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MALAYSIA

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MASTER PLAN

FOR

SEWERAGE AND DRAINAGE SYSTEM PROJECT

BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA

MALAYSIA

VOLUME I

SUMMARY REPORT

MAY 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of Malaysia, the Government of Japan decided to conduct a study on the master plan of the sewerage and drainage project in Butterworth/Bukit Mertajam metropolitan area in Penang State, and the Japan International Cooperation Agency (JICA) carried out the study.

The Government of Malaysia places high priority on the elevation of people's welfare against the background of its steady economic growth. Under such a policy, the construction of sewerage and drainage facilities in Butterworth/Bukit Mertajam area was planned in order to improve the living environment of the people.

The JICA dispatched a survey team to Malaysia for on-the-spot survey and data collection from 27th October to 30th December, 1976. After submitting and explaining the interim report in May and the draft final report in December, 1977, the JICA has completed the present report.

I sincerely hope that this report would contribute to the construction sewerage and drainage facilities in the said area and serve to strengthen the friendly relations existing between our two countries.

I wish to express my deep appreciation to the Malaysian Authorities concerned for their cooperation and hospitality extended to the teams dispatched by the JICA.

May 1978

Shinsaku Hogen
President
Japan International Cooperation Agency

ORDER OF PRESENTATION

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List of Abbreviations

(a) Unit

cu m	-	Cubic meters
cu m/day	-	Cubic meters per day
cu m/day/cap	-	Cubic meters per day per capita
cu m/sec	-	Cubic meters per second
g/cap	-	Grams per capita
g/day	-	Grams per day
ha	-	Hectares
IG	-	Imperial gallon
IGD	-	Imperial gallons per day
kg	-	Kilograms
km	-	Kilometers
l/day	-	Liters per day
l/day/cap	-	Liters per day per capita
m	-	Meters
mg/l	-	Milligrams per liter
MIGD	-	Million imperial gallons per day
mm	-	Millimeters
ppm	-	Parts per million
sq m	-	Square meters
yr	-	Years

(b) Organization

DID	-	Drainage and Irrigation Department
EG	-	Engineering Department, Local Government of Penang Island
EPU	-	Economic Planning Unit, Prime Minister's Department Federal Government
LD	-	Labour Department, PSG
MHD	-	Medical and Health Department, PSG
MPSP	-	Majlis Perbandaran Seberang Perai (Municipal Council Province Wellesley)
PDC	-	Penang Development Corporation
PSG	-	Penang State Government

PWA	-	Penang Water Authority
PWD	-	Public Works Department, PSG
SEPU	-	State Economic Planning Unit, PSG
TCP	-	Town and Country Planning, PSG
WHO	-	World Health Organization

(c) Others

BOD	-	Biochemical oxygen demand (5 day, 20 centigrade)
COD	-	Chemical oxygen demand
CPI	-	Consumer Price Index
DMP	-	Design Master Plan
DO	-	Dissolved oxygen
GNP	-	Gross National Products
HP	-	Hume Pipe
M$	-	Malaysian Dollars
pH	-	Hydrogen ion potential
PMP	-	Preventative Master Plan
PV	-	Permanganate Value
PW	-	Province Wellesley
RCP	-	Reinforced concrete pipe
RL	-	Reduced Level
SMP	-	Second Malaysia Plan
SOD	-	Survey Ordinance Datum
SS	-	Suspended Solids
TMP	-	Third Malaysia Plan
VCP	-	Vitrified clay pipe

Conversion Tables

(a) Length (1)

m	cm	Yards	Feet	Inches
1	100	1.0936	3.2808	39.370
0.01	1	0.0109	0.0328	0.3937
0.9144	91.440	1	3	36
0.3048	30.480	3.3333	1	12
0.0254	2.540	0.0278	0.0833	1

(b) Length (2)

km	Yards	Miles
1	1,093.61	0.62137
0.00091	1	-
1.60934	1,760	1

(c) Area

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

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

(d) Volume

Liters	cu m	cu ft	Imp.gal.(IG)
1	0.001	0.03531	0.220
1,000	1	35.31	220
28.317	0.02832	1	6.231
4.546	0.004546	0.1605	1

(e) Weight

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

(f) Velocity

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

(g) Rate of Flow

1/sec	cu m/hr	cu m/sec	Imp.gal./min	cu ft/hr	cu ft/sec	Imp.MGD	cu m/day
1	3.6	0.001	13.198	127.13	0.03531	0.01901	86.4
0.2778	1	2.778×10^{-4}	3.666	35.31	9.810×10^{-3}	5.279×10^{-3}	24
1,000	3,600	1	1.3198×10^{4}	1.2713×10^{5}	35.31	19.01	86,400
0.07578	0.2728	7.577×10^{-5}	1	9.632	0.002676	1.440×10^{-3}	6.547
7.866×10^{-3}	0.02832	7.866×10^{-6}	0.10381	1	2.778×10^{-4}	1.495×10^{4}	0.6796
28.32	101.94	0.02832	373.7	3,600	1	0.5383	2,447
52.61	189.41	0.05261	694.4	6,688.2	1.858	1	4,546
0.01157	$4,167 \times 10^{-2}$	0.1157×10^{-4}	0.1528	1.471	4.087×10^{-4}	2.200×10^{-4}	1

I. INTRODUCTION

A. Project Background

In the Penang Master Plan prepared for the Penang Master Plan Committee in 1970, it was proposed to establish a metropolitan area in Province Wellesley, which includes the two towns of Butterworth and Bukit Mertajam. According to the Plan, such metropolitan area would be well established by the year 1985. On the basis of this, the Project Area of the present report for Sewerage and Drainage Master Plan is defined basically as the Butterworth/Bukit Mertajam Metropolitan Area with total area of 11,600 ha (28,663 acres), excluding the airbase.

In 1976, some 238,000 people live within the Butterworth/Bukit Mertajam Metropolitan Area of approximately 11,600 ha. During this century, the Area has experienced a high growth rate in population, due to the rapid increase of commercial and industrial activities, far out-stripping the national average. Because of its attractive setting, the area is expected to continue its growth, reaching a population of 648,000 by the year 2000 according to our projection.

Rising standards of living and increase of industries have caused, and will continue to cause an increasing rate of consumption of water with the attendant increased burden of waste discharges to the natural waterways and sea. The current wastewater discharge within the Project Area is estimated at approximately 110,000 cu m/day and is expected to increase at a rate exceeding that of population growth and to reach a level of over 340,000 cu m/day by the year 2000. At present, most of the wastewaters are discharged into the rivers and drains flowing into Penang Channel.

There is at present no sanitary sewerage system in the Project Area except limited small scale communal systems. Most of the domestic sewage and industrial wastes are discharged directly to drains and other available waterways, or in case of human excreta from homes, after passing through septic tanks, they find their ways into the open ditches or are collected through bucket system. Thirty percent of houses within the urban area and 7 percent of houses within the rural area have septic tank systems for excreta disposal. The remainder of the houses dispose of their human wastes either by means of pit latrines or buckets.

The discharge of most of the municipal wastes without treatment, is causing increased pollution in the existing rivers and drains while flowing through the two areas, particularly during the low flows in the dry seasons, and are eventually polluting the beaches and offshore marine waters. Such conditions have resulted in adverse biological effects, odours and nuisances. It is evident that the pollution will become more apparent by the year 2000 if no action is taken to alleviate the wastewater burden to the waterways.

For the past several years, public interest has become more sharply focused on the need for clean water bodies to satisfy the need for rapidly increasing land development with better sanitation facilities for living condition, to provide the capability for water oriented recreation, and to conserve the natural qualities of the environment. Both the Government of Malaysia and the Penang State Government have commenced intensive programme to prevent and improve the deteriorated of the environmental conditions in Penang State, including water pollution control on the waterways, sanitation improvement and flood control of major rivers and drains in Metropolitan Area.

The magnitude of the problem of disposal of wastewater and the importance of maintaining a desirable minimum level of quality in the river and marine waters of Penang State, with due consideration on magnitude of expenditures needed for these purposes, requires careful long range planning and immediate implementation programme.

The provision of an adequate sewerage and drainage systems for Butterworth/Bukit Mertajam Metropolitan Area for the year 2000 poses problems both technical and managerial. The task is of such magnitude as to require a formal long-range projected programme consisting of four staged undertakings sequenced over a period of 20 years. This report submitted herewith contains the results of a comprehensive study of the problems and its practical solution in the form of a master plan for the proposed ultimate system. This comprises the overall scope of work within which individual stages may be scheduled and implemented with due effectiveness for the measured progress in orderly and reasonable manner towards an ultimate goal of the Project.

This report includes and incorporates the results of field investigations, surveys, population forecasts, and interrelated technical and management studies, which broadly establish the basis of a multi-staged programme for the future development of the sewerage and drainage systems within the Project Area. The total programme is envisaged to give sufficient impact for improvement of environmental sanitation of the Area by providing adequate facilities for wastewater control programme inclusive of prevention of water pollution, which will undoubtedly contribute to enhance rapid development of the Area for commercial, industrial and residential purposes.

B. Purpose and Scope of the Study

The main purpose of the study is to develop a master plan of sanitary sewerage and drainage systems for Butterworth/Bukit Mertajam Metropolitan Area:

(a) To develop comprehensive long-range plans for the solution of existing sewerage and drainage problems in Butterworth/Bukit Mertajam Metropolitan Area.

(b) To achieve improvement in institutional arrangement in coordination of efforts in the technical areas.

To carry out the Project, Japan International Cooperation Agency (JICA) has identified the following specific study objectives, with major consideration to be given to the period from 1977 to 2000:

(a) Establish a master plan for the development of economically viable sewerage and drainage system in which the elements of work necessary are forecast and generally defined in successive stages to meet the present and future needs of the Project Area up to the year 2000, compatible with sound projections of population increase, housing development, water consumption and water system expansion, income growth, and other national and local socio-economic factors affecting the future of Province Wellesley.

(b) Undertake studies and formulate recommendations regarding the proper organization, an agency of department to carry out the planning, construction, operation, maintenance, management and administration of a sewerage and drainage system for the Project Area, together with proper legislative provision to provide sound legal basis for all the activities proposed.

(c) Submit project reports, including:

1) Progress report at the end of data collection at the project site.

2) Draft and final reports on the Master Plan for the Sewerage and Drainage System Project.

II. FINDINGS

A. Present Conditions of the Project Area

(1) At present, entire Project Area is classified into six land use categories: a) industrial, b) social and commercial, c) residential, d) rural, e) agricultural, and f) others. These are illustrated in Figure 1, and acreage of each category is shown in Table 1.

Table 1 Land Use in the year 1976

Land Use Pattern	Area (ha)
Social and Commercial	85
Residential	913
Industrial	844
Rural	3,484
Agricultural	4,049
Others	2,225
Total	11,600

(2) For the sewerage master planning purposes a total area of 10,854 ha (26,820 acres) is considered, excluding non-habitable areas such as, cemeteries, rivers, etc. For drainage master planning purpose, outside of the Project Area of 4,290 ha (10,600 acres) are taken into account, mainly due to topographical conditions, thus the total area considered for drainage system planning is 15,890 ha (39,260 acres).

(3) On the basis of 1970 National Census and by summation of ourselves for the Project Area, the population of the Project Area in 1970 is estimated to be 172,230. The population in 1976 is then estimated to be 238,000, assuming an 5.5 percent annual increase as in case of the Penang Master Plan.

(4) Province Wellesley, in which the Project Area is situated, is essentially a flat alluvial plain, lying below RL+15m (+50 feet), being interrupted by patches of hilly land at its south-eastern border. The highest point of these hills is in the Bukit Mertajam,

which is RL+536m (1,787 feet) and is located south-east end of the Project Area. These hills are formed in Mesozoic, Post Triassic Period and their formation is granite.

The Project Area is dominated by the Prai and Juru rivers, but is typified by natural river profiles meandering amongst tidal and fresh water swamps. With controlled drainage and irrigation, the Area is agriculturally productive and well suited to a variety of crops including rice, coconuts, pineapples, rubber and oil palms.

(5) Temperature is relatively constant throughout the year and the average monthly temperature varies by about 2°C (4°F). However, the daily temperatures show a greater variation of 5°C to 8°C (10°F to 15°F), with a mean day time maximum of 29°C (85°F) and a mean minimum of 22°C (71°F) at night.

(6) Heavy rain was recorded during the months of September, October and November. According to the rainfall records obtained in five years from 1965 through 1970, the total precipitation during these months was 810 mm (31.9"), accounting for 37 percent of the average annual rainfall of 2,172 mm (85.5").

(7) The economy of whole Malaysia, inclusive of Project Area, has recently been remarkably improved by the vigorous government effort for the exploitation of affluent natural resources. In line with the economic development, the industrialization has been emerged as important economic sector to accommodate the increasing labour force.

The third Malaysia Plan (1976~1980, has been launched and development expenditure of the government is expected to increase for the consecutive years, reflecting the government's emphasis on the improvement of infrastructural facilities.

(8) Penang is presently at a stage of its economic development as it is currently undergoing a process of economic restructuring, necessitating by its desire for economic growth and advancement. This economic restructuring has successfully been implemented by the strong support of both the State and the Federal Governments. In the Project Area, it is evident that industrial developments are significant and quite a number of factories are in operation in Mak Mandin and Prai industrial areas. With the implementation of these industrial development programmes, the State will attract more and more investors which will enable the State to significantly increase in the Gross Regional Product and at the same time increase in population.

(9) The results of the surveys indicate that the effect of pollution by domestic, industrial and other sources has been evident in waterways of the area surrounded by commercial and residential zones and also in offshore marine waters facing the industrial zones suggesting the need for implementation of the comprehensive sewerage programme with due consideration on industrial waste control at the earliest possible date.

(10) Existing individual excreta disposal systems in the Project Area are mostly bucket system and/or septic tank with flush toilet. About 30 percent of the population in urbanized areas of the Project Area use flush toilet with septic tank, and from 60 to 70 percent of population use bucket system, while Kampongs (villages) generally use pit privies and others.

Sludge from septic tank is transported by vacuum lorries (desludgers) to trenching ground for burial. V-trenches of 1 m (3 ft) depth are dug and filled with sludge, and when full, they are covered with earth and levelled. Human excreta collected in bucket is dumped at the restricted site.

(11) One general hospital, eight hospitals, 11 maternity hospitals, and 13 main health centers, excluding private clinics, are in Penang State. Generally, they are distributed adequately.

According to the record obtained from the Government District Hospitals/Clinics, the largest number of patients of water-borne diseases is of infectious hepatitis, followed by of dysentery and typhoid fever.

(12) Water supply conditions in Province Wellesley are generally satisfactory in terms of quantity and quality. The entire Province Wellesley is already covered by main pipe lines, and therefore, all of the population in the Province may soon be covered in the foreseeable future.

(13) About 80 percent of the Project Area is the tributary of the Prai and Juru rivers and the remaining parts discharge to the sea via existing numerous natural and piecemeal improved water course. Generally, the existing drains are with meandering alignment with varied widths and depths, which require need for improvements. The predominant topographical features of the area are low-lying and flat influencing most of the existing drains by the tide, which are commonly provided with tidal gates to prevent the flooding or damages to agricultural products due to the sea water. Average elevation in the Project Area is about RL+2.0 meters (+6.5 ft) while major areas lie below the RL+1.0 meter (3.0 ft). The recorded mean high tide of the sea level was RL+1.1 meters (+3.6 ft) and the maximum was RL+1.68 meters (+5.5 ft).

(14) Due to the rapid development, numerous swamps now functioning as reservoirs for controlling considerable flooding of the Area are demolishing. As a result, significant increase of the peak discharge of stormwater runoff is expected in the future. It is also observed during field surveys that even the existing drains have been or are to be overloaded by on-going development programmes especially in two urban areas, Butterworth and Bukit Mertajam.

B. Result of Studies

In pursuance of the ultimate objective of improving environmental sanitary conditions throughout the Project Area, investigations have been made into the adequacy of the existing waste disposal and drainage facilities, and methods whereby deficiencies can be eliminated.

On the basis of the results of the investigations, basic design bases for the system have been developed in relation to project implementation, population estimates, wastewater productions, stormwater runoffs, characteristics of wastewaters, and design standards for the facilities. These basic aspects are summarized in the following:

(1) According to the plan envisaged by the Government, the whole Project Area should be essentially urbanized and no rural and agricultural areas should remain by the target year. Entire Project Area is currently classified into six categories, i.e. industrial, social and commercial, residential, rural, agricultural and others (nonhabitable). This is planned to be developed into four categories in the target year of 2000 converting the present rural and agricultural areas to urbanized areas due to the reduced swamp area owing to the land development programmes.

Taking the above conditions into account, the land use plan for the year 2000 is developed and agreed with the Government, as shown in Table 2 and Figure 2.

Table 2 Land Use in the year 2000

Land Use Pattern	Area (ha)
Industrial	1,289
Social and Commercial	168
Residential	9,397
Others	746
Total	11,600

(2) An anticipated population of the Project Area in 1985, based on the projection of Penang Master Plan, is 385,000, which will further increase, with reduced rate of 3.5 percent to 545,000 in 1975 in accordance with the Assignment Report of WHO. Taking the above data into account, the population in the year 2000 is projected to be 648,000, as shown in Table 3. (Ref. Chapter 3 of Part III, Volume II)

Table 3 Projected Population in the Project Area

Year	Population	Averqge Annual Growth Rate (%)
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) Average per capita sewage flow rates, both at present and in the future, have been estimated at 170 l/day/cap (37 IG/day/cap) and 230 l/day/cap (50 IG/day/cap) respectively on the basis of the results of field surveys and studies. (Ref. Chapter 5 of Part III, Volume II)

(4) On the basis of the field surveys, both the average BOD and SS of the domestic sewage in the year 2000 are estimated at the range of about 200 mg/l. In view of the present conditions, the average strength of combined industrial waste water discharged to the public sewers in the year 2000 is estimated at around 150 mg/l both for BOD and SS. (Ref. Chapter 5 of Part III, Volume II)

(5) For the purpose of sewerage planning, after considering several alternatives, whole Project Area is divided into four sewerage districts, namely, Butterworth, Seberang Jaya, Prai, and Bukit Mertajam. They are further divided into 20 sewerage zones, as shown in Table 4, considering geographical, topographical, demographical and other conditions, so that the works for overall system and design individual facilities can be made. (Ref. Chapter 2 of Part III, Volume II)

Table 4 Proposed Sewerage Districts and Zones

Name of District	Name of Zone	Area (ha)	Covered by Sewerage (ha)
Butterworth	Zone - 1	390	367
"	" - 2	200	182
"	" - 3	490	457
"	" - 4	450	444
"	" - 5	570	551
"	" - 6	670	670
Seberang Jaya	Zone - 1	480	438
"	" - 2	360	305
"	" - 3	510	510
"	" - 4	430	430
"	" - 5	420	368
Prai	Zone - 1	1,230	1,063
"	" - 2	280	268
Bukit Mertajam	Zone - 1	940	892
"	" - 2	730	715
"	" - 3	980	927
"	" - 4	470	467
"	" - 5	490	459
"	" - 6	660	573
"	" - 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, and cemeteries from the entire Project Area of 11,600 ha (28,660 acres).

(6) In line with the proposal in the Assignment Report of WHO and accounting existing watershed and general features of land use, the Project Area is divided into six drainage basins for the convenience of drainage system planning. The drainage basins are further divided into 45 sub-basins, as shown in Table 5, considering topographical conditions. (Ref. Chapter 1 of Part IV, Volume II)

Table 5 Proposed Drainage Basins and Sub-Basins

(ha)

Basin	Name of Sub-basin	Area	Area Contributing from Outside of the Project Area	Total
I		1,073	55	1,128
	Sungai Kubang Semang			
	Ulu Drain			
	Tengah Drain			
	Petani Drain			
	Sungai Tuan Abdullah			
II		3,793	1,669	5,462
	Sungai Rambai			
	Sungai Ara			
	Tanah Drain			
	Paya Drain			
	Bukit Mertajam Drain			
	Sungai Pasir			
	Sungai Pekan Bharu			
	Sungai Kelang Ubi			
	Binjal Drain			
	Ubi Drain			
	Cherok Drain			
	Bharu Drain			
	Minyak Drain			
	Pmtg Kebun Siren Drain			
	Bukit Tengah Drain (B)			
	Bukit Tengah Drain (C)			
	Bukit Tengah Drain (D)			
	Juru Drain			
III		3,964	993	4,957
	Bukit Tengah Drain (A)			
	Sungai Derhaka To Panjang			
	Sungai Derhaka			
	Seberang Jaya Drain			
	Lubok Bunral Drain			
	Sama Cagah Drain			
IV		1,656	42	1,698
	Butterworth Drain (A)			
	" (B)			
	" (C)			
	" (D)			
	" (E)			
V		570	1,063	1,633
	Sungai To Sani			
	Jaya Drain			
	Merah Drain			
	Sungai Lokan			
	Manggis Drain			
VI		544	468	1,012
	Benggali Drain			
	Bagan Tambang Drain			
	Gelam Drain			
Total		11,600	4,290	15,890

(7) Using the estimated population densities by land use as shown in Table 6 and the land use pattern for the year 1976, the population of each sewerage district and zone is estimated and then the year 2000 is projected. Present and projected population of sewerage zone is shown in Table 7. (Ref. Chapter 3 of Part III, Volume II)

Table 6 Estimated Population Density by Land Use Pattern

Land Use Pattern	Population Density (persons/ha)
Social and Commercial (Public building)	0, 120, or 160
Social and Commercial (Commercial)	120
Residential (Built-up urban)	160
Residential (New housing)	120
Residential (Others)	52
Industrial	0
Others (Non-habitable)	0

Table 7 Projected Population of Sewerage Zone

Name of Sewerage Zone		Population (persons)	
		1976	2000
Butterworth	- 1	37,900	45,400
	- 2	3,600	21,800
	- 3	28,200	37,100
	- 4	26,300	37,600
	- 5	4,000	33,700
	- 6	8,900	37,300
Sub-Total		108,900	212,900
Seberang Jaya	- 1	13,600	46,700
	- 2	100	25,200
	- 3	3,000	26,500
	- 4	7,500	20,800
	- 5	4,400	19,200
Sub-Total		28,600	138,400
Prai	- 1	1,900	-
	- 2	2,000	13,900
Sub-Total		3,900	13,900
Bukit Mertajan	- 1	7,600	47,500
	- 2	6,400	39,800
	- 3	45,500	73,700
	- 4	6,100	24,900
	- 5	7,300	23,900
	- 6	13,800	33,000
	- 7	9,900	40,000
Sub-Total		96,600	282,800
Total		238,000	648,000

III. RECOMMENDATIONS

A. Proposed Plans

(1) Sewerage

(a) The sewerage system should be principally a separate system, but as an interim measure, combination of sanitary sewers, storm sewers and partially combined sewers be adopted in the areas where local drains are already provided, until such time when financing of the complete separate system is possible. (Ref. Chapter 4 of Part III, Volume II)

(b) The physical facilities recommended for sewerage system to be developed includes, (i) system of sanitary main, branch and lateral sewers, (ii) pumping stations, and (iii) sewage treatment facilities in the form of stabilization pond process. However, if the required land area for stabilization pond process becomes not available in some of built-up areas in the future, the process will be easily modified to other processes such as aerated lagoon or oxidation ditch. (Ref. Chapter 4 of Part III, Volume II)

(c) Industrial wastewater is also taken into account for sewerage planning. Factories in the Project Area may be classified into two forms, i.e. the one is those scattered within the Area and the other for those concentrated in group in the form of industrial estates. Major polluters of the factories are of food, palm oil, rubber and textile industries generally discharging high BOD and SS which can be, in principle, treated by biological treatment methods. The joint treatment with domestic wastes using stabilization pond is recommended for current industrial wastes from the view point of economy and stability of effluent, although necessary counter measures will be taken in accordance with the future changes in characteristics of the industrial wastes. (Ref. Chapter 4 of Part III, Volume II)

(d) 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. Sewers more than 300 mm (12 in.) in diameter should generally be of centrifugally-cast reinforced concrete pipes either coated or lined by suitable materials. (Ref. Chapter 6 of Part III, Volume II)

(e) Recommended sewerage system plan is shown in Figure 3. This plan is based on data obtained from field surveys conducted under this project and available topographic and other map. 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 programmes.

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. Average flow rate of each sewerage zone is shown in Table 8. (Ref. Chapter 6 of Part III, Volume II)

Table 8 Average Flow Rate of Sewerage Zone

Name of Sewerage Zone		Average Flow Rate (cu m/day)
Butterworth	- 1	15,800
	- 2	7,200
	- 3	21,500
	- 4	13,000
	- 5	12,500
	- 6	14,100
Seberang Jaya	- 1	15,800
	- 2	12,900
	- 3	10,200
	- 4	8,400
	- 5	7,400
Prai	- 1	90,400
	- 2	5,400
Bukit Mertajam	- 1	18,100
	- 2	15,000
	- 3	25,900
	- 4	9,500
	- 5	9,200
	- 6	12,400
	- 7	15,300

(2) Drainage

(a) The drainage system is proposed to comprise open channels, and reservoirs together with land filling. Stormwater will be collected through roadside drains, then flows to main drains discharging either directly into the Prai river, Juru river or to the sea. These drains are to be improved under this project but using to the fullest extent the existing natural water courses throughout the Area.

(b) In built-up area of Butterworth and Bukit Mertajam, open channels with enough capacity of conveying stormwater runoff from the Initial Storm (caused by the rainfall intensity of 2 or 5-year return period) are proposed (Ref. Figure IV-2 and 3). In Butterworth area, construction of two reservoirs is also proposed as the preferable alternative system. For undeveloped areas, the storage system to prevent major damage from major storm (100 year return period) is proposed to reduce the peak flow rates of the stormwater runoff.

(c) Recommended drainage system plan is shown in Figure 4. This plan is based on data obtained from field survey conducted under this project and available topographic and other map.

Stormwater quantities are calculated by "Rational Formula" with a storage coefficient using which is recommended in the Malaysian Standards. (Ref. Chapter 3 of Part IV, Volume II)

B. Proposed Staging of Construction

(1) Sewerage

(a) Careful consideration has been given to establish the priority for implementation of construction programme by using rating procedure for evaluation of each of 20 zones with the following assessment elements: (Ref. Chapter 6 of Part III, Volume II)

i. Population density
ii. Waste loads
iii. Availability of excreta disposal system
iv. Flooding
v. Availability of water supply
vi. Incidence of water-borne diseases

The results of the rating indicate that four sewerage zones, namely zones 1, 3 and 4 of Butterworth, and zone 3 of Bukit Mertajam sewerage districts, are among those to be given higher priority for the immediate implementation of construction. (Ref. Chapter 6 of Part III, Volume II)

(b) It is considered appropriate, on the basis of consideration on priorities referred above, to divide the total programme into four construction stages, namely, 1981-1985 (1st stage), 1986-1990 (2nd stage), 1991-1995 (3rd stage), and 1996-2000 (4th stage). For the 1st stage, zones, 1, 3 and 4 of Butterworth and zone 3 of Bukit Mertajam are recommended. (Ref. Chapter 6 of Part III, Volume II). According to government request, however, the zones which are to be covered by new housing and industrial development programme will be given higher priority for implementation of sewerage programme.

(c) The First Stage programme comprises main sewers ranging from 225 mm (9 in.) to 1,050 mm (41 in.) dia. with the total length of about 196 km (123 miles) to transport collected sewage to the treatment plant with four stabilization ponds which will discharge effluent into either the Prai or Juru rivers directly through nearby waterways. One treatment plant is proposed for each of the four zones, each having the different capacity in accordance with the estimated volume of wasterwater. (See Figure 3)

(2) Drainage

(a) In accordance with the urgency of the requirement, proposed drainage programme is divided into four consecutive construction stages to be implemented over 20 years. The First Stage programme is proposed in two urbanized areas, Butterworth and Bukit Mertajam. (See Figure 4, and Ref. Chapter 4 of Part IV, Volume II)

(b) The First Stage programme includes the improvement and rehabilitation of the existing major drains to utilize them as the main drains in the proposed new drainage system. The sizes of these drains range between 2,200 x 1,300 mm (7 x 4 ft) and 25,000 x 3,000 mm (82 x 10 ft) with the total length of approximately 25 km (15.5 miles). (Ref. Chapter 4 of Part IV, Volume II)

The construction of two reservoirs each with the capacity of 10,000 cu m and 17,000 cu m and a provision of the network of smaller drains in central portion of Butterworth area are also included in this stage.

C. Costs of Recommended Programme

The recommended plan for implementing sewerage and drainage systems calls for construction, operation and maintenance in the four stages. Tables 9 through 13 show the construction costs for each completion period, including both local currency and foreign currency. Operation and maintenance costs by stage are summarized in Table 14. All the construction costs include contingency of 20 percent and engineering fee of 10 percent. All costs are estimated on the basis of 1976 price levels and no escalation is considered.

TABLE 9 Total Construction Cost by Stage at 1976 Price Level

(M$ 1,000)

		1st Stage (1981-1985)	2nd Stage (1986-1990)	3rd Stage (1991-1995)	4th Stage (1996-2000)	Total
Government Contribution	Sewerage	63,250	116,850	85,300	86,200	351,600
	Drainage	68,330	8,410	38,550	111,940	227,230
	Total	131,580	125,260	123,850	198,140	578,830
Private Contribution	Sewerage	100,790	51,410	137,110	163,480	452,790
	Drainage	52,580	25,140	45,170	83,020	205,910
	Total	153,370	76,550	182,280	246,500	658,700
Grand-Total		284,950	201,810	306,130	444,640	1,237,530

TABLE 10 Total Construction Cost of First Stage at 1976 Price Level

(M$1,000)

Items	Government Contribution (*1)		Private Contribution (*2)		Total		Remarks
	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	
Sewerage System							
Main Sewers	25,980	6,500	-	-	25,980	6,500	
Branch & Lateral Sewers	-	-	47,530	11,880	47,530	11,880	
House Connections	-	-	13,560	3,390	13,560	3,390	
Pumping Stations	-	-	-	-	-	-	
Treatment Plants	7,890	1,970	-	-	7,890	1,970	
Land Aquisition	5,590	-	-	-	5,590	-	
(A) Sub-Total	39,460	8,470	61,090	15,270	100,550	23,740	
(B) Contingency	7,890	1,690	12,220	3,050	20,110	4,740	(A) x 0.20
(C) Engineering Fee							
Design	1,720	1,150	4,580	-	6,300	1,150	(A+B) x 0.05
Supervision	1,720	1,150	4,580	-	6,300	1,150	(A+B) x 0.05
Total	50,790	12,460	82,470	18,320	133,260	30,780	
Drainage System							
Main Drains	37,550	9,390	-	-	37,550	9,390	
Networks of Smaller Drains	-	-	31,870	7,970	31,870	7,970	
Reservoirs for Initial Storm	280	70	-	-	280	70	
Reservoirs for Major Storm	-	-	-	-	-	-	
Land Aquisition	4,490	-	-	-	4,490	-	
(A) Sub-Total	42,320	9,460	31,870	7,970	74,190	17,430	
(B) Contingency	8,460	1,890	6,370	1,590	14,830	3,480	(A) x 0.20
(C) Engineering Fee							
Design	3,100	-	2,390	-	5,490	-	(A+B) x 0.05
Supervision	3,100	-	2,390	-	5,490	-	(A+B) x 0.05
Total	56,980	11,350	43,020	9,560	100,000	20,910	
Grand-Total	107,770	23,810	125,490	27,880	233,260	51,690	
	131,580		153,370		284,950		

Note: (*1) Construction costs for main sewers, main drains, pumping stations, treatment plants and reservoirs, and land aquisition costs

(*2) Construction costs for branch & lateral sewers, networks of smaller drains and house connections

Estimated foreign currencies are as follows:

a. Twenty percent of all construction costs

b. For sewerage construction, 40 percent of engineering fee for construction of main sewers, pumping stations, and treatment plants, but no foreign currency of engineering fee for branch & laterals and house connections

c. For drainage construction, no foreign currency of engineering fee

TABLE 11 Total Construction Cost of Second Stage at 1976 Price Level

(M$1,000)

Items	Government Contribution (*1)		Private Contribution (*2)		Total		Remarks
	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	
Sewerage System							
Main Sewers	27,610	6,900	-	-	27,610	6,900	
Branch & Lateral Sewers	-	-	20,540	5,130	20,540	5,130	
House Connec- tions	-	-	10,630	2,660	10,630	2,660	
Pumping Stations	3,800	950	-	-	3,800	950	
Treatment Plants	17,180	4,290	-	-	17,180	4,290	
Land Aquisition	27,800	-	-	-	27,800	-	
(A) Sub-Total	76,390	12,140	31,170	7,790	107,560	19,930	
(B) Contingency	15,270	2,430	6,230	1,560	21,500	3,990	(A) x 0.20
(C) Engineering Fee							
Design	3,190	2,120	2,330	-	5,520	2,120	(A+B) x 0.05
Supervision	3,190	2,120	2,330	-	5,520	2,120	(A+B) x 0.05
Total	98,040	18,810	42,060	9,350	140,100	28,160	
Drainage System							
Main Drains	4,040	1,010	-	-	4,040	1,010	
Networks of Smaller Drains	-	-	15,240	3,810	15,240	3,810	
Reservoirs for Initial Storm	-	-	-	-	-	-	
Reservoirs for Major Storm	800	200	-	-	800	200	
Land Aquisition	330	-	-	-	330	-	
(A) Sub-Total	5,170	1,210	15,240	3,810	20,410	5,020	
(B) Contingency	1,030	240	3,050	760	4,080	1,000	(A) x 0.20
(C) Engineering Fee							
Design	380	-	1,140	-	1,520	-	(A+B) x 0.05
Supervision	380	-	1,140	-	1,520	-	(A+B) x 0.05
Total	6,960	1,450	20,570	4,570	27,530	6,020	
Grand-Total	105,000	20,260	62,630	13,920	167,630	34,180	
	125,260		76,550		201,810		

Note: (*1) Construction costs for main sewers, main drains, pumping stations, treatment plants and reservoirs, and land aquisition costs

(*2) Construction costs for branch & lateral sewers, networks of smaller drains and house connections

Estimated foreign currencies are as follows:

a. Twenty percent of all construction costs

b. For sewerage construction, 40 percent of engineering fee for construction of main sewers, pumping stations, and treatment plants, but no foreign currency of engineering fee for branch & laterals and house connections

c. For drainage construction, no foreign currency of engineering fee

TABLE 12 Total Construction Cost of Third Stage at 1976 Price Level

(M$1,000)

Items	Government Contribution (*1)		Private Contribution (*2)		Total		Remarks
	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	
Sewerage System							
Main Sewers	37,600	9,400	-	-	37,600	9,400	
Branch & Lateral Sewers	-	-	71,660	17,920	71,660	17,920	
House Connections	-	-	11,440	2,860	11,440	2,860	
Pumping Stations	180	50	-	-	180	50	
Treatment Plants	6,880	1,720	-	-	6,880	1,720	
Land Aquisition	8,810	-	-	-	8,810	-	
(A) Sub-Total	53,470	11,170	83,100	20,780	136,570	31,950	
(B) Contingency	10,690	2,230	16,620	4,150	27,310	6,380	(A) x 0.20
(C) Engineering Fee							
Design	2,320	1,550	6,230	-	8,550	1,550	(A+B) x 0.05
Supervision	2,320	1,550	6,230	-	8,550	1,550	(A+B) x 0.05
Total	68,800	16,500	112,180	24,930	180,980	41,430	
Drainage System							
Main Drains	13,660	3,420	-	-	13,660	3,420	
Networks of Smaller Drains	-	-	27,380	6,850	27,380	6,850	
Reservoirs for Initial Storm	-	-	-	-	-	-	
Reservoirs for Major Storm	9,200	2,300	-	-	9,200	2,300	
Land Aquisition	630	-	-	-	630	-	
(A) Sub-Total	23,490	5,720	27,380	6,850	50,870	12,570	
(B) Contingency	4,700	1,140	5,470	1,370	10,170	2,510	(A) x 0.20
(C) Engineering Fee							
Design	1,750	-	2,050	-	3,800	-	(A+B) x 0.05
Supervision	1,750	-	2,050	-	3,800	-	(A+B) x 0.05
Total	31,690	6,860	36,950	8,220	68,640	15,080	
Grand-Total	100,490	23,360	149,130	33,150	249,620	56,510	
	123,850		182,280		306,130		

Note: (*1) Construction costs for main sewers, main drains, pumping stations, treatment plants and reservoirs, and land aquisition costs

(*2) Construction costs for branch & lateral sewers, networks of smaller drains and house connections

Estimated foreign currencies are as follows:

a. Twenty percent of all construction costs

b. For sewerage construction, 40 percent of engineering fee for construction of main sewers, pumping stations, and treatment plants, but no foreign currency of engineering fee for branch & laterals and house connections

c. For drainage construction, no foreign currency of engineering fee

TABLE 13 Total Construction Cost of Fourth Stage at 1976 Price Level

(M$1,000)

Items	Government Contribution(*1)		Private Contribution(*2)		Total		Remarks
	Local Currency	Foreign Currency	Local Currency	Foreign Currency	Local Currency	Foreign Currency	
Sewerage System							
Main Sewers	41,520	10,380	-	-	41,520	10,380	
Branch & Lateral Sewers	-	-	85,230	21,310	85,230	21,310	
House Connec-tions	-	-	13,850	3,460	13,850	3,460	
Pumping Stations	160	40	-	-	160	40	
Treatment Plants	8,020	2,000	-	-	8,020	2,000	
Land Aquisition	3,200	-	-	-	3,200		
(A) Sub-Total	52,900	12,420	99,080	24,770	151,980	37,190	
(B) Contingency	10,580	2,480	19,820	4,950	30,400	7,430	(A) x 0.20
(C) Engineering Fee							
Design	2,350	1,560	7,430	-	9,780	1,560	(A+B) x 0.05
Supervision	2,350	1,560	7,430	-	9,780	1,560	(A+B) x 0.05
Total	68,180	18,020	133,760	29,720	201,940	47,740	
Drainage System							
Main Drains	31,380	7,840	-	-	31,380	7,840	
Networks of Smaller Drains	-	-	50,320	12,580	50,320	12,580	
Reservoirs for Initial Storm	-	-	-	-	-	-	
Reservoirs for Major Storm	36,480	9,120	-	-	36,480	9,120	
Land Aquisition	-	-	-	-	-	-	
(A) Sub-Total	67,860	16,960	50,320	12,580	118,180	29,540	
(B) Contingency	13,570	3,390	10,060	2,520	23,630	5,910	(A) x 0.20
(C) Engineering Fee							
Design	5,080	-	3,770	-	8,850	-	(A+B) x 0.05
Supervision	5,080	-	3,770	-	8,850	-	(A+B) x 0.05
Total	91,590	20,350	67,920	15,100	159,510	35,450	
Grand-Total	159,770	38,370	201,680	44,820	361,450	83,190	
	198,140		246,500		444,640		

Note: (*1) Construction costs for main sewers, main drains, pumping stations, treatment plants and reservoirs, and land aquisition costs

(*2) Construction costs for branch & lateral sewers, networks of smaller drains and house connections

Estimated foreign currencies are as follows:

a. Twenty percent of all construction costs

b. For sewerage construction, 40 percent of engineering fee for construction of main sewers, pumping stations, and treatment plants, but no foreign currency of engineering fee for branch & laterals and house connections

c. For drainage construction, no foreign currency of engineering fee

TABLE 14 Operation and Maintenance Cost at 1976 Price Level

(M$1,000/year)

Classification	Area	1st Staged Area	2nd Staged Area	3rd Staged Area	4th Staged Area	Whole Area
Government Contribution	Sewerage, Sewer (main)	330	350	470	560	1,710
	Sewer (branch & lateral)	720	310	1,080	1,300	3,410
	Pumping Station	-	110	30	20	160
	Treatment Plant	250	310	260	270	1,090
	Drainage, Drain (main)	590	740	930	1,210	3,470
	Drain (small)	280	450	610	830	2,170
	Sub-Total	2,170	2,270	3,380	4,190	12,010
Private Contribution*	Sewerage, House Connection	400	310	340	410	1,460
	Drainage -	-	-	-	-	-
	Sub-Total	400	310	340	410	1,460
Total		2,570	2,580	3,720	4,600	13,470

* Operation and maintenance cost of private contribution is estimated only for house connection.

D. Benefits of the Proposed Programme

Significant benefits to public health and economy can be derived from the proposed programme, including both direct and indirect. All anticipated benefits have been evaluated on the basis of either quantifiable or non-quantifiable benefits. However, since these benefits are not fully quantifiable, non-quantifiable considerations have become important in the overall economic justification of the programme.

Evaluation of the major benefits includes avoidance of productivity losses due to water-borne diseases and avoidance of the much higher cost of controlling water pollution by other means, but, it is not possible to quantify all the benefits expected in monetary terms, and benefit to cost ratio has not been estimated. Although no b/c analysis was made, health and sanitation benefits, water pollution control benefit, benefit derived from increasing land value and other benefits are expected. If no sewerage and drainage systems were provided in the Area, sanitary conditions, which are already deplorable in many areas in the City, will become progressively worse.

E. Managerial Arrangements

(a) The managerial arrangement with due considerations on organizational framework, legal support and financial planning are made in order to introduce a new institution to be responsible for the sewerage and drainage activities in the Project Area.

(b) After reviewing existing organizations, consideration on some alternatives are attempted and a new organization is suggested with due consideration on combination of the existing agencies with the standard generally accepted for the sewerage and drainage works.

(c) The Municipal Council, Province Wellesley (MPSP), which is presently administering the Project Area will be required to be responsible for the proposed sewerage project. The drainage system project is recommended to be undertaken by tripartite agencies as Drainage and Irrigation Department (DID) and Public Works Department (PWD) of the State Government and MPSP with appropriate share of responsibility.

The Engineering Department in the Council is suggested to expand its functions adding new functional units as appropriate. The existing functional units are proposed to be involved in the new organizational arrangement to the maximum extent possible.

(d) As to the existing regulations and by-laws pertinent to proposed Project, "The Municipal Ordinance enacted as Chapter 133 of old strait Settlement in 1913", "Local Government Act. 1976", "Town and Country Planning Act. 1976" and "The Street, Drainage and Building Act, 1974" are reviewed. The provisions of above Ordinance and Acts pertinent to the work proposed are studied and major items of them are presented. "The Street, Drainage and Building Act, 1974" is considered most appropriate to be applied for the relative sewerage and drainage works although this has not yet gazetted. The certain adjustment and addition of the provisions are also recommended particularly on the industrial effluent control.

(e) Preliminary financing plan up to the year 2000 with the objective of estimating the minimum requirements for the implementation of the planned Project was worked out, and the components of the recommended financial plan are presented with basic guideline. The details will be provided in feasibility report to be prepared consecutively.

F. Implications for Further Actions and Studies

Because of the limited time available to prepare the study programme and recommended plan for positive control of water qualities in waterways of the Project Area, several special actions and investigations are necessary and urgent to provide a sound basis for detailed planning and system design. Specifically, urgent studies and actions that should be undertaken for the continued protection and improvement of the environment of the Project Area are as follows:

(a) Within the Project Area, especially in the urbanized areas, water in the drains and rivers 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 polluted and degraded in the immediate future. It is therefore recommended that the preliminary engineering and feasibility studies for the selected First Stage programme areas be commenced as soon as possible. It represents a solution to immediate problems as well as a logical basis for the best long-term solution.

(b) In the interim period, prior to the formation of the new organization for the sewerage and drainage programme, continuing advance planning will be required, and actions will be needed to begin the additional studies recommended and also to transfer technology to the staff of the organization. To perform these functions for continuity of the study activities of the Master Plan programme and to follow up the legislative requirements for additional information or clarification of materials presented in this report, it is recommended that Municipal Council Province Wellesley (MPSP) should take initiative on this matter in coordination with agencies concerned in Penang State Government and the Ministries of Local Government and Federal Territory and of Health in the Federal Government.

(c) The object of study for the Juru river is limited to the reserve requirements estimation based on standard prepared by the Government of Malaysia in accordance with the scope of works for the programme. However the Government is concerned about the organic pollution of the River and realizes the necessity of the preparation of the study programmes and recommended plan for positive control of water qualities and hydraulic and hydrological analyses of the Juru river, special actions and investigations under a separate project are necessary and urgent to establish water quality criteria and flood control programme for the river, coupled with appropriate surveillance programme for wastewaters and hydrologic data.

(d) Long-range industrial wastes control programme should be established at the eariest possible date for Prai Industrial Estate, to prevent the further water pollution in the nearby waterways of the estate, including monitoring of wastewaters produced in the factories and also establishing effluent standards for wastewater discharges.

(e) Prior to the preliminary engineering and feasibility studies for the First Stage programme, the following studies should be carried out:

i. Topographic surveys, including leveling, measuring cross sectional areas of the existing drains, and boring of the soils at the expected construction sites of major facilities.

ii. Study on waste loads estimation.

iii. Water quality survey in the waterways.

iv. Institutional and financial studies.

(f) It is recommended that regulations and laws to control the wastes discharged from the real estate development areas to the public sewer system be established immediately, including guideline or criteria for wastewater qualities and methods for treatment.

(g) Necessary actions should be taken to acquire in advance the land spaces required for the sewerage facilities proposed in the Master Plan, so that the difficulties can be avoided in obtaining enough areas for the system in the future, since the Project Area is rapidly developing and vacant lots being occupied for housing and industrial development programmes.

FIGURE 1

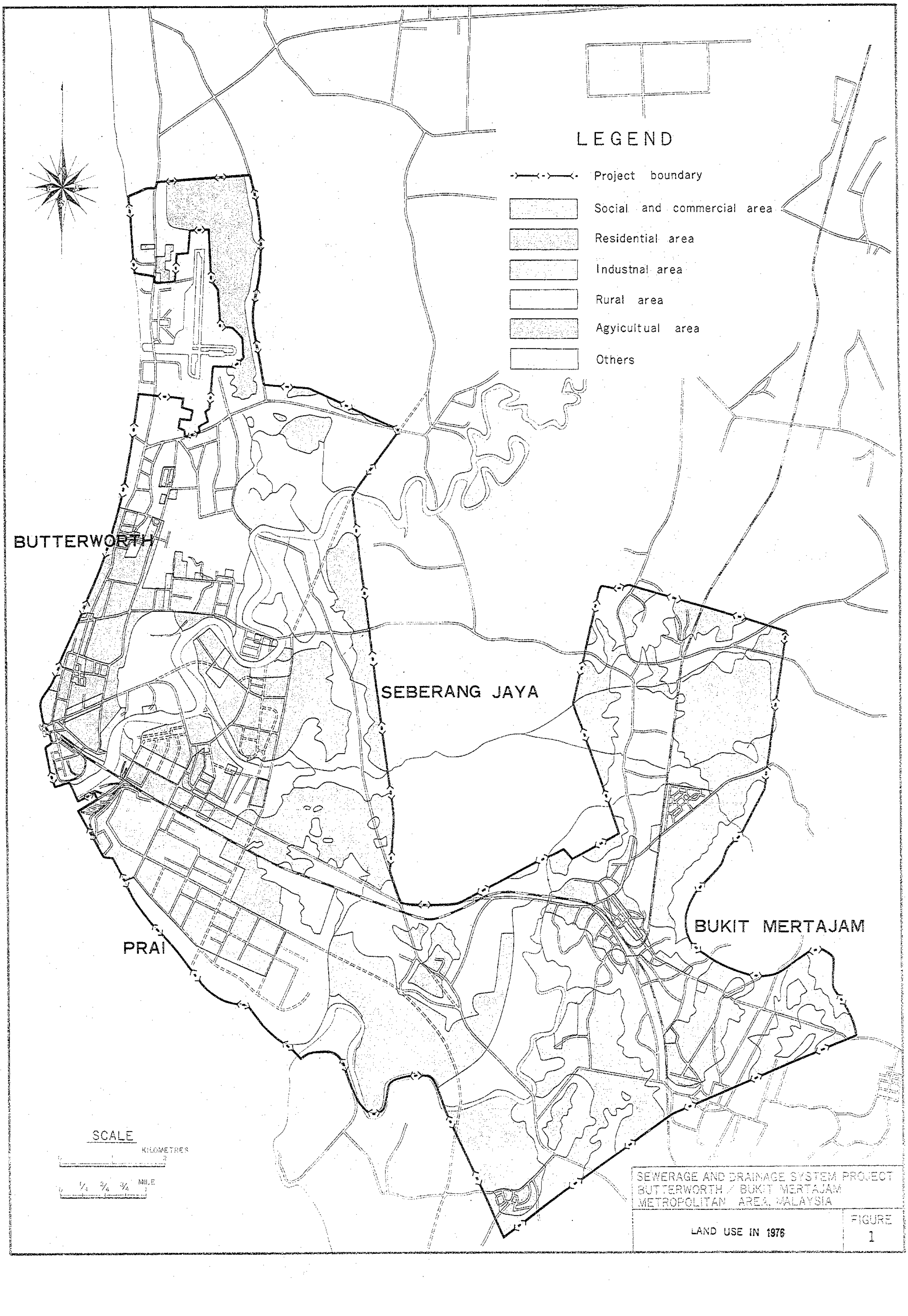
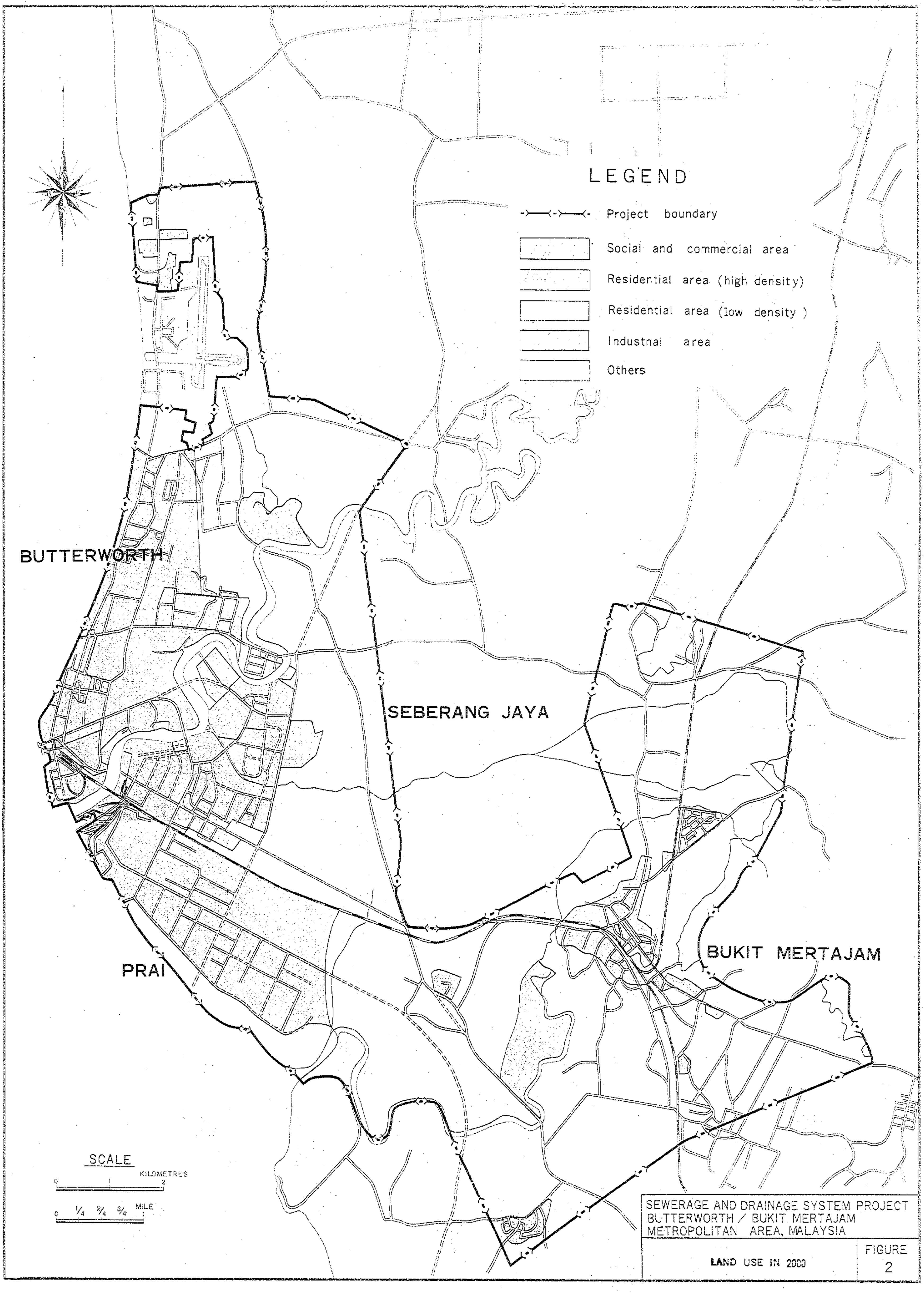
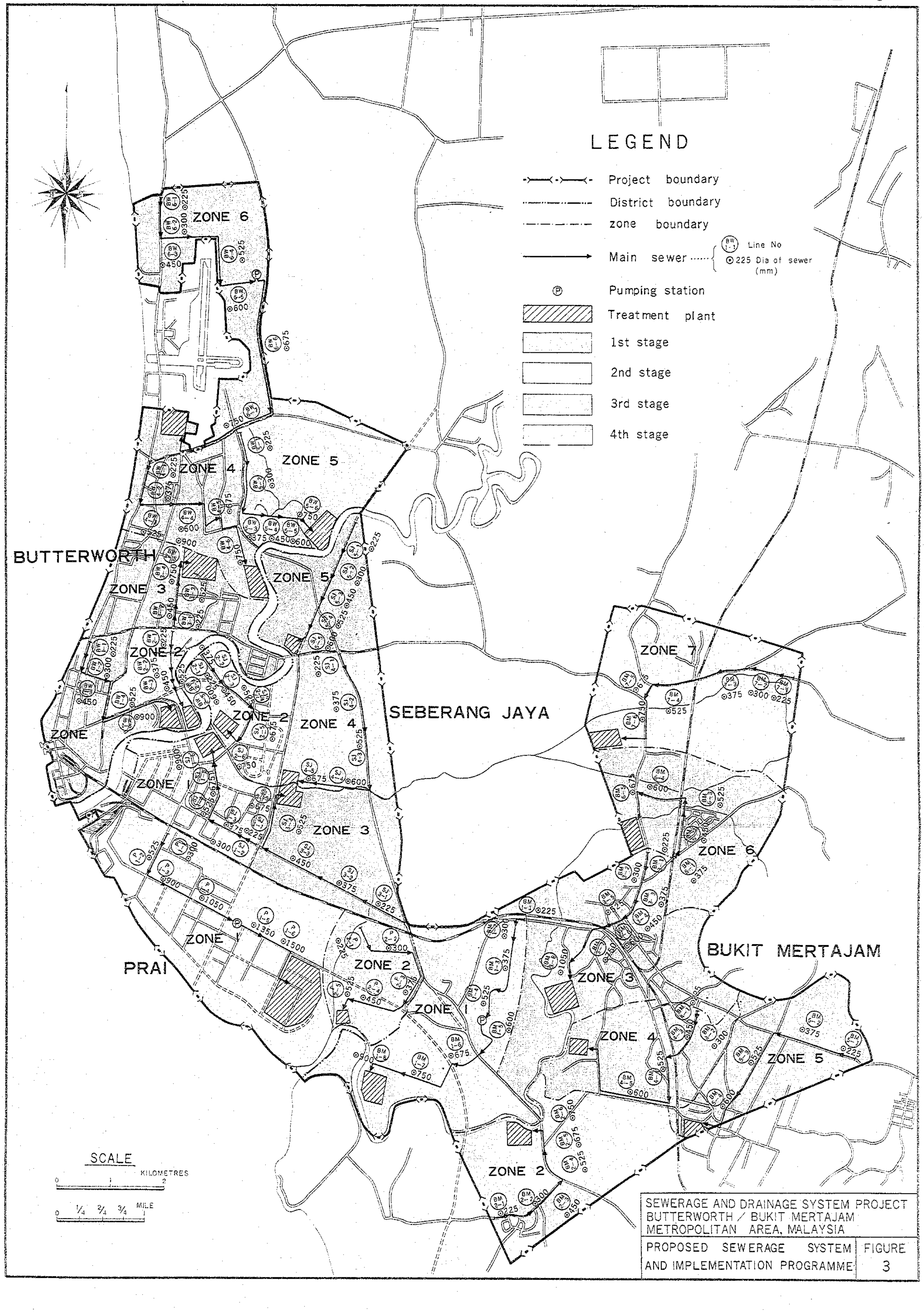
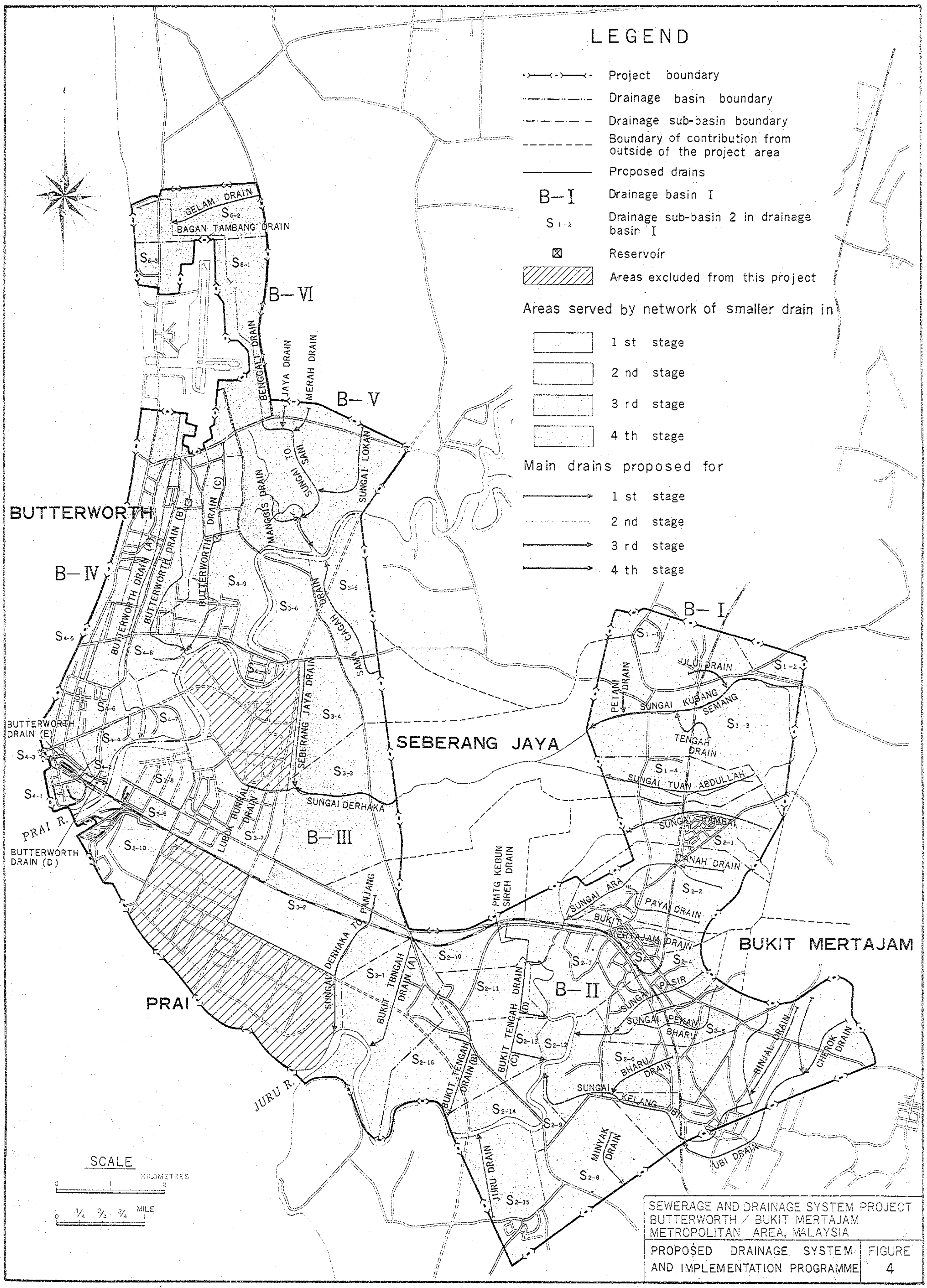

LEGEND
Project boundary
Social and commercial area
Residential area
Industnal area
Rural area
Agyicultual area
Others
BUTTERWORTH
SEBERANG JAYA
BUKIT MERTAJAM
PRAI
SCALE
KILOMETRES
MILE
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA MALAYSIA
LAND USE IN 1976
FIGURE
1

FIGURE 2


LEGEND
Project boundary
Social and commercial area
Residential area (high density)
Residential area (low density)
Industnal area
Others
BUTTERWORTH
SEBERANG JAYA
BUKIT MERTAJAM
PRAI
SCALE
KILOMETRES
0 1 2
MILE
0 1/4 2/4 3/4 1
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
LAND USE IN 2000
FIGURE
2


LEGEND
Project boundary
District boundary
zone boundary
Main sewer
Line No
225 Dia of sewer (mm)
Pumping station
Treatment plant
1st stage
2nd stage
3rd stage
4th stage
BUTTERWORTH
SEBERANG JAYA
BUKIT MERTAJAM
PRAI
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
ZONE 7
SCALE
KILOMETRES
0 1 2
MILE
0 1/4 2/4 3/4
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
PROPOSED SEWERAGE SYSTEM AND IMPLEMENTATION PROGRAMME
FIGURE 3


LEGEND
Project boundary
Drainage basin boundary
Drainage sub-basin boundary
Boundary of contribution from outside of the project area
Proposed drains
B—I Drainage basin I
S 1-2 Drainage sub-basin 2 in drainage basin I
Reservoir
Areas excluded from this project
Areas served by network of smaller drain in
1 st stage
2 nd stage
3 rd stage
4 th stage
Main drains proposed for
1 st stage
2 nd stage
3 rd stage
4 th stage
BUTTERWORTH
SEBERANG JAYA
BUKIT MERTAJAM
PRAI
B—I
B—II
B—III
B—IV
B—V
B—VI
GELAM DRAIN
BAGAN TAMBANG DRAIN
BENGGALI DRAIN
JAYA DRAIN
MERAH DRAIN
SUNGAI TO SAINI
SUNGAI LOKAN
MANGGIS DRAIN
BUTTERWORTH DRAIN (A)
BUTTERWORTH DRAIN (B)
BUTTERWORTH DRAIN (C)
BUTTERWORTH DRAIN (D)
BUTTERWORTH DRAIN (E)
SAMA CAGAH DRAIN
SEBERANG JAYA DRAIN
SUNGAI DERHAKA
LUBOK BUNRAI DRAIN
SUNGAI DERHAKA TO PANJANG
BUKIT TENGAH DRAIN (A)
BUKIT TENGAH DRAIN (B)
BUKIT TENGAH DRAIN (C)
BUKIT TENGAH DRAIN (D)
PMTG KEBUN SIREH DRAIN
JURU DRAIN
MINYAK DRAIN
SUNGAI KELANG
UBI DRAIN
BHARU DRAIN
SUNGAI PEKAN BHARU
SUNGAI PASIR
BUKIT MERTAJAM DRAIN
SUNGAI ARA
PAYA DRAIN
TANAH DRAIN
SUNGAI RAMSAI
SUNGAI TUAN ABDULLAH
TENGAH DRAIN
SUNGAI KUBANG SEMANG
PETANI DRAIN
ULU DRAIN
BINJAL DRAIN
CHEROK DRAIN
PRAI R.
JURU R.
SCALE
KILOMETRES
MILE
SEWERAGE AND DRAINAGE SYSTEM PROJECT BUTTERWORTH / BUKIT MERTAJAM METROPOLITAN AREA, MALAYSIA
PROPOSED DRAINAGE SYSTEM AND IMPLEMENTATION PROGRAMME
FIGURE 4

ANNEX - 1

PROJECT ORGANIZATION FOR THE STUDY

The members of the Steering and Technical Committee of the Government of Malaysia and the Japanese Supervisory Committee, JICA, are as follows:

(1) Steering Committee (From the committee held on the 16th May 1977)

Encik Ali Yusof	- Kementerian Kerajaan Tempatan & Wilayah Persekutuan - (Pengerusi).
Ir. A. Sekarajasekaran	- Kementerian Kesihatan.
Ir. PIERRE LAURIAULT	- W.H.O./Kementerian Kesihatan.
Ir. LUM Weng Kee	- Kementerian Kesihatan (Setiausaha).
Cik Rosmah Hj. Jentra	- Yunit Perancang Ekonomi/Jabatan Perdana Menteri.
Ir. Azizan b. Ariffin	- Pengarah Parit & Taliair Negeri P. Pinang.
Encik Teo Cheng Piau	- Pengarah Ukur, P. Pinang.
Cik Cheah Gaik Lian	- Wakil Setiausaha Kerajaan Negeri P. Pinang.
Ir. Choo Ewe Guan	- Ketua Jurutera, Majlis Perbandaran, Seberang Perai.
Encik Loo Kam Weng	- Penolong Setiausaha, Majlis Perbandaran, Seberang Perai.
Ir. Koh Kok Ee	- Pengarah Kerja Raya, P. Pinang.
Encik Fong Chek Sam	- Pengarah Perancangan Bandar & Desa, P. Pinang.

(2) Technical Committee (From the committee held on 13th and 14th May 1977)

Ir. A. Sekarajasekaran (Chairman)	- Kementerian Kesihatan.
Ir. Ooi Teik Boon	- Majlis Perbandaran P. Pinang.
Ir. Choo Ewe Guan	- Majlis Perbandaran, Seberang Perai.
Ir. Koh Kok Ee	- Pengarah, J.K.R., P. Pinang.
Ir. Azizan b. Ariffin	- Pengarah, J.P.T., P. Pinang.

Ir. Khoo Soo Hock	- Ibu Pejabat J.P.T., (Planning Branch).
Ir. Kenneth V. Lewis	- Ibu Pejabat J.P.T., (Urban Drainage Unit).
Ir. Lum Weng Kee (Secretary)	- Kementerian Kesihatan.

(3) Japanese Supervisory Committee

Dr. M. Kashiwaya	- Head, Water Quality Control Division Public Works Research Institute Ministry of Construction
Mr. Y. Nakagawa	- Deputy Head, Sewerage Planning Division Sewerage and Sewage Purification Dept. City Bureau, Ministry of Construction.
Mr. T. Murayama	- Technical Officer, River Basin & Sewerage Division. Sewerage and Sewage Purification Dept., City Bureau, Ministry of Construction.
Mr. K. Urata	- Technical Officer Municipal Sewerage Division Sewerage and Sewage Purification Dept., City Bureau, Ministry of Construction.
Mr. A. Shinbuchi	- Assistant Chief, Design Division Planning Dept. Japan Sewerage Works Agency.
Mr. K. Inaba	- Deputy head, Sewerage Planning Division Sewerage and Sewage Purification Dept. City Bureau, Ministry of Construction
Mr. H. Sookawa	- Technical Officer, River Basin & Sewerage Division, Sewerage and Sewage Purification Dept., City Bureau, Ministry of Construction

(4) Nihon Suido Consultants (NSC)

Mr. A. Saita	- Project Manager
Mr. T. Ueno	- Co-Project Manager, Site Representative of NSC.
Mr. H. Shono	- Senior Engineer
Mr. S. Shibui	- Senior Engineer

Mr. M. Miyamoto	- Urban & Sanitary Engineer
Mr. Y. Hirau	- Civil Engineer
Mr. O. Fujikawa	- Sanitary Engineer
Mr. T. Horikawa	- Civil Engineer
Mr. M. Kajikawa	- Civil Engineer
Mr. T. Mizutani	- Chemist
Mr. H. Yuasa	- Economist

Additional staff of the following partially participated in the field activities:

Mr. T. Tsutsumi	- Senior Engineer
Mr. S. Nakatake	- Senior Engineer
Mr. H. Yoneya	- Sanitary Engineer
Mr. T. Tashiro	- Sanitary Engineer

Mr. A. Saita, Project Manager, is responsible for overall operation of the Project throughout the Contract period, and Mr. T. Ueno, Co-Project Manager, serving as Site Representative of NSC, supervises entire work throughout the period of the Project. Mr. T. Tsutsumi, one of the Senior Engineer serves as overall technical advisor to the team activities during the life of the Project.

ANNEX - 2

GLOSSARY (DEFINITIONS OF TERMS)

* Activated Sludge Process

A process for achieving biological stabilization of sewage based on use of activated sludge generated under aerobic conditions maintained by included aeration in a reaction chamber, with the effluent subsequently settled and part of the sludge returned to the reaction chamber.

* Aeration

The bringing about of intimate contact between air and a liquid by one or more of the following methods: (a) spraying the liquid in the air, (b) bubbling air through the liquid, (c) agitating the liquid to promote surface abosrption of air.

* Aerated Lagoon

A natural or artificial wastewater treatment pond in which mechanical or diffused-air aeration is used to supplement the oxygen supply.

* Aerobic

Requiring, or not destroyed by, the presence of free elemental oxygen.

* Aerobic Bacteria

Bacteria that require free elemental oxygen for their growth.

* Benefit-Cost Ratio

A theoretical economic concept, usually expressed by relating the present value of the stream of capital costs and annual expenses of the project.

* Biochemical Oxygen Demand (BOD)

Abbreviation for biochemical oxygen demand. The quantity of oxygen used in the biochemical oxidation of organic matter in specified time, at a specified temperature, and under specified conditions.

* Box Culvert

A culvert with a rectangular cross section.

* Branch Sewer

A sewer which receives wastewater from a relatively small area, and discharges into a main sewer serving more than one branch-sewer area.

* Coefficient

A numerical quantity, determined by experimental or analytical methods, interposed in a formula which express the relationship between two or more variables to include the effect of special conditions or to correct a theoretical relationship to one found by experiment or actual practice.

* Chlorination

The application of chlorine to water or wastewater, generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

* Coliforms

An important parameter for assessing the level of pollution in receiving waters, based on measuring the concentration of coliform bacteria, which is a rough index of the probable level of contamination by human excreta.

* Collecting System

A system of sewers and appurtenances for the collection, transportation, and pumping of sewage and industrial wastes.

* Combined Sewer

A sewer receiving both surface runoff and sanitary and/or industrial wastewater.

* Concentration Time

The period of time required for storm runoff to flow from the most remote point of a catchment or drainage area to the outlet or point under consideration. It is not constant, but varies with depth of flow and condition of channel.

* Culvert

A closed conduit for the free passage of surface drainage water under a high-way, railroad, canal, or other embankment.

* Demographic Characteristics

The vital statistics of a population, such as births, deaths, marriages, rate of growth, age distribution, literacy and levels of education, skills and/or income.

* Depreciation

The amount which must be charged against profits each year in a series which will equal the original purchase price of a given asset at the end of its useful life expectancy.

* Discount Rate

The compound rate of interest which measures the difference between two values separated by one or more successive periods of time. The rate is applied to the ultimate value to determine the present value of the series at any prior point in time.

* Design Rainfall

The rainfall estimate corresponding to an enveloping depth - duration curve for the selected frequency, often referred to as the "Design Storm".

* Discharge

As applied to a stream or conduit, the rate of flow, or volume of water flowing in the stream or conduit at a given place and within a given period of time.

* Dissolved Oxygen

The oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter, parts per million, or percent of saturation. Abbreviated - DO.

* Domestic Wastewater

Wastewater derived principally from dwellings, business buildings, institutions and the like. It may or may not contain ground water, surface water or storm water. Also called sanitary sewage.

* Drainage Basin

An area from which surface runoff is carried away by a single drainage system. Also called catchment area, watershed, drainage area.

* Feasibility Study

A compilation of the economic benefits of a proposed project for comparison with engineering and other estimates of total costs to determine the relative merits of the project vis-a-vis other potential social investments.

* Force Main

A pressure pipe joining the pump discharge at a water or waste-water pumping station with a point of gravity flow.

* Gradient

The rate of change of any characteristic per unit of length or scope. The terms is usually applied to such terms as elevation, velocity, pressure.

* Head

The height of the free surface of fluid above any point in a hydraulic system; a measure of the pressure or force exerted by the fluid.

* House Connection

The pipe carrying sewage from the building to a public sewer. Also called Building Sewer and House Sewer.

* Hydraulic Gradient

The slope of the hydraulic grade line; the rate of change of pressure head; the ratio of the loss in the sum of the pressure head and position head to the flow distance. For open channels, it is the slope of the water surface and is frequently considered barallel to the invert. For closed conduits under pressure, it is the slope of the line jointing the elevations to which water would rise in pipes freely vented and under atmospheric pressure. A positive slope is usually one which drops in the direction of flow.

* Industrial Wastes

The liquid wastes from industrial processes, as distinct from domestic or sanitary wastes.

* Infiltration

(1) The flow or movement of water through the interstices or pores of a soil or other porous medium. (2) The quantity of groundwater that leaks into a pipe through joints, porous walls, or breaks. (3) The entrance of water from the ground into a gallery. (4) The absorption of liquid by the soil, either as it falls as precipitation or from a stream flowing over the surface.

* Infrastructure

The basic structures and facilities upon which the economic activities of a community or region are dependent, such as roads, railways, school systems, water and power supply and other public utilities. Sometimes referred to as Social Overhead Capital

* Initial Storm

The storm having a return period of 2 or 5 years.

* Inlet

(1) A surface connection to a drain pipe. (2) A structure at the diversion end of a conduit. (3) The upstream end of any structure through which water may flow. (4) A form of connection between the surface of the ground and a drain or sewer for the admission of surface or storm water. (5) An intake.

* Invert

The floor, bottom, or lowest portion of the internal cross section of a closed conduit. Used particularly with reference to aqueducts, sewers, tunnels, and drains. Originally, it referred to the inverted arch which was used to from the bottom of a masonry-lined sewer.

* Land Use

The culture of the land surface, which affects the social and economic conditions of a region and which determines the amount and character of the runoff and erosion. Existing or zoned economic use of land, such as residential, industrial, farm, commercial.

* Pumping Station

A wastewater pumping station that lifts the wastewater to a higher elevation when the continuance of the sewer at reasonable slopes would involve excessive depths of trench, or that raises wastewater from areas too low to drain into available sewers. These stations may be equipped with pneumatic ejectors, centrifugal pumps, or other pumps.

* Main Sewer

A sewer that receives many tributary branches and serves a large territory. Also called Trunk Sewer. In small systems, a sewer to which one or more branch sewers are tributary.

* Major Storm

The storm having a return period of 100 years.

* Manhole

An opening in sewer provided for the purpose of permitting a man to enter or leave the sewer.

* Metropolitan Area

The area which was defined to be urbanized within around 20 years from the basic year.

* Micro and Macro Drainage

Storm water systems are commonly considered as divided into local/ smaller conduit systems (micro-drainage), which discharge into larger conduits or systems (macro-drainage).

* Municipality

The officials governing such a community as city, town, etc.

* Outfall Sewer

A sewer which receives the sewage from a collecting system and carries it to a point of final discharge. See Pipe Outlet.

* Open Channel

  Any natural or artificial waterway or conduit in which water flows with its surface exposed to the outside atmosphere.

* Outlet

  Downstream opening or discharge end of pipe, culvert or canal.

* Overland Flow

  The flow of water over the ground before it enters some defined channel.

* Oxidation Pond

  A basin used for retention of wastewater before final disposal, in which biological oxydation of organic material is effected by natural or artificially accelerated transfer of oxygen to the water from air.

* pH

  The reciprocal of the logarithm of the hydrogen-ion concentration in grams per liter of solution. Neutral water, for example, has a pH value of 7 and a hydrogen-ion concentration of 10^{-7}.

* Pipe Outlet

  A pipeline which conveys the effluent from a reservoir, sewage treatment plant, or other structure to its point of discharge.

* Present Valve

  The economic method which recognizes and quantifies the values of differences in time. Benefits or costs which are expected to be received or incurred at a future date are worth less than those which can be enjoyed or must be paid currently. Present value at any point in time is determined by applying a given discount rate to the ultimate value for the appropriate number of years.

* Public Sewer

  All sanitary sewers, except house connections.

* Primary Treatment

(1) The first major (some times the only) treatment in wastewater treatment works, usually sedimentation. (2) The removal of a substantial amount of suspended matter but little colloidal and no dissolved matter.

* Rainfall Intensity

Amount of rainfall occuring in a unit of time, converted to its equivalent in millimeters per hour at the same rate.

* Rainfall-Intensity Curve

A curve that expresses the relation on rate of rainfall and their duration. Each curve is generally for a period of years during which time the intensities shown will not, on the average, be exceeded more than once.

* Rational Method

A method of estimating the runoff in a drainage basin at a specific point and time by means of the rational runoff formula. For each drainage area, the rainfall rate under a stated intensity-duration relationship, the fraction that will appear as runoff, and the basin area above the specific point are estimated. Their products is the flow. This method is used to estimate storm runoff in urban areas and flood flows in streams.

* Roughness Coefficient

A factor in the Chezy, Darcy-Weisbach, Hazen-Williams, Kutter, Manning, and other formulae for computing the average velocity of flow of water in the conduit or channel, which represent the effect of roughness of the confining material on the energy losses in the flowing water.

* Runoff

(1) That portion of the earth's available water supply that is transmitted through natural surface channels. (2) That part of the precipitation which runs off the surface of a drainage area and reaches a stream or other body of water or a drain or sewer.

* Runoff Coefficient

The ratio of the maximum rate of the runoff to the uniform rate of rainfall with a duration equaling or exceeding the time of concentration which produced this rate of runoff.

* Sanitary sewer

A sewer which carries liquid and water-carried wastes from sanitary conveniences of residences, commercial buildings, industrial plants, and institutions, together with quantities of ground, storm and surface water which are not admitted intentionally.

* Sanitary Wastewater

(1) Domestic wastewater with storm and surface water excluded. (2) Wastewater discharging from the sanitary conveniences of dwellings (including apartment houses and hotels), office buildings, industrial plants, or institutions. (3) The water supply of a community after it has been used and discharge into a sewer. Also called sanitary sewage.

* Secondary Treatment

The treatment of wastewater by biological or chemical methods after primary treatment by sedimentation.

* Separate System

A system of sewers and drains in which sanitary wastewater and storm water are carried in separate conduits.

* Septic Tank

A settling tank in which settled sludge is in immediate contact with the wastewater flowing through the tank and the organic solids are decomposed by anaerobic bacterial action.

* Sewage

The spent water of a community. Term now being replaced in technical usage by the preferable term wastewater.

* Sewage Works

All-inclusive term for wastewater collection, pumping, treatment, and disposal facilities. Term declining in use.

* Sewer

A pipe or conduit that carries wastewater or storm water drainage.

* Sewerage

System of piping, with appurtenances, for collecting and conveying wastewater from source to discharge. Term declining in use.

* Stabilization Lagoon

A shallow pond for storage of wastewater before discharge. Such lagoons may serve only to detain and equalized wastewater composition before regulated discharge to a stream, but often they are used for biological oxidation.

* Stabilization pond

A type of oxidation pond in which biological oxidation of organic matter is effected by natural or artificially accelerated transfer of oxygen to the water from air.

* Storm Sewer

A sewer that carries storm water and surface water, street wash and other wash waters, or drainage but excludes domestic wastewater and industrial wastes. Also called storm drain.

* Storm Water

The excess water running off from the surface of a drainage area during or immediately after a period of rain. It is that portion of the rainfall and resulting surface flow that is excess of that which can be absorbed through the infiltration capacity of the surface of the area.

* Sullage

Any household waste liquids discharged from any bath, shower, lavatory, basin, floor gully, laundries or sink (not being a slop sink) but excludes faecal water and urine.

* Term

The period of time stated in the loan contract by the end of which the loan must be fully repaid.

* Tidal River

A river in which flow and water surface elevation are effected by the tides. Such effect usually occurs in the lower stretch near the mouth, where the gradient is very flat. In some streams, the effect may extend a hundred or more kilometers upstream from the mouth.

* Time Lag

(1) Referring to discharge or water level, the time elapsing between the occurrence of corresponding changes in discharge or water level at two points in a river. (2) Referring to runoff of rainfall, the time between the center of mass, or beginning, or rainfall to the peak, or center of mass, of runoff.

* Useful Life Expectancy

The period of time during which a piece of equipment a building or other physical asset is expected to render the service or perform the function for which it is intended, at an acceptable level of efficiency, with ordinary maintenance and under operating conditions expected in the given situation. Technical and financial planning assumes that the asset will have to be replaced at the end of its expected useful life.

* Wastewater

The spent water of a community. From the standpoint of source, it may be a combination of the liquid and watercarried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater, surface water, and storm water that may be present. In recent years, the ward wastewater has taken precedence over the work sewage.