work.

- Since submersible pump is placed completely in the water, the noise from pump operation will be less than other types.

- In the existing sewage pumping stations in the area, submersible pumps have been widely used for years, and the skilled operators familiar with this type of pump are available for operating the new pumping stations.

- One of the disadvantages with respect to submersible pump is that when the pump cleaning is necessary, the unit must be completely withdrawn from the wet well before any work can be carried out.

In view of the above descriptions, it is reasonable to consider that the advantages expected from the adoption of submersible pump overcome the disadvantages.