CHAPTER 6

EXISTING EXCRETA DISPOSAL SYSTEMS

6.1 Existing Toilet and Excreta Disposal System

Existing toilet facilities in the houses are classified into three categories, flush toilet with septic tank or Imhoff tank, bucket toilet, and pit privy.

Data obtained from "Population and Housing Census of Malaysia 1970" shows distribution of these facilities in the town area and in the rural area. Number of houses classified according to the toilet facilities in the town and the rural area are shown in Table II - 15 .

It should be noted that the town area, more than 90 percent of the houses are convered by flush or bucket toilets, but pit privy is predominant in the rural area. Toilets over the waterways or no toilet houses are mostly located in the rural areas outside of the Project Area.

TABLE II - 15 Toilet facilities in North and Central Districts in 1970

		Flush toilet	Bucket toilet	Pit privy	Toilet waterway	No toilet	Total
Central District	Bukit Metarjam	993 (28.5)	2,396 (68.9)	54 (1.6)	2 (0.)	34 (1.0)	3,479 (100)
	Rural	1,355 (8.7)	3,485 (22.4)	6,955 (44.7)	1,182 (7.6)	2,593 (16.7)	15,570 (100)
North District	Butterworth	2,620 (30.6)	5,177 (60.4)	501 (5.8)	55 (0.6)	218 (2.5)	8,571 (100)
	Rural	2,548 (7.5)	5,898 (17.5)	14,150 (41.9)	1,800 (5.3)	9,354 (27.7)	33,750 (100)

Note: North and Central Districts includes the outside areas of the Project Area. Rural means the remainder of Butterworth and Bukit Mertajam Town Areas in the North and Central Districts respectively.

New housing complexes which have been developed recently have their own cpommunal 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 Municipal 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 and private septic tanks are managed by Municipal Council of Province Wellesley (MCPW). Sludge from these facilities are collected by tank lorry and dumped at disposal site. All sludge collected within the Project Area is disposed into dug ditches at Bagan Ajan near the airforce base and sludge is penetrated into the earth.

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 is provided for its disposal. Lorries route and the location of night soil disposal site are shown in Figure II-9 .

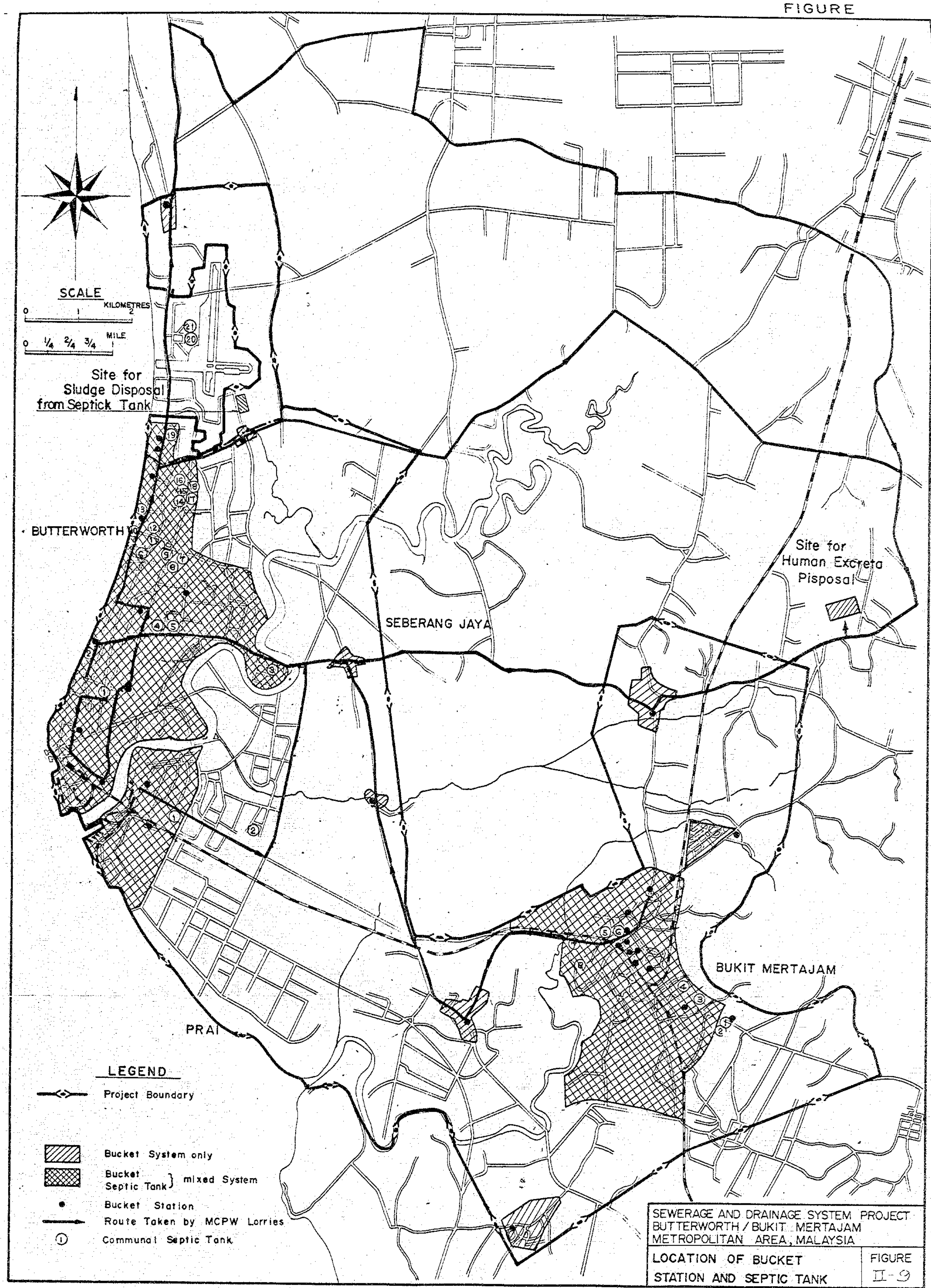


FIGURE
SCALE
KILOMETRES
0 1 2
MILE
0 1/4 2/4 3/4 1
Site for Sludge Disposal from Septick Tank
BUTTERWORTH
SEBERANG JAYA
Site for Human Excreta Pisposal
BUKIT MERTAJAM
PRAI
LEGEND
Project Boundary
Bucket System only
Bucket
Septic Tank
mixed System
Bucket Station
Route Taken by MCPW Lorries
Communal Septic 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 communial systems. There are drainage system, made of open ditches which serve as crude conbined sewerage system by receiving sullage from residences and area drainage, together with from septic tanks and industrial wastes. As the Projct Area are roughly divided into residential and industrial areas, and many of the factories are either gathered or scattered in the residential areas which discharged their wastes into the receiving water through the drains together with the wastes from the residence, the consideration on the waste production and dispoal is naturally confirmed to domestic and industrial wastes, which are described as follows:

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.

The sullage waters produced by the residents in the area are discharged without any treatment.

7.1.2 Sewage Flow & Strength

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

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 by this Project Team. The surveys consisted of home visits and actual measurements including volume measurement, sampling and chemical analyses.

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 Estimated Unit Flow Rate and Strength of Domestic Sewage Produced in the Project ARea

Concentration*		Volume**	Unit Production***	
BOD	SS		BOD	SS
185	180	200	37	20

* Unit : mg/l
** Unit : l/day.cap
*** Unit : g/day.cap

7.1.3 Septic Tank Effluent

Approximately 30% of population in the Project Area are served by communial or private "septic tank" systems for human excreta disposal, which are equiped with septic tank, Imhoff tank, or oxydation pond. The details are described in PART III of the this Volumes.

The effluent quality is ranging from 15 to more than 250 mg/l of BOD, and from 5 to 700 mg/l 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 contamination by coliforms as described in APPENDIX F.

7.2 Industrial Wastewater

7.2.1 Industries in the Project Area

PDC is conducting industrial development in the industrial areas of Mak Mandin Industrial Estate, Prai Industrial Complex*, 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 the industrial areas. (See APPENDIX E)

Small scale (like home-size) factories distributed 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, 3 industrial wastewater surveys were made by LPKT SP conducted by the Sub-Committee of Pollution Control, the Ministry of Environment, and by this Project team during the year 1976.

---

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

At the first survey, questionnaires for getting information on the volumes of water consumption and discharge were sent by LPKT SP 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 analyzed.

The second survey was carried out by the Ministey of Environment to estimate quantity of pollutants of industrial wastewaters 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 Master Plan in butterworth-Bukit Mertajam Metropolitan Area, was carried out by the Project Team. This survey consists of the questionnaires including the questions on (1) water consumption, (2) waste production and disposal, (3) treatment facilities, (4) effluent quality, (5) factory scale and expansion planning, (6) working hours, and (7) main process related to waste production, and supplemental wastewater analyses.

The results are summarized and discussed in APPENDIX E.

7.2.3 Industrial Wastewater Quality and Characteristics

The wastewaters discharged by factories in the Project Area widely varies in quantity and characteristics according to the types of industries and/or by factory-scale. The detailed studies on industrial wastewater are described in APPENDIX E.

Table II-17 summarises per unit site-area water consumptions of present major industries and average BOD and SS concentrations of their wastewaters. And Table 8-3 shows unit wastewater production on average of whole industries obtained available data.

TABLE II-17 Average Water Consumption and WAstewater Quality of Major Industrial Classes in the Project Area

		Food	Textile	Chemical	Others
Water Consumption*		120.6	165.7	104.6	20.8
Concentration	BOD**	200	122	73	67
	SS**	399	58	106	127

* unit : cu m/day per unit factory site area

** unit : mg/l

TABLE II-18 Unit Wastewater Production

Concentration*		Volume**	Unit Production***	
BOD	SS		BOD	SS
122	125	90.9	11	11

* unit : mg/l

** unit : cu m/day per unit fáctory site area

*** unit : kg/day per unit factory site area

7.2.4 Industrial Wastewater Treatment

The industries producing toxic quality wastewater are food (high BOD), textile (high BOD and colour), chemical (harmful chemicals), and others (plating and battery : heavy metals). On a visit to existing larger scale factories, it is observed that some of them have their own pre-treatment facilities, if not, have construction capacity and sufficient space. At present, the regulation to govern 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 (like home-size) factories scattered in the residential areas are increasing in number, but volume of their wastewater, is comperatively small, so that would be able to be taken case of the proposed sewerage treatment factilies.

CHAPTER 8

DRAINAGE SYSTEM

8.1 Existing Drainage System

The Project Area is flat and low-lying, and in a tributary of the Prai and Juru river and the sea, with the area of 11,600 ha for 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 metres (0.33 ft) to 3.8 metres (12.5 ft). The Prai river is very flat "tidal river" which is indluenced by the ocean tides to its very upstream.

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 topographical conditions in the tributary area can be identified as steep portion and flat portion. About percent of the whole tributary lies on the steep terrain with the surface elevation ranges from 5.0 metres (16.4 ft) to 230 metres (750 ft), and remaing parts on low-lying areas with the elevation of 0.0 - 2.9 metres (9.5 ft).

On the other hand, the sea water level by which river water levels are influenced directly is 1.68 metres (5.5 ft) in the highest record and 1.10 metres (3.- 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 backing 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 developments in low-lying areas. This is seen in 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 piece meal improvement in developed areas. They are heavily silted and overloaded. On the part of flat area, 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 V, 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, provided that certain improvement, such as desilting, and maintenance are carried out, except in case of specific areas where repetitious floodings are experienced, for which immediate remedial programme has to be considered.

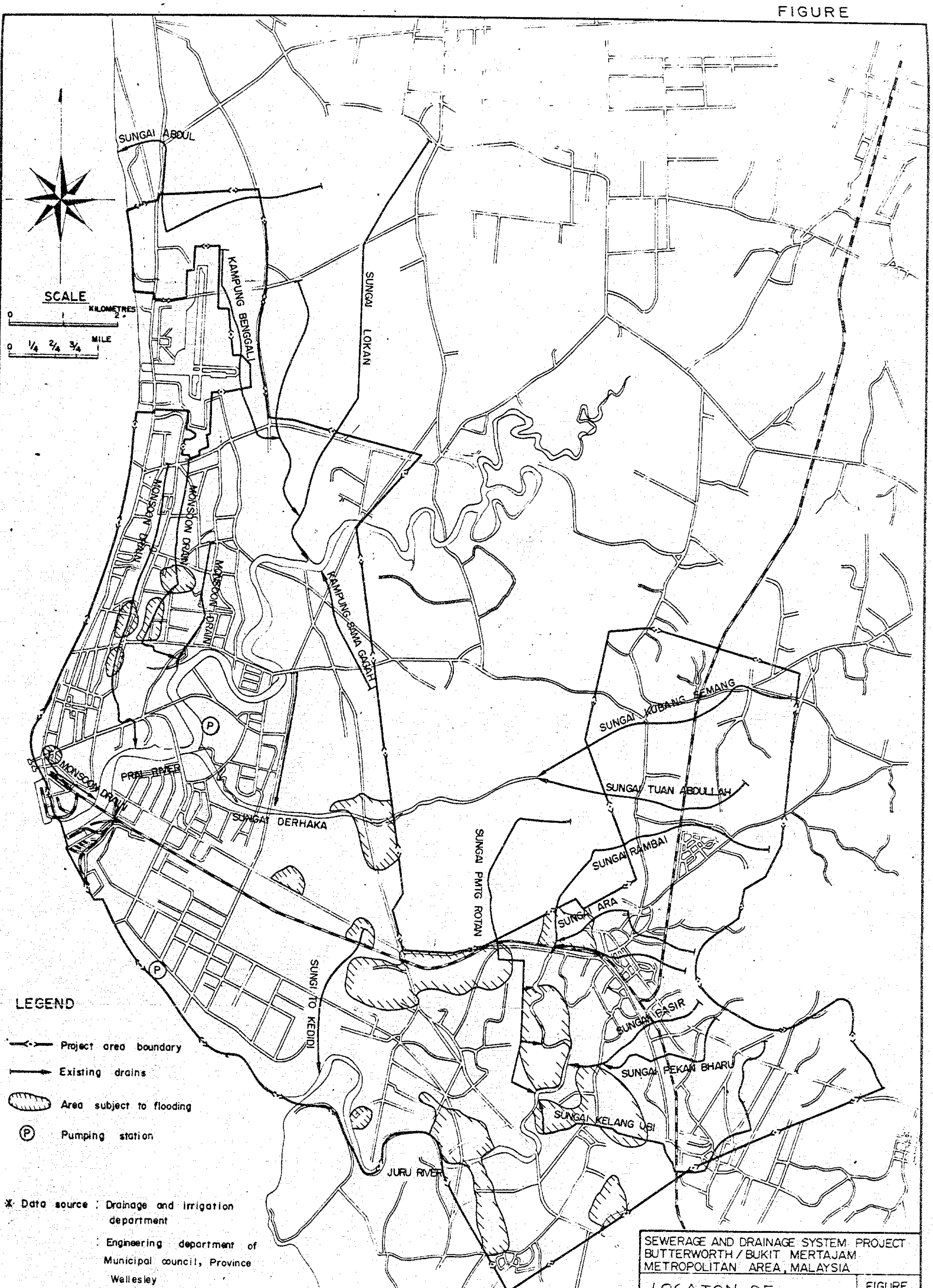
8.2 Flooding in Project Area

As shown in Figure II- , flood experienced areas are spreading along the Butterworth drain A, B, D and the Juru river. Flooding in Butterworth is due to backing up of existing major drains, deriving from inadequate capacity of heavily silted cross sections and high water levels at the outlets. Although no data are available, the local authourity has estimated that flooding damages are minor. However, complaints of residents are reported.

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. Therefore, flooding does not cause any serious problem to be solved immediately.

It is understood that flooding damages at the present stage are of in the degree of "nuisance" for the people concerned, and it is considered during the field survey that the majority of small "nuisance" floods in the Project Area can be relieved with desilting and improvement of culverts crossing roads.

FIGURE



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

Since there is at present no sanitary sewerage system in the Project Area, all the wastewaters produced within the Area, including domestic sewage, industrial wastewater, and commercial wastewater, is 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.

Although the cause of water pollution is not fully attributable to the uncontrolled wastewater disposal to the waterways, it is roughly estimated that a half of the BOD in the stream is due to liquid wastewaters and half to solid wastes. Because the ground surface slope in the area (especially in Butterworth area) is generally flat and flow velocities in the existing drains are low, wastewaters tend to stagnate and to decompose causing odours and visible nuisances as well as hazards to public health.

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 multi-purpose needs, such as fishery, agriculture, and navigation. These rivers are the recipients of much of the sanitary wastes from the population and industry as well as other pollution contained in surface runoff.

These river and drain systems comprise a complicated network of water courses, including 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-sourface elevation are affected by the tides and the effects extend beyond the boundary of the Project Area from the mouth of the rivers.

At present, most of domestic wastewaters 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 is generally around 0.5 m/sec or less, which intensities stagnation and biological decomposition. The effects of pollution are most pronounced in the town areas and industrial areas.

As described in Appendix F, the pollution surveys of waterways in Project area, conducted by NSC, confirm that the rivers in urban areas are generally polluted mostly by the direct discharge of wastewaters. Water qualities at the selected major monitoring points of two rivers, namely the Prai and Juru, range between 0.3 mg/l and 8.7 mg/l, in terms of DO concentrations. Even where the pollution is not so heavy, at estuary of the Juru river, the water is grey in colour.

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

The pollutants discharged into the waterways affect fisheries in the area. Fishing in rivers and drains is relatively small. Although no accurate data indicating the inter-relation between the water pollution of rivers and drains were available, data on annual fishery production of Penang Channel and inland waters indicate, while there has

The pollutants discharged into the waterways affect fisheries in the area. Fishing in rivers and drains is relatively small. Althouth no accurate data on fisheries in the rivers indicating inter-relation between the water pollution of rivers and drains are available, data on annual fishery production of Penang Channel and inland waters indicate, while there has been a steady increase in the gross annual inland fishery production over the past decade, the rate of increase has been decreased in recent years. Whether or not this is due to the increasing pollution of watercourses and offshores is the matter which requires further detailed study.

Penang State is one of the most important health resorts in Malaysia, so that to keep public environment clean has significant meaning as well as to keep living environment clean.

PART III

SEWERAGE MASTER PLAN

PART III

SEWERAGE MASTER PLAN

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Chapter

CHAPTER 1

PREVIOUS STUDIES

Reports and studies important to this project have been completed on several aspects of Butterworth/Bukit Mertajam Metropolitan Area (BBMA) and its surrounding area. The important recent reports and studies are discussed here.

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 programmes were outlined extending over the period 1971 to 1985.

Since resource base was analized in the year 1969, Population and Housing Census of Malaysia 1970 was not utilized in this Master Planning. Some over-estimation of state Population due to the lack of relevant information was found.

Three basic strategies were established for acceleration of economical growth. They are development of manufacturing, tourism, and fisheries. Agricultural development is pointed out to be hopeless to develop employment opportunities. Among the three basic strategies, manifacturing was expected to develop greatest portion of employment opportunities.

Therefore, development of industrial estates were established in the outline of physical plan. Most of the planned industrial estates are in the Butterworth and Bukit Mertajam Metropolitan Area, i.e. the Project Area of this Master Plan. One of the purposes of physical planning is to make a framework to facilitate detailed planning for the different (physical) sectors of the plan.

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

1.2 Water Supply Project

The report was prepared for the Penang State Government by Binnie & Partners Consultant Co., 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 future average water requirement is 277,000 cum/day in 2000.

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

(d) Average industrial water use was estimated at 126,000 cum/day for the year 2000.

These data were used tor estimating the future wastewater production in the sewerage system master planning.

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 area.

It recommends that each drainage basin to be established be dealt with separately 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 a minimum flow of 118 million gallons per day (MGD) 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 ponds if one or more for each drainage basin, 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 utilized in this report.

(1) Third Malaysia Plan, by Government Printer

(2) Kuala Lumpur Sewerage Master Plan, by D. Balsour & Sons

(3) Ipoh Sewerage Feasibility Study, by Ennex of New Zealand

CHAPTER 2

PHYSICAL PLANNING AND LAND USE

2.1 Background Information

The sewaerage and drainage master plan must be closely related to the state urban development programme prepared by the authorities concerned.

Town and Country Planning Department, PSG, formulated a 15 year plan which aimed to develop the state in accordance with the socioeconomic and physical needs of the population. The plan called for the improvement of the general physical condition of the Penang State, as well as proper land use.

The land use plan for the BBMA prepared by TCP divided the whole metropolitan area into 4 different zones, depending upon the type of future development of the area. Since the plan was prepared, conditions of the area have changed substantially, and the case of the sewerage master plan is for the year 2000 conditions, it is thus necessary to adjust the land use pattern to indicate the appropriate future status of the Project Area.

The current state of land use is that industrial estates in the Project Area, Prai, Seberang Jaya, and Mak Mandin have been developed or is now under development by Penang Development Cooperation (PDC). Also, new housing areas and social and administrative areas such as sites for courthouse and hospital complexes at Seberang Jaya are under planning of PDC.

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

2.2 Land Uses Adopted for Sewerage & Drainage Master Plan

On the basis of the foregoing future land use for the sewerage and drainage master plan is considered in the following manner:

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

2) Identify the industrial areas, i.e. Prai, Seberang Jay, and Mak Mandin, according to PDC's plan. No industrial development is considered except PDC's plan by the year 2000.

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

4) Identify the residential areas according to the new housing schemes by the private developers submitted approval to MCPW.

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

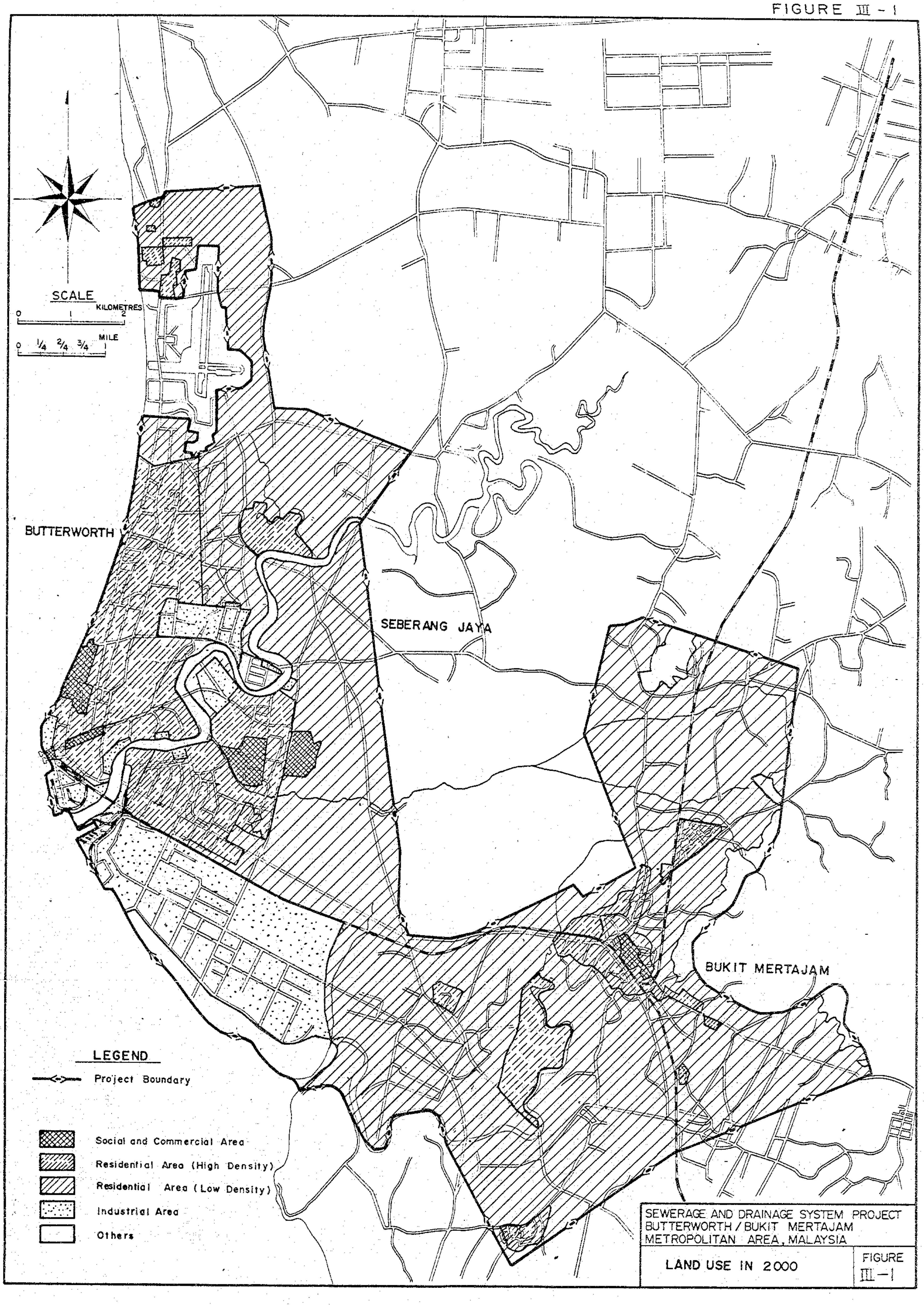
According to the plan envisaged, whole Project Area should be essentially urbanized by the target year. Therefore, no rural and agricultural areas should remain. Entire Project Area should currently be classified into 6 categories which are industrial, social and commercial, residential, rural, agricultural and others (nonhabitable), which should grow into 4 categories in the target year of 2000 by eliminating rural and agricultural areas due to urbanization.

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 2000

a)	industrial	1,289 ha	(3,185 acres)
b)	social and commercial	168 ha	(415 acres)
c)	residential	9,397 ha	(23,220 acres)
d)	others	746 ha	(1,840 acres)
	Total	11,600 ha	(28,660 acres)

As regards the residential area, it is considered appropriate to further delineate areas into high density of built-up urban area of averagely 160/ha average new housing area of 120/ha and low density area of 52/ha.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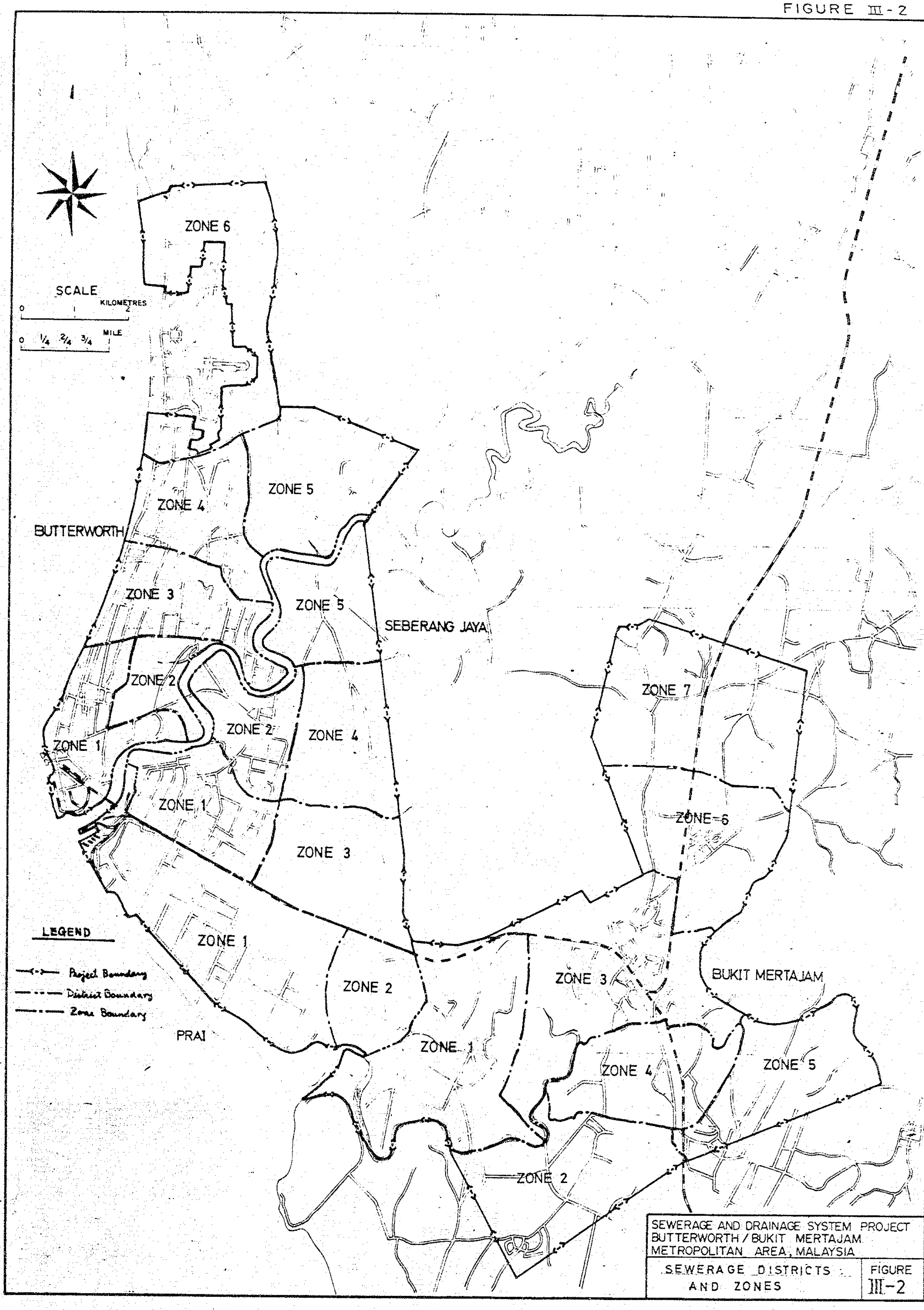
BUTTERWORTH
SEBERANG JAYA
BUKIT MERTAJAM
LEGEND
Project Boundary
Social and Commercial Area
Residential Area (High Density)
Residential Area (Low Density)
Industrial Area
Others
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
LAND USE IN 2000
FIGURE
III - 1

2.3 Sewerage districts and zones

On the basis of the geographical conditions, the entire Project Area was divided into 4 independent sewerage districts, and then each district was divided into several zones, taking into account such salient factors as location of rivers and drains, railways, ground slope, and administrative boundaries, as shown in Figure III-2 and listed below (Ref. Appendix B Sewerage System Consideration);

Name of Sewerage Zone		Area (ha) Sewerage Served	Others	Total
Butterworth	Zone - 1	367	23	390
"	Zone - 2	182	18	200
"	Zone - 3	457	33	490
"	Zone - 4	444	6	450
"	Zone - 5	551	19	570
"	Zone - 6	670	-	670
Seberang Jaya	Zone - 1	438	42	480
"	Zone - 2	305	55	360
"	Zone - 3	510	-	510
"	Zone - 4	430	-	430
"	Zone - 5	368	52	420
Prai	Zone - 1	1,063	167	1,230
"	Zone - 2	268	12	280
Bukit Metrajam	Zone - 1	892	48	940
"	Zone - 2	715	15	730
"	Zone - 3	927	53	980
"	Zone - 4	467	3	470
"	Zone - 5	459	31	490
"	Zone - 6	573	87	660
"	Zone - 7	768	82	850
	Total:	10,854	746	11,600

Excluding nonhabitable areas such as mountains, rivers, and cemeteries, from total area of 11,600 ha sewerage served area of 10,854 ha is obtained.


SCALE
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ZONE 5
ZONE 4
BUTTERWORTH
ZONE 3
ZONE 5
SEBERANG JAYA
ZONE 2
ZONE 2
ZONE 4
ZONE 1
ZONE 1
ZONE 3
ZONE 7
ZONE 6
LEGEND
Project Boundary
District Boundary
Zone Boundary
ZONE 1
ZONE 2
PRAI
ZONE 3
BUKIT MERTAJAM
ZONE 1
ZONE 4
ZONE 5
ZONE 2
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
SEWERAGE DISTRICTS AND 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 Chapter 4. Population & Land Use. On the basis of the National Census for 27 mukims of population, applicable to 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 gravity rate of 5.5% trends, they constitute the best available evaluations of many factors affecting population growth. As such, they serve as a reasonable basis to determine future water requirements and sewage quantities. These projections are discussed in Appendix A.

3.2 Population of Project Area

On the basis of the estimates for the years 1970 & 1976 for the Project Area, population of the Project Area up to the year 2000 are estimated as shown in Table III-2. Population in 1970 was obtained from 1970 Census. Population in 1985 is the value projected in the Penang Master Plan. Annual growth rate from 1970 to 1985 is assumed at uniform rate of 5.5 percent in BBMA (the Project Area), while that of Penang State is 2.2 percent. Population in 1995 is from the assignment Report by WHO, and the annual growth rate from 1985 to 1995 is assumed at uniform rate of 3.5 percent. Up to the year 2000, the average growth rate of 3.5 ercent is adopted. (Ref. Appendix A. 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 the divided into 4 sewerage districts, each having a different tendency in population growth rate, according to its characteristics. Since data on future population increase trends by district was not available, the future population by district was assumed on the basis of future land use pattern and estimated population density.

Estimated future population densities by land use categories are as follows:

(1) Social and commercial area (Public building) .... 0, 120, or 160 persons/ha

(2) " (Commercial) .... 120 persons/ha

(3) Residential area (Built-up urban area) .... 160 "

(4) " (New housing) .... 120 "

(5) " (Others) .... 52 "

(6) Industrial area .... 0 "

(7) Others (Non-habitable area) .... 0 "

On the basis of above conditions, the population of each sewerage district according to the land use pattern for the year 1976 was estimated and then the year 2000 was projected, which are shown in Tables III-3 & III-4. (Ref. Appendix A. Population and Land Use Distribution). The population in 1985, 1990, and 1995 were 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	108,955	146,205	164,705	186,753	212,854
Seberang Jaya	28,604	67,983	87,540	110,846	138,439
Prai	3,834	7,460	9,261	11,407	13,948
Bukit Mertajam	96,607	163,352	196,494	235,994	282,759
Total	238,000	385,000	458,000	545,000	648,000

As noted, Tables III-3 & III-4 referred above indicate land use pattern and population distribution accordingly in the districts with breakdown into each proposed sewerage zones.

TABLE Ⅲ-3 Land Use and Population by Zone in 1976 (area: ha)

District	Zone No.	Area							Population Density				Population			
		Total	Social Commer-cial	Residen-tial	Indust-rial	Rural	Agri-cul-tural	Others	Total	Social Commer-cial	Residen-tial	Residen-tial	Total	Social Commer-cial	Residen-tial	Rural
Butterworth	1	390	16* 47	190	67			70	97.2	0 160	160		37,920	0 7,520	30,400	
	2	200		33				167	17.9		108.6		3,585		3,585	
	3	490	2	176	107	119		86	57.7	120	120	57.9	28,255	240	21,120	6,895
	4	450		21		411		18	58.5		120	57.9	26,332		2,520	23,812
	5	570				231	75	264	6.9			17.1	3,961			3,961
	6	670		18		316	336		13.3		120	21.3	8,902		2,160	6,742
Seberang Jaya	1	480		157	2	48	159	114	28.5		80	22.9	13,657		12,560	1,097
	2	360			29	3	229	99	0.2			23.0	69			69
	3	510				155	300	55	5.9			19.3	2,991			2,991
	4	430				143	264	23	17.5			52.6	7,518			7,518
	5	420				138	115	167	10.4			31.7	4,369			4,369
Prai	1	1,230			639	94	93	404	1.5			19.8	1,860			1,860
	2	280				106	138	36	7.1			18.6	1,974			1,974
Bukit Meltajam	1	940		16		299	450	175	8.0		80	21.0	7,559		1,280	6,279
	2	730		38		144	509	39	8.7		80	23.2	6,387		3,040	3,347
	3	980	20	209		376	87	288	46.5	120	119.2	48.5	45,540	2,400	24,920	18,220
	4	470		9		193	248	20	12.9		80	27.8	6,0-7		720	5,357
	5	490				235	224	31	14.8			30.9	7,257			7,257
	6	660		46		208	319	87	21.0		120	40.0	13,840		5,520	8,320
	7	850				265	503	82	11.7			37.5	9,947			9,947
Total		11,600	16* 69	913	844	3,484	4,049	2,225		0 147.2	118.1	34.4	238,000	10,160	107,325	120,015

Note: * is not inhabited area, e.g. government office.

TABLE III-4 Land Use and Population by Zone in 2000 (area: ha)

District	Zone No.	Total	Social Commer-cial	Residen-tial (high)	Residen-tial (low)	Indus-trial	Others	Total	Social Commer-cial	Residen-tial (high)	Residen-tial (low)	Total	Social Commer-cial	Residen-tial (high)	Residen-tial (low)
Betterworth	1	390	16* 47	237		67	23	116.5	0 160	160		45,440	0 7,520	37,920	
	2	200		182			18	109.2		120		21,840		21,840	
	3	490	2	275	73	107	33	75.6	120	120	52.0	37,039	240	33,000	3,799
	4	450		212	232		6	83.4		120	52.0	37,514		25,440	12,074
	5	570		74	477		19	59.1		120	52.0	33,705		8,880	24,825
	6	670		36	634			55.7		120	52.0	37,316		4,320	32,996
Seberang Jaya	1	480		354	82	2	42	97.4		120	52.0	46,748		42,480	4,268
	2	360	18* 35	154	48	50	55	69.9	0 120	120	52.0	25,178	4,200	18,480	2,498
	3	510			510			52.0			52.0	26,543			26,543
	4	430	30*		400			0 48.4			52.0	20,818			20,818
	5	420			368		52	45.6			52.0	19,152			19,152
Prai	1	1,230				1,063	167	0							
	2	280			268		12	49.8			52.0	13,948			13,948
Bukit	1	940		16	876		48	50.5		120	52.0	39,794		4,560	35,234
	3	980	20	355	552		53	75.2	120	120	52.0	73,729	2,400	42,600	28,729
	4	470		9	458		3	53.0		120	52.0	24,917		1,080	23,837
	5	490			459		31	48.8			52.0	23,889			23,889
	6	660		46	527		87	49.9		120	52.0	32,948		5,520	27,428
	7	850			768		82	47.0			52.0	39,970			39,970
Total		11,600	64* 104	1,988	7,409	1,289	746		0 138.1	124.8	52.0	648,000	14,360	248,040	385,600

Note: * is not inhabited area, e.g. government office etc.

CHAPTER 4

BASIC 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 as possible and as rapidly as possible to keep pace with the waste loads of a growing community. Financial feasibility is especially important with respect to the areas populated by lower income groups. Economical solutions are also needed because of limited financial means of most of the municipalities.

Taking these factors into account, all feasible alternatives for the sewerage and drainage systems for the Project Area have been considered and analyzed from both the technical and economic view points. Analysis made for each of alternatives are described briefly in the following sections.

4.2 Conveyance System

To determine the most suitable sewerage system for the Project Area various relevant factors are taken into consideration, including the method of disposal, rainfall characteristics, topography, water uses, limitations due to physical planning features, etc.

(a) Basic considerations influencing the selection of the sewerage system in the Project Area is the existence of an established flood control system constructed by DID. Hence, there is little point in building another different system of major closed conduits to handle storm runoff because the extensive existing river and drainage system, if improved, will serve adequately for handling storm runoff. Furthermore, it is considered that with this natural flood control and storm drainage system existing, the concept of combined sewers is hardly applicable.

(b) A survey of the existing conditions of water pollution in the area shows that the rivers and drains of the Area are polluted with sanitary wastes, especially during the dry season when the rivers and drains serve essentially as the trunk and intercepting sewers of the Area, and that only the establishment of a separate system of major trunk and intercepting sewers, to keep sanitary wastes out of the rivers and drains, can be expected to change the present gross pollution situation and set the basis for progressive clean-up of the Area. Thus, a system of separate sanitary trunks and interceptors is the requirement for the Project Area, as the first step for the right direction.

(c) It is recognized, for the sake of economy, that separate sanitary collecting sewers can hardly be provided for all of the Area, at this time. It will be necessary, therefore, to defer construction of sanitary sewers in certain areas where sanitation problems are less critical, for example, those reasonably well served by septic tanks, currently and during the foreseeable future. Also on an interim basis, advantage can be taken of the local storm drainage systems in kampong areas, to serve temporarily for transporting dry weather sullage flows to the main sanitary trunks. Similarly, in other areas where house sewers discharge 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 trunks/interceptors. In both cases overflow structures can be provided to prevent overtaxing of the sanitary trunks/interceptors and treatment facilities during times of storm.

(d) The basic concept of the master plan therefore is (1) to delineate the necessary minimum system of main sanitary trunks and interceptors needed to serve the Project Area, beginning with the more critical areas than others, especially in town area, (2) to develop a plan for orderly development of provision of local sanitary sewers, with priority attention to areas having the most critical sanitation conditions, and with interim use of local storm drains wherever advantageous, and (3) to develop a plan of sewage treatment and disposal which will provide adequate protection to the waterways in the Project Area, including the coastal marine waters of Penang Channel, and especially to protect the recreational beach areas.

(e) Because combined sewers are normally deeper than storm channels, excavation costs will be increased. Further, pumping up from greater depths would be required, thus increasing pumping station and power costs to levels usually exceeding costs for separate storm and sanitary sewer systems added together.

(f) Because traffic conditions in the Project Area are often critical, excessive disruption of traffic and normal activities during construction of deep and large sewers, will generally be greater with a combined sewer system.

(g) Recommended Conveyance System

For the above reasons and on the basis of field surveys of the existing drainage facilities, it is recommended that the sewerage conveyance system for the Project Area be basically a separate system, but as an interim measure, combinations of sanitary sewers, storm sewers, and temporarily combined sewers be adopted in the areas where local drains are already provided, until such time when financing of a complete separate system is possible.

4.3 Treatment and Disposal Process

It has been described in Appendix I that drains and rivers in the municipal have already become polluted to be depository nightsoilds, sewage, industrial waste and garbage generated, and then discharging into rivers and/or sea.

If no steps are taken to alleviate waste loads discharged to them, these areas are expected to be further contaminated, and degraded in the future.

It is now necessary to consider what role treatment should play within a sanitary sewerage programme and where the collected and suitably treated waste waters should be disposed of.

Generally, there are essentially two alternatives to be considered, for final disposal.

(1) Discharge into a river and a short outfall into shallow waters near the beach, with a high Level of treatment (secondary treatment) and (2) discharge through an ocean outfall extending a considerable distance offshore, with only a minimum level of treatment as needed to supplement a purifying action of the ocean.

However, the results of the study described in Appendix F was concluded to be needed the treatment plant in this Project Area, it is as that no ocean outfall is desirable treatment system, then a high degree of secondary treatment would be proposed.

(a) Comparison of Treatment and Disposal process.

A study was made to select the most reasonable disposal system in this project area, from the method of (1) stabilization pond process, (2) aerated lagoon process, (3) oxidation ditch process, as discussed in Appendix G, by the consideration of the local conditions such as possibility of land acquisition, availability of skilled labours, conditions of receiving water and the cost.

For each alternative, costs for construction and operation and maintenance were estimated and compared. The results of which show that the alternative of stabilization pond process is by far the most economical in confirming that the best plan for waste disposal at the project area. This alternative has considerable advantage in that,

(1) This process is the most economical sewerage treatment and disposal system particulary, as regarding costs of construction and maintenance as discussed in Appendix G.

(2) Sufficient land in this project area is available, which enable stagewise expantion as population projection increase even huge proposed land acquisition, if the required land area is not available on site, the process will be easily modified to the snother method, such as oxidation ditch for the reduction of land requirement.

(3) Neither mechanical nor electrical equipment are necessary, which contribute to the economical financing because the major portion of the construction costs can be borne locally.

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

(5) Strong solar radiation is available throughout the year in the project site.

(b) Alternative Treatment and Disposal System.

On the basis of preceding discussion, it is concluded that stabilization pond process is the most suitable treatment and disposal system to consyruct the each of sewerage zones selected to the 20 regional sewerage system networks, from the points of economical analysis studied and local conditions.

However, if the required land is not available on site, this process which needs the huge land acquisition is at a disadvantage to be compared the other methods, such as aerated lagoon, and oxidation ditch processes. Thus, the evaluation was made to set out the stabilization pond for each of sewerage zones divided into 20 regional sewerage zones, then, it was found that zone 1 and 2 of Butterworth District, and zone 2 of Seberang Jaya District do not have available land area for the construction of stabilization pond.

Therefore, for these areas including neighbouring area, it considered to be treated by another method with the combination of some sewerage zones, in terms of satisfying land acquisition and economical analysis of treatment system alternatives.

As discussed in Appendix B , a study was confirmed to be confined the areas of that Zones 1, 2 and 3 of Butterworth, and zones 1, 2 and 4 of Seberang Jaya district is to be planned by the conveyance system considered, and considerable alternatives for treatment system are described as belows.

Case 1. Considered these sewerage zones consist of independent treatment systems are constructed at the zones 1 and 3 of Butterworth District, and zones 1 and 4 of Seberang Jaya District. These treatment systems are planned and estimated by the stabilization pond process except the zone 1 of Butterworth District are compared by the process of stabilization pond, aerated lagoon and oxidation ditch due to available land area confined.

Case 2. The three independent treatment systems are considered to be constructed at the zone 3 of Butterworth District, zones 1 and 4 of Seberang Jaya District. These treatment systems also are planned by the stabilization pond process, while the zone 1 of Seberang Jaya District is compared by the process of stabilization pond, aerated lagoon and oxidation ditch.

A comparison of alternative was made on the basis of each regional sewerage system selected including the sanitary sewer system and treatment system, with respect to their capital, operation and maintenance costs, as well as effects on water pollution of water ways, to identify the most economical disposal system achieving the desired results.

(c) Recommended Process

It is evident from an examination of the study results that stabilization pond process has a substantial economic benefit to be compared the all other alternative considered.

However, where no sufficient land for stabilization pond was found then oxidation ditch process would be accepted to meet the proposed land acquisition and economical factor in the study of alternative considered as discussed previously.

Hence, therefore, stabilization pond and oxidation ditch processes, in order to meet the required benefits to each of sewerage zones, are considered to be recommendable.

4.4 Industrial Wastewater Treatment

4.4.1 Consideration on Joint Treatment with Domestic Sewage

Municipal sewage generally includes domestic sewage and industrial wastewaters. Usually, biological treatment methods are used to employ for the treatment, and they are capable of removing organic matters, such as mineral and organic matters in various forms contained in the industrial water.

The primary purpose of wastewater treatment is to prevent injury to receiving waters. For this purpose, the treatment plant should be composed of a suitable unit process and operated under good maintenance to eliminate pollutional component to the desired level.

However, depending on the composition and characteristics of industrial wastes, it may be necessary to rearrange the unit or to put another method as compared with normal sewage treatment process, and perticularly, in case of objectionable matters as oil, gasoline and flammable solvents, concentrated acids and poisonous substances consideration should be given to protect a conduit system and treatment processes to avoid corrosion, clogging, explosion, or other damage regulating action may be required to control the quality of the inflowing industrial wastes into municipal sewerage system.

Such action may include in principal, the following consideration, for which pre-Treatment procedures will be required:

1) To exclude objectionable wastes from the sewerage system
2) To regulate the rates at which potentially dangerous wastes may be admitted to conduits
3) To prescribe the degree of pretreatment in the factory site before the wastes discharge into municipal sewers.

4.4.2 Sewerage System Recommended

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

Here in this report, stabilization pond oxidation ditch process as one of biological treatment methods is recommended, because of its capability to give adequate treatment for current domestic wastes and industrial wastes from the scattered areas, together with easy maintenance and cheaper cost, as mentioned before, most industrial wastes are amenable to treatment with domestic sewage, and the joint treatment system is recommendable in the scattered areas. However, for the wastes from industrial estates, careful further consideration is required to determine the method of conveyance and treatment in accordance with the kind of wastes to be produced.

4.4.3 Projected Industrial Wastes and their Treatment in the Future

According to the data collected and the results of field survey by NSC (see ANNEX E), amount and quantity of the industrial wastes being estimated in the year of 2000 are as follows :

1) Average daily flow from the sewerage zone

No of zone	cu m/d	domestic sewage cu m/d
Butterworth district		
1*	1600	10450
3[i)]	8500	8520
Seberang Jaya district		
1*	160	10750
2[ii)]	4000	5790
Prai district		
1[iii)]	85040	

Note: * isolated factories:

i) Mak Mandin Industrial Estate

ii) Seberang Jaya Complex

iii) Prai Industrial Complex (including Prai Industrial Estate, Prai Free Trade Zone, Prai Wharves Free Trade Zone, and other industrialized Prai Area)

2) Waste strength as described in terms of BOD and SS, average strength is estimated a uniform stated below

BOD .... 150 ppm

SS .... 150 ppm

3) Characteristics of the wastes
Most of wastes are produced from food industries and textile industries, these wastes may treatment with ordinary method as stated before.

On the basis of the information stated above, the ratio of the industrial wastes to the domestic sewage of that zone 3 in Butterworth district and zone 2 in Seberang Jaya district are approx. 1 : 1 and 1 : 1.4 respectively, and the wastes from Prai Complex is solely composed of industrial wastes. The characteristic of the wastes seems to become fairely different from the domestic sewage only, and it may affect the performance of the treatment process. This seems to suggest that pre-treatment facilities have to be seriously considered in the future before the wastes discharge into sewers and then to the treatment plant in order to adjust to the presently proposed stabilization pond/oxidation ditch process.

The required level of pretreatment might be in accordance with "Guidelines for Evaluation of Industrial Waste Water Effluents", Anti-Pollution Comittee, Federal Government, Malaysia.

This subject matter however has to the carefully followed in the future, taking into consideration of the progress of development including increase of industrial establishment in quantities and qualities.

Cahpter 5

DESIGN BASES

5.1 Wastewater Volume and Strength

5.1.1 Domestic Sewage

On the basis of the data and discussions in APPENDIX E, the future domestic sewage flow rate and strength are estimated as follows:

Table III - 6 Estimated Per Capita Sewage Flow, BOD, and SS

Year	Flow	BOD	SS
1976	200 l/cap/day	36 g/cap/day	20 g/cap day
1980	206	38	23
1985	212	40	26
1990	218	42	30
1995	224	44	33
2000	230	46	46

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

For sewer design purposes, 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 densities for the zone included in its tributary area, based on the future land use and population density distribution.

5.1.2 Industrial Wastes

On the basis of the data and discussions in APPENDIX E, the wastewater production in industrial zone is estimated at 80 cu m/ha/day, which will be distributed over the total 1,242 ha., industrial zone expected to be developed by the year 2000, according to the developed land use plan for Project Area.

As described in APPENDIX B, wastewater characteristics of different industry groups are estimated, but for the purposes of master planning, it is assumed that in general the future industrial wastewater flows will have essentially the same characteristics as municipal sanitary sewage.

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

5.1.3 Extraneous Water

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

As discussed in APPENDIX E, 18 cu m/km/day is considered to be a fair estimate of the extraneous flows to sewers, including groundwater and surface water infiltration from public sewers and house connection, through broken manholes, etc..

This should be adquate since the sewer joints specified for the project are of rubber ring type for concrete pipes and of the factory applied resident type for clay pipes, both types affording an almost bottle-tight system.

5.1.4 Overall Volume

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

5.2 Design Criteria

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 is used. Some important elements to be considered in designing sewer capacity are reviewed in Appendix D.

A minimum size of 225 mm is adopted for sanitary sewers, but for house connexion 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 for VCP, based on the Manning equation using an 'n' value of 0.013. For RCP or any cement-bonded pipe material, for an 'n' value of 0.013, a minimum velocity of 75 cm/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 for cement-bonded pipes, and 60 cm/sec for VCP. The recommended minimum slopes for sanitary sewers are presented in Appendix D.

All sewers are designed not to exceed a velocity of flow of 3 m/sec, to protect against sewer erosion. Where the ground slope is steep and a velocity may come up to more than 3 m/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 smaller sewer joins 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 unless special protection measures against the expected load are provided.

Chapter 6

SEWERAGE SYSTEM

6.1 Description of Individual Sewerage District

Area and present population of each sewerage district are separately described as follows (more detailed descriptions are in Appendix B):

(1) Butterworth Sewerage District

	Area (ha)	Persons	Persons/ha
Zone - 1	367	37,920	103
Zone - 2	182	3,585	20
Zone - 3	457	28,255	62
Zone - 4	444	26,332	59
Zone - 5	551	3,961	7
Zone - 6	670	8,902	13
Total:	2,671	108,955	41

(2) Seberang Jaya Sewerage District

	Area (ha)	Persons	Persons/ha
Zone - 1	438	13,657	31
Zone - 2	305	69	0.2
Zone - 3	510	2,991	6
Zone - 4	430	7,518	11
Zone - 5	368	4,369	12
Total:	2,051	28,604	14

(3) Prai Sewerage District

	Area (ha)	Persons	Persons/ha
Zone - 1	1,063	1,860	2
Zone - 2	268	1,974	7
Total:	1,331	3,834	3

(4) Bukit Mertajam Sewerage District

	Area (ha)	Persons	Persons/ha
Zone - 1	892	7,559	8
Zone - 2	715	6,387	9
Zone - 3	927	45,540	49
Zone - 4	467	6,077	13
Zone - 5	459	7,257	16
Zone - 6	573	13,840	24
Zone - 7	768	9,947	13
Total	4,801	96,607	20

6.2 Design Sewerage Facilities

6.2.1 Design of Main and Submain Sewers

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 was determined on the basis of the available state plan or other development programme plans.

In deciding the capacities of main and submain sewers, the area to be served by each sewer was calculated on the basis of available maps in the scale of 1/7500, 1/10000 and 1/25000. Flows were calculated on the basis of the projected population densities for the year 2000, plus industrial wastes contributions and extraneous flows including ground-water infiltration.

All sewers are designed to give mean velocities when flowing full or half-full, of not less than 60 cm/sec for VCP, based on the Manning formula using an 'n' value of 0.013, but for RCP or any cement-bonded pipe material, the minimum design velocity of flow of 75 cm/sec is specified, in order to prevent 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 can be expected that sulfide control will be major problem.

6.2.2 Design of Branch and Lateral Sewers

The branch and lateral sewers are to be generally laid following, insofar as possible, lines of maximum available surface slope.

Although the layout maps of the branch and lateral sewers are not prepared for the purposes of master planning, for the major branch and lateral sewers which are influential in determining the invert elevations of main and submain sewers, profiles are prepared to examine whether main or submain sewers can receive the sewage from the tributary. Maps used for this planning are those of 1/7500, 1/10000 and 1/25000 scales. These maps are also adjusted for ground elevations on the basis of topographic survey carried out during this project, to indicate current conditions.

Housing and industrial estate development programmes are currently underway by MCPW and PDC, however, for most of these areas the road network plans are still at the preliminary planning stage and is expected another few years will be needed to establish the final plans. Routing of branch and lateral sewers for these areas, therefore, are planned on the basis of the presently available data and may be subject to minor change at the later stage when the final plan is made. Because the relative timing for implementation of some of these development plans and for construction of sewers are still unknown, the final design and construction of branch and lateral sewers for these areas must be coordinated with secondary sewers and urban planning, road construction and any urban development, and detailed studies of population, land use and industrial wastes. Detailed surveys of lines, levels, and grades will be necessary before final design and construction.

Branch and lateral sewer sizes have been estimated on the basis of the projected population densities, per capita sewage flow rates, industrial waste productions, and extraneous inflows, projected for the year 2000 conditions.

Sewers are designed to have mean flow velocities, when flowing full or half-full, of not less than 60 cm/sec for VCP, and for concrete or cement bonded pipes not less than 75 cm/sec, to prevent sulfide build up in the sewers.

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 metre, except for specific situations where shallower depth is feasible.

6.2.3 Manholes

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

Sewer Diameter (mm)	Maximum Manhole Spacing
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.

6.2.4 Type and Materials of Sewers

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 are designed on the basis of centrifugally-cast reinforced concrete pipes, but smaller sewers, less than 375 mm in diameter, 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, all branch and lateral sewers are designed with circular sections, with a minimum diameter of 225 mm.

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

6.2.5 House Connexions

Households within areas provided with separate sewer service will be connected with street 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 street sewers to minimize infiltration and root penetration. Although layouts and profiles for these pipes are not prepared for master planning purposes, an average house connexion pipe length for individual household is estimated at 15 metres. To meet the future needs of unsubdivided properties, wyes or tees are to be installed at intervals, with the locations selected using the best judgement at the time as to the likely development of the nearby properties.

6.2.6 Pumping Stations

Some of general items considered in the design of sewage pumping stations are presented below:

(a) Type

Sewerage 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 the expected peak flow, with some allowances for abnormal sewage increases. Enough storage capacity is to be provided in wells, especailly where automatic controls and variable speed drives are not furnished, to balance pumping rates with inflow 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 each station. The number of pumps 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, so that with any 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 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 and Disposal Systems

On the basis of the preliminary studies described in Appendix B, and taking into account various other influential factors, it is concluded that stabilization pond and oxidation ditch processes are most suitable treatment system to be envisaged for the Project Area.

The proposed sewage treatment and disposal systems can be divided into three basic categories and some of general items considered in the design of sewage treatment plants are described as below.

a) Treatment and disposal process

1) Primary treatment

Primary treatment is the first major treatment in a waste water treatment works consisting of screening and sedimentation by the facilities of pumping station with grit chamber depending upon flow rate scale, and sedimentation tank.

Removed of BOD and SS up to 30 percent can be expected.

It may be followed by secondary treatment.

2) Secondary treatment

Secondary treatment is the treatment of waste water by biological method after primary treatment by the facilities of stabilization pond an/or oxidation ditch with secondary sedimentation tank. Treatment by stabilization pond works by natural conditions involving the action of algae and bacteria under the influence of sunlight (photosyntheses) and air. In order to facilitate repairs, maintenance and flexibility in operation, it is proposed that stabilization pond have to distribute with at least more than two ponds provided in parallel, depending upon the magnitude of the flow and the topography of the site, and then considered flow partterns are of two series arrangement which calls first and second ponds, due to in the interest of avoiding anaerabic conditions in the first pond, and hence it is recommended that the first pond is kept at 65 percents of the total pond area.

Oxidation ditch is essentially modification of the activated sludge process.

Considered this method of aerobic stabilization takes waste water which may have received primary treatment and circulates it in a closed circuit ditch aerated by mechanical aerators. Solids are removed in a clarifier after circulation in the ditch, then final clarifiers and chlorination requirements would be proposed by the second sedimentation tank same as for the activated sludge plants.

These facilities mentioned above, both the stabilization pond and oxidation ditch with second sedimentation tank would be expected to remove the BOD of up to 20 mg/l, in a properly designed and efficiently operated plant. While the actual BOD of effluents of stabilization pond was estimated as of 31 mg/l discussed in Appendix B .

3) Sludge disposal process

In the sewage treatment processes both the stabilization pond and oxidation ditch, sludge are produced that must be disposed of in an inoffensive manner.

There are two type of sludge that must be processed in the proposed treatment facility. They are raw primary sludge removed from promary sedimentation tank and secondary sludge removed from secondary sedimentation tank, however sludge in the process of stabilization pond be only taken to be produced from primary sedimentation tank.

It is recommended for the sludge disposal system that primary and/or mixing of primary and secondary sludges be treated in a two stage anaerobic digester, then dumped into drying bed also recommended.

The digester recommended is unheating digester to be anticipated desired degree of temperature as of 30°C approximately in the Project Area climate.

The final disposal for sludge after drying is considered to be disposed into filling of swamps and barging to the sea, however, these disposal may be no longer suitable in the future, the sludge may be disposed of by incineration. This is a generally high capital cost process, and operation and maintenance costs also are high.

A complete solids incineration facilities should be investigated to determine the later stage.

b) Design Flow

Design of treatment process units shall be based on the daily average rate of sewage flow, except the pumping station would be expected peak flow.

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

c) 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 be received from the contribution areas including commercial residential and industrial.

Estimated qualities of BOD and SS are as of 200 mg/l respectively.

d) Quality of Effluent

Treatment plant effluents may be discharged into a drain, river and/or to directly ocean. The required degree of treatment shall be based on the ability of the receiving waters to assimilate the waters and the use to which of the receiving water are put.

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

The selection of the type of treatment process involved must be such as to meet these requirement, so that stabilization pond and oxidation ditch processes would be proposed to be expected the protection of all essential environmental values.

For the design, expected sewage quality of the effluent in terms of BOD is as of 20 mg/1.

e) Construction

1) Sedimentation Tank

Both the primary and secondary sedimentation tank are circular in shape, and are provided with hopeers for the collection of sludge. These tanks are equipped with mechanical sludge-collecting device.

They are constructed with substantial flat bottoms and have sludge hoppers with relatively steep side, and a stable structure required to be constructed from reinforced concrete.

2) Stabilization Pond

Pond shall consist of the first and second pond to be constructed separately due to different function, and at least two units of the pond both the first and second pond depending upon the magnitude of the flow, shall be constructed in parallel to substitute each other in case one/s are blocked with sediment of sludge.

The pond shall be constructed by excavation and embankment with earth. Bank shall be sloped at 1/3, and further to avoid percolation and ground water pollution, sealing of the pond bottom is considered with blanket of clayey soil or other local material.

3) Oxidation Ditch

It is concluded that the ditch is a long continuous channel, and equipped with mechanical aerator placed across the channel.

Reinforced concrete for the channel constructed is applied to prevent damage due to high turbulence by the aerator.

4) Digester

It is recommended that digestion tank is cylindrical in shape with inverted conical bottom, and constructs from re-inforced concrete.

5) Drying Bed

It is concluded that drying bed is concrete lining basins receiving digested sludge from digestion tank, and recommended depth is as of 20 cm for the sludge storage basin.

6.3 Proposed Sewerage Systems

As described in Appendix B, entire Project Area is divided into 20 sewerage zones, and as the first step for the analysis, 20 independent sewerage systems including separate sanitary sewers, pumping stations, and stabilization pond treatment process are considered.

Then, among these zones, where no sufficient site area for stabilization pond process is available, and if it is more economical than transporting the sewage to next zone and treat sewage together, oxidation ditch process is adopted.

And, for industrial waste treatment, oxidation ditch process is recommended.

As the result of alternative considerations seventeen treatment plants by the process of stabilization pond and one treatment plant by the process of oxidation ditch, are considered necessary for the Project Area by the year 2000.

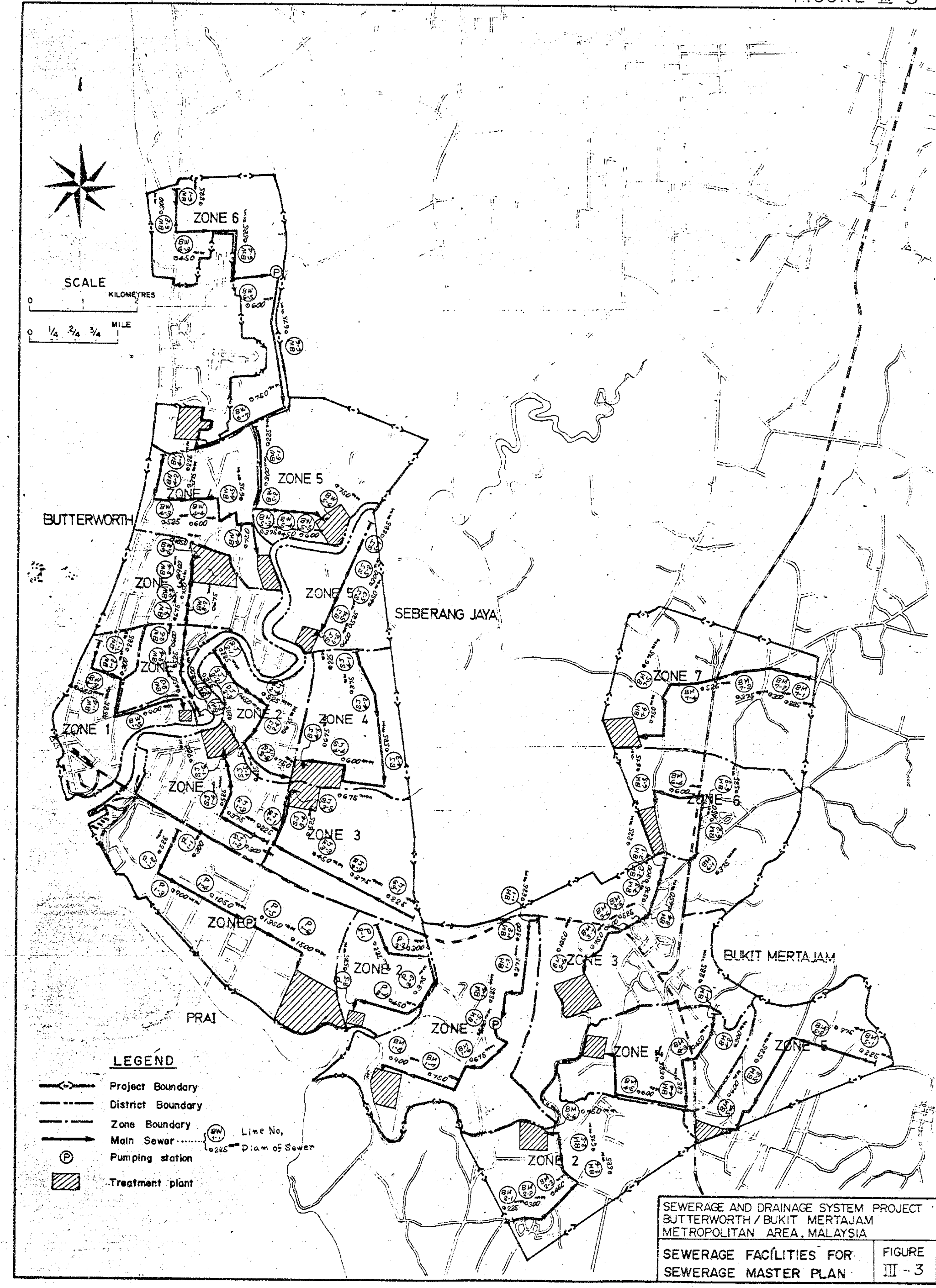
One treatment plant by the process of oxidation ditch would be required for the zone 1 of Butterworth District,

one treatment plant by the process of stabilization pond would be required with combination of zones and 3 of Butterworth, and zones 2 and 4 of Seberang Jaya Districts respectively, and

the other for the remainder of sewerage zones also would be required and recommended the treatment plant in each sewerage zone by the stabilization pond process.

Site possibilities for treatment plant locations were investigated under the present project, and the locations were selected on the site of water ways nearby for discharging directly from the treatment plant treated.

Figure III-3 and Table III-7 show the proposed sewerage system in each sewerage zone. Flow charts of represented stabilization pond and oxidation ditch processes are presented in Figure III-4.

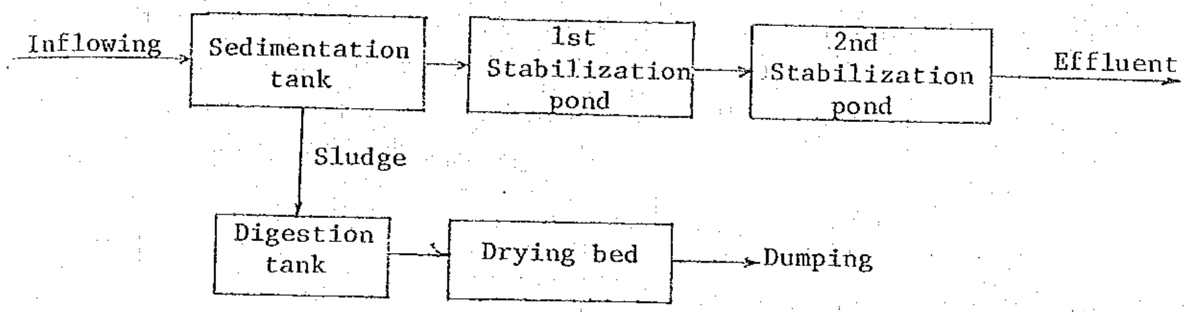

SCALE
KILOMETRES
0 1 2
MILE
0 1/4 2/4 3/4 1
ZONE 6
ZONE 5
ZONE 4
ZONE 3
ZONE 2
ZONE 1
ZONE P
BUTTERWORTH
SEBERANG JAYA
PRAI
ZONE 7
ZONE 6
ZONE 3
ZONE 2
ZONE 1
ZONE 4
ZONE 5
ZONE 2
BUKIT MERTAJAM
LEGEND
Project Boundary
District Boundary
Zone Boundary
Main Sewer
Line No,
Diam of Sewer
Pumping station
Treatment plant
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
SEWERAGE FACILITIES FOR
SEWERAGE MASTER PLAN
FIGURE
III - 3

Name of Sewerage zone	Sewer (public)		Sewer (house connexion)		Pumping station		Treatment plant			Receiving Water
	diam. (mm)	Length(m)	diam(mm)	Length(m)	Peak flow (cu m/s)	Required land area (m^2)	Process	Daily average flow (cum/day)	Required land area (ha)	
Butterworth, zone-1	225 - 900	92200	150	110800			OD	15,800	5.2	Prai river
" zone-2	" - 600	54600	"	65500			} SP	28,700	56.1	
" zone-3	" -1050	116800	"	125700						Drain
" zone-4	" - 750	133200	"	111100			SP	13,000	27.0	Prai river
" zone-5	" - 750	165300	"	98200			"	12,500	26.0	"
" zone-6	" - 750	201000	"	108000	0.18	100	"	14,100	29.1	Drain
Seberang Jaya, zone-1	" - 900	131000	"	140000			"	15,800	32.3	Prairiver
" zone-2	" - 750	82000	"	88700			"			
" zone-3	" - 675	153000	"	76500				10,200	21.6	Drain
" zone-4	" - 675	129000	"	70800			"	21,300	42.7	Drain
" zone-5	" - 600	110400	"	55200			"	7,400	16.1	Prai river
Prai, zone-1	" -1500	116900	"	148800	0.89	1540	"	90,400	160.9	Juru river
" zone-2	" - 525	80400	"	40200			"	5,400	12.0	"
Bukit Mertajam, zone-1	" - 900	267600	"	137200	0.14	90	"	18,100	36.8	"
" zone-2	" - 750	214500	"	115200			"	15,000	30.8	"
" zone-3	" -1050	278100	"	217800			"	25,900	51.1	"
" zone-4	" - 600	140100	"	71900			"	9,500	20.2	"
" zone-5	" - 600	137700	"	68900			"	9,200	19.6	Drain
" zone-6	" - 675	171900	"	95600			"	12,400	25.8	"
" zone-7	" - 750	230400	"	115200			"	15,300	31.4	"

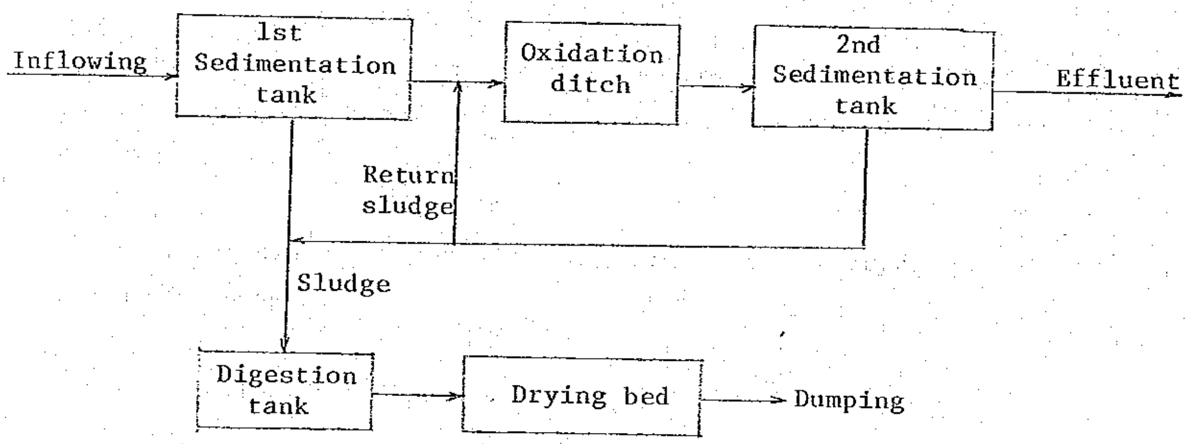
Note : SP ..... Stabilization pond process
OD ..... Oxidation ditch process

FIGURE III-4 Flow Chart

(1) Stabilization pond process



(2) Oxidation ditch process



6.4 Staging of Construction

6.4.1 Development of Construction Programme

As described in Chapter 2 of PART III, the sewerage implementation area to be served by the sewerage system by the year 2000 should include all the sewerage zones which consists of residential, commercial and industrial areas, covering a total area of 10,854 ha (excluding nonhabitable areas from total area of 11,600 ha).

Considered project period is of 20 years including design and construction implementation years starting in 1981 divided into four continuous stage, and will be feasible both from technical and financial viewpoints.

Accordingly, consideration was given to determine the most viable staging of sewerage system construction for the project area, taking into account the following important factors.

1) Degree of need for the sewerage system, number of persons who will benefit, cost of construction, and possible generation of revenue.

2) Relationship of the proposed construction to preceding and subsequent stages.

3) Availability of financing.

4) Availability of materials and capability of local and foreing contractors.

5) Relative independence between the sewage and storm water system.

6) Other socioeconomic consideration.

6.4.2 Priorities of Sewerage Construction

Construction of the sewerage system will be divided into four consecutive stages up to the year 2000.

The first stage programme will be of six years' duration including one year for engineering and preparatory work for implementation of the project and five years for construction. Five years are allowed each for the Second, Third and Fourth Stages for the construction.

In determining the priority of the sewerage system construction, various factors are taken into consideration.

First the project area was divided into 20 regional sewerage zones, taking into account such salient factors as location of administrative boundaries, rivers and canals, ground slopes, railways and etc, as shown in Figure III-2 .

The names of sewerage districts and/or numbers of zone# are as follows:

District	Zone	Area (ha)
Butterworth	1	390
	2	200
	3	490
	4	450
	5	570
	6	670
Seberang Jaya	1	480
	2	360
	3	510
	4	430
	5	420
Prai	1	1,230
	2	280

- to be continued -

District	Zone	Area (ha)
	1	940
	2	730
	3	980
BuKit Mertajan	4	470
	5	490
	6	660
	7	850

Each of the sewerage zones was then studied as to its characteristics, considering seven important elements which affect sanitary conditions in the Project Area, and using an arbitrary rating procedure believed to assign reasonable relative weights to these various parameters. Thus the seven elements were assigned points to reflect their relative importance to sanitation, and each of the 20 sewerage zones was examined and graded for each element representing the degree of adequancy from the viewpoint of sewerage construction priority.

The seven important elements considered and assigned points for the ratings are as follows:

(1)	Population Density ....-........	400
(2)	Waste Load Production Aspects	250
(3)	Excreta Disposal System	100
(4)	Flooding	100
(5)	Housing and Industrial Development Programs.	50
(6)	Availability of Water Supply	50
(7)	Incidence of Water-Borne Diseases	50
		Total 1,000 points

As mentioned above, a total of 1,000 points was assigned to each of seven major elements, according to order of important, as described below.

(1) One of the most important factors is the number of persons who will be benefited by the system, it is, therefore, particulary significant to provided sewerage facilities in high population density area, in order to gain the maximum benefit with the minimum expenditure, thus making the benefit-cost ratio higher. Hence, highest point was assigned for the population density.

(2) Second highest point was assigned for the waste load production aspects. In view of Project Area, waste load produced from the housing, commercial and industrial area are generally discharged into drains and rivers without passing through the treatment plant, except the septic tank, while no comprehensive water pollution control programme covering the whole project area has been provided, hence it is necessary to establish the control of the waste load discharged into drains and rivers.

(3) Since there is no sanitary sewerage system in the Project Area, except a few local systems, practically all of the excreta produced in the area is disposed of either septic tank, bucket, pit privy or directly to waterways, while the existing excreta disposed system also was analyzed from the view point of environment, and then third highest point was assigned.

(4) Although the government has undertaken improving existing streams and drains, flooding has frequently occurred causing samage to the built-up urban areas. These areas which have significantly affecting the sanitary conditions should be improved by provision of sewerage system.

Therefore, flooding factor also was given to same as weighted points of excreta disposal system assigned.

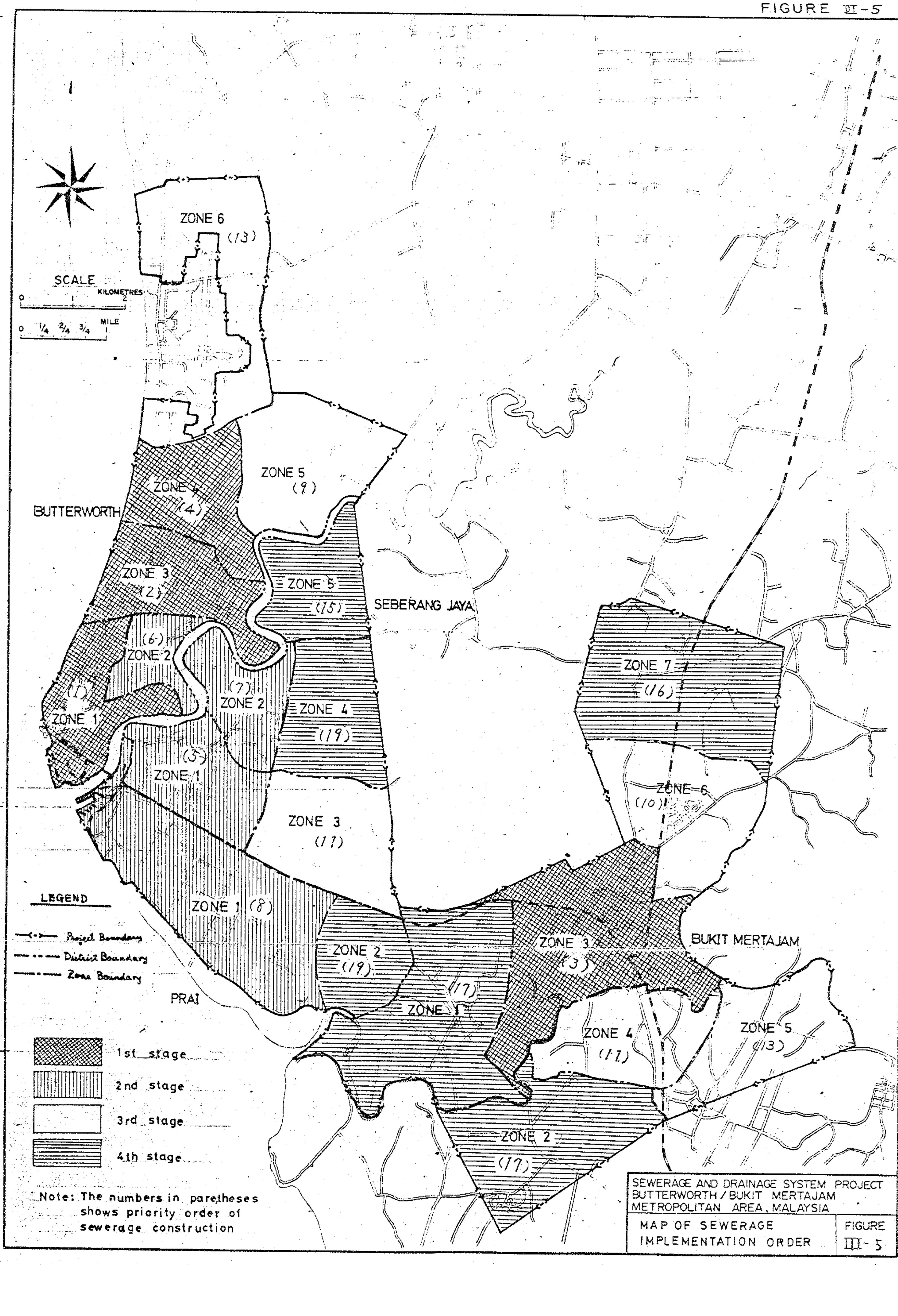
The remaining element, namely, (5) housing and industrial development programmes, (6) availability of water supply, and (7) incidences of water borne diseases also effect to sanitation problems, but these are less critical than four categories.

The result of rating indicates that the zone 1 of Butterworth District has the highest total number of points, representing the combined rating for all the seven elements followed by the zone 3 of Butterworth, zone 3 of Bukit Mertajan Districts and so forth as listed below.

Priority of Construction	District	Zone	Assigned Points
1	Butterworth	1	815
2	"	3	650
3	Bukit Mertajan	3	560
4	Butterworth	4	540
5	Seberang Jaya	1	437
6	Butterworth	2	365
7	Seberang Jaya	2	315
7	Prai	1	315
9	Butterworth	5	232
10	Bukit Mertajan	6	205
11	Seberang Jaya	3	188
11	Bukit Mertajan	4	188
13	Butterworth	6	186
14	Bukit Mertajan	5	186
15	Seberang Jaya	5	185
16	Bukit Mertajan	7	182
17	Bukit Mertajan	1	181
17	"	2	181
19	Seberang Jaya	4	180
19	Prai	2	180

On the basis of these studies, four sewerage zones, namely, zones 1, 3 and 4 of Butterworth, and zone 3 of Bukit Mertajam Districts, are included in the first stage programme of sewerage construction.

The implementation of sewerage construction in other sewerage zones will also be staged in accordance with the priority determined in this study. Details of the study are described in Appendix H, "Staging of Sewerage Construction", and also illustrated in Figure III-5.


ZONE 6
(13)
SCALE
KILOMETRES
0 1 2
MILE
0 1/4 2/4 3/4 1
ZONE 5
(9)
BUTTERWORTH
ZONE 4
(4)
ZONE 3
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ZONE 5
(15)
SEBERANG JAYA
(6)
ZONE 2
(7)
ZONE 2
ZONE 7
(16)
(1)
ZONE 1
ZONE 4
(19)
(5)
ZONE 1
ZONE 6
(10)
ZONE 3
(11)
LEGEND
Project Boundary
District Boundary
Zone Boundary
ZONE 1 (8)
ZONE 2
(19)
ZONE 3
(3)
BUKIT MERTAJAM
PRAI
(17)
ZONE 1
ZONE 4
(11)
ZONE 5
(13)
1st stage
2nd stage
3rd stage
4th stage
ZONE 2
(17)
Note: The numbers in paretheses
shows priority order of
sewerage construction
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
MAP OF SEWERAGE
IMPLEMENTATION ORDER
FIGURE
III-5