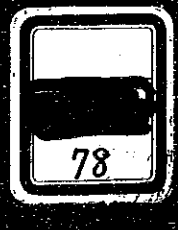
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MASTER PLAN
FOR
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH/BUKIT MERTAJAM METROPOLITAN AREA
MALAYSIA

VOLUME II

MASTER PLAN REPORT

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ORDER OF PRESENTATION

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PART I

SUMMARY OF FINDINGS AND RECOMMENDATIONS

1. INTRODUCTION

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.

2. FINDINGS

2.1 Present Conditions of the Project Area

(a) 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. (Ref. Part II, "Background") 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. (Ref. Part III, "Sewerage Master Plan") 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). (Ref. Part IV "Drainage Master Plan")

(b) 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 average 5.5 percent annual increase as in case of the Penang Master Plan. (Ref. Part II, "Background")

(c) 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. (Ref. Part II, "Background")

(d) 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°C), with a mean day time maximum of 29°C (85°F) and a mean minimum of 22°C (71°F) at night. (Ref. Part II, "Background")

(e) 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"). (Ref. Part II, "Background")

(f) 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.

(g) 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.

(h) 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. (Ref. Part II, "Background")

(i) 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. (Ref. Part II, "Background")

(j) 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. (Ref. Part II, "Background")

(k) 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. (Ref. Part II, "Background")

(l) About 80 percent of the Project Area is served the tributary of the Prai and Juru rivers and the remaining parts discharge to the sea via existing numerous natural and piecemeal improved water courses. 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 damage 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). (Ref. Part II, "Background")

(m) 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 programme, especially in two urban areas, Butterworth and Bukit Mertajam. (Ref. Part II, "Background")

2.2 Conclusions and 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 basis 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:

(a) 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

1995 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. (Ref. Part III, "Sewerage Master Plan")

(b) 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. Part III, "Sewerage Master Plan")

(c) On the basis of the field surveys, both the average BOD and SS of the domestic sewage in the year 2000 are estimated to be 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.

(d) 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, considering geographical, topographical, demographical and other conditions, so that the works for overall system and design individual facilities can be made. (Ref. Figure III-5 and Part III, "Sewerage Master Plan")

(e) 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 on the basis of topographical conditions shown in Figure IV-2. (Ref. Part IV, "Drainage Master Plan")

3. RECOMMENDATIONS

3.1 Proposed Plans

Sewerage

(a) The sewerage system should be principally a separate system, but as 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. Part III, "Sewerage Master Plan")

(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. Part III, "Sewerage Master Plan")

(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. Part III, "Sewerage Master Plan")

(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. Part III, "Sewerage Master Plan")

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. Figures 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.

3.2 Proposed Staging of Construction

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. Part III, "Sewerage Master Plan")

i. Population density

ii. Waste load

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. Part III, "Sewerage Master Plan")

(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. Part III, "Sewerage Master Plan") According to government's 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 wastewater. (Ref. Figure III-5)

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.

(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 2,000 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. Part IV, "Drainage Master Plan")

The construction of two reservoirs earth 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.

3.3 Cost of Recommended Programme

The recommended plan for implementing sewerage and drainage systems calls for construction, operation and maintenance in the four stages. Tables I-1 through I-5 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 I-6. 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.

3.4 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.

TABLE I-1 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 I-2 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 I-3 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 Connections	-	-	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 I-4 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 I-5 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 Connections	-	-	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 I-6 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.

3.5 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.

3.6 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 waste 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.

PART II

BACKGROUND

CHAPTER 1

PURPOSE AND SCOPE OF STUDY

1.1 Background of the Study

The Penang Master Plan, 1970, proposed to establish a metropolitan area on the mainland, which included areas covered by two towns, Butterworth (BW) and Bukit Mertajam (BM). On the basis of the proposal the Government of Malaysia requested the Japanese Government to assist in developing a programme to establish comprehensive sewerage and drainage planning for the Butterworth/Bukit Mertajam Metropolitan Area.

1.2 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.

1.3 Definition of Project Area

For the purpose of Sewerage and Drainage Project for the Butterworth/Bukit Mertajam Metropolitan Area, the Metropolitan Area of 11,600 ha is considered as the Project Area. Among the entire Metropolitan Area, the area of air force base is excluded from the Project Area (Ref. Figure II-4).

Acreages of the Metropolitan Area, air force base, and the Project Area are as follows:

- Butterworth/Bukit Mertajam Metropolitan Area ..... 12,020 ha (29,700 acres)
- Air Force Base (excluded) ..... 420 ha (1,040 acres)
- Project Area ..... 11,600 ha (28,660 acres)

For master planning purposes, non-habitable areas such as cemeteries, rivers and others of 746 ha (1,840 acres) are excluded from the Project Area, but for the drainage master plan, additional catchment areas of 1,751 ha (4,327 acres) outside the Project Area are taken into account for determining the drain capacities due to the topographical conditions. (Ref. PART IV, "Drainage Master Plan")

1.4 Problem and the Need for Study

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 settings, 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. Approximately 30 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 plllution 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 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 present report endeavours to cover the preliminary programme of long range outlook on the basis of sound consideration on technical and socio-economic factors.

CHAPTER 2

PHYSICAL CHARACTERISTICS OF PROJECT AREA

2.1 Location

Peninsular Malaysia forms the southern tip of the South-East Asia land mass; to the west and south are the islands of Indonesia; and to the east the island of Kalimantan and East Malaysia. Peninsular Malaysia lies entirely within the tropics extending from latitude 1° to 7° north and from longitude 100° to 104° east. East coast of the peninsular faces to the South China Sea and west coast to the Straits of Malacca (See Figure II-1).

Penang State, the second smallest State among the thirteen States of Malaysia, is situated on the northwestern coast of Peninsular Malaysia between latitudes 5°7' to 5°35' north and longitudes 100°9' to 100°32' east. It is bounded on the north and east by Kedah State, to the south by Perak State, and to the West by the Straits of Malacca.

Geographically, Penang State consists of two separate physical entities, Penang Island, a rectangular island 23 km (14 miles) long and 16 km (10 miles) wide, and Province Wellesley, a rectangular strip 48 km (30 miles) long and 17 km (11 miles) wide situated on the Peninsular Malaysia.

The Project Area for the Sewerage and Drainage Master Plan is situated in the midst of Province Wellesley. West end of the Project Area is the nearest point to the Penang Island from the Peninsular. From the north end to the south end of the hook-shaped Project Area is about 20 km (13 miles) long, and from the east end to the west end is about 15 km (9 miles) wide (See Figure II-2).

2.2 Geology

The topography of Peninsular Malaysia is characterized by a series of mountain ranges of igneous intrusions through older sedimentary rocks running parallel to the coast and flanked on both sides by wide alluvial plains which extend from the coast to the foothills. The mountains rise to heights of 2,150 m (7,000 ft) in the north and 900 m (3,000 ft) in the south of Peninsular.

Province Wellesley, in which the Project Area is situated, is essentially a very flat alluvial plain. Some of the areas are lying below 15 m (50 ft) contour being interrupted by patches of hilly land at its southeastern border. The highest point of these

hills is in the Bukit-Mertajam, which is 536 m (1,787 ft) above sea level 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.

Geological map in the Project Area and its vicinity is shown in Figure II-3.

2.3 Climate and Rainfall Characteristics

Proximity to the equator has given Peninsular Malaysia a climate of high humidity with uniformly high temperature and rainfall. The equatorial climate is modified by the region's insularity and exposure to monsoonal wind system that originate in the Indian Ocean and the South China Sea. On the whole, the climate is pleasant and equable and the humidity is bearable though sometimes unpleasant.

Thunderstorms are frequent, and, although Malaysia is outside the typhoon and cyclon belts, the south-west monsoon is frequently accompanied by sudden squalls and violent gusty winds, especially along the Straits of Malacca where they are known as "Sumatras".

Temperature is relatively constant throughout the year and the average monthly temperature varies only 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 daytime maximum of 29°C (85°F) and a mean minimum of 22°C (71°F) at night.

The climate in Penang State is same as to west coast of Peninsular Malaysia including Project Area and the records available in Penang Island are applicable to the Project Area. The records of rainfall, temperature, relative humidity and daily sunshine are shown in Tables II-1, II-2, II-3, and II-4.

For Penang State, rainfall has been recorded by Drainage and Irrigation Department (DID) and Penang Water Authority (PWA). Recorded data are available since 1933 in DID; from 1933 to 1969 with recording once a day, and from 1970, continuous recording with self-registering gauges. Rainfall data are also available in PWA with automatical gauges since 1954.

It is considered that five year length of record in DID is

too short to expect a reliable result of statistical analysis of rainfalls. Thus, the data in PWA is used for developing intensity-duration rainfall curves, and the record most suitable among eight gauges in and around the Project Area are shown in Figure II-5. Table II-5 shows the data obtained at No. 6 gauge, because they are deemed to be more accurate than others.

Although the data are obtained at No. 6 station, the difference between the Island and the Project Area, in terms of topographic and climate conditions, are quite small and are adoptable for the Project Area. This is confirmed and agreed by the government officials concerned.

TABLE II-1 Record of Rainfall (at Bayan Lepas, 1946 ~ 1976)

(mm)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean	125.7	95.0	195.6	245.6	227.8	159.5	160.5	193.0	261.6	329.7	303.3	194.4	2,445.0
Max. 24 hrs.	94.5	95.0	177.0	97.5	111.5	126.2	119.9	119.9	139.2	164.8	157.5	114.3	177.0
Max. 48 hrs.	100.1	104.1	177.0	111.8	206.0	182.6	119.9	176.8	154.9	164.8	198.1	125.2	206.0
Max. 72 hrs.	154.4	104.1	177.0	113.3	222.3	225.3	123.4	181.6	207.0	189.5	233.2	188.0	233.2

Data Source: DID

TABLE II-2 Record of Temperature (at Bayan Lepas, 1959 ∿ 1972)

(°C)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
24 hr Mean	26.8	27.2	27.4	27.6	27.6	27.2	26.9	26.7	26.5	26.3	26.4	26.6	26.9
Mean Daily Max.	31.1	31.7	31.7	31.8	31.7	31.3	31.0	30.8	30.7	30.3	30.3	30.5	
Mean Daily Min.	22.9	23.1	23.4	23.9	24.1	23.7	23.3	23.3	23.1	23.2	23.1	23.2	
Highest Max.	35.6	35.0	35.0	34.4	33.9	33.9	33.3	33.3	33.3	33.9	33.3	33.9	
Year		1959		1963		1959		1960				1970	
	1959	1965	Sev.	1971	1963	1972	sev.	1972	sev.	1972	1972	1972	
Lowest Min.	18.9	20.6	20.6	21.7	21.7	21.1	20.6	20.6	20.6	21.7	21.1	20.6	
Year		1962			1968	1960			1964				
	1972	1968	sev.	sev.	1972	1961	1971	1964	1966	sev.	sev.	1959	

Note: "sev." means several years

Data Source: DID

TABLE II-3 Record of Relative Humidity (at Bayan Lepas)

(percent)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
24 hr Mean	74.9	75.7	78.9	83.0	84.2	83.8	83.5	83.7	85.1	86.2	84.4	80.3	82.0
Mean Daily Max.	92.5	94.2	96.3	97.2	97.5	97.6	97.4	97.5	97.8	97.9	97.1	94.6	96.5
Mean Daily Min.	55.2	53.1	56.3	62.4	64.5	64.3	63.2	63.5	64.5	66.1	64.1	60.8	61.5
Lowest Min.	35	34	27	45	46	49	48	45	46	50	40	31	27
Year	1973	1973	1973	1972 1974	1972	1972	1974	1974	1973	1970	1968	1968	1973

Note: 24 hours mean, mean daily max., and mean daily min. are obtained from 1963 to 1974, 12 years records. Lowest min. and year are obtained from 1968 to 1974, seven years records.

Data Source: DID

TABLE II-4 Record of Daily Sunshine (at Bayan Lepas, 1968 ∿ 1976)

(hours)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean	8.0	8.2	7.8	7.5	6.5	6.3	6.4	6.3	5.2	5.2	5.6	5.0
Highest	11.4	11.2	11.1	11.3	11.3	11.3	11.5	11.2	10.9	10.5	11.2	11.3
Lowest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Data Source: DID

The climate in the Area is governed by the monsoons. From November to March, it is dry season with monsoons of north-east, and wet season is from June to October with south-west monsoons. In September and October in which the south-west wind is predominant and also in November when the monsoon changes its direction, there are heavy rains in the Area. The total rainfall depth of 810 mm (31.9") is recorded through these three months, which is 37 percent of the total rainfall of one year of 2,172 mm (85.5"), both of which are averages of five years from 1965 to 1970. The most dry month is February with the rainfall of 65.5 mm (2.58") as an average of six years, from 1965 to 1970. The monthly rainfall records from 1965 to 1970 are shown in Table II-6.

TABLE II-5 Rainfall Gauge Stations

No.	Name	Location	Responsible Organization	Records Available Since
1.	Ibu Bekalan Sungai Kulim	Province Wellesley	DID	1970 -
2.	Komplek Perai	"	DID	1970 -
3.	Station Located in Stream of SG. Ayer Terjun	Penang Island	PWA	1954 -
4.	Kolam Bersih Pulau Pinang	"	DID	1970 -
5.	Klinik Bukit Bendera	"	DID	1970 -
6.	Station Located in Ayer Itam Old Intake Catchment	"	PWA	1954 -
7.	Kolam Takongan Ayer Itam	"	DID	1970 -
8.	Rumah Kebajikan Pulau Pinang	"	DID	1970 -

TABLE II-6 Rainfall Records at Ibu Bekalan Sungai Kulim (1965 ~ 1970)

(mm)

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
1965/66	125	244	380	226	371	321	704	803	178	183	160	82
1966/67	315	207	182	277	182	269	254	22	117	255	278	173
1967/68	36	153	164	374	388	29	21	29	171	287	101	110
1968/69	231	374	111	290	260	292	208	22	180	33	220	88
1969/70	99	142	174	351	271	180	269	17	81	309	214	93

Data Source: DID

2.4 Present River System

The Project Area has two major rivers, namely Prai and Juru, with many branches and drains within their catchment areas, collecting stormwater runoff and finally discharging it into the sea. The features of these two rivers are as follows:

(a) Prai river

Prai river is a wide and fast flowing tidal river covering an area of about 16 sq km (4,000 acres) and discharging into the sea. Because of the tidal influences, no water is used for water supply and irrigation within the Project Area. At present, the river water is utilized mainly for navigation between Penang Harbour and inland industrial estates, but fishing and recreational activities are few.

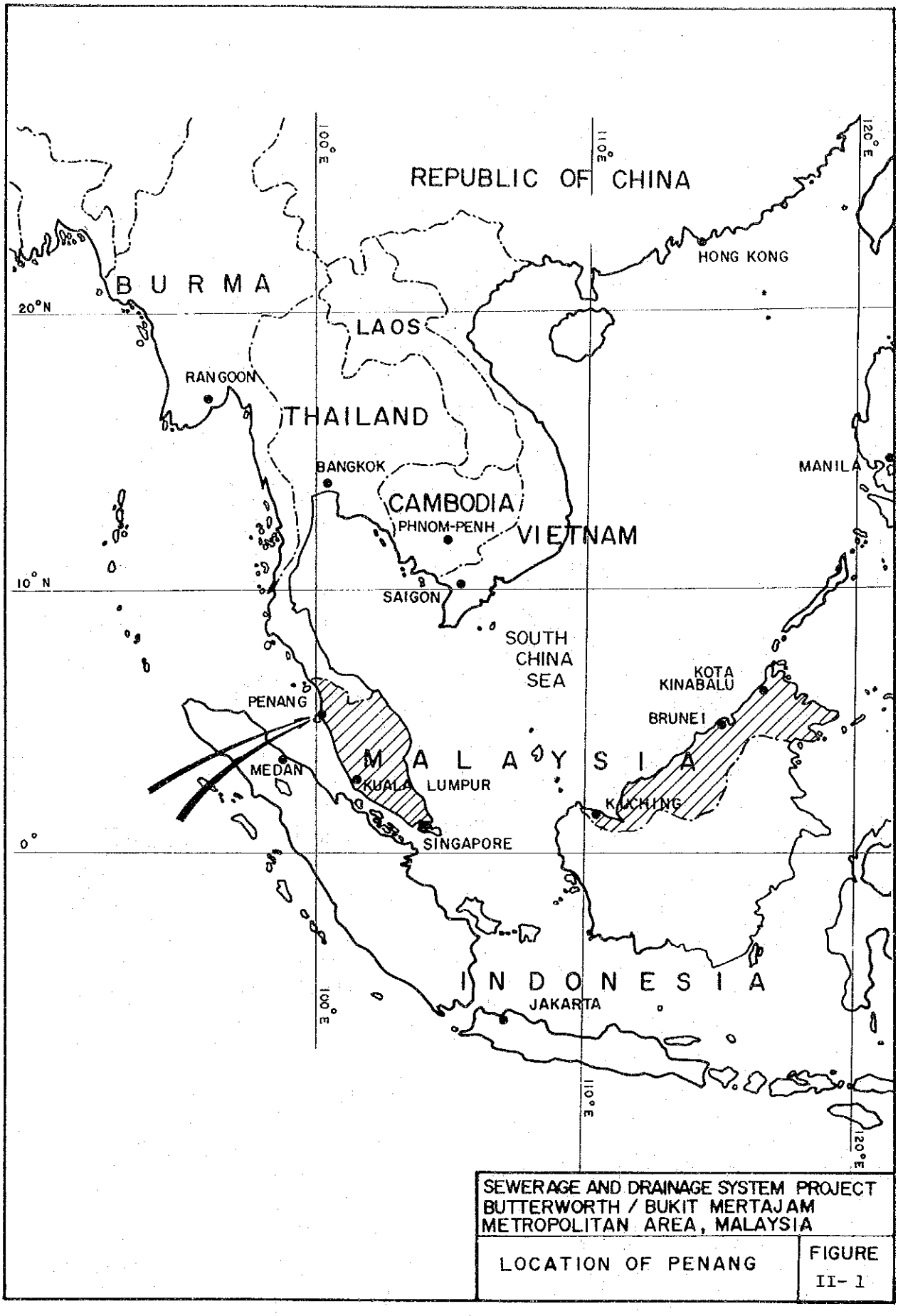
DID is not considering the construction of a barrage across the river near the Pontoon bridge at Permatang Pauh to drain the swamps within the catchment area for land reclamation. The fresh water to be produced by the barrage is planned to be used for industrial purposes.

Tributaries of the Prai river, Jarak, Korok and Kulim are used for irrigation and water supply purposes. However, their intake points are located outside of the Project Area.

(b) Juru river

The Juru river has a catchment area of about 2.6 sq km (630 acres) covering flat plain, swamp and paddy with the hill of Bukit Mertajam in its north-east corner. Water is heavily polluted by the discharge from the urbanized area and animal farms of Bukit Mertajam area. The river water has not been used for any purpose in the Project Area.

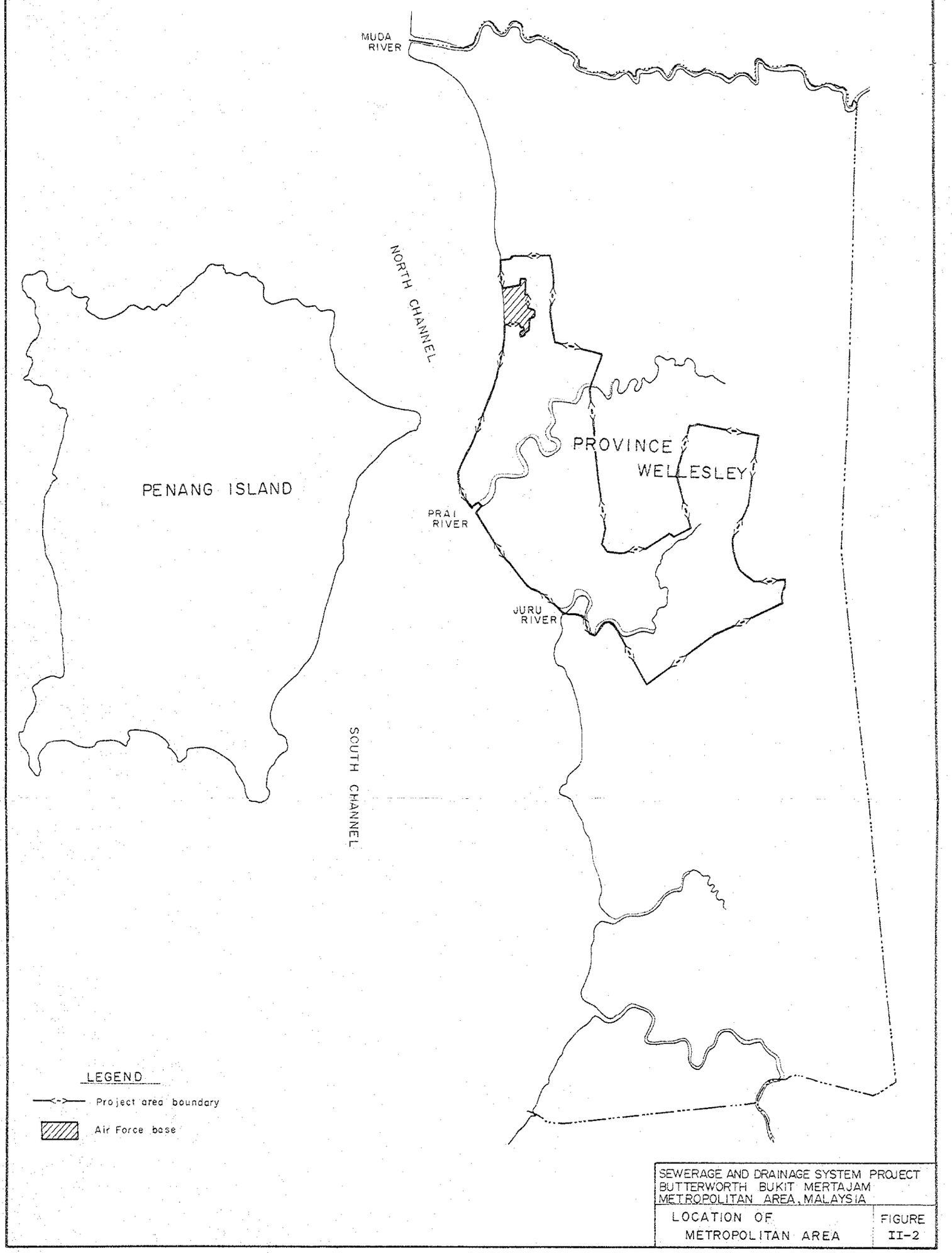
Figure II-1



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

LOCATION OF PENANG

FIGURE
II-1



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

LOCATION OF METROPOLITAN AREA — FIGURE II-2

FIGURE II-3

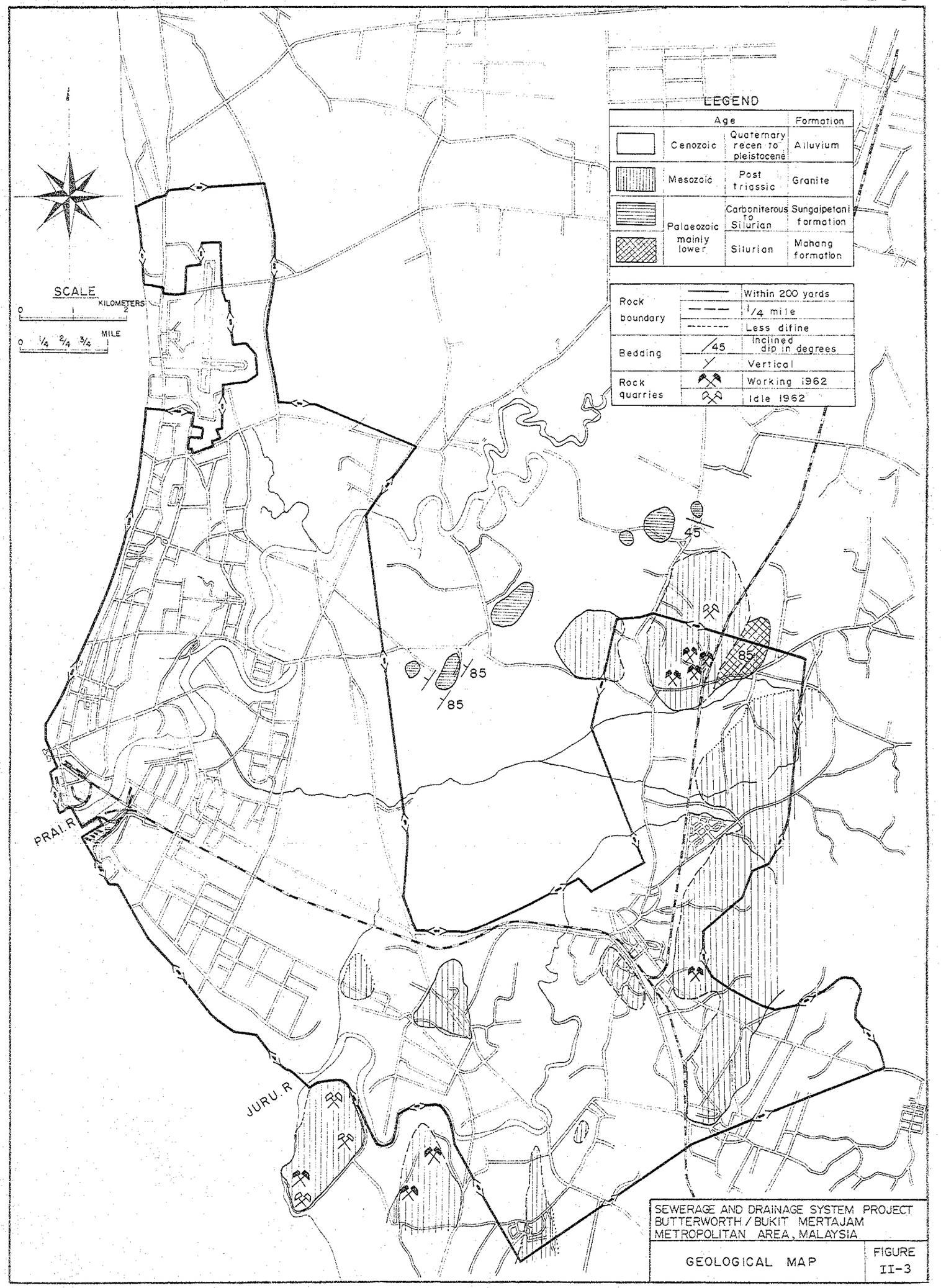
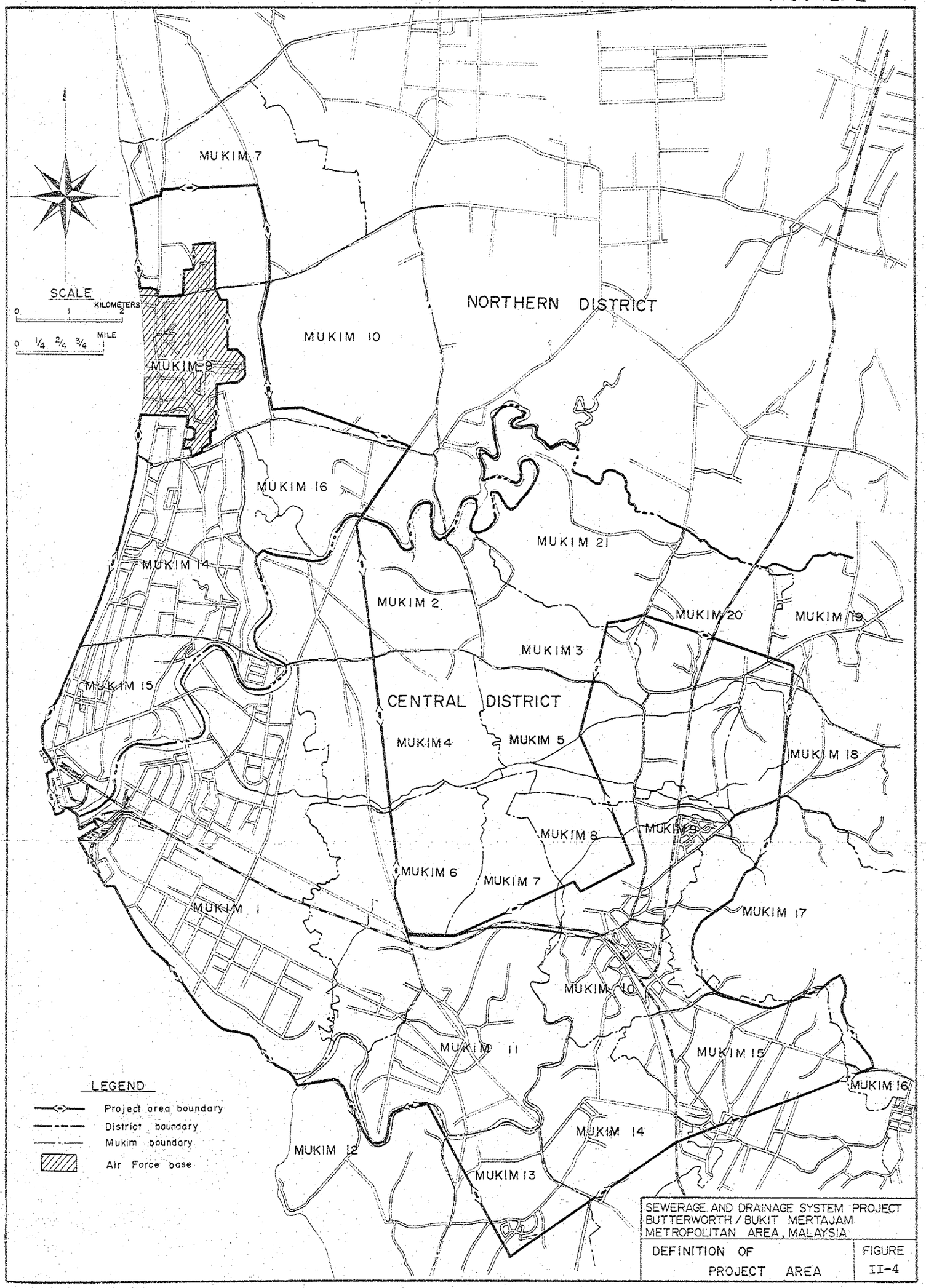
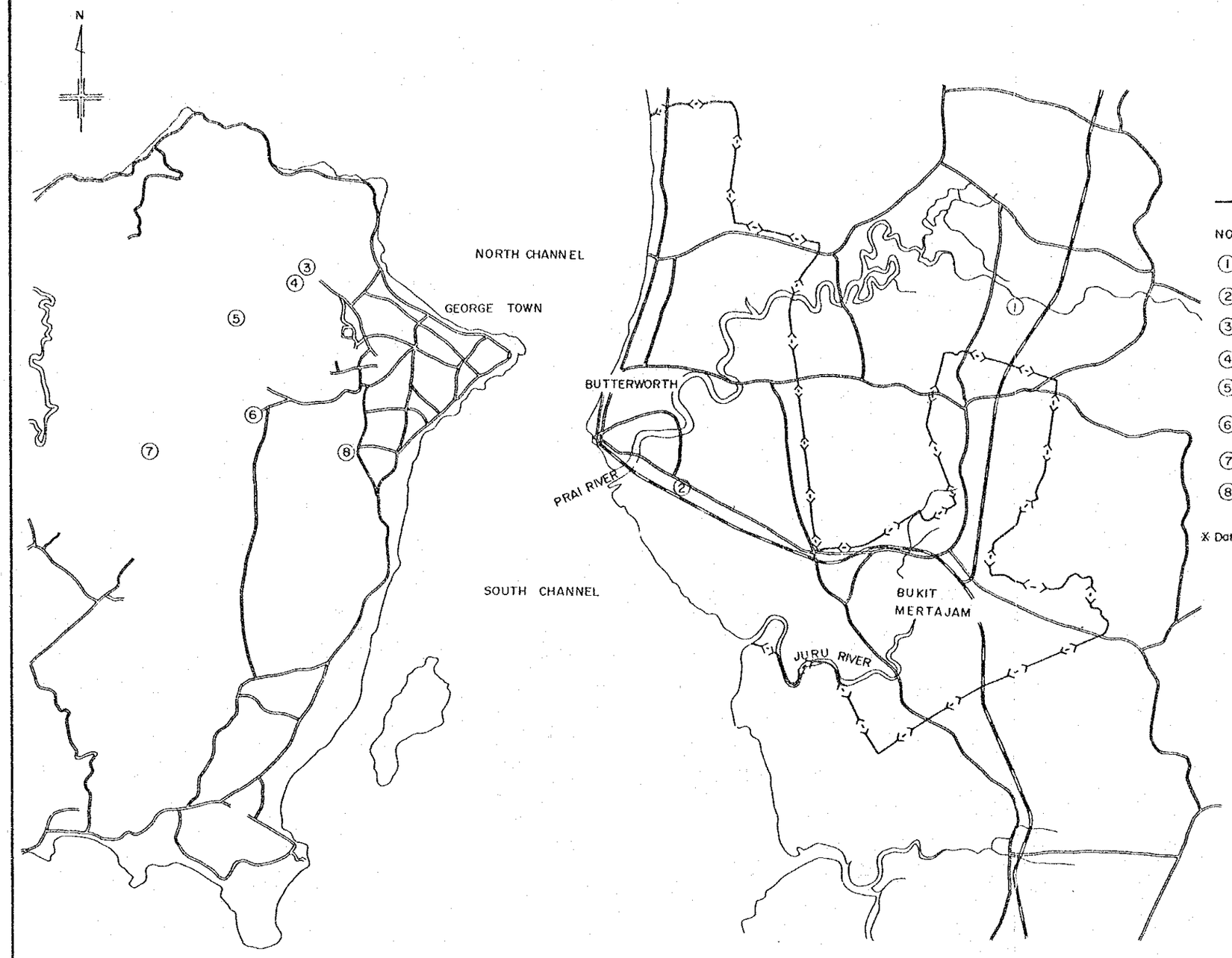

LEGEND
Age
Formation
Cenozoic
Quaternary recen to pleistocene
Alluvium
Mesozoic
Post triassic
Granite
Palaeozoic mainly lower
Carboniterous to Silurian
Sungaipetani formation
Silurian
Mahang formation
Rock boundary
Within 200 yards
1/4 mile
Less difine
Bedding
45
Inclined dip in degrees
Vertical
Rock quarries
Working 1962
Idle 1962
SCALE
KILOMETERS
0 1 2
MILE
0 1/4 2/4 3/4 1
PRAI. R
JURU. R
45
85
85
85
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
GEOLOGICAL MAP
FIGURE II-3

FIGURE II-4


SCALE
KILOMETERS
0 1 2
MILE
0 1/4 2/4 3/4 1
MUKIM 7
MUKIM 9
MUKIM 10
NORTHERN DISTRICT
MUKIM 16
MUKIM 21
MUKIM 14
MUKIM 2
MUKIM 20
MUKIM 19
MUKIM 3
MUKIM 15
CENTRAL DISTRICT
MUKIM 4
MUKIM 5
MUKIM 18
MUKIM 8
MUKIM 6
MUKIM 7
MUKIM 1
MUKIM 17
MUKIM 10
MUKIM 11
MUKIM 15
MUKIM 16
MUKIM 14
MUKIM 12
MUKIM 13
LEGEND
Project area boundary
District boundary
Mukim boundary
Air Force base
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
DEFINITION OF PROJECT AREA
FIGURE II-4



LEGEND

	Project area boundary
NO	Name of gauge station
①	Ibu Bekalan Sungai Kulim
②	Komplek Peral
③	Station at Upstream of SG. Ayer Terjun
④	Kolam Bersih Pulau Pinang
⑤	Klinik Bukit Bendera
⑥	Station at Ayer Itam Old Intake Catchment
⑦	Kolam Takongan Air Itam
⑧	Rumah Kebajikan Pulau Pinang

※ Data source : Drainage and irrigation department
: Penang water authority

Scale 1 :126,720

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

LOCATION OF RAIN GAUGE | FIGURE II-5

CHAPTER 3

PUBLIC HEALTH CONDITIONS

3.1 Health and Medical Facilities

The distribution of the health and medical facilities in the Penang State has been generally adequate. There are one general hospital, eight hospitals, 11 maternity hospitals, and 13 main health centers excluding private clinics in the Penang State.

Among these facilities, two hospitals are located in the Project Area. They are district hospitals in Butterworth and Bukit Mertajam. Total number of beds in each hospital is 134 and 206 respectively in 1975, and number of admissions in 1975 are 8,679 and 14,505, with average length of stay as 5.65 days and 5.18 days respectively. Bed occupancy rate, calculated from number of beds and average daily number of patients, is 85.07 percent in Butterworth district hospital and 120.39 percent in Bukit Mertajam district hospital.

The site of 30 ha (74 acres) for new hospital complex, serving for the Butterworth and Bukit Mertajam areas, is planned at Seberang Jaya in the Project Area.

3.2 Incidence of Diseases

Number of patients of water-borne communicable diseases for both of the North and Central Districts in Province Wellesley, including adjacent areas of the Project Area. It is pointed out that these figures are reported cases only which are considered to be approximately 75 percent of the total incidence actually occurred.

TABLE II-7 Number of Patients of Water Borne Disease

	1970		1971		1972		1973		1974		1975	
	PWN	PWC	PWN	PWC	PWN	PWC	PWN	PWC	PWN	PWC	PWN	PWC
Cholera	(7.4) 12	(42.5) 50	-	-	-	(5.7) 7	-	-	(5.1) 9	(0.8) 1	-	-
Dysentery		(0.8) 1	(1.2) 2	(3.3) 4	(4.7) 8	(2.4) 3	(17.9) 31	(3.2) 4	(5.1) 9	(7.8) 10	(2.2) 4	(5.3) 7
Infectious Hepatitis	-	-	-	-	-		(35.3) 61	(4.8) 6	(26.6) 47	(1.6) 2	(25.4) 46	(5.3) 7
Typhoid fever	(0.6) 1	(1.7) 2	(4.2) 7	(9.2) 11	(26.6) 45	(4.9) 6	(26.6) 46	(9.5) 12	(2.3) 4	(5.4) 7	(2.8) 5	(6.1) 8
Leptospiral Infections	-	-	-	-	-	-	(0.6) 1	-	-	-	-	-

Note: PWN: Province Wellesley North District

PWC: Province Wellesley Central District

Figures in ( ) = incidence rate per 100,000 population in the district

These figures reflect the data obtained from Government District Hospitals/Clinics, and do not reflect the whole number of patients.

CHAPTER 4

POPULATION AND LAND USE

4.1 Present Population and Distribution

As the population and its distribution in the Project Area at the time of the present study is not readily available, assumption is undertaken by using 1970 National Census and other available study data. Of the 1970 Census which includes the breakdown in mukims, 27 mukims are identified as included in the Project Area, wholly or partially. To determine the population in each of these mukims within the Project Area from the data of the Census, the total population within the Area in 1970 at the time of National Census is estimated to be 172,230, as shown in Table II-8. (Ref. Appendix B, "Population & Land Use Distribution")

The population data provided in the Penang Master Plan Report 1970, which includes the population projection for 1970, 1975 and 1985, is found to be useful source of information for projection of population for the year 1976. Assuming that 5.5 percent annual growth rate up to the year 1985 is reasonable and realistic, with a few percent of plus and minus deviation, it is considered appropriate to apply the same average of 5.5 percent annual growth rate to each of the 1970 population of mukims within the Project Area as referred above up to the year 1976, which leads to the conclusion that the total population of the Area in 1976 to be 238,000, as indicated in Table II-8.

4.2 Present Land Use

It is considered that Province Wellesley is the State's major agricultural area. At present, agricultural area of 4,049 ha (10,000 acres) which consists of paddy field, rubber farm, and coconut farm is still located in the total Project Area of 11,600 ha.

The built-up areas are Butterworth and Bukit Mertajam town areas covering a total area of 649 ha (1,600 acres).

Three large scale industrial development programmes by Penang State Government are now underway, and fastly being established. In 1976, total industrial area including areas of large scale factories cover 844 ha (2,090 acres).

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. Present land use is illustrated in Figure II-6, and acreage of each category is shown in Table II-9.

TABLE II-8 Population Distribution in Mukim in 1970, with 1976 Projection

No. of Mukim	Mukim Total*			Project Area**			
	Area (ha)	1970		Area (ha)	1970	1976	
		Population	Population Density Persons/ha		Population	Population	Population Density Persons/ha
N 7	1,152	8,485	7.4	389	3,751	5,183	13.3
N 9	650	6,917	10.6	281	2,691	3,719	13.2
N10	1,059	3,286	3.1	47	146	202	4.3
N14	885	39,502	44.6	885	39,502	54,587	61.7
N15	645	30,035	46.6	645	30,035	41,505	64.3
N16	668	3,441	5.2	523	2,720	3,759	7.2
C 1	2,174	10,875	5.0	2,174	10,875	15,028	6.9
C 2	848	3,952	4.7	420	3,162	4,369	10.4
C 3	457	3,381	7.4	88	2,029	2,804	31.9
C 4	781	5,934	7.6	354	5,341	7,381	20.9
C 5	625	2,816	4.5	187	2,253	3,113	16.6
C 6	1,035	4,096	4.0	762	4,096	5,660	7.4
C 7	1,176	1,665	1.4	54	1,665	2,301	42.6
C 8	406	10,116	24.9	193	10,116	13,979	72.4
C 9	270	9,131	33.8	270	9,131	12,617	46.7
C10	445	19,641	44.1	445	19,641	27,141	61.0
C11	1,060	5,116	4.8	1,060	5,116	7,070	6.7
C12	1,480	2,740	1.9	60	114	158	2.6
C13	1,328	2,776	2.1	366	2,776	3,836	10.5
C14	1,813	6,645	3.7	618	3,323	4,592	7.4
C15	1,535	9,706	6.3	681	8,735	12,071	17.7
C16	1,688	5,567	3.3	5	17	23	4.6
C17	2,195	1,100	0.5	309	155	214	0.7
C18	1,055	1,405	1.3	215	280	387	1.8
C19	1,551	2,137	1.4	5	7	10	2.0
C20	1,008	6,477	6.4	557	4,534	6,265	11.2
C21	902	2,438	2.7	7	19	26	3.7
Total	28,891	209,380	7.2	11,600	172,230	238,000	20.5

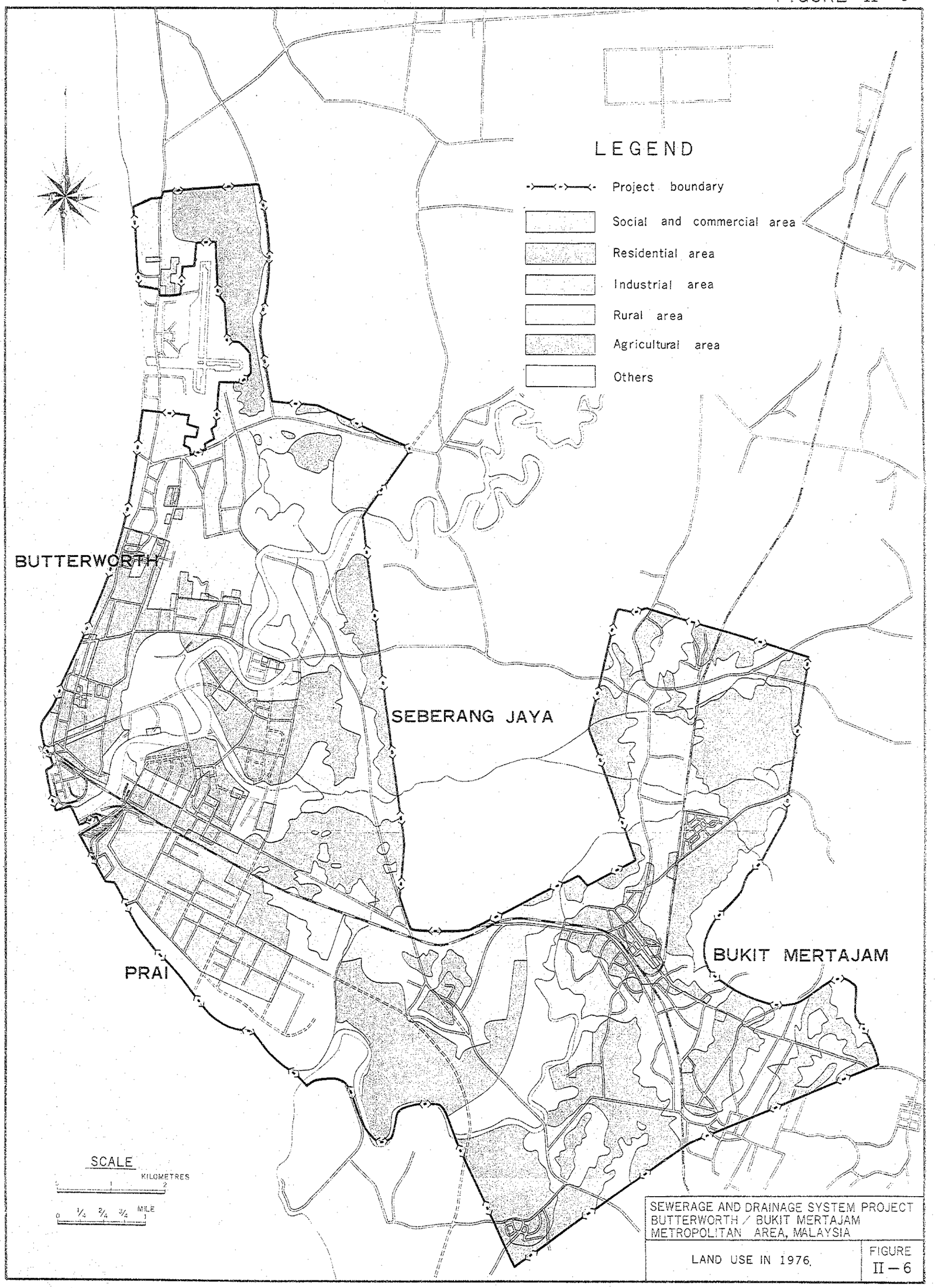
Note: *: from 1970 Census
**: Calculated by Survey Team

TABLE II-9 Population and Land Use of Mukim in 1976 (in Project Area)

No. of Mukim	Area (ha)							Population Density (persons/ha)			Population			
	Social & Commercial	Residential	Industrial	Rural	Agricultural	Others	Total	Social & Commercial	Residential	Rural	Social & Commercial	Residential	Rural	Total
N 7		18		141	230*		389		120	21.4		2,160	3,023	5,183
N 8				175	106*		281			21.3			3,719	3,719
N10				30	17*		47			6.7			202	202
N14	2	197	95*	530		61*	885	120	120	57.9	240	23,640	30,707	54,587
N15	16*	133						0	108.6		0	3,585		
	47	190	79*			280*	645	160	160		7,520	30,400		41,505
N16				201	58*	246*	523			18.7			3,759	3,759
C 1		157	670*	108	593*	646*	2,174		80	22.9		12,560	2,468	15,028
C 2				138	115*	167*	420			31.7			4,369	4,369
C 3				67	21*		88			41.9			2,804	2,804
C 4				137	208*	9*	354			53.9			7,381	7,381
C 5				61	126*		187			51.0			3,113	3,113
C 6				304	382*	76*	762			18.6			5,660	5,660
C 7				49	5*		54			47.0			2,301	2,301
C 8	1	86		72	34*		193	120	120	49.2	120	10,320	3,539	13,979
C 9		57		148	65*		270		120	39.0		6,480	5,777	12,617
C10	19	108		221	28*	69*	445	120	120	53.9	2,280	12,960	11,901	27,141
C11		16		292	450*	302*	1,060		80	19.8		1,280	5,790	7,070
C12				4		56*	60			39.5			158	158
C13		38		24	288*	16*	366		80	33.2		3,040	796	3,836
C14				216	359*	43*	618			21.2			4,592	4,592
C15		13		344	324*		681		80	32.1		1,040	11,031	12,071
C16				3	2*		5			7.7			23	23
C17				11	154*	144*	309			19.5			214	214
C18				10	185*	20*	215			38.7			387	387
C19				2	3*		5			5.0			10	10
C20				189	296*	72*	557			33.1			6,265	6,265
C21				7			7			3.7			26	26
Total	16* 69	913	844*	3,484	4,049*	2,225*	11,600	0 147.2	118.1		10,160	107,825	120,015	238,000

Note: * is non-habitable area, e.g. government office zone, water courses, cemeteries, mountainous areas, parks, industrial areas, agricultural areas.

FIGURE II—6



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

LAND USE IN 1976

FIGURE II—6

CHAPTER 5

WATER SUPPLY SYSTEM

5.1 Existing Water Supply System

5.1.1 Water Agency

The water supply system of the State of Penang is operated by the Penang Water Authority (PWA) which was established on 1st January 1973 by amalgamation of the former City Water Department of the City Council of George Town and the former Water Supply Section of the State Public Works Department.

5.1.2 Areas and Population Served

Presently, about 280,000 persons or about 80 percent of the total population in Province Wellesley is served by the water supply system. The water supply area is illustrated in Figure II-7.

5.1.3 Water Production and Use

Yearly water productions in the last six years in Province Wellesley are shown in Table II-10.

TABLE II-10 Total Annual Water Production (1969~1974)

(1,000 cu m)

Year	NORTH	CENTRAL	SOUTH	TOTAL
1969	12,029	1,500	1,786	15,315
1970	13,438	1,772	1,723	16,933
1971	17,770	1,587	1,987	21,344
1972	19,116	1,623	1,627	22,366
1973	21,230	1,623	2,223	25,076
1974	24,430	1,714	1,623	26,767

Data Source: 1969~1974 water supply record of the Penang Water Authority

5.1.4 Water Supply Conditions

Water supply conditions in Province Wellesley are generally satisfactory on both aspect 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.

5.1.5 Private Water Supply Systems

There are at present privately owned water supply systems in Province Wellesley, some of which are using wells and irrigation water but the areas will not doubt be included in the city water service area in the near future.

5.2 Existing Water Supply Facilities

5.2.1 Outline of Existing Facilities

The served area in Province Wellesley is divided into three zones, namely North, Central, and South.

(a) North Zone

This system covers rural areas in the north of Province Wellesley and the town of Butterworth. The water is derived from the Sungai Kulim and flows along a channel to the Bukit Toh Allang treatment plant. The plant and the existing mains to Butterworth and Bukit Mertajam have a capacity of 40,914 cu m/day (9 MIGD).

(b) Central Zone

This system supplies water to the towns of Bukit Mertajam and Prai. The water is obtained from three streams on the slopes of Bukit Mertajam hill where storage reservoirs exist, and supplemental water is sent from the Bukit Toh Allang treatment works in the north.

(c) South Zone

The principal areas supplied in this zone are Nibong Tebal and Sungai Bakap. Water is obtained from a impounding reservoir and is treated in the treatment plant at Bukit Panchor.

The total rated output of the existing treatment plants in Province Wellesley is 49,870 cu m/day (11 MIGD).

Storage tanks have the following capacities:

Bukit Toh Allang	27,276	cu m/day	(6.0	m.g.d.)	
Bukit Mertajam	9,092	"	(2.0	")	(2 reservoirs)
Sungai Bakap	4,546	"	(1.0	")	
Bukit Panchor	4,546	"	(1.0	")	
Butterworth	2,546	"	(0.56	")	(4 elevated reservoirs)
North Province Wellesley	955	"	(0.21	")	(2 elevated reservoirs)
Prai	909	"	(0.2	")	(elevated reservoir)
Total	49,870	cu m/day	(10.97	MIGD)	

5.2.2 Water Sources

Water Sources of the water supply system in Province Wellesley are described in Table II-11.

TABLE II-11 Water Sources

Name of Treatment Plant	Water Source
Bukit Toh Allang	Sungai Kulim
Bukit Mertajam	Streams on the hill
Bukit Panchor	Impounding reservoir
Sungai Dua	Sungai Muda

5.2.3 Pumping Stations

There are five pumping stations in operation for the water supply system in Province Wellesley. The quantities of water pumped from low level intakes to supplement yields of high level intakes are as follows.

TABLE II-12 Total Annual Quantities of Pumping Station in 1973

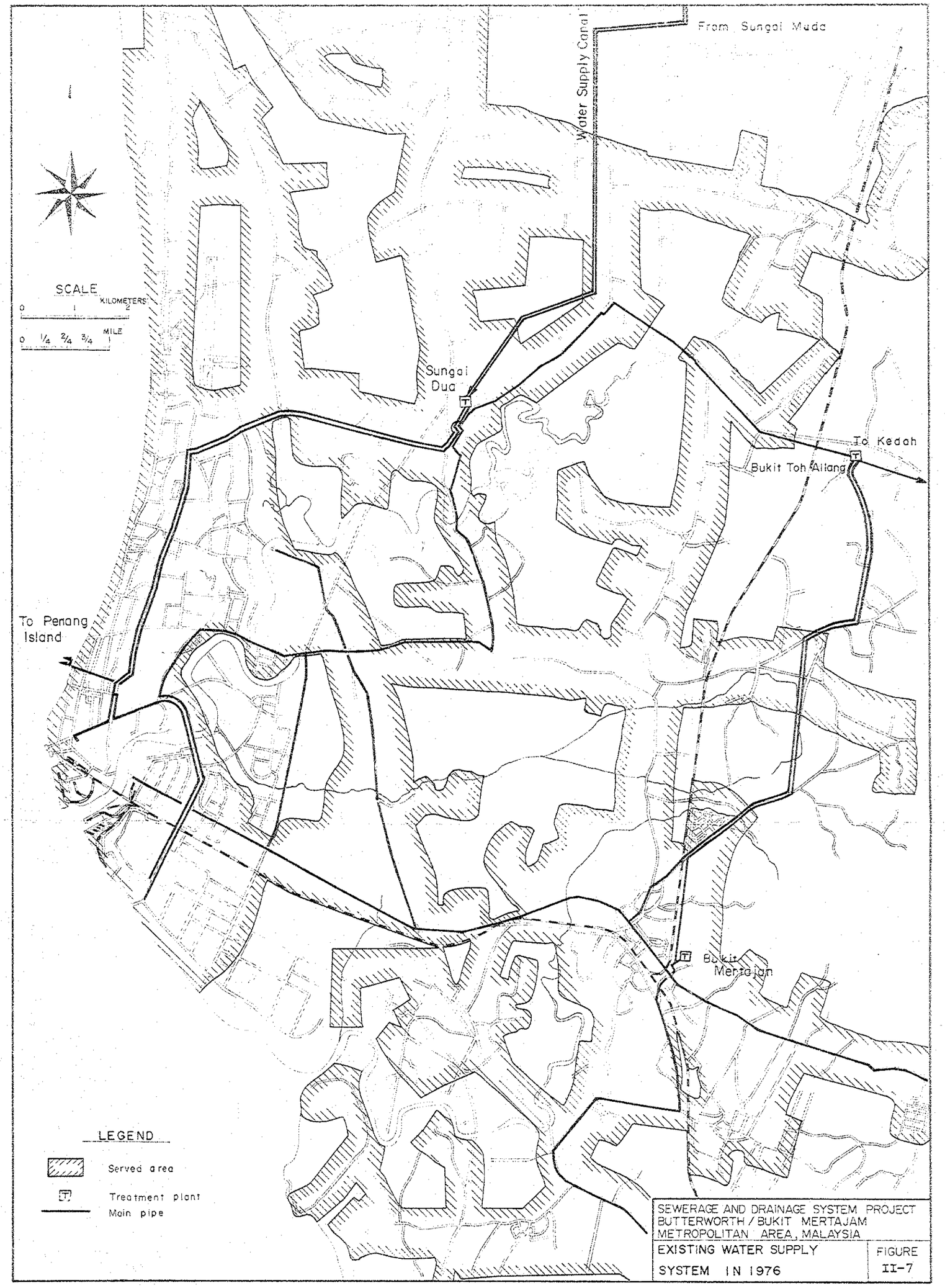
(1,000 cu m/year)

Name of Pumping Station	Quantities
Bukit Toh Allang Pumping Station	37,446
Bukit Mertajam Pumping Station	728
Bukit Panchor Pumping Station	412
Sungai Buaya Pumping Station	138
* Sungai Dua Pumping Station	1,467
Total	40,191

Note: * Commenced its operation from April 1973.

Data Source: 1973 Annual Report of Penang Water Authority.

FIGURE II-7


From Sungai Muda
Water Supply Canal
SCALE
KILOMETERS
0 1 2
0 1/4 2/4 3/4 1 MILE
Sungai Dua
To Kedah
Bukit Toh Aliang
To Penang Island
Bukit Mertajam
LEGEND
Served area
Treatment plant
Main pipe
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
EXISTING WATER SUPPLY SYSTEM IN 1976
FIGURE II-7

5.2.4 Treatment Plants

The treatment processes of plants are shown in Table II-13.

TABLE II-13 Treatment Process of Plants

Treatment Plant	System	Chemicals for Pre-Sedimentation	Sedimentation	Filtration	Sterilization	Conditioning
Bukit Toh Allang	Pumped	Chlorine Soda Ash Alum	Lovo Type	Rapid Gravity	Chlorine	Lime Dry Feed
Bukit Mertajam	Gravity w/Pumped Auxiliary Supply	Alum Lime Chlorine	Horizontal Type	Rapid Gravity	Chlorine	Lime Slurry Feed
Bukit Panchor	Gravity w/Pumped Auxiliary Supply	Alum Lime Sodium Aluminate	Horizontal Type	Rapid Gravity	Chlorine	Lime Dry Feed
Sungai Dua	Pumped	Lime Alum Soda Ash	Horizontal Type	Rapid Gravity	Chlorine	Lime Dry Feed

Source: PWA

5.2.5 Water Quality

The results of the water quality analysis at several points are shown in Tables II-14.

TABLE II-14 Results of Water Analysis

Location: (1) Bukit Toh Allang Service Reservoir (Treated water)
(2) Sungai Kulim (Raw water)
(3) Prai Post Office (Treated water)
(4) Kg. Sekolah Sekolah (Treated water)

Sample taken on: Month (1976) Day Time	(1) 8:50	(2) 10:15	(3) 8:00	(4) 10:25
CHEMICAL ANALYSIS (mg/l)				
Salinity	0.1	-	0.1	0.1
Chlorides as Cl	6	3	5	6
Total solids dried at 105° - 100°C	75	160	55	75
Oxygen absorbed from $KMnO_4$, 4 hrs., 27°C	0.25	1.65	0.20	0.25
Ammonical Nitrogen	0.01	0.09	0.01	0.01
Albuminoid "	0.02	0.10	0.01	0.01
Oxidized "	0.30	0.15	0.15	0.35
Nitrite "	-	0.001	-	-
Iron expressed as Fe	0.15	0.25	0.15	0.10
Total Hardness as $CaCO_3$	35	10	20	30
Fluoride as F	0.08	0.04	0.02	0.04
Turbidity	Clear with slight sedimentation	Turbid	Clear	Clear
Odour	Nil	Nil	Nil	Nil
Colour	-	-	-	-
pH	6.7	7.8	8.3	8.4

Data Source: PWA

5.3 Management and Operation

The Penang Water Authority was established in 1973 in accordance with the Penang Water Authority Enactment 1972. The present organization of the PWA is shown in Figure II-8.

FIGURE II-8 The Organization of the Penang Water Authority

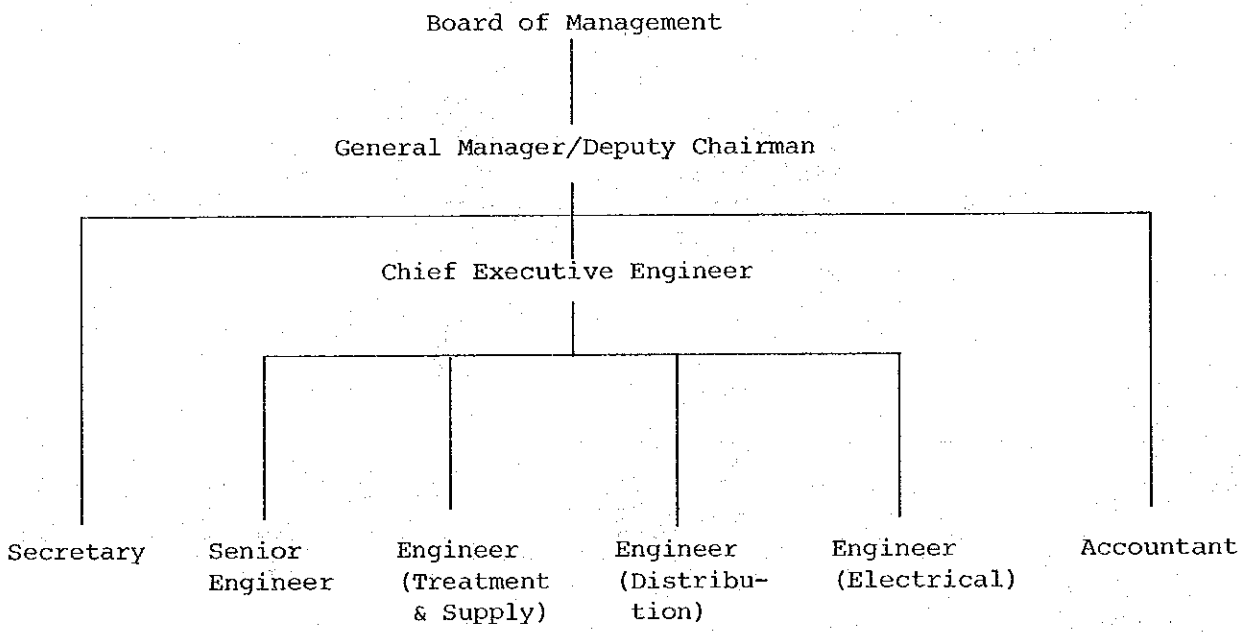


Table II-15

CHAPTER 6

EXISTING EXCRETA DISPOSAL SYSTEMS

6.1 Existing Toilet and Excreta Disposal System

Existing toilet facilities of the houses may be classified into three categories, namely flush toilet with septic tank or Imhoff tank, bucket toilet, and pit privy. Data obtained from "Population and Housing Census of Malaysia 1970" show the distribution of these facilities in the town areas and in the rural area. Number of houses classified according to the toilet facilities are summarized in Table II-15.

It should be noted that in the town areas, more than 90 percent of the houses are covered by flush or bucket toilets, while pit privy is predominant in the rural area. Houses with toilets over the waterways or no toilet 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 Mertajam	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 include the outside areas of the Project Area. Rural means the remainder of Butterworth and Bukit Mertajam Town Areas in the North and Central Districts.

New housing complexes have their own communal night soil treatment facilities, such as septic tanks or Imhoff tanks, with filtration

beds, except the treatment facility installed in Seberang Jaya, where kitchen wastes and night soil from 1,900 population are treated together by stabilization pond process. Communal septic and Imhoff tanks are managed by Minicipal Council of Province Wellesley. Location of these facilities and area served by night soil collection are as shown in Figure II-9.

6.2 Sludge Collection and Disposal

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

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

Existing facilities for excreta disposal are shown in following photographs.

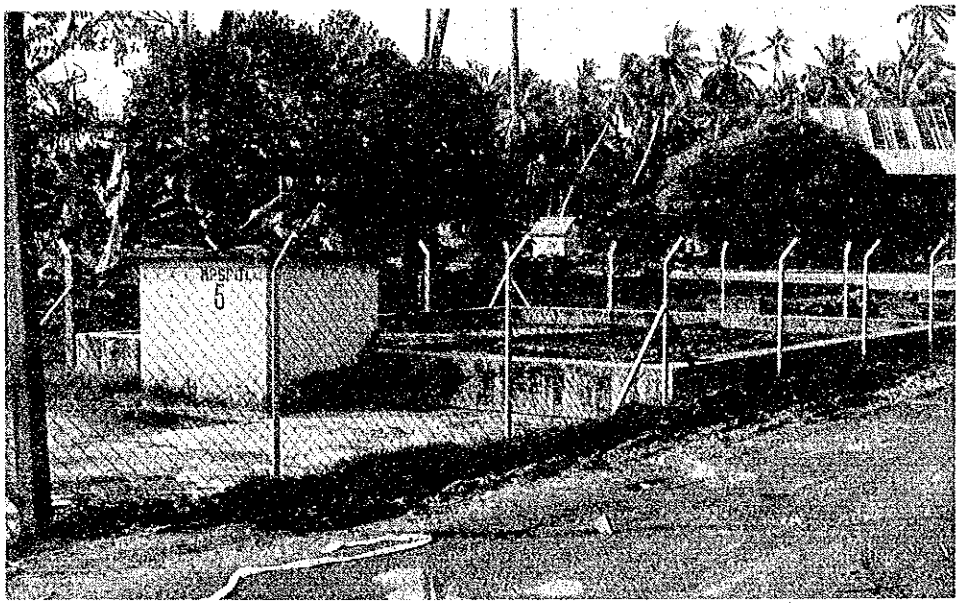


PHOTO II-1 Typical communal septic tank

PHOTO II-2 Typical pit-privy

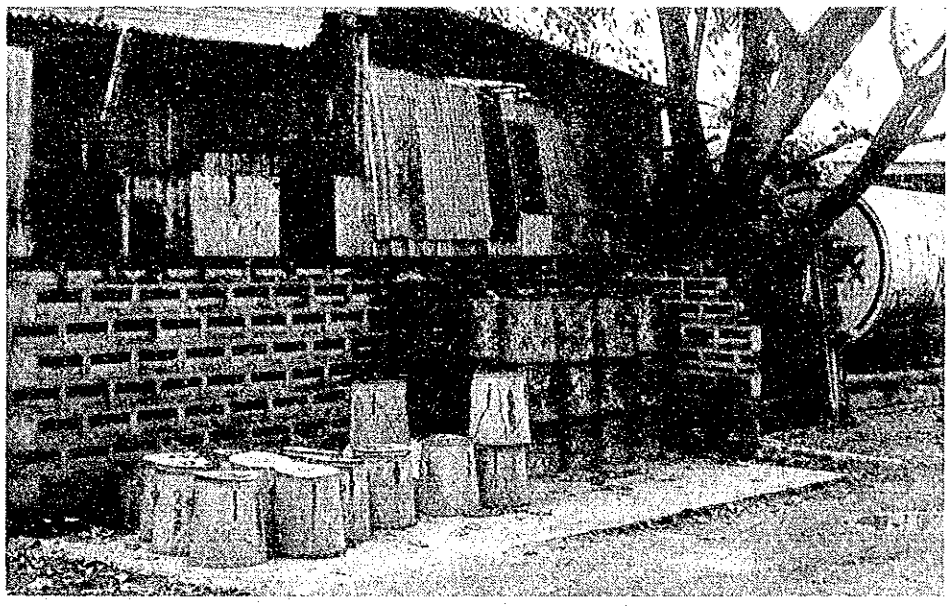
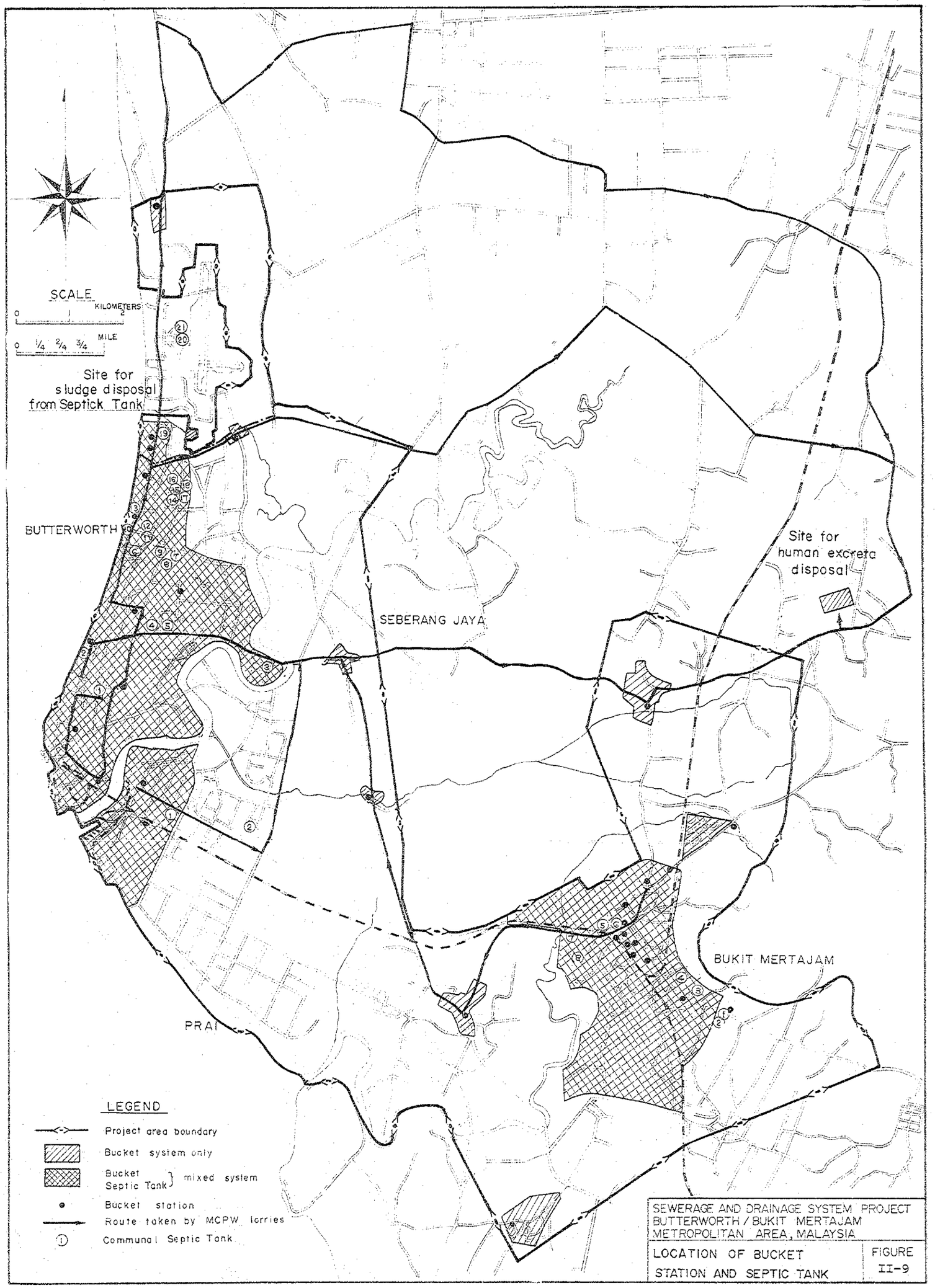


PHOTO II-3 Terminal of night-soil disposal buckets

PHOTO II-4 Vacuum lorry for sludge collection from septic tank

PHOTO II-5 V-trenches for sludge dumping

FIGURE II-9


SCALE
KILOMETERS
0 1 2
0 1/4 2/4 3/4 MILE
Site for sludge disposal from Septick Tank
BUTTERWORTH
SEBERANG JAYA
Site for human excreta disposal
BUKIT MERTAJAM
PRAI
LEGEND
Project area boundary
Bucket system only
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 communal systems. Sullage from residence, together with effluents from septic tanks and industrial wastes, are discharged into the existing open drainage system, which are serving as crude combined sewerage system. Since the major sources of wastewater in the Project Area are form the residential and industrial areas, and many of the factories are in fact either concentrated or scattered in the residential areas discharging their wastes into the nearby receiving waters through the drains together with the wastes from the residence, the consideration on the waste production and disposal referred here confined to domestic and industrial wastes.

7.1 Domestic Wastes

7.1.1 Existing Domestic Wastewater Discharge

There are many open roadside ditches in the existing town areas and new housing areas, receiving sullage waters together with the effluents from septic tanks and finally discharge them into the storm drains or natural waterways, flowing out to the sea through rivers or directly.

7.1.2 Sewage Flow and Strength

There are approximately 238,000 persons in the Area, of which more than 80 percent are served by municipal water supply system by PWA, but the rest of the people are served by either wells or surface water and wells are scarcely used for domestic use.

To estimate sewage flow rate strength produced by residents in the Project Area, field surveys were carried out at the selected representative housing blocks in the Area. The surveys covered home visits and actual measurements at the sites including volume measurements, samplings and chemical analyses.

Sewage flow and strength are estimated based on 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 (Ref. Appendix F, Volume III).

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

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

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

7.1.3 Septic Tank Effluent

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

The effluent quality ranges from 15 to more than 250 mg/l of BOD, and from 5 to 700 mg/l of SS, and often the effluents of more than 1,000 coliforms/ml are discharged into the open drains, rivers and/or coastal waters, causing contamination in the waters (See Appendix D, "Water Pollution Studies", Volume III).

7.2 Industrial Wastewaters

7.2.1 Industries in the Project Area

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

In these three industrial areas, more than 100 factories have

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

been established thus far and 36 more proposed by the year 1976. Food and textile factories predominate in these areas. (See Appendix F, "Wastewater Characteristics")

Small scale (home-size) factories scattered in the town areas and new housing areas are mostly of metal works, woodworks, motor repair-workshop, food manufactures, generally producing less wastes than other larger scale factories.

7.2.2 Industrial Wastewater Survey

For the purpose of estimating quantity and quality of industrial wastewater, surveys were made by Majlis Perbandaran Seberang Perai (MPSP), the Ministry of Environment, and during the year 1976.

As a preliminary survey, questionnaires for information on the volumes of water consumption and discharge were sent by MPSP to 73 factories in Prai Industrial Complex, and 56 percent of them were returned. Further, effluent samples taken from 22 factories which are deemed to be the major wastewater producers were analyzed.

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

The third survey, which was related to the Sewerage and Drainage Master Plan in Butterworth/Bukit Mertajam Metropolitan Area, was carried out by our Team. Questionnaires were sent including (1) water consumption, (2) wastewater loads and disposal, (3) treatment facilities, (4) effluent quality, (5) factory scale and expansion planning, (6) working hours, and (7) main process related to wastewater production, and supplemental wastewater analysis. The results are summarized and discussed in Appendix F, "Wastewater Characteristics".

7.2.3 Industrial Wastewater Quantity and Characteristics

The characteristics of wastewater produced by factories in the Project Area varies widely in quantity and quality according to the types of industries and by factory-scale. Detail of the studies are described in Appendix F, volume III .

Table II-17 summarizes per unit water consumptions of present major industries and average BOD and SS concentrations of their wastewaters, while Table II-18 shows unit wastewater production on

Table II-17
Table II-18

average of whole industries on the basis of available data.

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

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

TABLE II-18 Industrial Waste Load

Quality (mg/l)		Flow Rate (cu m/day/ha)	Unit Waste Load (kg/day/ha)	
BOD	SS	90.9	BOD	SS
122	125		11	11

7.2.4 Industrial Wastewater Treatment

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

The small scale (home-size) factories scattered in the residential areas are increasing in number, but volume of their wastewater is comparatively small so that it may be possible to discharge them to the public sewerage and treat in the proposed sewage treatment facilities jointly with domestic sewage.