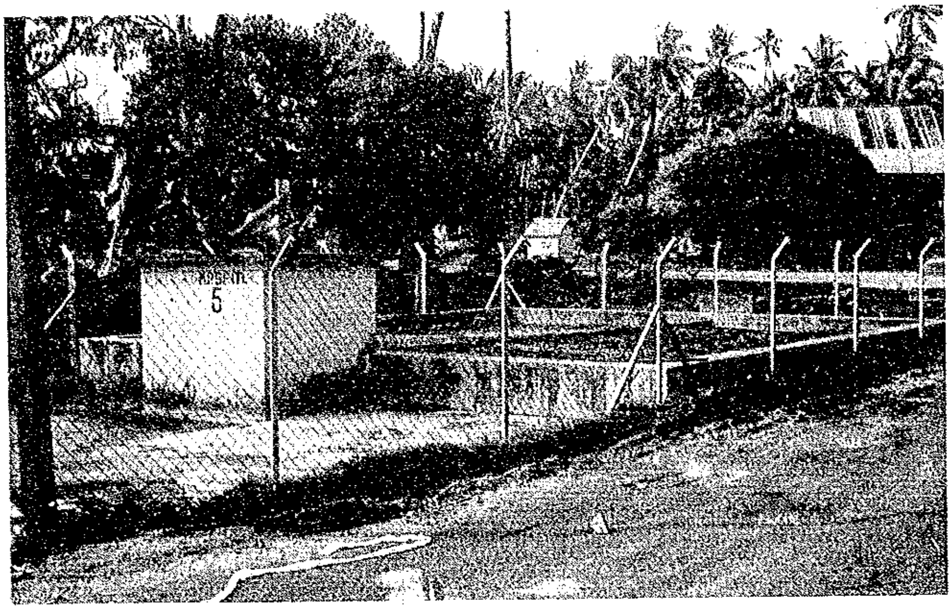
New housing complexes which have been developed recently have their own communal night soil treatment facilities, such as septic tanks or Imhoff tanks, with filtration beds. One exceptional treatment facility in new housing complexes is installed in Seberang Jaya where both of kitchen wastes and night soil are treated together by stabilization pond process. Population served by this system is about 1,900 as of 1976. Communal septic and Imhoff tanks are managed by Minicipal Council of Province Wellesley. Location of these facilities and area served by night soil collection are as shown in Figure II-9.

6.2 Sludge Collection and Disposal

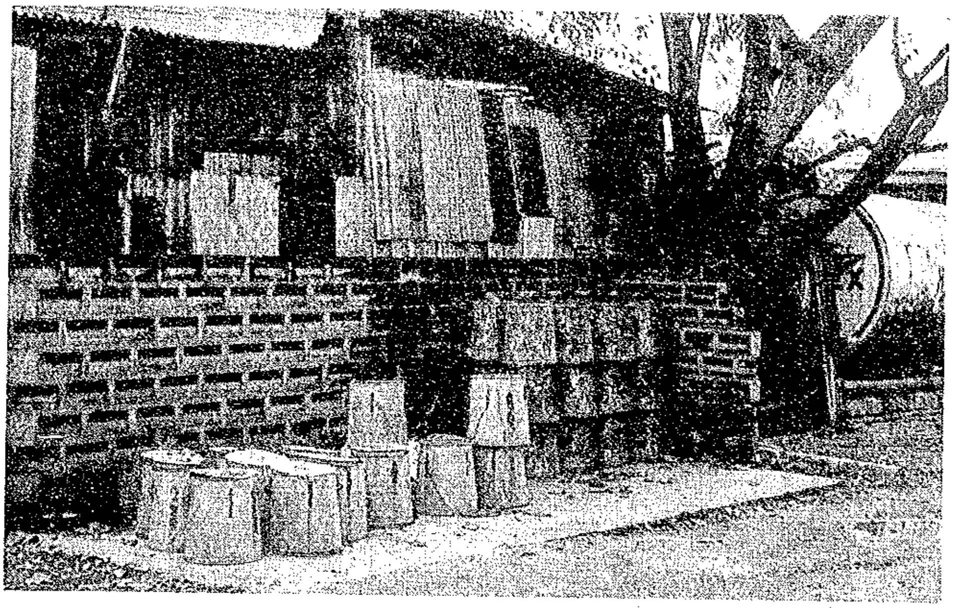
Sludge collection and disposal for communal septic tanks, Imhoff tanks, and private septic tanks are managed by Municipal Council of Province Wellesley (MPSP). All Sludge collected within the Project Area is transported in vacuum lorries (desludgers) to trenching ground for burial. V-trenches of one meter (3 ft) depth are dug and filled with sludge, and when full are covered with earth and levelled. It is located at Bagan Ajan near the airforce base as indicated in Figure II-9.

The night soil disposal spot is at Telok Wang outside and near the north-east corner of the Project Area. Night soil is dumped at the site and no facilities are provided for its disposal. Lorries route and the location of night soil disposal site are shown in Figure II-9.

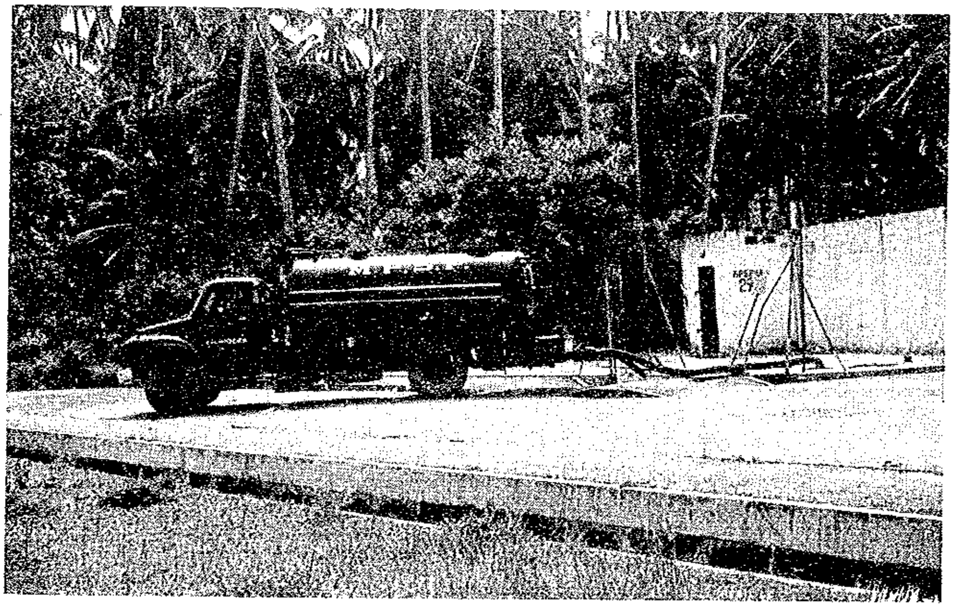


Typical communal septic tank

Typical pit-privy

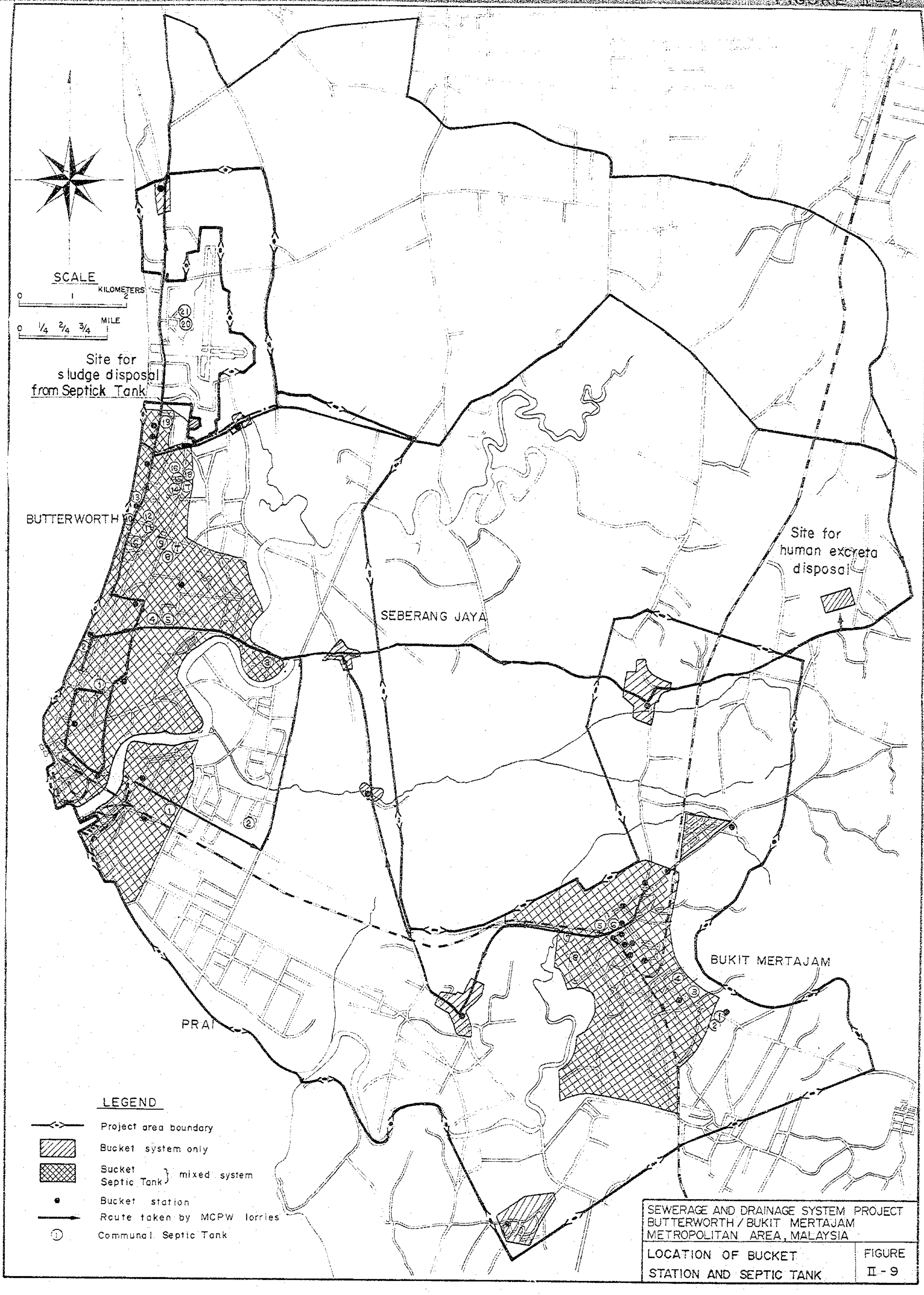


Terminal of night-soil disposal buckets



Vacuum lorry for sludge collection from septic tank

V-trenches for sludge dumping


SCALE
KILOMETERS
0 1 2
MILE
0 1/4 2/4 3/4 1
Site for
sludge disposal
from Septick Tank
BUTTERWORTH
SEBERANG JAYA
Site for
human excreta
disposal
BUKIT MERTAJAM
PRAI
LEGEND
Project area boundary
Bucket system only
Sucket
Septic Tank } mixed system
Bucket station
Route taken by MCPW lorries
Communal Septic Tank
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
LOCATION OF BUCKET
STATION AND SEPTIC TANK
FIGURE
II-9

CHAPTER 7

WASTEWATER PRODUCTION AND DISPOSAL

There is no sanitary sewerage system, except limited small scale communal systems. There are drainage system, made of open ditches which serve as crude combined sewerage system by receiving sullage from residence and area drainage, together with wastewater from septic tanks and industrial wastes. As the major sources of wastewater from the Project Area are from the residential and industrial areas, and many of the factories are in fact either gathered or scattered in the residential areas which discharge their wastes into the receiving water through the drains together with the wastes from the residence, the consideration on the waste production and disposal referred here confined to domestic and industrial wastes.

7.1 Domestic Wastes

7.1.1 Existing Domestic Wastewater Discharge

There are many open road-side-ditches in the existing town areas and new housing areas. The ditches receive sullage water from wash basins, baths and sinks, together with the effluents from septic tanks, and discharge them into the storm drains or natural water ways, flowing out to the sea through rivers or directly.

7.1.2 Sewage Flow & Strength

There are approximately 238,000 persons, of which more than 80% are served by municipal water supply system by PWA in the Project Area. Wells are scarcely used for domestic use.

To estimate sewage flow and strength produced by residents in the Project Area, field surveys were carried out at the typical housing blocks in the Area. The surveys consisted of home visits and actual measurements including volume measurement, sampling and chemical analysis.

Sewage flow and strength are estimated by using the results of the field surveys, reliable records on water consumption of individual houses, and data on municipal water supply obtained from PWA. The results of the study are compared with the information obtained from similar cities, both in Malaysia and other Asian countries.

The estimated unit flow rate and strength of domestic sewage produced in the Project Area are shown in Table II-16.

TABLE II-16 The Present Per Capita Load of Domestic Sewage Produced in the Project Area

Concentration (mg/l)		Volume (l/cap/day)	Per Capita Waste Load (g/cap/day)	
BOD	SS		BOD	SS
185	185	200	37	37

7.1.3 Septic Tank Effluent

Approximately 30% of population in the Project Area are served by communal or private "septic tank" systems for human excreta disposal, which are equiped with septic tank, Imhoff tank, or oxidation pond.

The effluent quality ranges from 15 to more than 250 mg/1 of BOD, and from 5 to 700 mg/1 of SS, and more than 1,000 coliforms/ml of effluents are often discharged into the open drains mentioned above and to the rivers and coastal waters which are contaminated by coliforms as described in Appendix D, Water Pollution Studies.

7.2 Industrial Wastewater

7.2.1 Industries in the Project Area

Penang Development Corporation (PDC) is presently undertaking industrial development in the industrial areas of Mak Mandin Industrial Estate, Prai Industrial Complex[1/], and Seberang Jaya Complex.

In the 3 industrial areas, more than 100 factories have been constructed, and 36 proposed by the year 1976. Food and textile factories predominate in these areas. (See Appendix F, Wastewater Characteristics)

Small scale (home-size) factories scattered in the town areas and new housing areas are metal works, woodworks, motor repair-work-shop, foodmanufactures, all of which are generally considered as industries of less water consumption.

7.2.2. Industrial Wastewater Survey

For the purpose of estimating quantity and quality of industrial wastewater, industrial wastewater surveys were made by Lembaga Pengurus Kerajaan Tempatan Seberang Perai (MPSP), the Ministry of Environment, and by our Team during the year 1976.

1/ This consists of Prai Industrial Estate, Prai Free Trade Zone, and Prai Whalves Free Trade Zone.

At the first survey, questionnaires for information on the volumes of water consumption and discharge were sent by MPSP to 73 factories in Prai Industrial Complex, and 56% of them were returned. Further, effluent samples from 22 factories suspected to be the worst polluters were taken and analysed.

The second survey was carried out by the Ministry of Environment to estimate quantity of pollutants of industrial wastewater for the selected factories in Prai Industrial Complex and Bukit Mertajam. Both of the above surveys were related to the Juru River Pollution Problems.

The third survey, which was related to the Sewerage and Drainage Master Plan in Butterworth/Bukit Mertajam Metropolitan Area, was carried out by our Team. This survey consists of the questionnaires including the questions on (1) water consumption, (2) wastewater loads and disposal, (3) treatment facilities, (4) effluent quality, (5) factory scale and expansion planning, (6) working hours, and (7) main process related to wastewater production, and supplemental wastewater analysis.

The results are summarized and discussed in Appendix F," Wastewater Characteristics."

7.2.3 Industrial Wastewater Quantity and Characteristics

The wastewater discharged by factories in the Project Area widely varies in quantity and characteristics according to the types of industries and by factory-scale. The detailed studies on industrial wastewater are described in Appendix F, referred above.

Table II-17 summarises per unit water consumptions of present major industries and average BOD and SS concentrations of their wastewater, and Table II-18 shows unit wastewater production on average of whole industries on the basis of available data.

TABLE II-17 Average Water Consumption and Wastewater Quality of Major Industries in the Project Area

		Food	Textile	Chemical	Others
Water Consumption (cu m/ha/day)		120.6	165.7	104.6	20.8
Concentration (mg/l)	BOD	200	122	73	67
	SS	399	58	106	127

TABLE II-18 Industrial Waste Load

Concentration (mg/l)		Volume (cu m/ha/day)	Per Hectare Waste Load (kg/ha/day)	
BOD	SS		BOD	SS
122	125	90.9	11	11

7.2.4 Industrial Wastewater Treatment

The industries producing hazardous quality wastewater are food (high BOD), textile (high BOD and colour), chemical (harmful chemicals), and others (plating and battery : heavy metals). On visits to existing larger scale factories, it is observed that some of them have their own treatment facilities, or have sufficient space for construction of such facilities. At present, the regulation for industrial wastewater control is being considered by the Government including standard of treatment facilities for acceptable effluents to the receiving water bodies.

The small scale (home-size) factories scattered in the residential areas are increasing in number, but volume of their wastewater is comparatively small so that it would be able to be taken care of by the proposed sewerage treatment facilities.

CHAPTER 8

DRAINAGE SYSTEM

8.1 Existing Drainage System

The Project Area is flat and low-lying, in a tributary of the Prai and Juru river, with the area of 11,600 ha of the entire Project Area. Prai river flows through northern part of the area from east to west and functions as an outlet of Butterworth and Seberang Jaya areas. Ground elevations of the tributary area range from 0.1 meters (0.33 ft) to 3.8 meters (12.5 ft). It is very flat "tidal river", which is influenced by the ocean tides to the point of about 20 km (12 mile) from the river mouth.

The Juru river has similar characteristic of the Prai river, i.e., the flat "tidal river". The river flows through the southern part of the Project Area from east and west with meandering course, and serves as an outlet of Bukit Mertajam district.

The tributary area consists of steep portion with the ground elevation of RL +5.0 - +230 meters (+16.4 - +750 ft) and flat portion with elevation of RL 0.0 - +2.9 meters (0 - +9.5 ft).

On the other hand, the sea water level by which river water levels are influenced directly is RL +1.68 meters (+5.5 ft) as the highest record and RL +1.10 meters (+3.6 ft) as the average high water level of the spring tide.

In consequence of low-lying and flat situations mentioned above, considerable parts of the Project Area are swampy areas and major parts of the area are subjected to back up of the sea water, which makes it usual for the existing outlet drains to be provided with tidal gates. Reclamation of lands and/or pumping up of storm water runoff becomes necessary in the case of development in low-lying areas. This is seen in the Prai industrial and Seberang Jaya development areas which have been developed on reclaimed land and provided by the drainage system comprising pumping stations and open channels with low velocity resulting from flatness of tributary areas.

The existing drainage facilities consist of open, lined and unlined, channels discharging into rivers, major drains and the ocean. They are basically natural watercourses with piecemeal improvement in developed areas. Main drains are heavily silted and overloaded. On the part of flat areas, these drains disperse into ponding areas which are drained out to rivers and the sea. Road side drains are of "U" or "V" shape with semicircular invert, and are maintained well. Details of the individual systems are given in Sections 2.1 and 2.2, Part IV, "Drainage Master Plan" of this report. In general, it is considered that the existing storm drainage systems would be sufficient to cope with the present drainage requirements in case of certain improvement such as desilting and better maintenance are carried out, except in the areas where repetitious floodings are experienced, for which immediate remedial programme has to be considered.

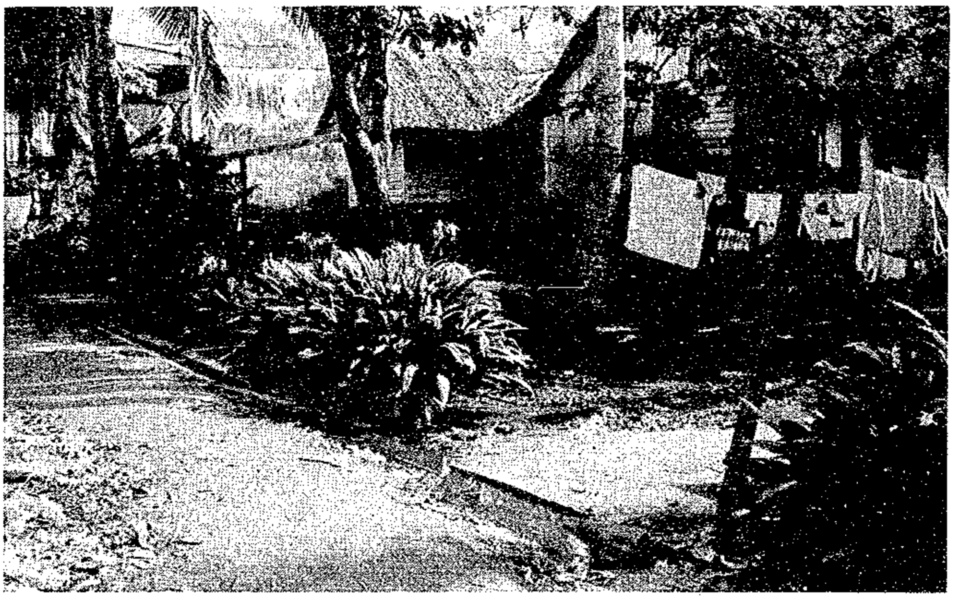
8.2 Flooding in the Project Area

As shown in Figure II-10, flood experienced areas are spreading along the Butterworth and the Juru river. Flooding in Butterworth is due to back up of existing major drains, deriving from inadequate capacity of heavily silted cross sections and high water levels at the outlets.

Areas liable to flooding in the tributary areas of the Juru river consist primarily of undeveloped swamps or palm and rubber plantation fields, and only the southern fringe of Bukit Mertajam town is inhabited sparsely. However, since this area will be zone for housing development in the foreseeable future, improvement of drainage system will be needed.

It is expected that majority of the flooding damages at the present stage can be relieved with desilting and improvement of culverts crossing roads.

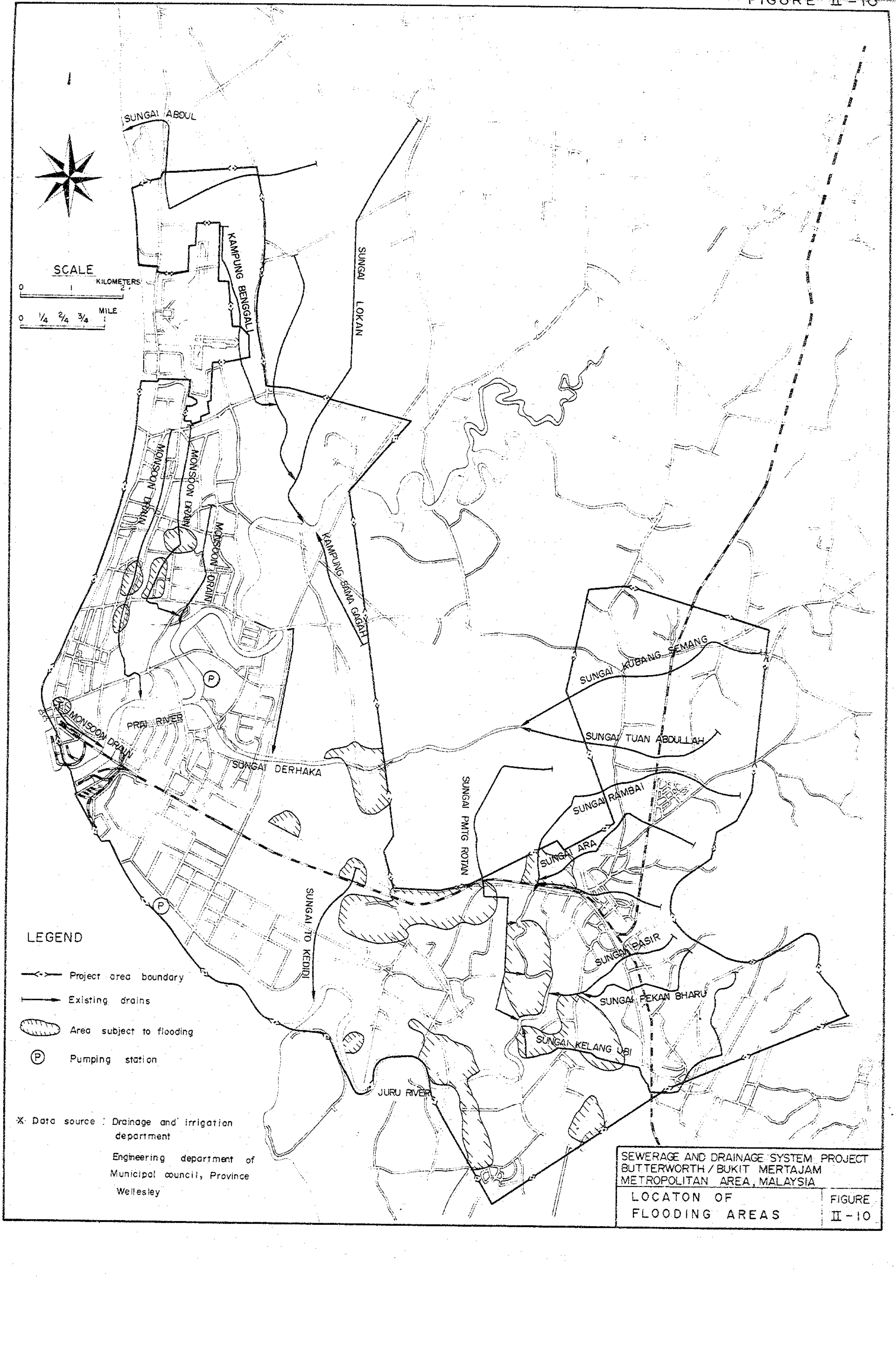
Inundation in Butterworth town area



Inundation in Butterworth kampong area

Flooding in Butterworth area

Flooding in Butterworth area


SUNGAI ABOUL
SCALE
KILOMETERS
0 1 2
MILE
0 1/4 2/4 3/4
KAMPUNG BENGGAL
SUNGAI LOKAN
MONSOON DRAIN
MONSOON DRAIN
MONSOON DRAIN
MONSOON DRAIN
KAMPUNG SAMA GAGAH
PRAI RIVER
SUNGAI DERHAKA
SUNGAI KUBANG SEMANG
SUNGAI TUAN ABDULLAH
SUNGAI PMTG ROTAN
SUNGAI RAMBAI
SUNGAI ARA
SUNGAI TO KEDIDI
SUNGAI PASIR
SUNGAI PEKAN BHARU
SUNGAI KELANG UBI
JURU RIVER
LEGEND
Project area boundary
Existing drains
Area subject to flooding
Pumping station
※ Data source : Drainage and irrigation department
Engineering department of Municipal council, Province Wellesley
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
LOCATON OF FLOODING AREAS
FIGURE II-10

CHAPTER 9

EFFECTS OF PRESENT WASTE DISPOSAL SYSTEM

9.1 Environmental Effects

9.1.1 Living Environment

The wastewater produced within the Project Area, including domestic sewage, industrial wastewater, and commercial wastewater, are mostly discharged to the existing drains and other available waterways directly, while night-soil is mostly discharged to open-ditches through septic tanks or disposed of by means of bucket system. These are producing septicity in the waterways and causing water pollution in the rivers and drains of the area.

Because the ground surface slope in the area (especially in Butterworth area) is generally flat and flow velocities in the existing drains are low, wastewater tend to stagnate and decompose, causing odours and visible nuisance as well as hazards to public health. One of the major causes of water pollution is the uncontrolled wastewater disposal to the waterways.

9.1.2 Water Pollution

Project Area has two major rivers with many branches within their tributaries collecting the runoff and discharging it to the sea. These rivers are utilized for irrigation and navigation. These rivers are the recipients of much of the sanitary wastes from the population and industrial wastes as well as other pollution contained in surface runoff.

These rivers and drain systems comprise a complicated network of water courses, with the gates which have been operated for controlling water level against tidal influence. Both of main rivers, the Prai and Juru, are tidal rivers, in which flow and water-surface elevation are affected by the tides, and the tidal area of the Prai river extends beyond the boundary of the Project Area from the mouth of the rivers.

At present, most of domestic wastewater and industrial wastes are discharged directly to drains and other available waterways discharging to the river systems. The pollutant loads discharged to the waterways are transported eventually to the sea, but all the pollutants do not necessarily reach the sea. Some portion of them either settle on the bottom of water courses or decompose biologically on their way to the sea. The flow velocity of these waterways excluding two main rivers is generally around 0.5 m/sec or less, which intensifies stagnation and biological decomposition. The effects of pollution are most pronounced in the town areas and industrial areas.

As described in Appendix D, Water Pollution Studies, the pollution in Project Area conducted by the Survey Team confirm that the rivers in urban areas are generally polluted mostly by the direct discharge of wastewater. Water qualities at the river mouth of two rivers, the Prai and Juru, range between 3.6 mg/l and 6.9 mg/l, in terms of DO concentrations.

Since all of the main intakes for water supply for the Penang State are located outside of the Project Area, pollution in the Project Area as described does not affect the intake water.

Penang State including Province Wellesly includes some of the most important recreational resorts in Malaysia, and therefore to keep public environment clean has significant meaning in addition to the improvement of living environment of the residents.

PART III

SEWERAGE MASTER PLAN

PART III

SEWERAGE MASTER PLAN

Table of Contents

CHAPTER 1

PREVIOUS STUDIES

Reports and studies relevant to this Project are availabe on several aspects of Butterworth/Bukit Mertajam Metropolitan Area and its surroundings. The important recent reports and studies are discussed herewith.

1.1 Penang Master Plan

This Master Plan was prepared for the Penang Master Plan Committee by Robert Nathan Associates Inc. in March, 1970. The purpose of this study was to establish a long-term programme for urban development of the Penang State. Emphasis was on resource base study, socio-economic programme, and physical planning, and programme was outlined extending over the period of 1971 to 1985.

Since data used for analysis were those available in the year 1969, Population and Housing Census of Malaysia, 1970, was not used in this Master Plan. Some over-estimation of State population is therefore found on the basis of actual development of land use and population growth in recent years.

In the plan, three basic strategies are established for acceleration of economic growth. They are development of manufacturing, tourism, and fisheries. Agricultural development is considered not contributable to stimulate employment opportunities. Among the three basic strategies, manufacturing is expected to develop greatest portion of employment opportunities.

The physical plan for development of industrial estates are also established in the outline of this Plan. Most of the planned industrial estates are in the Butterworth and Bukit Mertajam Metropolitan Area. One of the purposes of physical planning is to establish a comprehensive framework to facilitate detailed planning for the different (physical) sectors of the overall plan.

Sewerage schemes for Butterworth and Bukit Mertajam areas, as one of the short-term physical plans, are included in the consideration of the Plan.

1.2 Water Supply Project

The report was prepared for the Penang State Government by Binnie & Partners, Ltd., Malaysia, in 1967 to present a long range projection for the water supply system of Penang State up to the year 2000. The main features of the plan are summarized below:

(a) The population to be served by water supply system will be between 944,600 (upper growth limit) and 683,900 (lower growth limit) in the year 2000.

(b) The estimated average water requirement in 2000 is 277,000 cu m/day.

(c) In terms of per capita water consumption, 230 l/day (50 Imp. gal/day) for direct consumers is assumed for the year 2000.

(d) Average industrial water use is estimated at 126,000 cu m/day for the year 2000.

These data are usefully considered for estimating the future waste-water production in the present Master Plan studies.

1.3 WHO Assignment Report, 1973

The report is based on the Penang Master Plan referred above, and includes brief recommendation of future sewerage system at Butterworth and Bukit Mertajam Metropolitan Area.

It recommends that each sewerage area to be established be dealt with independently and that the main sewer be laid with minimum gradient to a sewage pond. It also points out that due to the high tide level and consequently high ground water level, the sewage has to be pumped up to the ponds by means of a lift station with assumption of a minimum flow of 536,000 cu m per day (118 MIGD) at the Prai River, the main recipient of the effluent from the sewage ponds, after the construction of the Prai barrage.

Due to the poor ground condition, it recommends, rubber ring jointed reinforced concrete pipes and/or asbestos cement pipes of high quality be used, and as for the treatment facilities oxidation pond/s for each area without preceding settlement is proposed as a reasonably satisfactory treatment method.

1.4 Others

Listed below are the references of the main studies which were also used in this report.

(1) Third Malaysia Plan, by Government of Malaysia
(2) Kuala Lumpur Sewerage Master Plan, by D. Balfour & Sons of U.K.
(3) Ipoh Sewerage Feasibility Study, by Ennex of New Zealand

CHAPTER 2

PHYSICAL PLANNING AND LAND USE

2.1 Background Information

Town and Country Planning Department (TCP) of the Penang State formulated a 15 year plan which aimed to develop the State in accordance with the socio-economic and physical needs of the population. The plan called for the improvement of the general physical condition of the Penang State, including its proper land use.

The land use plan for Butterworth/Bukit Mertajam area prepared by TCP divided the whole metropolitan area into 4 different zones, taking into consideration of the type of future development of the area. Since the plan was prepared, conditions of the area have changed substantially, and also as the case of the sewerage master plan is for the year 2000, it is necessary to adjust the land use pattern accordingly in order to indicate the appropriate future status of the Project Area.

The current state of land use includes the industrial estates of Prai and Seberang Jaya, and Mak Mandin is now under development by Penang Development Cooperation (PDC). New housing areas and social and administrative areas such as sites for courthouse and hospital complexes at Seberang Jaya are also under consideration by PDC.

In addition to Seberang Jaya, new housing schemes have recently been actively considered by private developers in the Project Area. These schemes are planned on the condition by approval of MPSP. Some of them are already approved and others are under consideration.

2.2 Land Use Adopted for Sewerage Master Plan

On the basis of the foregoing, future land use by the year 2000 for the sewerage master plan is considered in the following manner:

(a) Identify the nonhabitable areas such as major rivers (Prai and Juru), cemeteries, swamps and hills of which ground elevations are more than 60 m (200 ft) above mean sea level, in which any development will not be possible.

(b) Identify the industrial areas, i.e. Prai, Seberang Jaya, and Mak Mandin, according to PDC's plan. No other industrial development is considered before the year 2000.

(c) Identify the residential, social and commercial areas in Seberang Jaya according to the development plan of PDC.

(d) Identify the residential areas according to the new housing schemes by the private developers submitted for approval of MCPW.

(e) Remainder of the above mentioned areas are considered to be residential areas.

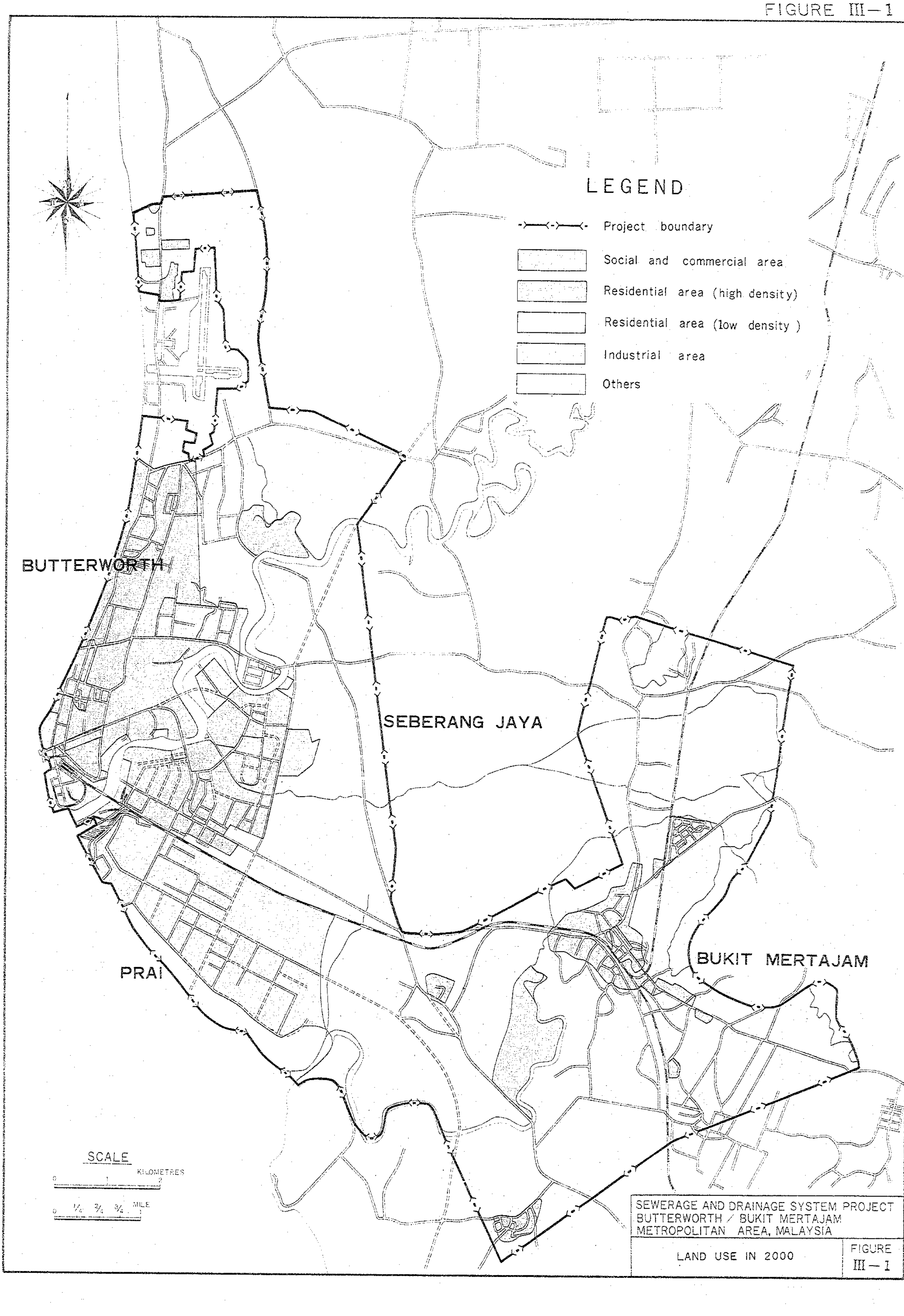
According to the plan envisaged by the government, whole Project Area should be essentially urbanized by the target year. Therefore, no rural and agricultural areas should remain. Entire Project Area is currently classified into 6 categories, i.e. industrial, social and commercial, residential, rural, agricultural and others (nonhabitable), which should be developed into 4 categories in the target year of 2000 by eliminating rural and agricultural areas due to urbanization with reduced coverage of decreased swamp area owing to the land development.

Taking the above conditions into account, the future land use in the Project Area in the year 2000 is estimated as shown in Table III-1 and Figure III-1.

TABLE III-1 Land Use in the year 2000

		(ha)
a)	industrial	1,289
b)	social and commercial	168
c)	residential	9,397
d)	others	746
	Total	11,600

As regards the residential area, it is considered appropriate for planning purpose to further delineate areas into high density of built-up urban area of averagely 160 persons/ha, average new housing area of 120 persons/ha and low density area of 52 persons/ha.


LEGEND
Project boundary
Social and commercial area
Residential area (high density)
Residential area (low density)
Industrial area
Others
BUTTERWORTH
SEBERANG JAYA
BUKIT MERTAJAM
PRAI
SCALE
KILOMETRES
0 1 2
0 ¼ ½ ¾ MILE
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
LAND USE IN 2000
FIGURE
III－1

2.3 Sewerage Districts and Zones

Initially, two alternative sewerage systems, the one for whole Project Area covered by one comprehensive sewerage system and another for more than one sewerage systems in the Project Area, are considered. Desirability of either one of the system depends upon the characteristics of the Area with due consideration on economical impact.

The physical characteristics of the Project Area are (1) populated urban areas are limited, (2) huge rural areas still remain at present to be developed in the future, and (3) mostly flat ground surface.

If comprehensive sewerage system is planned in a huge flat ground surface as described above, big sized deep main sewers are required to convey sewage from individual house all the way to the treatment plant, causing high initial investment in addition to the difficulties in implementing construction programme particularly in the built-up areas. Consequently, immediate implementation of the sewage system construction will be delayed with added difficulties in obtaining sufficient funds for small sewers such as laterals, and branches.

Under the circumstance, it is considered practical, as WHO Assignment Report recommends, that the Project Area be properly divided into districts and zones to be dealt with separately, rather than planning area-wide system to cover whole Project Area. The advantages considered would be:

(a) It is possible to design sewer facilities according to the characteristics of each of such districts and zones.

(b) Implementation of construction plan will be flexible to adjust according to the degree of requirement and availability of financial resources.

(c) Long conveyance can be avoided, which will avoid inconvenience in construction and enable earier maintenance and better control of sulfide build-up.

(d) Rural areas, in which urbanization plan is yet to be developed, will remain flexible for future implementation.

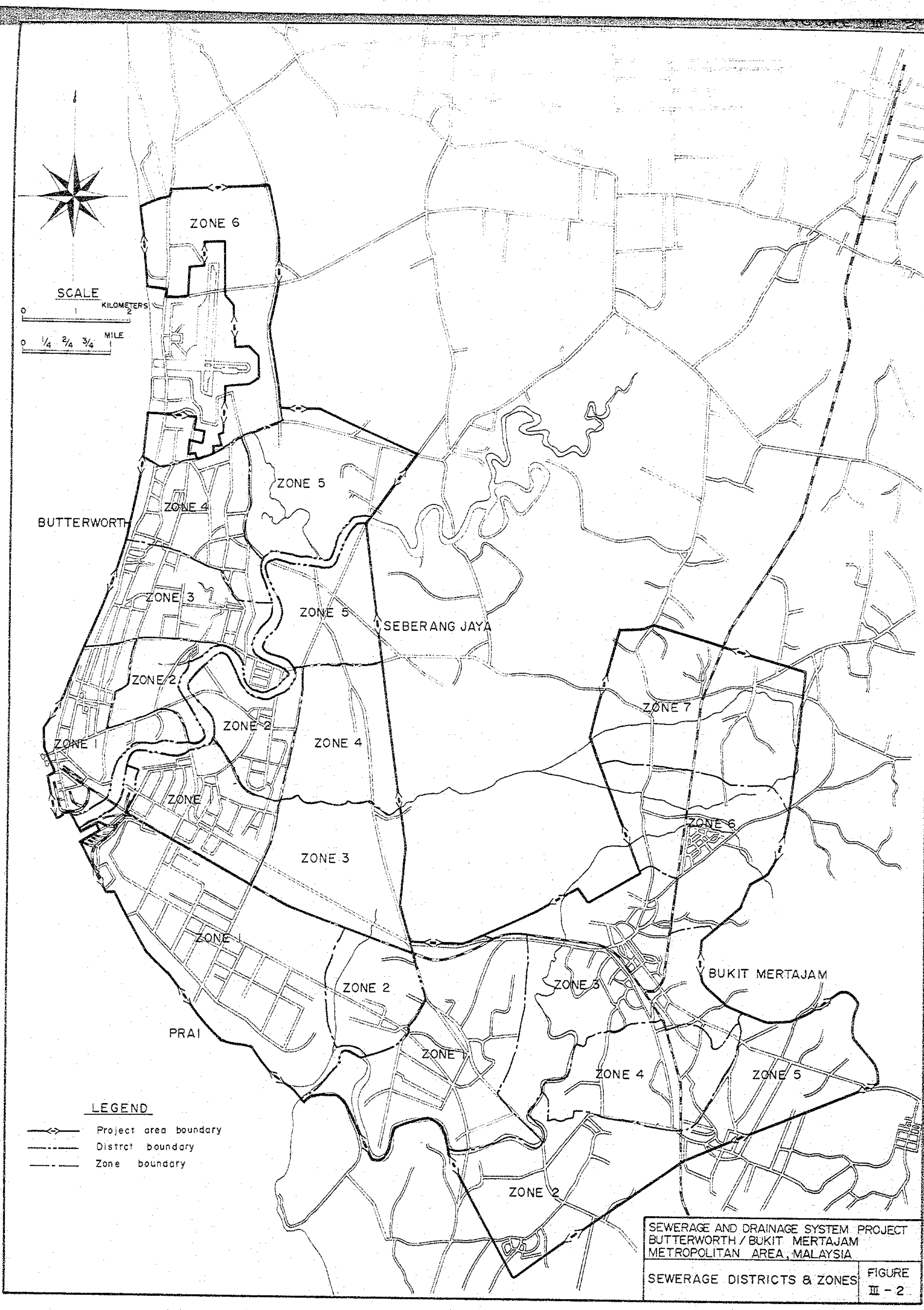
The Project Area has, as indicated earlier, total of 11,600 ha altogether, but, excluding watercourses, swamps and other non-habitable areas, total area for sewerage planning purpose is 10,854 ha. For the convenience of planning, an attempt is made to divide the total area into 4 districts, namely, Butterworth, Seberang Jaya, Prai and Bukit Mertajam in accordance with the geographical conditions. They are further divided for implementation purpose into zones with due consideration of the followings.

(i) Population density by area
(ii) Existence of rivers, railways, and roads
(iii) Land use situation
(iv) Administrative boundaries (Mukim)
(v) Condition of built-up area
(vi) Topography

Several alternative deliniations are considered, but with due note of the advantages for smaller deliniation as stated earlier, the following is considered to serve the purpose.

	Name of District	Name of Zone	Area (ha)	Covered by Sewerage (ha)
1.	Butterworth	Zone - 1	390	367
2.	"	" - 2	200	182
3.	"	" - 3	490	457
4.	"	" - 4	450	444
5.	"	" - 5	570	551
6.	"	" - 6	670	670
7.	Seberang Jaya	Zone - 1	480	438
8.	"	" - 2	360	305
9.	"	" - 3	510	510
10.	"	" - 4	430	430
11.	"	" - 5	420	368
12.	Prai	Zone - 1	1,230	1,063
13.	"	" - 2	280	268
14.	Bukit Mertajam	Zone - 1	940	892
15.	"	" - 2	730	715
16.	"	" - 3	980	927
17.	"	" - 4	470	467
18.	"	" - 5	490	459
19.	"	" - 6	660	573
20.	"	" - 7	850	768
	Total		11,600	10,854

NOTE: The area covered by sewerage of 10,854 ha (26,820 acres) is derived from excluding nonhabitable areas such as mountains, rivers, swamps and cemeteries from the entire Project Area of 11,600 ha (28,660 acres).



SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA

SEWERAGE DISTRICTS & ZONES — FIGURE III - 2

CHAPTER 3

POPULATION PROJECTIONS

3.1 Introduction

Population estimates for the Project Area in 1970 & 1976 is already described earlier in PART II Background, Chapter 4 Population & Land Use. On the basis of the National Census in 27 mukims, which are partially or totally included in the Project area, 1970 population for Project Area is estimated to be 172,230, based on which 1976 population for the Area is estimated to be 238,000 by using the annual growth rate of 5.5%, as used in Penang Master Plan, as the most reliable data for the population growth up to the present. They are used as a reasonable basis to determine future water requirements and sewage quantities. These projections are discussed in Appendix B. "Population & Land Use Distribution."

3.2 Population of the Project Area

On the basis of the estimates for the years 1970 & 1976 for the Project Area as stated earlier, population of the Project Area up to the year 2000 are estimated as shown in Table III-2. Population estimate for 1985 is the value projected in the Penang Master Plan. Annual growth rate from 1970 to 1985 is assumed at uniform annual rate of 5.5% in BBMA (the Project Area), while that of Penang State is 2.2%. Population in 1995 is from the Assignment Report by WHO, which is considered appropriate and on the basis of which the annual growth rate from 1985 to 1995 is assumed at uniform rate of 3.5%. Up to the year 2000, the same average growth rate of 3.5% is adopted. (Ref. Appendix B. Population & Land Use Distribution).

TABLE III-2 Future Population of the Project Area

Year	Population	Average Annual Growth Rate
1970	172,230	
		5.5%
1976	238,000	
		5.5%
1980	294,400	
		5.5%
1985	385,000	
		3.5%
1990	458,000	
		3.5%
1995	545,000	
		3.5%
2000	648,000	

3.3 Population Distribution by District

The Project Area is proposed to be divided into 4 sewerage districts, each having a different trend in population growth rate, according to its land use characteristics. Since data on future population growth by districts and zones is not available, the future population by districts is assumed on the basis of future land use pattern and estimated population density.

The basis in estimating future population densities by land use categories are as follows:

(a) Social and commercial area (Public building) .... 0, 120, or 160 persons/ha
(b) " (Commercial) .... 120 persons/ha
(c) Residential area (Built-up urban area). .... 160 "
(d) " (New housing) .... 120 "
(e) " (Others) .... 52 "
(f) Industrial area .... 0 "
(g) Others (Non-habitable area) .... 0 "

On the basis of above conditions, the population of each sewerage district and zone according to the land use pattern for the year 1976 is estimated and then the year 2000 is projected, which are shown in Tables III-3 & III-4. (Ref. Appendix B. Population and Land Use Distribution). The population in 1985, 1990, and 1995 are then estimated in the similar manner, which are shown in Table III-5.

TABLE III-5 Population Distribution by Sewerage District

District	Year				
	1976	1985	1990	1995	2000
Butterworth	108,900	146,200	164,700	186,800	212,900
Seberang Jaya	28,600	68,000	87,500	110,800	138,400
Prai	3,900	7,500	9,300	11,400	13,900
Bukit Mertajam	96,600	163,300	196,500	236,000	282,800
Total	238,000	385,000	458,000	545,000	648,000

TABLE III-3 Land Use and Population of Zone in 1976

District	Zone No.	Area (ha) Total	Area (ha) Social Commer-cial	Area (ha) Residen-tial	Area (ha) Indust-rial	Area (ha) Rural	Area (ha) Agri-cul-trual	Area (ha) Others	Population Density (persons/ha) Total	Population Density Social Commer-cial	Population Density Residen-tial (high)	Population Density Residen-tial (low)	Population Total	Population Social Commer-tial	Population Residen-tial	Population Rural
Butterworth	1	390	16* 47	190	67*			70*	97.2	0 160	160		37,900	0 7,500	30,400	
	2	200		33				167*	17.9		108.6		3,600		3,600	
	3	490	2	176	107*	119		86*	57.7	120	120	57.9	28,200	200	21,100	900
	4	450		21		411		18*	58.5		120	57.9	26,300		2,500	23,800
	5	570				231	75*	264*	6.9			17.1	4,000			4,000
	6	670		18		316	336*		13.3		120	21.3	8,900		2,200	6,700
Sub-Total		2,770	16* 49	438	174*	1,077	411*	605*					108,900	7,700	59,800	41,400
Seberang Jaya	1	480		157	2*	48	159*	114*	28.5		80	22.9	13,600		12,500	1,100
	2	360			29*	3	229*	99*	0.2			23.0	100			100
	3	510				155	300*	55*	5.9			19.3	3,000			3,000
	4	430				143	264*	23*	17.5			52.6	7,500			7,500
	5	420				138	115*	167*	10.4			31.7	4,400			4,400
Sub-Total		2,200	-	157	31*	487	1,067*	458*					28,600	-	12,500	16,100
Prai	1	1,230			639*	94	93*	404*	1.5			19.8	1,900			1,900
	2	280				106	138*	36*	7.1			18.6	2,000			2,000
Sub-Total		1,510	-	-	639*	200	231*	440*					3,900			3,900
Bukit Mertajam	1	940		16		299	450*	175*	8.0		80	21.0	7,600		1,300	6,300
	2	730		38		144	509*	39*	8.7		80	23.2	6,400		3,000	3,400
	3	980	20	209		376	87*	288*	46.5	120	119.2	48.5	45,500	2,400	24,900	18,200
	4	470		9		193	248*	20*	12.9		80	27.8	6,100		700	5,400
	5	490				235	224*	31*	14.8			30.9	7,300			7,300
	6	660		46		208	319*	87*	21.0		120	40.0	13,800		5,500	8,300
	7	850				265	503*	82*	11.7			37.5	9,900			9,900
Sub-Total		5,120	20	318	-	1,720	2,340*	722*					96,600	2,400	35,400	58,800
Total		11,600	16* 69	913	844*	3,484	4,049*	2,225*		0 147.2	118.1	34.4	238,000	10,100	107,700	120,200

Note: * is not inhabited area, e.g. government office zone, water courses, cemeteries, mountainous areas, parks, industrial areas, agricultural areas.

TABLE III-4 Land Use and Population of Zone in 2000

District	Zone No.	Area (ha) Total	Area Social Commercial	Area Residential (high)	Area Residential (low)	Area Industrial	Area Others	Population Density (Persons/ha) Total	Density Social Commercial	Density Residential (high)	Density Residential (low)	Population Total	Population Social Commercial	Population Residential (high)	Population Residential (low)
Butterworth	1	390	16* 47	237		67*	23*	116.5	0 160	160		45,400	0 7,500	37,900	
	2	200		182			18*	109.2		120		21,800		21,800	
	3	490	2	275	73	107*	33*	75.6	120	120	52.0	37,100	300	33,000	3,800
	4	450		212	232		6*	83.4		120	52.0	37,600		25,500	12,100
	5	570		74	477		19*	59.1		120	52.0	33,700		8,900	24,800
	6	670		36	634			55.7		120	52.0	37,300		4,300	33,000
Sub-Total		2,770	16* 49	1,016	1,416	174*	99*					212,900	7,800	131,400	73,700
Seberang Jaya	1	480		354	82	2*	42*	97.4		120	52.0	46,700		42,500	4,200
	2	360	18* 35	154	48	50*	55*	69.9	0 120	120	52.0	25,200	4,200	18,500	2,500
	3	510			510			52.0			52.0	26,500			26,500
	4	430	30*		400			0 48.4			52.0	20,800			20,800
	5	420			368		52*	45.6			52.0	19,200			19,200
Sub-Total		2,200	48* 35	508	1,408	52*	149*					138,400	4,200	61,000	73,200
Prai	1	1,230				1,063*	167*	0							
	2	280			268		12*	49.8			52.0	13,900			13,900
Sub-Total		1,510	-	-	268	1,063*	179*					13,900	-	-	13,900
Bukit Mertajam	1	940		16	876		48*	50.5		120	52.0	47,500		1,900	45,600
	2	730		38	677		15*	54.5		120	52.0	39,800		4,600	35,200
	3	980	20	355	552		53*	75.2	120	120	52.0	73,700	2,400	42,600	28,700
	4	470		9	458		3*	53.0		120	52.0	24,900		1,100	23,800
	5	490			459		31*	48.8			52.0	23,900			23,900
	6	660		46	527		87*	49.9		120	52.0	33,000		5,500	27,500
	7	850			768		82*	47.0			52.0	40,000			40,000
Sub-Total		5,120	20	464	4,317	-	319*					282,800	2,400	55,700	224,700
Total		11,600	64* 104	1,988	7,409	1,289*	746*					648,000	14,400	248,000	385,600

Note: * is not inhabited area, e.g. government office zones, water courses, cemeteries, mountainous areas, industrial

CHAPTER 4

BASIC ENGINEERING CONSIDERATION

4.1 Introduction

Every wastewater control system, from the crude cesspool to the most sophisticated wastewater collection and treatment system, has one or both of two purposes; first to remove the waste materials from the place of origin to the place of disposal, and second, to achieve the disposal, usually into a waterway, without undesirable effects on the receiving water values. This needs to be done as economically and as rapidly as possible to cope with the increase of the waste load of a growing community. Technical soundness and financial feasibility should be kept in mind for realistic and bankable plan for the project, and economical approach should particularly be stressed to minimize financial burden of the authorities concerned in the way of initial investment, operational cost and recoveries thereof.

Taking these factors into account, possible feasible alternatives for the sewerage system for the Project Area have been considered and analyzed from both the technical and economical view points. Analysis made are described briefly in the following sections.

The basic approach for the master planing is (1) to establish overall sanitary system required by delineating sewerage districts and zones needed to serve the Project Area, (2) to develop a plan for orderly implementation of provision of a separate system sanitary sewers, with priority attention to areas having the most critical sanitation conditions, with due consideration of the existing local storm drains for use with proper improvement programme wherever advantageous, and (3) to develop a plan for facilities for treatment and disposal in each zones which will provide adequate protection to the waterways in the Project Area, including the coastal marine water of Penang Channel with emphasis on protection of the recreational beach areas.

4.2 Sewerage System

To determine the most suitable sewerage system for the Project Area various relevant factors are taken into consideration of the following:

(a) Basic consideration for the sewerage system in the Project Area is the existence of natural watercourses and the established flood control system constructed by DID. Hence, there is little point in building another system of closed conduits to take care of storm water runoff together with wastewater, as the existing river and drainage system serving for flood control will serve adequately for handling storm water runoff, if they are properly improved. This situation excludes the concept of combined sewer facilities for the Project Area.

(b) A survey of the existing conditions of water pollution in the Area shows that the rivers and drains are mainly polluted by sanitary wastes, especially during the dry season when the rivers and drains are in fact serving essentially as the main sewers of the Area, and that only the establishment of a separate sewerage system to keep sanitary wastes out of the rivers and drains will be sufficient to change the present gross pollution situation and set the basis for progressive clean-up of the Area.

(c) Because combined sewers are normally deeper than storm channels, excavation costs will be greater. Furthermore, pumping up from greater depths would be needed, which requires increasing pumping station and power costs usually exceeding those for separate storm and sanitary sewer systems added together.

(d) Because traffic conditions in the Project Area are often critical, excessive distruption of traffic and other normal social activities during construction of deep and large sewers for the combined system will generally be greater than the separate sewer system.

(e) It is recognized that sanitary collecting sewers can hardly be provided for all of the Area, simultaneously at the same time. For practical purpose, the plan has to be developed on priority basis for implementation in accordance with the degree of urgency. Thus, the areas currently served by septic tanks reasonably well even to the foreseeable future may safely be deferred their construction, and even in case of areas to be provided with sanitary sewers, advantage may be taken of the existing local storm drainage systems in kampong areas, to serve temporarily for transporting dry weather sullage flows to the main sanitary sewers. Similarly, in the areas where currently house sewers discharge the wastes into the existing local storm drains which in turn flow to the rivers and drains, these drains can in some cases serve to convey the dry weather sullage waste flows to the sanitary sewers by providing overflow structures to prevent overtaxing of the sanitary sewers and treatment facilities during the time of storm weather.

4.3 Treatment and Disposal System

As discussed in Appendix D, "Water Pollution Studies", water in the drains and rivers in the urbanized areas have already become polluted by domestic and industrial wastes. If no steps are taken to alleviate waste loads discharged to drains and rivers, these areas are expected to be further contaminated and degraded in the immediate future.

It is therefore necessary to consider the extent and method of treatment within a sanitary sewerage programme and location of the collected and suitably treated waste water to be disposed of.

4.3.1 Need of treatment

Taking into account of the locality for final disposal, treatment-level/disposal method should be considered to safeguard the beneficial values of the receiving area.

Generally, there are three alternatives to be considered for final disposal, as described in the following.

(1) Nontreatment - Discharge into a river or shallow waters near the beach

Along the Butterworth beach, there are many sewer outfalls including domestic wastewater and septic tank effluents. As mentioned in Appendix D, "Water Pollution Studies", the areas near sewer outfall points are polluted by coliforms. This also is recognized by the result of the pollution control studies by the Ministry of Health.[1/]

1/ "Pollution Control Study of the Batu Fringgi/Telok Behang Coastal Areas", Ministry of Health (1972).

The water from the rivers of the Prai and the Juru are also polluted by coliforms. This may be due to faecal pollution of human wastes after discharging the effluents of septic tanks which may sometimes be mal-functioning for elimination of coliform bacteria.

Although coliform contamination is found in riverwater and coastal water, the organic contamination is not highly significant in coastal and river pollution at the present stage. This seems to indicate that direct discharge of domestic wastewater except human excreta into a river or coastal water is not sufficiently destructive for the water quality conservation under the present conditions, due mainly to the unconcentrated discharge of human excreta to the waterways. If significant volume of wastewater were concentrated to a limited receiving water such as the Juru river in the future, direct discharge would undoubtedly bring about noticeable environmental disruption.

(2) Nontreatment - Ocean outfall

Non treatment - Ocean outfall system is very economical if the following problems can be solved;

(a) in case suitable outfall points are available.
(b) in case safeguard measures for beneficial use of the receiving water can be established,
(c) in case construction and maintenance of long piping systems for sewage collection are feasible.

(a) Outfall points

For outfall points, the open ocean with strong oceanic currents is the best to protect from environmental pollution. If ocean outfall is accepted for this sewerage system, the Penang Channel should be the receiving area from the economical view point because the Project Area is facing the Channel.

The Penang Channel is narrow with minimum width of about 2km (3.2 miles) with strong tidal current roughly estimated at 26 to 100 cm/sec (0.85 to 3.28 ft/sec) in daily maximum. Therefore capacity of flushing out effects by the tidal currents will be sufficient to receive the organic pollutions (BOD or PV) from the Project Area.

(b) Safeguard measures

The port of Penang is one of the important ports in Malaysia, and the port area extends over the whole Penang Channel. The area in front of the Project Area is the most important for anchoring of vessels, for which submarine facilities should be avoided for safety of navigation and for safeguard of facilities themselves.

Water pollution control is also necessary because the beaches along or neighbouring the Channel are used for bathing or other water contact sports. The outfall should therefore be long enough to avoid carry back of the sewage pollutants (floating matters and coliforms). However construction of long outfall sewers will be difficult because of narrowness of the Channel and high velocity of the tidal current.

According to the experience on George Town sewage disposal, it should be concluded that coliform contamination could not be avoided by nontreatment-ocean outfall.

(c) Long piping system

It is necessary to construct and maintain long piping system connecting individual sewage producers and outfall points. As the Project Area is flat except portion of Bukit Mertajam district, the long piping system would require deep piping or many pumping stations to keep minimum velocity for preventing sedimentation and sulfide built-up. It is natural that long piping system would require high primary investment for construction and also greater maintenance cost in the succeeding years.

(3) Secondary Treatment - Short outfall into river or shallow water near the beach

According to the field surveys conducted referred above, it is evident that the properly treated effluent by way of secondary treatment can safely be discharged into a river or shallow water near the beach, preferably with location near a river or coastal area.

(4) Conclusions

As a result of consideration mentioned previously, it is concluded that construction of secondary treatment is desirable to be recommended for final disposal in order to establish water pollution control in the Project Area.

4.3.2 Comparison of Alternative Treatment Methods

On the basis of the above consideration, three alternatives are considered, as discussed in Appendix G."Sewerage System Consideration", namely (1) stabilization pond process, (2) aerated lagoon process, and (3) oxidation ditch process, which are analyzed for the purpose of selection of the most adequate disposal system in the Project Area, in terms of the local conditions such as possibility of land acquisition, availability of skilled labours, conditions of receiving water and the construction cost. These alternatives considered in the design are described below.

(1) Stabilization Pond Process

Treatment by stabilization pond works by natural conditions involving the action of algae and bacteria under the influence of sunlight (photo-syntheses) and air. In order to facilitate easy repairs, maintenance and flexibility in operation, stabilization pond is provided with at least more than two ponds in parallel, depending upon the magnitude of the flow and the topography of the site, and then considered flow patterns are of two series arrangement which calls facultative and maturation ponds.

(2) Aerated Lagoon Process

Aerated lagoon process shall consist of aerated lagoon and maturation pond.

There is the activated sludge units operated without sludge returns. Commonly, floating aerators are used to supply the necessary oxygen and mixing power.

The effluent from the treatment in the aerated lagoon is to be treated further in a maturation pond which will achieve high degree of bacteriological purification. Both the aerated lagoon and maturation pond shall be provided with at least more than two ponds in parallel due to easy repairs, maintenance and flexibility in operation.

(3) Oxidation Ditch Process

Oxidation ditch is essentially modification of the activated sludge process. This method of aerobic stabilization circulates waste water in a closed circuit ditch aerated by mechanical aerators. After circulation in the ditch, the mixed liquor is sent to the sedimentation tank and solids are removed, then waste water is discharged through disinfection process to water way. In the sedimentation tank, sludge are produced that must be dumped into drying bed. Oxidation ditch process shall consist of oxidation ditch, sedimentation tank, and drying bed.

In these treatment systems mentioned above, namely (1) stabilization pond, (2) aerated lagoon and (3) oxidation ditch process, the treated water is designed to flow by gravity into the receiving body of water, and would be expected of the BOD of more than 75 percent removal of influent BOD in a properly designed and efficiently operated plant.

To compare the alternatives, each type of treatment facilities are designed to flow rate of waste water from 5,000 to 200,000 cu m daily average flow, then all cost, accruing to alternatives considered, are estimated on the basis of cost functions developed as discussed in Appendix E,"Design Data."

As noted in Appendix G, Sewerage System Consideration, Table III-6 shows the results of comparison of cost and land space required. The cost of each selected alternative is estimated in terms of total annual cost with respect to construction cost, operation and maintenance, and depreciated capital cost at 1976 levels taking into account of life of the facilities provided.

The results of cost analysis indicate that alternative of stabilization pond process would be the most suitable treatment and disposal system to be constructed in the Project Area.

(4) Recommended System

On the basis of preceding discussions and from an examination of the study results, it is evident that stabilization pond system has a substantial benefit compared with other alternatives considered. Advantages and disadvantages to be derived from stabilization pond system are as follows:

(a) This process is the most economical sewerage disposal system, in terms of construction, operation and maintenance costs, even it may require more land space compared to the other process.

(b) Sufficient land in the Project Area seems to be available, which enables stagewise expansion as the population increase. If the required land area is not available in the final stage, the stabilization pond may then be modified to the another treatment method such as aerated lagoon or oxidation ditch for the reduction of land requirement.

(c) This method can meet the future modification of design conditions simply by adjusting surface area.

(d) A minimum mechanical and electrical equipment are necessary, which contribute to the economical financing because the major portion of the construction costs can be borne locally.

(e) The maintenance and operational costs are mainly for labour, which will provide opportunity of an employment and easiness of maintenance and operation.

(f) Ponds may occasionally emit odors so that ponds should be located as far from existing or future residential or commercial development as is practical or reasonable.

Although stabilization pond system has both advantages and disadvantages as discussed above, it can be concluded that the advantages may overcome the disadvanteges and that the system will reasonably be adopted to the sewage disposal system in the Area, construction of the system may be divided into stages, initial and final stage. The initial stage will be to construct some portion of the system, then to monitor performance to determine the extent of requirements either for extending the system and/or installing higher level treatment processes such as aerated lagoons, activated sludge process, etc., which may possibly be required in the future when the stitutation of the Area changes.

TABLE III-6 Comparison on Alternative Treatment/Disposal Systems

1) Cost comparison on the basis of total annual cost

(unit 1,000 M$)

Alternatives	Flow Rate (cu m/day)				
	5,000	10,000	50,000	100,000	200,000
Alt. I Stabilization pond Process	66.8	122.7	571.0	1,131.4	2,252.0
Alt. II Aerated Lagoon Process	150.2	288.8	1,389.3	2,761.2	5,511.4
Alt. III Oxidation Ditch Process	220.1	419.9	1,916.3	3,644.9	7,254.7

2) Land Area required

(ha)

Alternatives	Flow Rate (cu m/day)				
	5,000	10,000	50,000	100,000	200,000
Alt. I Stabilization Pond Process	6.0	11.2	52.4	98.7	197.3
Alt. II Aerated Lagoon Process	2.3	4.3	20.2	38.0	76.1
Alt. III Oxidation Ditch Process	0.6	1.1	4.9	9.2	18.5

4.4 Industrial Wastewater Treatment

4.4.1 Consideration on Joint Treatment of Domestic and Industrial Wastes

Municipal sewerage often involves both domestic sewage and industrial wastewater. Combined domestic and industrial waste treatment is the most desirable arrangement, but it always accompanies with certain problems which have to be carefully considered.

As industrial wastes sometime include objectionable matters, such as oils, grease, flammable solvents, excessive acidity or alkalinity and poisonous substances, it is necessary to give due consideration for protection of a conduit system from corrosion, clogging, explosion, and other damages, and for adequate maintenance of each treatment processes.

Since most sewage treatment plants use some form of biological treatment, it is essential for satisfactory operation that extremes in industrial waste characteristics be avoided and the waste mixture be (1) as homogenous in composition and uniform in flow rate as possible and free from shock loads, (2) not highly loaded with floatables and suspended matters, (3) free of excessive acidity or alkalinity, (4) free of undecomposable materials and toxic metals, (5) not too high in BOD materials, such as carbohydrates, sugar, starch and cellulose and (6) low in oil and grease content.

However, in case that industrial wastes are comparatively little compared to domestic wastewater, process of pretreatment may not necessarily be required because the minor objection of industrial wastes could be eliminated by overwhelming domestic wastewater in treatment plant.

In case of dominant industrial wastes, however, careful consideration on the characteristics of the wastes is required, and adequate measures of the following will be required by implementing either one or all of them according to the degree of the actual needs.

(a) To lengthen the detention time of the wastes on treatment process.

(b) To modify or supplement adequate facilities such as oil skimmer, aerators, final sedimentation tank, sludge return system, etc.

(c) To regulate the effluent quality and quantity of individual factories, which will include, by enacting laws on industrial effluent regulation, (i) control of the amount and concentration of potentially objectionable matters of high BOD and/or SS from the factories and, (ii) removal of harmful wastes such as toxic metals and/or undecomposable matters before discharging into municipal sewers.

4.4.2 Industrial Wastes Treatment of the Project Area

There are two distribution forms of factories within the Project Area, the one is scattered within the area and the other concentrated in group as industrial estates.

Studies on industrial wastewater (Ref. Appendix F, Wastewater Characteristics) are summarized as follows:

(1) Average daily flows from major sewerage zones

Name of District	No. of Zones	Industrial Wastes* (A)	Domestic Sewage* (B)	Ratio (A):(B)
Butterworth	1	1,600	10,450	1 : 6.5
	3	8,560**	8,520	1 : 1
Seberang Jaya	1	160	10,750	1 : 67
	2	4,000**	5,790	1 : 1.5
Prai	1	85,040**	-***	-

* unit; cu m/day
Projection in the year 2000

** Industrial Estates including domestic wastes producing in industries

*** Domestic waste is included in Industrial Wastes

(2) Waste strength in terms of BOD and SS average strength is estimated at;

BOD ..... 150 mg/l

SS ..... 150 mg/l

(3) Characteristics of the wastes

With assumption that the present industrial wastes produced from food and textile industries will continue with little changes of quality and quantity, these wastes could remain to be treated by biological process. A few factories in the estates currently producing objectionable quality effluent including heavy metals and/or much floatables may increase in the future, for which certain consideration may become necessary in the future.

On the basis of the above information, most of the industrial wastes in the Area are amendable to treat with domestic sewage, and the joint treatment system is feasible.

The joint treatment system using stabilization pond, one of the biological treatment methods, is recommended because of its capability to give sufficient treatment for domestic wastes and current industrial wastes, together with easy maintenance and cheaper cost.

However, careful further observation is required as to the increase of volume and changes of characteristics of industrial wastes particularly from the industrial estates to take necessary steps to modify the methods of conveyance and treatment in accordance with the measures mentioned in Section 4.4.1 wherever required.

Chapter 5

DESIGN BASIS

5.1 Wastewater Volume and Strength

5.1.1 Domestic Sewage

On the basis of the data and discussions in Appendix F, "Waste Water Characteristic," the future domestic sewage flow rates and strength are estimated as follows:

TABLE III - 7 Estimated Sewage Volume and Strength

Year	Flow	BOD	SS
1976	170 l/cap/day	37 g/cap/day	37 g/cap/day
1980	182	38	38
1985	194	40	40
1990	206	42	42
1995	218	44	44
2000	230	46	46

Based on the tabulated data above, both of the average BOD and SS of the sanitary sewage in the year 2000 will be in the range of about 200 mg/l.

For sewer design purpose, the estimated domestic sewage flow rate for the year 2000 is used to project domestic sewage volumes. The capacity for each of the sewer lines is calculated from the projected 2000 year population for the zones included in its tributary areas, based on their land use and population density distribution.

5.1.2 Industrial Wastes

On the basis of the data and discussions in Appendix F, referred above, the wastewater production in industrial zones is estimated at 80 cu m/ha/day, which will be distributed over the total 1,289 ha of industrial zones expected to be developed by the year 2000, according to the development land use plan for Project Area.

As described in Appendix E, wastewater characteristics of different industry groups are estimated, and for the purpose of master planning, it is assumed that in general the future industrial wastewater will not substancially be different from that of domestic sewage.

In view of these conditions, it is estimated that the average strength of industrial waste water discharged to the public sewers from factories in the year 2000, will be 150 mg/l of BOD and SS.

5.1.3 Extraneous Water

For separate sewers, an infiltration allowance is considered in determining sewer capacities.

As discussed in Appendix F, 18 cu m/km/day is considered to be a fair estimate of the extraneous flows to sewers, including groundwater infiltration and surface water inflow from public sewers, house connections, and manhole covers, etc.

5.1.4 Overall Volume

The overall sewage volumes of different stages have been calculated, by adding together the domestic sewage and industrial waste water, and multiplying by a peaking factor, depending upon the scale of tributary area, and adding the extraneous flow allowance.

5.2 Design of Sewers

For determining sewer capacities, the Manning equation is used for pipes and conduits, flowing full or partially full to accommodate the peak flows, with 'n' values of 0.013. For stone masonry, an 'n" value of 0.025 us used. Some important elements to be considered in designing sewer capacity are reviewed in Appendix E."Design Data."

A minimum size of 225 mm (9 in) is adopted for sanitary sewers, but for house connection pipes 150 mm may be used.

All sanitary sewers are designed to maintain a mean flow velocity, when flowing full or half full, of not less than 60 cm/sec (2 ft/sec) for VCP, based on the Manning equation using an 'n' value of 0.013. For RCP or any cement-bonded pipe materials, for an 'n' value of 0.013, a minimum velocity of 75 cm/sec (2.5 ft/sec) is used.

Minimum sewer slopes for different pipe sizes are adopted so that the velocity of flow will be not less than 75 cm/sec (2.5 ft/sec) for cement-bonded pipes, and 60 cm/sec (2 ft/sec) for VCP. The recommended minimum slopes for sanitary sewers are presented in Appendix D. Design Data.

All sewers are designed not to exceed a velocity of flow of 3 m/sec (10 ft/sec), to protect against sewer erosion. When the ground slope is steep and a velocity may come up to more than 3 m/sec (10 ft/sec), special provision is to be made to protect against displacement by erosion and shock.

For sanitary sewer pipe design, full capacity of the design peak flow rate is provided. When a smalller sewer is connected to a large sewer, the crown of both sewers are to be placed at the same elevation.

Earth covering of sewer pipes is not to be less than 1 meter (3.3 ft) unless special protection measures against the expected load are provided.

Chapter 6

PROPOSED SEWERAGE SYSTEM

6.1 Population of Individual Sewerage District

Area and present population of each sewerage district are separately described as follows (more detailed descriptions are in Appendix G. Sewerage System Consideration.)

(1) Butterworth Sewerage District

	Area (ha)	Persons	Persons/ha
Zone - 1	367	37,900	103
Zone - 2	182	3,600	20
Zone - 3	457	28,200	62
Zone - 4	444	26,300	59
Zone - 5	551	4,000	7
Zone - 6	670	8,900	13
Total:	2,671	108,900	41 (AV.)

(2) Seberang Jaya Sewerage District

	Area (ha)	Persons	Persons/ha
Zone - 1	438	13,600	31
Zone - 2	305	100	0.2
Zone - 3	510	3,000	6
Zone - 4	430	7,500	11
Zone - 5	368	4,400	12
Total:	2,051	28,600	14 (AV.)

(3) Prai Sewerage District

	Area (ha)	Persons	Persons/ha
Zone - 1	1,063	1,900	2
Zone - 2	268	2,000	7
Total:	1,331	3,900	3 (AV.)

(4) Bukit Mertajam Sewerage District

	Area (ha)	Persons	Persons/ha
Zone - 1	892	7,600	8
Zone - 2	715	6,400	9
Zone - 3	927	45,500	49
Zone - 4	467	6,100	13
Zone - 5	459	7,300	16
Zone - 6	573	13,800	24
Zone - 7	768	9,900	13
Total	4,801	96,600	20 (AV.)

6.2 Design of Swerage Facilities

6.2.1 Design of Public Sewer

Recommended sewerage system plan is shown in Figure III-3. This plan is based on data obtained from field surveys conducted for this Project, and on data contained in available topographical and other maps. For the areas where the exact locations of the road network are not available, routing of sewers is determined on the basis of the available state plan or other development programme plans.

In deciding the capacities of public sewers, the area to be served by each sewer is calculated on the basis of available maps in the scale of 1/7500, 1/10000 and 1/25000. Flows are calculated on the basis of the projected population densities for the year 2000, plus industrial wastes contributions and extraneous flows including groundwater infiltration.

Housing and industrial estate development programmes are currently underway by MCPW and PDC in certain parts of the Project Area, but, for most of these areas the road network plans are still at the preliminary planning stage and another few years will be needed to establish the final plans. Routing of public sewers for these areas, therefore, are planned on the basis of the presently available data, and may be subject to minor changes at the later stage when the final plan is made. Because the relative timing for implementation of some these development plans and for construction of sewers are still to be decided, the final design and construction of sewers are still to be decided, coordinated with urban planning including road facilities. Detailed surveys of lines, levels, and grades will be necessary before final design and construction.

All sewers are designed to give mean velocities when flowing full or half-full of not less than 60 cm/sec (2 ft/sec) for VCP, based on the Manning formula using an 'n' value of 0.013, but for RCP or any cement-bonded pipe materials, the minimum design velocity of flow of 75 cm/sec (2.5 ft/sec) is specified, in order to prevent hydrogen sulfide generation and accumulation. Because of the combination of relatively high BOD and temperature anticipated for the sewage to be produced in the Project Area, it is expected that sulfide control will need serious consideration.

Sufficient earth covering is to be left between the top of the sewer and the roadway surface to protect the sewers from traffic loads and to avoid undue interference with other underground facilities, with a minimum earth covering of 1 meter, except for specific situations where shallower depth is feasible.

6.2.2 Manhole

Manholes are not indicated on the plans and profiles of the sewers but will be provided at each changes in direction, in grade, and in sewer diameter, generally with the following maximum spacings:

Sewer Diameter (mm)	Maximum Manhole Spacing (m)
300 or less	50
600 or less	80
1,000 or less	100
1,500 or less	150
1,650 or more	200

Except for very shallow sewers, all manholes are planned to have adequate dimensions for entry and for operation of cleaning equipment. The internal size of manholes is 120 cm or more, and they are also designed for future extension of the sewers.

6.2.3 Type and Materials of Sewer

Pipes currently available in Malaysia are limited in sizes and materials. Asbestos-cement, centrifugally-cast reinforced concrete, vitrified clay pipes, and pitch fibre pipes, confirming to internationally accepted standard, are being manufactured (or imported) in Malaysia. The main and submain sewers from 375 mm (15 in.) in diameter are designed on the basis of centrifugally-cast reinforced concrete pipes, but smaller sewers, less than 375 mm (15 in.) in diameters, are on the basis of vitrified clay pipes. Where sulfide corrosion is anticipated, the coating or lining centrifugally-cast reinforced concrete pipes are used.

As described in Appendix D. Design Data, all branch and lateral sewers are designed with circular sections, with a minimum diameter of 225 mm (9 in.).

Because of the resistance to corrosion from acids, alkalies, and virtually all corrosive substances, as well as resistance to erosion and scour, vitrified clay pipes are recommended for smaller sizes up to 300 mm (12 in.) in diameter.

6.2.4 House Connection

Households within areas provided with separate sewer service will be connected with public sewers to discharge their domestic sewage to the sewerage system. These pipes are designed to be not less than 150 mm in diameter, preferably with a slope of more than 2 percent. Materials, joints, and workmanship should be equal to those of the public sewers to minimize infiltration and root penetration. Although layout and profile for these pipes are not prepared for master planning purposes, an average house connection pipe length for individual household is estimated at 15 meters.

6.2.5 Sewer Joint

The sewer joints specified for the Project Area are of rubber ring type for concrete pipes and of the factory applied flexible type for clay pipes.

6.2.6 Pumping Station

Some of general items considered in the design of pumping stations required are as below:

(a) Type

Sewage pumping stations are to be principally of the dry-well type, except for small intermediate stations where a dry-well is difficult to provide or where the wet-well type will give satisfactory service.

(b) Design Flow

The design of stations is based on the peak flow of the sewage unless special conditions justify use of a lower rate. All piping and conduits are also designed to carry to expected peak flow, with some allowances for abnormal sewage increases. Enough storage capacity is to be provided in wells, especially where automatic controls and variable speed drives are not furnished, to balance pumping rates within flow rates.

(c) Structure

Wet and dry wells, including their structures, are separated. Provision is also considered in design to facilitate removing pumps and motors. Suitable and safe means of access are provided for dry wells and wet-wells, containing either bar screens or mechanical equipment requiring inspection or maintenance.

(d) Pumps

At least two pumps should be provided for station required. The number of pump is to be determined on the basis of flow quantities and variations. Where possible, pumps should have the same capacity and design, with interchangeable parts. Each should be capable of handling flows in excess of the expected maximum flow. Where three or more units are provided, they should be of such capacity that with one unit out of service, the remaining units will have capacity to handle maximum flows.

In addition to the capacities of pumps, careful consideration is to be given to the selection of a pump having the proper head rating, considering the fluctuations of the water surface of the wet-well and the discharge elevation. Due to restricted diameters, small capacity pumps should always be of the non-clog type.

6.2.7 Sewage Treatment Plant

As already referred in Chapter 4, Basic Engineering Consideration, it is considered that stabilization pond process is the most suitable treatment plant to be provided for the Project Area.

Some of general items considered in the design of sewage treatment plant are described below:

(a) Design Flow

Design of treatment process units shall be based on the daily average rate of sewage flow.

All piping, conduits and other hydraulic units should be designed to carry the expected peak flow.

(b) Quality of Influent

For design of the treatment process units, the expected sewage quality of the influent shall be estimated in terms of BOD and SS based on evaluation of all types of waste to receive from the contributing areas, including commercial, residential and industrial.

Estimated BOD and SS of domestic and industrial wastewater are approximately 200 mg/l and 150 mg/l respectively.

(c) Quality of Effluent

Treatment plant effluents may be discharged into a drain, river and/or directly to the sea. The required degree of treatment shall be based on the ability of the receiving water to assimilate the wastes.

The condition of the receiving water, rate of flow, existing or potential use of water bodies (fishing, bathing, etc.), and seasonal variations are factors to be considered.

For the design work, expected sewage quality of the effluent in terms of BOD is less than 50 mg/l.

(d) Construction

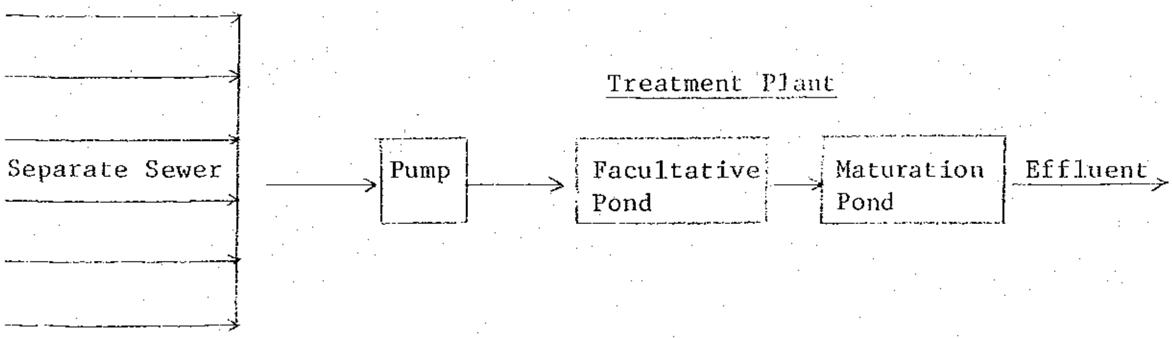
The pond as recommended shall consist of the facultative and maturation ponds to be constructed separately due to different function, and at least two units of the pond both in the facultative and maturation, depending upon the magnitude of the flow, shall be constructed in parallel to substitute each other in case the one is blocked with sediment of sludge.

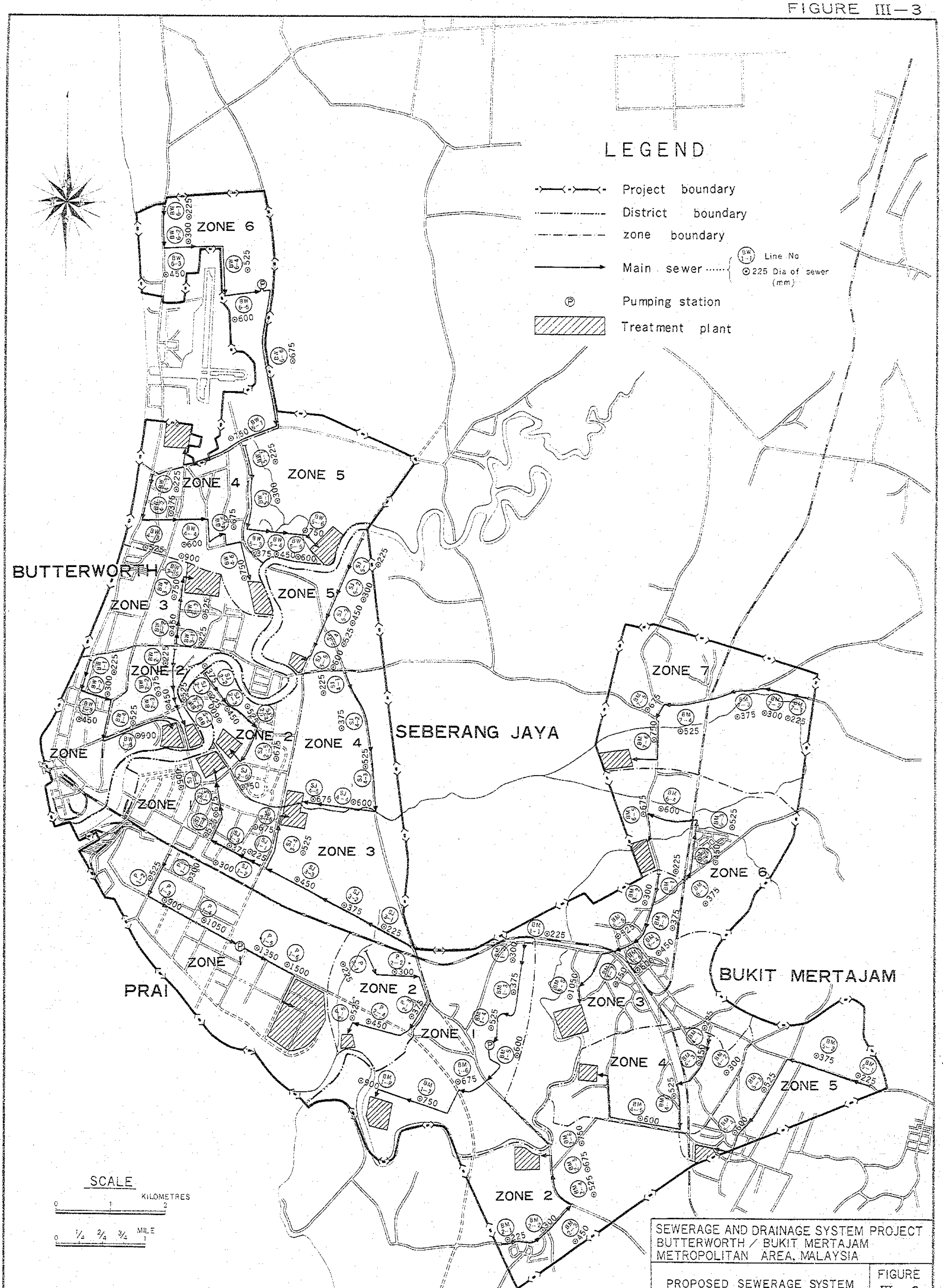
The pond will be constructed by excavation and embankment. An embankment of pond shall be sloped at 1/3, and should be constructed of impervious materials as far as possible and compacted sufficiently to form a stable structure. The pond bottom should be made as flat as possible. The soil formation for the bottom should be relatively impervious to avoid percolation and ground water pollution as far as possible, using either blanket of clayer soil or other local material such as vinyl sheet.

6.3 Proposed Sewerage System

In order to establish the most preferable collection system in the Project Area on the basis of the above considerations, twenty independent sewerage systems based on twenty sewerage zones duly dividing the entire Project Area are considered. Site location of sewage treatment plant were investigated, and outfalls considered accordingly to the nearby water ways.

For each of sewerage zones, sanitary sewers, pumping requirement and treatment facilities by stabilization pond process are recommended. Figure III-3 and Table III-8 show the proposed sewerage system throughout the Project Area. Flow sheet of stabilization pond process recommended is illustrated as below.




LEGEND
Project boundary
District boundary
zone boundary
Main sewer
Line No
225 Dia of sewer (mm)
Pumping station
Treatment plant
BUTTERWORTH
SEBERANG JAYA
BUKIT MERTAJAM
PRAI
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
ZONE 7
SCALE
KILOMETRES
MILE
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
PROPOSED SEWERAGE SYSTEM
FIGURE III—3

Name of Sewerage Zone	Public Sewer		House Connection		Pumping Station		Treatment Plant		
	Dia. (mm)	Length (m)	Dia. (mm)	Length (m)	Peak flow (cu m/s)	Req'd land Area(sq m)	Process	Average flow(cu m/day)	Req'd land area (ha)
Butterworth, zone-1	225- 900	92,200	150	110,800			S.P.	15,800	17.6
" 2	〃 - 600	54,600	"	65,500			"	7,200	8.4
" 3	〃 - 900	116,800	"	125,700			"	21,500	23.6
" 4	〃 - 750	133,200	"	111,100			"	13,000	14.6
" 5	〃 - 750	165,300	"	98,200			"	12,500	14.1
" 6	〃 - 750	201,000	"	108,000	0.18	100	"	14,100	15,8
Seberang Jaya, zone-1	225- 900	131,000	"	140,000			"	15,800	17.6
" 2	〃 - 750	82,000	"	88,700			"	12,900	14.5
" 3	〃 - 675	153,000	"	76,500			"	10,200	11.6
" 4	〃 - 675	129,000	"	70,800			"	8,400	9.7
" 5	〃 - 600	110,400	"	55,200			"	7,400	8.6
Prai, zone-1	225-1,500	116,900	"	148,800	0.89	1,540	"	90,400	92.0
" 2	〃 - 525	80,400	"	40,200			"	5,400	6.4
Bukit Mertajam zone-1	225- 900	267,600	"	137,200	0.14	90	"	18,100	20.0
" 2	〃 - 750	214,500	"	115,200			"	15,000	16.8
" 3	〃 -1,050	278,100	"	217,800			"	25,900	28.1
" 4	〃 - 600	140,100	"	71,900			"	9,500	10.9
" 5	〃 - 600	137,700	"	68,900			"	9,200	10.5
" 6	〃 - 675	171,900	"	95,600			"	12,400	14.0
" 7	〃 - 750	230,400	"	115,200			"	15,300	17.1

NOTE: S.P. ------- Stabilization pond