6.4 Staging of Sewerage Construction

6.4.1 Priorities of Sewerage Zones

The schedule of construction of the sewerage system is considered based on priorities of each zones in the sewerage districts. In establishing such priorities, weighted system of 6 elements are considered in terms of improvement of sanitary conditions in the Project Area, using an arbitrary rating procedure by assigning reasonable relative weights to these various parameters.

The six major elements considered and assigned points for the ratings are as follows:

(1)	Population Density	400
(2)	Waste Load Production Aspect	250
(3)	Excreta Disposal System	150
(4)	Flooding	100
(5)	Availability of Water Supply	50
(6)	Incidence of Water-Borne Diseases	50
	Total	1,000 points

Detailed explanation for each of the elements are described in the following:

(1) Major factor is the improvement of environment for the welfare of the maximum population who will benefit by the system. It is, therefore, particularly important to provide sewerage facilities in high population density area, in order to gain the maximum benefit with the minimum expenditure, thus making the cost-benefit ratio higher. Hence, highest point is assigned for the population density.

(2) Second highest point is assigned to the waste load production aspect. In view of the waste load produced from the housing, commercial and industrial areas are generally discharged into drains and rivers without any treatment except the septic tank for human excreta, it is necessary to identify quantity of the waste load in each of the sewerage zones in order to determine the urgency of the sewerage facilities compared to other zones.

(3) Since there is no sanitary sewerage system in the Project Area, except a few local systems, practically all of the excreta produced in the area is disposed of either septic tank, bucket, pit privy or directly to waterways which is considered not satisfactory. The existing excreta disposal system is therefore analyzed from the view point of sanitation on excreta disposal and third highest point is given according to the unsatisfactory condition of zones.

(4) Although the government has undertaken improvement work for existing streams and drains, flooding frequently occurs causing damage in the built-up urban areas. These areas which have significantly affecting the sanitary conditions by way of flood should be improved by provision of sewerage system.

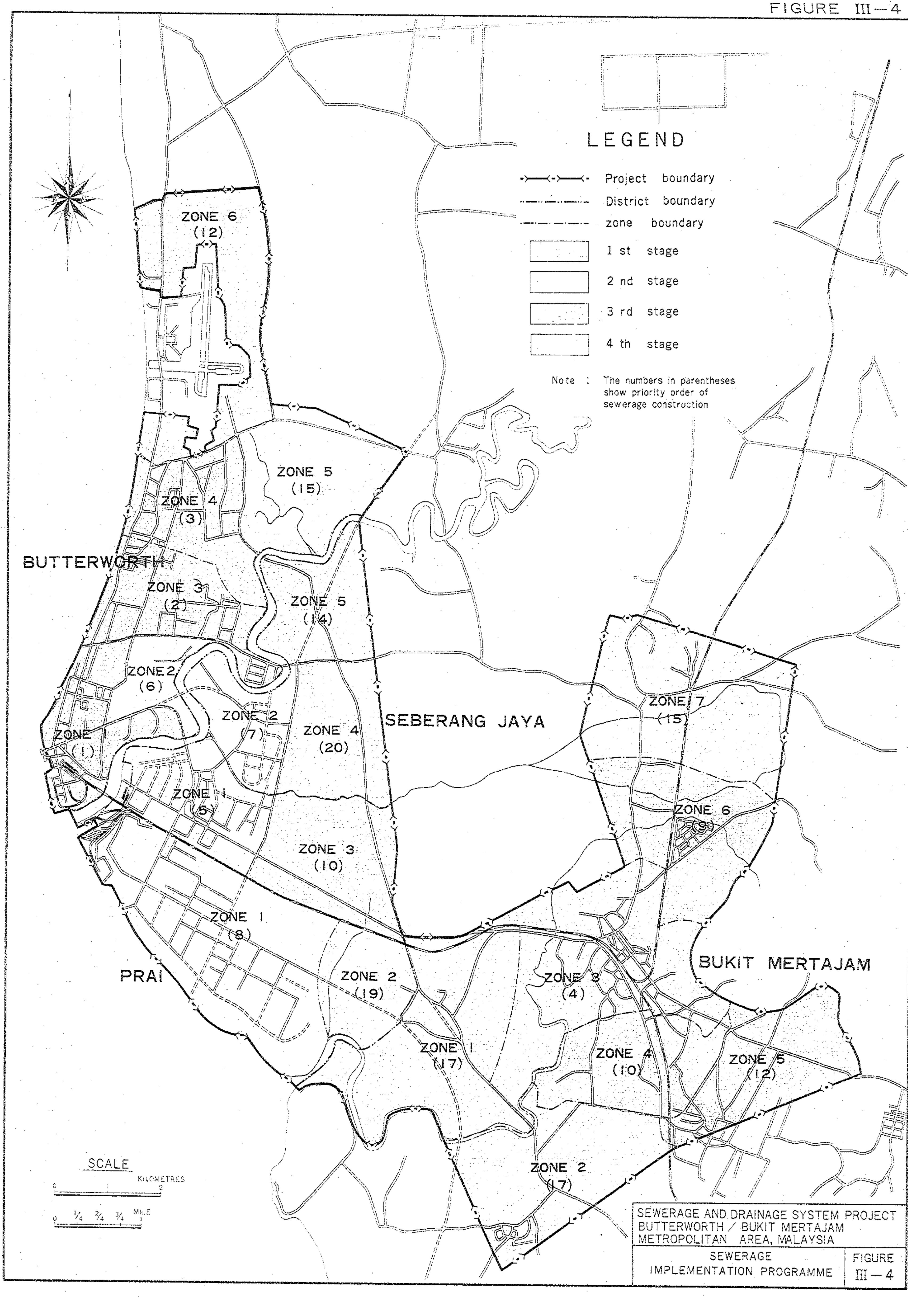
The remaining element, namely, (5) availability of water supply, and (6) incidences of water borne diseases also effect to sanitation conditions, but these are less critical than the above stated four categories. Therefore they are weighted accordingly.

The result of rating indicates that the zone 1 of Butterworth District has the highest total number of points, representing the combined rating for all the six elements, followed by the zones 3 and 4 of Butterworth, zone 3 of Bukit Mertajam District and so on as listed below.

Priority of Construction	District	Zone	Weighted Points
1	Butterworth	1	865
2	"	3	675
3	"	4	565
4	Bukit Mertajam	3	535
5	Seberang Jaya	1	387
6	Butterworth	2	315
7	Seberang Jaya	2	290
8	Prai	1	265
9	Bukit Mertajam	6	205
10	Seberang Jaya	3	188
10	"	4	188
12	Butterworth	6	186
12	Bukit Mertajam	5	186
14	Seberang Jaya	5	185
15	Butterworth	5	182
15	Bukit Mertajam	7	182
17	"	1	181
17	"	2	181
19	Prai	2	180
20	Seberang Jaya	4	130

The implementation of sewerage construction in the sewerage zones is proposed to be staged in accordance with the priority determined in this study. However, the zones, in which housing and industrial development programme is established, will be nominated in the first implementation programme by government policy. Detailes of the study are described in Appendix H. "Staging of Sewerage Construction", and also illustrated in Figure III-4.

FIGURE III－4



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

SEWERAGE IMPLEMENTATION PROGRAMME

FIGURE III－4

6.4.2 Staging of Programme

As the first step for determining the staging of sewerage construction, the possible alternatives on construction components and duration of time are considered for each stages, as described in Appendix G, "Sewerage System Consideration", and H, "Staging of Sewerage Construction". From these alternative studies, the most feasible alternative sewerage construction programmes are identified with due consideration on the components of the programme.

Thus, it is considered appropriate to divide the entire programme up to the year 2000 into 4 stages on the basis of the priorities of zones determined, according to the magnitude of investment and size of the component works. They are described in details in the following:

(1) First Stage Programme (1981 to 1985)

It is proposed that zones 1, 3 and 4 of Butterworth, and zone 3 of Bukit Mertajam, the 4 highest priorities of zones, be taken up in the first stage programme, and the component of work will include (a) the public sewers (main, branch, and lateral sewers) of 620 km, (b) house connections, and (c) sewage treatment plants. Implementation of this stage is recommenced to start in 1981, ending by 1985. When this stage is completed, 193,700 persons within a total area of 2,195 hectares will be served by the system in the year 1985.

Details of the recommenced sewerage facilities will be considered during the feasibility studies, which will follow after the present Master Plan is completed.

Areas and population to be served in this stage are as follows:

Name of Zone	Area Served (ha)	Population (persons in 2000)
Butterworth, Zone-1	367	45,500
" " -3	457	37,000
" " -4	444	37,500
Bukit Mertajam, Zone-3	927	73,700
Total	2,195	193,700

(2) Second Stage Programms (1986 to 1990)

With the completion of the sewage collection and disposal systems scheduled for the proposed first stage, it is provisionally proposed to set the years between 1986 to 1990 as second stage programme based on the current projection of development. The sewerage system components to be constructed during this stage include public sewers (main, branch, and lateral sewers) of 385 km, house connections, and treatment plant for each of zone 2 of Butterworth and zones 1 & 2 of Seberang Jaya, and zone 1, of Prai (with a pumping station). When this stage is completed, 93,800 persons within a total area of 1988 hectares will be served by the system. Areas and population to be served in this stage are as follows:

Name of Zone	Area Served (ha)	Population (persons in 2000)
Butterworth, Zone-2	182	21,800
Seberang Jaya, Zone-1	438	46,800
" " -2	305	25,200
Prai, Zone-1	1,063	
Total	1,988	93,800

(3) Third Stage Programme (1991 to 1995)

The sewerage system components to be constructed during this stage include public sewers (main, branch, and lateral sewers) of 910 km, house connections and treatment plant each for zone 6 (with a pumping station) of Butterworth, zones 3 and 5 of Seberang Jaya, and zones 4, 5 & 6 of Bukit Mertajam. When this stage is completed, 164,700 persons within a total area of 3,047 hectares will be served by the system.

Name of Zone	Area Served (ha)	Population (persons in 2000)
Butterworth zone - 6	670	37,300
Seberang Jaya, zone - 3	510	26,500
" - 5	368	19,200
Bukit Mertajam, zone - 4	467	24,900
" - 5	459	23,900
" - 6	573	32,900
Total	3,047	164,700

(4) Fourth Stage Programme (1996 - 2000)

By the year 2000, work can be completed on the entire sewerage implementation area, covering 10,854 hectares. This stage includes construction of sewers, pumping station, and treatment plants in the remaining portions of the entire Project Area, covering totally 3,624 hectares. Areas to be served by the system in this period are:

Name of Zone	Area Served (ha)	Population (persons in 2000)
Butterworth, zone - 5	551	33,700
Beberang Jaya, zone - 4	430	20,800
Prai, Zone - 2	268	14,000
Bukit Mertajam, Zone - 1	892	47,500
" - 2	715	39,800
" - 7	768	40,000
Total	3,624	195,800

Chapter 7

CONSTRUCTION AND MAINTENANCE COSTS

7.1 Construction Costs

7.1.1 Public Sewers

(a) Main Sewers

All construction costs for the recommended main sewer are estimated on the basis of the procedures described in Chapter 2 of Appendix E, "Design Data".

Construction costs for each size of sewer pipe are derived from unit construction costs which correspond to the design sewer depth.

(b) Barnch and Lateral Sewers

For estimating construction costs, the total length of these sewers by size are obtained, using per unit area sewer length of the different sewer size derived from the study of new housing scheme. Then, the construction costs for all the sewer size all estimated, multiplying the length by the unit cost developed on the basis of 1976 Malaysia price levels.

7.1.2 House Connections

Total length of these pipes are estimated for cost estimates, assuming that each household has 15 meters house connection pipe within the house plot. Then the total length of these sewers are calculated taking into account of the population served and the average size of family in each of the sewerage districts under considerations.

The average construction cost for house connection is estimated at 30 M$ per meter.

7.1.3 Pumping Stations

Three pumping stations are proposed to be provided to lift sewage at Butterworth (zone-6) in the third stage, Prai (zone-1) in the second stage and Bukit Mertajam (zone-1) in the fourth stage to convey the sewage flow to the treatment plants.

All construction costs for these stations are derived on the basis of the unit cost for buildings and equipment to be imported. It is assumed that most of equipment including pumps, controlling devices, electric facilities, screening and grit removal facilities, gate and piping materials will be imported, but materials for building and civil works will be available in Malaysia.

7.1.4 Sewage Treatment Plant

All construction costs for treatment plants are derived on the basis of the unit cost for civil works and equipment to be imported. It is assumed that most of equipment including pumps, flow measuring devices, electric facilities, aerators, and others will be imported, but materials for civil works will be available in Malaysia.

7.1.5 Construction Costs by Stage

On the basis of the above, the estimated sewerage construction cost by stages are as shown in Tables III-9 to III-16.

Table III-9 Sewerage Construction Cost by Stage at 1976 Price (Government Contribution)

1st Stage (1981-1985) (cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Public Sewers (main)	32,480	-	32,480	
b. Pumping Stations	-	-	-	
c. Treatment Plants	7,890	1,970	9,860	
d. Land Acquisition	5,590	-	5,590	
(A) Sub Total	45,960	1,970	47,930	
(B) Contingency	9,190	390	9,580	(A) x 0.20
(C) Engineering Fee				
Design	1,720	1,150	2,870	(A+B) x 0.05
Supervision	1,720	1,150	2,870	(A+B) x 0.05
Total	58,590	4,660	63,250	

Table III-10 Sewerage Construction Cost by Stage at 1976 Price (Private Contribution)

1st Stage (1981-1985) (cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Branch & Lateral Sewers	59,410	-	59,410	
b. House Connections	16,950	-	16,950	
(A) Sub Total	76,360	-	76,360	
(B) Contingency	15,270	-	15,270	(A) x 0.20
(C) Engineering Fee				
Design	4,580	-	4,580	(A+B) x 0.05
Supervision	4,580	-	4,580	(A+B) x 0.05
Total	100,790	-	100,790	

Table III-11 Sewerage Construction Cost by Stage at 1976 Price (Government Contribution)

2nd Stage (1986-1990) (Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Public Sewers (main)	34,510	-	34,510	
b. Pumping Stations	2,380	2,370	4,750	
c. Treatment Plants	17,180	4,290	21,470	
d. Land Acquisition	27,800	-	27,800	
(A) Sub Total	81,870	6,660	88,530	
(B) Contingency	16,370	1,330	17,700	(A) x 0.20
(C) Engineering Fee				
Design	3,190	2,120	5,310	(A+B) x 0.05
Supervision	3,190	2,120	5,310	(A+B) x 0.05
Total	104,620	12,230	116,850	

Table III-12 Sewerage Construction Cost by Stage at 1976 Price (Private Contribution)

2nd Stage (1986-1990) (Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Public & Lateral Sewers	25,670	-	25,670	
b. House Connections	13,290	-	13,290	
(A) Sub Total	38,960	-	38,960	
(B) Contingency	7,790	-	7,790	(A) x 0.20
(C) Engineering Fee				
Design	2,330	-	2,330	(A+B) x 0.05
Supervision	2,330	-	2,330	(A+B) x 0.05
Total	51,410	-	51,410	

Table III-13 Sewerage Construction Cost by Stage at 1976 Price (Government Contribution)

3rd Stage (1991-1995) (Cost Unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Public Sewers (main)	47,000	-	47,000	
b. Pumping Stations	120	110	230	
c. Treatment Plants	6,880	1,720	8,600	
d. Land Acquisition	8,810	-	8,810	
(A) Sub Total	62,810	1,830	64,640	
(B) Contingency	12,560	360	12,920	(A) x 0.20
(C) Engineering Fee				
Design	2,320	1,550	3,870	(A+B) x 0.05
Supervision	2,320	1,550	3,870	(A+B) x 0.05
Total	80,010	5,290	85,300	

Table III-14 Sewerage Construction Cost by Stage at 1976 Price (Private Contribution)

3rd Stage (1991-1995) (Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Branch & Lateral Sewers	89,580	-	89,580	
b. House Connections	14,300	-	14,300	
(A) Sub Total	103,880	-	103,880	
(B) Contingency	20,770	-	20,770	(A) x 0.20
(C) Engineering Fee				
Design	6,230	-	6,230	(A+B) x 0.05
Supervision	6,230	-	6,230	(A+B) x 0.05
Total	137,110	-	137,110	

Table III-15 Sewerage Construction Cost by Stage at 1976 Price (Government Contribution)

4th Stage (1996-2000)

(Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Public Sewers (main)	51,900	-	51,900	
b. Pumping Stations	100	100	200	
c. Treatment Plants	8,020	2,000	10,020	
d. Land Acquisition	3,200	-	3,200	
(A) Sub Total	63,220	2,100	65,320	
(B) Contengency	12,640	420	13,060	(A) x 0.20
(C) Engineering Fee				
Design	2,350	1,560	3,910	(A+B) x 0.05
Supervision	2,350	1,560	3,910	(A+B) x 0.05
Total	80,560	5,640	86,200	

Table III-16 Sewerage Construction Cost by Stage at 1976 Price (Private Contribution)

4th Stage (1996-2000) (Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Branch & Lateral sewers	106,540	-	106,540	
b. House Connections	17,310	-	17,310	
(A) Sub Total	123,850	-	123,850	
(B) Contingency	24,770	-	24,770	(A) x 0.20
(C) Engineering Fee				
Design	7,430	-	7,430	(A+B) x 0.05
Supervision	7,430	-	7,430	(A+B) x 0.05
Total	163,480	-	163,480	

7.2 Maintenance Costs

7.2.1 Sewers

Maintenance costs for sewer pipes are derived from data developed on the basis of the experience both in Malaysia and Japan, assuming that all sewers will be cleaned at least every four years by use of trusting rods and/or bucket machines, etc. Estimated maintenance costs for sewer pipes are given in detail in Appendix E."Design Data."

7.2.2 Pumping Stations

Operation and maintenance costs for pumping stations are derived from the current labour and material costs in Penang State, including power, fuel, water for cooling and sealing, lubrication, grit and screening removal, and minor repair of equipment. Needs for this operation and maintenance are estimated on the basis of daily average flow rates. Estimated maintenance and operation costs for pumping stations are given in detail in Appendix E."Design Data."

7.2.3 Treatment Plants

Operation and maintenance costs for treatment plants are derived from the current labour and material costs in Penang State, including power, water for cooling and sealing, lubrication, and minor repair of equipment. Estimated operation and maintenance costs for treatment plants are given in detail in Appendix E."Design Data."

7.2.4 Operation and Maintenance Costs by Stages

Estimated sewerage operation and maintenance costs by stages are shown in Table III-17.

TABLE III-17 Sewerage Operation and Maintenance Costs by Stage at 1976 Price

(1,000 M$/Year)

Description	Stage	1st Stage	2nd Stage	3rd Stage	4th Stage
Public Portion	a. Main Sewers	330	350	470	560
	b. Branch & Lateral Sewers	720	310	1,080	1,300
	c. Pumping Stations	-	110	30	20
	d. Treatment Plants	250	310	260	270
	Total	1,300	1,080	1,840	2,150
Private Portion	House Connection	400	310	340	410
	Total	400	310	340	410

Note: As for operation and maintenance cost, branch and lateral sewers are included in public portion.

CHAPTER 8

BENEFITS

8.1 Anticipated Benefits

Significant benefits to public health of the community can be derived from installation of an adequate sewerage system in the sewerage implementation area. The benefits to be derived from the construction and operation of the recommended sewerage system can be grouped in several categories, namely (1) health benefits, (2) environmental benefits, (3) economic benefits, and (4) general benefits.

All anticipated benefits have been evaluated for the sewerage project on the basis of either quantifiable or nonquantifiable benefits.

8.2 Recognition and Measurement of Benefits

Associated benefits through a more pleasant community environment, greater potential for tourism, opportunity for more intensive land use, and opportunities to facilitate housing and industrial construction, together with a cause of other less tangible benefits have been identified.

Major benefits resulting from the improvement of health conditions, environmental aspect, and from increases in land volues, are quantified as follows.

8.2.1 Health and Sanitation Benefits

The major benefit from the proposed sewerage system will be the sanitation improvement resulting from removal of human excreta and other wastes from the community.

Anticipated benefit resulting from the sewerage system can be measured if the cause and effect relationship of the sewerage system to incidence of the water-borne diseases and to the levels of mortality and morbidity of the populations served by the system, are determined, if reduction of pertinent diseases are estimated on the basis of reasonable assumptions.

A statistical data prepared by MHD indicates that the number of gastro-entritic disease cases in the Project Area was 81 per year by an average occurred from the year 1970 to 1975. Also, a survey on the cost for treatment of the diseases under the present Project in 1976 indicates that expenses for treating water-borne diseases, including amounts spent for medical care, cost about M$27 per person per day for an average of two weeks hospitalization. To estimate the benefit to be derived from the sewerage system, with modest assumption of approximately 50 percent of these is attributable to unsatisfactory excreta disposal, which can be eliminated by the sewerage system. This represents a quantifiable cost of about M$15,000 per year. (81/2 x 27M$ x 14 days).

The main elements of indirect cost can also be calculated assuming the average wage lost and the number of man-days lost due to disability. The wage lost is estimated to be about M$1,500 per year on an average at 1976 price levels, assuming from the data collected that the average income of labour participation group is M$250 per person per month. This is on the basis of assumption that the incidence and age distribution of diseases to be affected for assumption of wage loss will be limited to the labour force, which is approximately 47 percent of the total population, excluding unemployment factor.(Ref. Appendix A, Economy)

In addition, other benefits, although mostly unquantifiable, are expected, including (1) reduction of discomfort and distress, (2) improvements in environmental aesthetics from elimination of the present sewage odours emanating from drains and sludge accumulation, (3) reduction of groundwater contamination resulting from improves measures for handling sanitary wastes.

8.2.2 Water Pollution Control Benefit

From the extensive investigation to the drains and rivers under the present project (see Appendix I), most of drains in urbanized area of the Project Area have been polluted and are expected to become much more polluted in the future. Also rivers will be polluted from the drain flows. Currently these drain and river waters are used for the purpose of irrigation, fishing and etc.

The reduction of waste loads or improvement of water quality in the drains and rivers is therefore the major benefit to be derived from the sewerage system. Waste loads discharged in the sewered areas will be reduced considerably through the treatment plant before discharge into waterways, and will cause improvement of environmental aspects including also the river waters become available as new water resources for various purposes.

8.2.3 Values Added to Land

Investment in sewerage facilities will have the effect of raising the intrinsic values of the parcels of land served by the system. These additional land values constitute a major economic benefit of the project in that, by improving the sanitary and aesthetic quality of the community, they not only contribute to the quality of life of the residents, but also as additional source of taxation for the revenue in favour of government authorities. The value of such benefit is measured by the additional price observed in the areas where similar projects have been carried out, that buyers are willing to pay for properties on which such physical improvements have been made.

On the basis of the data obtained in project site during 1976, the present land value in sewerage implementation areas is rated to an average of M$8 per sq. meter by the categories of land use employed (i.e. social & commercial area of 85 ha, residential area of 913 ha, industrial area of 85 ha, residential area of 913 ha, industrial area of 844 ha, rural area (kampong) of 3,484 ha, and agricultural & non-habitable area of 6,274 ha). It is also obtained that, prior to any development programme were M$1.5 per sq. meter for agricultural and non-habitable areas such as mountain, M$3.0 per sq. meter for areas slightly inhabited or rural areas, and built-up urban area and developed industrial area were M$54 and M$22 per sq. meter respectively. Hence, after improvement by development programme, land value in present condition covering whole area is estimated to be M$928 million at 1976 price level.

After the Project Area is improved by development programme based on the land use envisaged by the year 2000 (Ref. Appendix B), the land value would be increased to an average of M$15 per sq. meter. Then, increased land value for the whole area is estimated to be 1740 million.

For evaluation of the benefit derived from the increase in land values, if twenty percent of land value increased is attributed by the construction of sewerage system, then quantifiable cost is represented to be 162 million approximately at 1976 price level [(1740-928) x 0.2)].

8.2.4 Other Economic Benefits

In the Project Area, there are many development programmes, including housing and industrial development. Although the exact construction schedules for these programmes are not yet firmly decided, if it is planned to be implemented during the same period as overall project period of provision of sewerage system, the cost of constructing septic tank will be avoided by providing the sewerage system for the Project Area. Table III-18 shows a comparison of septic tank and sewage treatment plant as recommended in the Master Plan including cost of construction, maintenance and operation. It is clear that the cost of inferior alternative system as the use of septic tank is higher, and further the septic tank is only to receive human excreta (W.C) and do nothing to resolve the problems of contaminated sullage on industrial wastes water. Thus, the provision of the sewerage system, consisting of sanitary sewer and treatment plant, would be of benefit to the individual expenditure in comparison with other sanitary system such as septic tank.

Table III-18 Cost Comparison of Alternative Sewage Treatment Plant

Alternatives	Construction Costs (Per Capita burden) M$	Maintenance/Operation Costs (Per Capita burden) M$ per year
*Septic tank	166	8.5
Recommended Sewage Treatment Plant	53.8	0.8

Note: * Data obtained from MPSP Septic tank covers only human excreta (W.C).

8.3 Benefit Justification

On the basis of the results of evaluations of benefits by the proposed sewerage system for the Project Area, tangible and intangible, it is concluded that the Project is definitely justifiable. If no sewerage system were provided in the areas, sanitary conditions, which are already deplorable in many areas of the city, will become progressively worse. Moreover, if this Project is not undertaken at this time, the cost for implementation at later times will become increasingly higher. Thus the accumulated total cost could become so high that Project could become almost unmangeable. The Project therefore is indeed timely now.

PART IV

DRAINAGE MASTER PLAN

Table of Contents

CHAPTER 1

AREA COVERED BY DRAINAGE PROGRAMME

1.1 Classification of Area

The Project Area concerned for consideration of the drainage systems proposed under this Project is identical to that for the sewerage system covering the area of 11,600 hectares inclusive of river surface, mountainous portion higher than RL + 60 meters (+200 ft) which is taken as nonhabitable area.

However, it is necessary, for planning purpose, to consider the catchment area, where stormwater inflows from outside of the Porject Area due to topographical condition for the basis of estimation of stormwater quantities. The total extent of these contributing areas is 4,290 hectares (10,600 acres). However no facilities will be planned to these area.

Thus the area concerned to drainage system planning is summarized as follows ;

The Project Area	11,600 ha	(28,660 acres)
Contributing Area	4,290 "	(10,600 ")
Total	15,890 "	(39,260 ")

On the other hand two development areas, Prai and Seberang Jaya, are not considered for the purpose of drainage master planning, as these two areas have already been served by existing drainage system. Because they form the independent drainage areas, it can safely be considered to exclude them from the planning consideration of the Drainage Master Plan.

Further, nonhabitable areas including river surface and mountain zone are to be excluded from the facility planning and construction cost estimation. Exluding areas are

Prai and Seberang Jaya	980 ha	(2,422 acres)
Nonhabitable area	746 "	(1,843 ")
Total	1,726 "	(4,265 ")

Therefore area to be served by drainage system under this project is ; 15,890 - (4,290 + 1,726) = 9,874 ha (24,398 acres).

1.2 Drainage Basin

Considering existing layout of water ways, natural and artificial, and general feature of land use, the proposal in the Assignment Report of WHO is considered reasonable, and therefore the Project Area is divided into six drainage basins as shown in Figure IV-1. Table IV-1 shows the area of individual drainage basin, with indication of contributing area and non habitable area.

TABLE IV-1 Area in Individual Drainage Basin (in ha)

Name of Drainage Basin	Area to be served by Drainage System	Area excluded from the Project	Sub-total	Area contributing from outside of the Project Area	Total
B-I	980	93	1,073	55	1,128
B-II	3,591	202	3,793	1,669	5,462
B-III	2,632	1,332	3,964	993	4,957
B-IV	1,576	80	1,656	42	1,698
B-V	551	19	570	1,063	1,633
B-VI	544	0	544	468	1,012
Total	9,874	1,726	11,600	4,290	15,890

1.3 Design Master Plan and Preventative Master Plan

In accordance with the terms of reference for drainage master plan, the area covered by drainage programme is divided into two kinds, Design Master Plan area and Preventative Master Plan area. These are defined as follows:

a. Design Master Plan (DMP)
   This is the plan for the built-up areas. Its objective is to prepare comprehensive long-range plans for the solution of existing drainage problems in the built-up areas.

b. Preventative Master Plan (PMP)
   This is for undeveloped areas. The objective of it, is to prepare drainage strategies to prevent drainage problems from occuring with future urban development of the land.

Figures IV-2 and 3 show the main drains. The main drains studied under DMP are RAM. 5, 6, ARA. 1 - 3, TAN., PAY. 1, 2, BUK. 1, 2, PAS 1 - 3, PEK. 1 - 3, BKC and BKD[1/] in Basin II and all main drains in Basin IV.

All remaining main drains are discussed under PMP, because they are located in the undeveloped areas or the vicinity of urbanized areas, in which the land spaces necessary for future drainage strategy are still available and the requirement for improvement of drainage situation is not imminent.

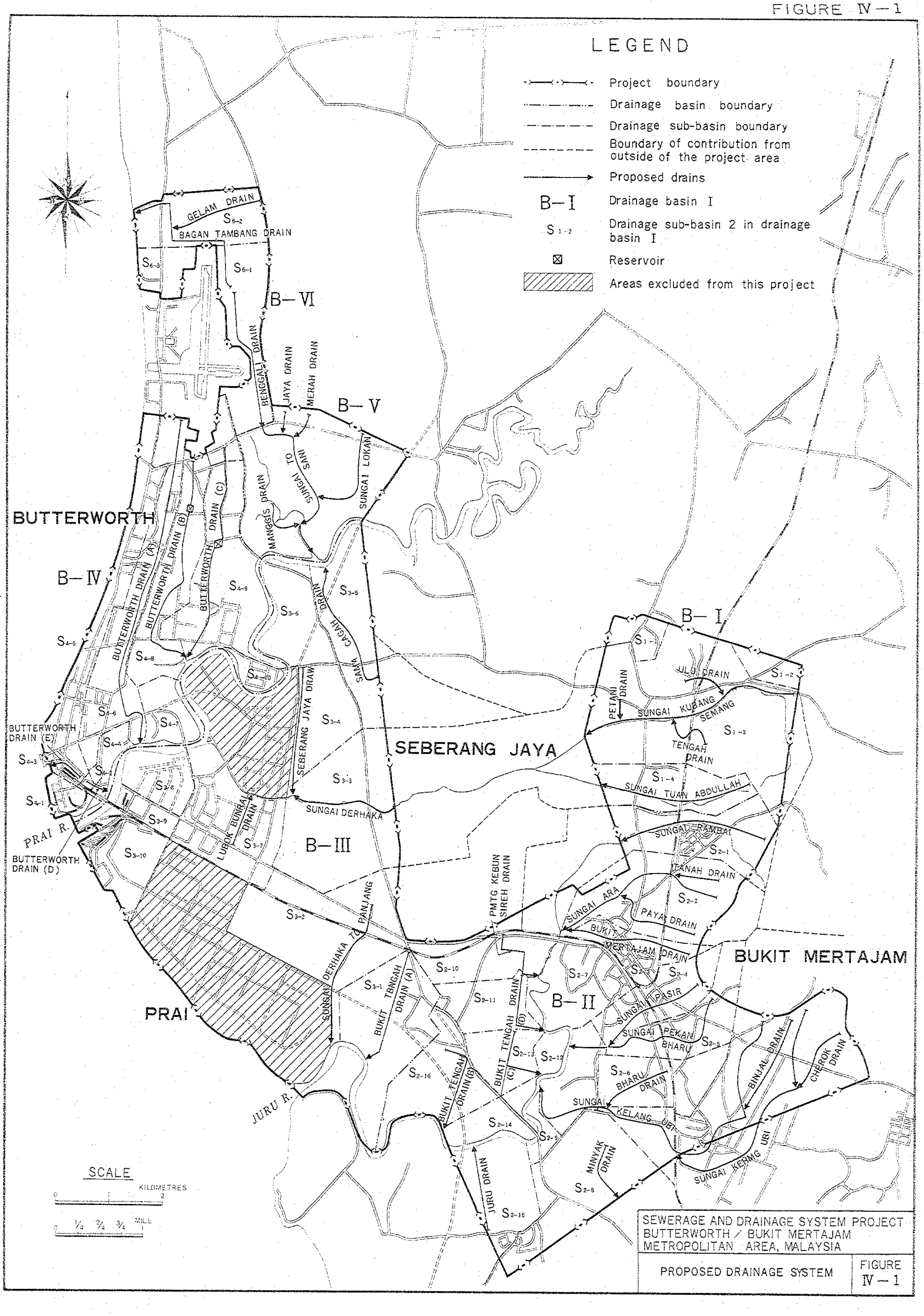
1/ These abbreviations are tabulated in Table IV-2.

TABLE IV-2 Abbreviation of Name of Drains

Basin	Name of Drain	Abbreviation
I	Sungai Kubang Semang	KUB
	Ulu Drain	ULU
	Tengah Drain	TEN
	Petani Drain	PET
	Sungai Tuan Abdullah	TUA
II	Sungai Rambai	RAM
	Sungai Ara	ARA
	Tanah Drain	TAN
	Paya Drain	PAY
	Bukit Mertajam Drain	BUK
	Sungai Pasir	PAS
	Sungai Pekan Bharu	PEK
	Sungai Kelang Ubi	KEL
	Binjai Drain	BIN
	Ubi Drain	UBI
	Cherok Drain	CHE
	Bharu Drain	BHA
	Minyak Drain	MIN
	Pmtg Kebun Siren Drain	PMT
	Bukit Tengah Drain (B)	BKB
	Bukit Tengah Drain (C)	BKC
	Bukit Tengah Drain (D)	BKD
	Juru Drain	JUR
III	Bukit Tengah Drain (A)	BKA
	Sungai Derhaka To Panjang	DEJ
	Sungai Derhaka	DER
	Seberang Jaya Drain	SEB
	Lubok Bunral Drain	LUB
	Sama Cagah Drain	SAM
IV	Butterworth Drain (A)	BWA
	" (B)	BWB
	" (C)	BWC
	" (D)	BWD
	" (E)	BWE

(to be continued)

Basin	Name of Drain	Abbreviation
V	Sungai To Sani	SAN
	Jaya Drain	JAY
	Merah Drain	MER
	Sungai Lokan	LOK
	Manggis Drain	MAN
VI	Benggali Drain	BEN
	Began Tambang Drain	BAG
	Gelan Drain	GEL



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

PROPOSED DRAINAGE SYSTEM

FIGURE IV-1

CHAPTER 2

BASIC ENGINEERING CONSIDERATION

It is necessary to find technically and economically feasible means for alleviating flood experienced at present and expected in the future. Existing built-up areas are served by concrete lined road side drains and trapezoidal main drains, lined or unlined. Those main drains are heavily silted and over loaded causing flood. Predominant topographical features in the Project Area are flatness and low ground elevation. The rivers and drains are effected by the tide and some part of the area is flooded due to back up of the river and/or sea water.

On the basis of situations mentioned above, it is considered that solutions to the flood problems in the Project Area could include:

a. Improvement of existing drains and/or provision of new drains for reinforcing collection and conveyance systems of stormwaters.

b. Storage of stormwaters in assigned area for alleviating flood in down stream areas,

c. Shutting out the back water effect to living and working environment by gates or levees, and removal of stormwaters by pumps during high water period in the outside of the area.

d. Raising up ground elevation by land filling.

2.1 Reinforcement of Collection and Conveyance Systems for Stormwaters

In considerable part of the Project Area, the lack of drains is the cause of flooding, and stormwaters can not find way to reach rivers smoothly. The existing drains are in many cases inadequate to accomodate runoff derived from heavy storm. The basic work to be implemented urgently in order to alleviate floods in the Project Area is therefore to improve existing inadequate facilities and to provide new drains in the area where they are required. This is included in the recommendation for the works to be undertaken in the 1st stage programme of the Master Plan.

2.2 Storage of Stormwaters for Alleviating Flood in Downstream Areas

To store stormwaters requires generally considerable amount of land spaces. Therefore, this should be considered for areas presently undeveloped within which land is still available. Even when some development is applied in such undeveloped areas, in the future, the concept of storing stormwaters for the purpose of limiting discharge to downstream and eliminating of major damages should also be adopted. Storage of stormwaters would be able to reduce the cost for improvement of downstream drainage system generally required due to development in upstream areas. In the Project Area, except some built-up portion, the land is relatively easily available, and the storage of runoff is the preferable measure for the Project Area.

The storage volume to be assigned when this is planned is calculated on the basis of following criteria which is considered in accordance with the DID standards and described below.

a. The allowable stormwater runoff quantities from considred area should be that which is equivalent to runoff volume derived from 2-yr storm with 0.35 runoff coefficient. The increment part have to be stored in retention reservoir which has capacity to cope with the stormwater discharge resulted from 100-yr frequency storm, with runoff coefficient of 0.65.

b. In areas within which land is not available, the storage volume may have to be adjusted from that mentioned in (a). However, to store storm runoff as much as possible has to be considered.

2.3 Pumped Drainage System

Cutting off back water effect from rivers or the sea by providing levees or gates and remove stormwaters within closed areas by pumps is one of measures applicable for drainage system.

One of major factors which have to be accounted when pumps are to be provided is the operation frequency expected. For lower areas subject to flood frequently due to back up water, provision of pumps will be warranted due to the frequency of their use. However, the application of pumped drainage systems would not be feasible for areas to be flooded infrequently.

The construction of pumping stations requires considerable amount of initial costs, including procurement of equipments and their spare parts to be imported, together with the recurrent maintenance costs. Careful operation and maintenance service would also be essential for proper functioning of the pumping station, otherwise it would not properly serve its purpose.

Accounting disadvantages of pumped drainage system as previously mentioned, the provision of pumps as drainage facility will be the last order in suitability of the drainage system alternatives for the Project Area.

2.4 Raising Up Ground Elevation by Land Filling

Land filling has been commonly applied for areas having been developed in the Project Area through it history.

Although it required considerable initial costs, once land filling has been carried out, no maintenance works and costs are expected thereafter. Therefore, if the fund is available and wherever the topography warrants, land filling is the advisable measure for alleviating floods, provided necessary consideration will be given to control the discharge rate from the area for preventing adverse effect to downstream areas.

Estimated elevation up to which land should be filled is RL +2.30 meters (+7.5 ft) in the tributaries of the Prai and Juru river (Ref. Appendix J, Volume II).

CHAPTER 3

DESIGN BASIS

3.1 Open Channel or Closed Conduit

Existing drains in the Project Area are open channels. Open channels have considerable advantages over closed conduits, the main ones being the ease of maintenance, lack of requirement of manholes, the comparatively shallow construction required and the fact that road kerbs and gulleys are not necessary to accept runoff from roads. In addition, the shallow construction requirement would minimise the crossings with sewer pipes in case of the separate system as recommended for the Project. The major disadvantage on the other hand in the open channel is to provide easy access to the disposal of refuse, which results in blockages. This disadvantage should be dealt with, although it would take time, by an educational campaign for cleanliness of environment to prohibit the disposal of refuse into open channels. Anti-litter campaign are now proceeding in the Area, and this should be the useful measure to protect open channels from clogging.

On the other hand, closed conduits have merits which conserve spaces for road and other utilities, and in the highly developed areas closed conduits have an advantage. However, the areas for the proposed drainage are mostly those where the stage of development does not warrant underground closed conduits. Even in case of open channels, spaces for other utilities can be provided by covering them when such are needed.

On the basis of the reasons above, basically, open channel will be used in the Project Area.

3.2 Survey Datum

The reference data used in this Report is Malaysian Survey Ordinance Datum, of which the zero point is mean sea level (1912 determination).

The ground elevation used in this Report is expressed as reduced level (RL) which has the same zero point with survey ordinance datum. The sea level as a design beasis of this Project is determined on the basis of records during 1952 - 1967. The applied figures, described below, are also quoted in the "Project Report on Drainage and Reclamation of Sungai Prai Basin". The above report has various relations with the drainage plan in the Project Area, and it is considered that the use of the same design sea level will be preferable. The applied sea level used in the present document is shown below:

HHWL (highest recorded level)	SOD	+1.68 m (+5.5 ft)
MHWL (spring tide)	"	+1.10 m (+3.6 ft)
Mean sea level	"	+0.15 m (+0.5 ft)
KLW (spring tide)	"	-0.79 m (-2.6 ft)

SOD: Survey Ordinance Datum which is the hight above mean sea level at Port Swettenham in 1912.
It is expressed as,
mean sea level (in 1912) ..... SOD + 0.00

3.3 STormwater Quantities

As the basis of the engineering design of drainage facilities, stormwater quantities have to be estimated as accurate as possible, for which many formulae and methods have been developed. The purpose of this section is to describe the various factors, required for this Project as a basis of design, which are developed in association with matters included in DID's Planning and Design Procedure No. 1 "Urban Drainage Design Standards and Procedures for Peninsular Malaysia." (hereinafter referred to as the Malaysian Standards)

(1) Runoff Formulae

The "Rational Formula" is widely used as current practice for computing quantities of stormwater runoff. Although, it is normal to apply the "Rational Method" in which no storage effects inside ditches are weighted, the Malaysian Standards mentioned above recommended the use of the "Rational Method" with a storage coefficient as described follow.

$$Q = \frac{1}{360} CsCIA \text{ ----------------- } (IV-1)$$

where

Q : the peak discharge, cu m/sec

I : the average intensity of rainfall, mm

A : the catchment area, ha

C : a runoff coefficient

Cs: a storage coefficient which is expressed as;

$$Cs = \frac{2tc}{2tc + td}$$

tc: the time of concentration

td: the time of flow in the drain

The application of a runoff formula modified by a storage coefficient is preferable in the Project Area which is totally flat and low-lying.

The relationship between Cs, tc and td in Malaysian Standard is derived on the basis of the theory acceptable internationally, and the result of its practical application on four drainage basins in KL coincide with those obtained by the more elaborate routing procedure by way of computor calculation. The derivation of Cs as a function of tc and td is explained in "Flood Estimation for Urban Areas in Peninsular Malaysia", Hydrological Procedure No. 16, published by Ministry of Agriculture and Rural Development Malaysia. With the background above, "Rational Method" with storage coefficient Cs, i.e., $Q = 1/360\ CsCIA$ is adopted for this Project.

(2) Rainfall Formula

The rainfall intensity-duration-frequency curve which has been developed on the basis of rainfall data in George Town and included in the Malaysian Standards is applied for this Project.

The curve is expressed in the following equation.

Two-year frequency $I_2 = \frac{6,270}{t + 32}$

Five-year frequency $I_5 = \frac{8,070}{t + 30}$

Hundred-year frequency $I_{100} = \frac{13,940}{t + 33}$

(3) Rainfall Frequencies for Design

Basically, storm drains could be designed to carry the runoff from the maximum stormwater expected for a given location. However, when construction cost of the required sewers and other facilities are considered, the determination of a rainfall frequency becomes necessary. The standards as for rainfall frequencies as a basis for the design of urban drainage systems are two years for residential areas and five years for commercial and industrial areas. These figures are acceptable for the size of municiparities like those in the Project Area and for the sake of design practices. For this Project, therefore, the same rainfall frequencies as that of the national standards is applied, except for major drains flowing through varied land-use areas, the five years is considered more adequate as design rainfall frequencies. The design rainfall frequencies are summarized as follows:

Residential area	2 years
Commercial area	5 years
Industrial area	5 years
Main drains	5 years

(4) Runoff Coefficient

Runoff coefficients to be used for drainage design are determined, taking into account the various types of surface of the Project Area. The recommended coefficients for the area by types of future land use are as follows: (Detailes refer to Appendix I. Stormwater Quantity)

Land Use		Runoff Coefficient
Residential area	Densely inhabited	0.70
	Sparsely inhabited	0.35
Commercial area		0.85
Industrial area		0.50
Mountainous area		0.50

(5) Time of Concentration

The concept of the time of concentration is used for the estimation of peak discharge rate derived from rainfall duration relationship curve for the given frequency. The time of concentration consists of the inlet time plus the time of flow in the sewer from the most remote inlet to the point under consideration.

Time of flow in the sewer is estimated depend upon the hydraulic properties of the individual conduit. Inlet time is estimated on the basis of situation in the area considered. In Appendix I."Stormwater Quantity,"the estimation of inlet time is described in detail.

3.4 Hydraulic Design of Open Channels

(1) Manning Formula

For the hydraulic design of open channels, Manning Formula is applied and expressed as follows:

$$V = \frac{1}{n} R^{2/3} \cdot I^{1/2}$$

where,

V : velocity, m/sec
n : roughness coefficient
R : hydraulic radius, m
I : gradient

The value of "n" is defined as follows:

cast-in-place concrete channel	n = 0.015
pre-cast concrete channel	n = 0.013
wet masonry channel	n = 0.025
earth channel	n = 0.030

(2) Type of Cross Section

As a results of cost comparison, it becomes clear that the earth channel is the cheapest, which means to suggest that earth drains should be used as much as possible in the proposed drainage system.

However, earth drains are specified with trapezoidal cross section which result in requirements for land space larger than the case of rectangular type. So, in the case of sufficient surface spaces are not available for drains, stone masonry channels or rectangular concrete channels should be used. In case of smaller road-side drains, pre-cast "U" shape channels are to be used taking advantage of the shorter construction time required.

3.5 Design of Reservoirs

The volume of reservoirs is calculated by following processes:

° develop inflow hydrograph
° develop cumulative inflow curve
° develop cumulative outflow curve
° read the maximum volume required

In usual case, the volume of reservoir is selected among those resulted from two types of inflow hydrograph, one is for the situation of $tc > te$ and another of $tc < te$ (Ref. Appendix J). Thus, maximum volume required would be found.

where,

tc : time of concentration
te : rainfall duration time

CHAPTER 4

PROPOSED DRAINAGE SYSTEM

4.1 Description of and Recommended for Individual Drainage Basin

Delineation of the drainage basins proposed is identical to that proposed in the WHO Assignment Report, which is elaborated in the following (Ref. Figures IV-2 and 3).

(1) Drainage Basin I

For this area PMP is applied. The basin is situated in the north-eastern part of the Project Area. It has steep terrain with palm and rubber tree cover and no sizable community exist in it. At the present stage, the area is not subject to flooding.

The outlets are Sungai Kubang Simang and Tuah Abdullah, which confluence to Sungai Derhaka. For the two drains, reserve requirement and storage area are recommended as shown in Figures IV-2 and 3.

Because the ground surface of the area is steep, developments in upstream portions will result in abrupt increase of runoffs. Therefore, it is preferable to store stormwaters inside areas to be developed and limit discharges to the two major outlets, which would result in alleviation of Sungai Derhaka in downstream portion.

(2) Drainage Basin II

The basin occupies a part of Mukim 6, 8, 11, 15 and 17 of Central district. The total area of the basin is 3,793 hectares (9,372 acres). The boundary is the watershed of the Sungai Rambai in the north and the limits of the Project Area in the south and east. The basin is bounded by the watershed of the Bukit Tengah drain (A) in the west as shown in Figures IV-2 and 3. The entire area except sub-basin S_{2-8} is tributary to the Juru river.

The basin comprises higher hilly residential and lower agricultural area. Areas east from about the railway is the hilly part with ground elevation ranging from 229 meters (751 ft) to around 5.0 meters (16.4 ft) in the west limits of Bukit Mertajam town. The Bukit Mertajam is only one urbanized area in this basin and is covered by commercial and densely populated residential area with population density of about 120 persons per hectare.

DMP (Design Master Plan) is applied for main drain ARA. 1 - 3, TAN., PAY. 1, 2, RAM. 5, 6, BUK. 1, 2, PAS. 1 - 3, PEK. 1 - 3, BKC. and BKD.[1/] Remaining drains are studied under PMP.

Stormwater runoff in the urban area flows into the Bukit Mertajam drain which have a capacity to convey stormwater derived from 5-yr frequency storm at the present stage. The drain flows through core portion of the urban area and it seems to be very difficult to find spaces for widening the drain for the future requirement. It is apparent that upstream of the built-up area still has a potential for development, it should be considered to limit discharge volume to the drain at the present level. And it is necessary to consider several submain drains which run parallel with the Bukit Mertajam drain and confluent to it at downstream of the urban area in which land spaces are still available for improvement of the drain. It would be also required to store stormwater increment inside areas to be developed hereafter. Other main drains which receive stormwater runoff from the urban area are the Sungai Ara, Rambai, Pasir and Pekan Baru. Although flooding problems have not been reported in the area served by these drains, runoff would be increased due to development in the near future. Therefore, cross-sections and longitudinal plan of these drains are proposed as shown in Figures IV-2 and 3.

1/ These abbreviations are tabulated in Table IV-2.

Outskirt of Bukit Mertajam urban portion can be delineated as mixture of sparsely inhabited residential and agricultural area within which land spaces for drainage facilities are relatively available. Therefore, main drains in this area are studied under PMP.

This portion of Drainage basin II is on the high terrain and is not subjected by back up of the Juru river. Stormwater runoff in this hilly area can gravitate into the Juru river. Urbanization of this area will cause flooding in the downstream areas, hence it is necessary to hold stormwaters inside the area during intense rainfall. The allowable discharge quantity to the Juru river is that derived from 2-yr frequency storm with 0.35 runoff coefficient. The required storage volume is indicated in Figures IV-2 and 3. Because of the absence of any regional or town plan, location of storage ponds can not be clarified at the present stage.

When the major storm occurs, the water level in the proposed drains will rise about 0.6 meters from the existing ground elevation. Due to the steep topography the velocity in the drains would be very large and damages would be of considerable ones. The concept to be applied here is to spread and conduct stormwaters by planning the layout of drains within which several sub-main are running in parallel with the main drain. The combination of this measure and the storage of stormwater increment in areas to be developed will alleviate or eliminate damages due to the major storm.

The west side area of the railway is flat and low-lying and tributary to the Juru river. The cover of this area are palm or rubber platation, paddy field and swamps. Although, data on the ground elevation in this low-lying area are not available, information* obtained when the Juru tidal gate was constructed, suggest that the low side of the ground elevation is around RL +0.46 meters (+1.5 ft). Comparing with the mean high water level in the sea of

RL +1.10 meters (+3.6 ft) it is understood that this area is very low. To cope with the expected flood here, land filling would generally be preferable to internal storage, because of the expected type of development, which supposedly is piece by piece. In case of internal storage, due to necessity of bunding, the basin wide drainage strategy would have to be incorporated. A basin wide development is not likely to happen in the area hereafter but it would be piecemeal one resulting in gradual urganization.

The storage area and reserve requirement as shown in Figures IV-2 and 3, have to be included for any new developments when planning permission is applied for.

* During the construction of the tidal gate, it was experienced that numerous complaints for prolonged flooding were received from the farmers when the river was kept at levels between RL +0.46 meters (+1.5 ft) and RL +0.61 meters (+2.0 ft).

(3) Drainage Basin III

The basin bounded by the Prai river in the west and north, and in the east the watershed of Bukit Tengah drain (A) and a boundary of the Project Area. The southern limit of this basin is the shore line along Prai industrial development area. The basin is undeveloped area which is covered by rubber trees and swamps. For this basin PMP is applied.

In the west adjacencies of the basin, Butterworth town extends and in the east paddy fields. It covers and area of 3,964 hectares (9,795 acres). Throughout the basin it is flat and low-lying, with ground elevation ranging from RL +3.48 meters (+11.4 ft) to Rl +0.61 meters (+2.0 ft).

Stormwaters in the basin discharge into three different receiving water bodies including the Prai river, the Juru river and the sea.

The two development areas, the Prai and Seberang Jaya, have their own drainage systems with catchment area independent from surroundings, therefore these areas are not included in study.

Quantity of discharges from paddy field are considered to be equal to the volume resulted from 2-yr frequency storm with 0.35 runoff coefficient. Reserve requirement and storage area are proposed as shown in Figures IV - 2 and 3. When the area is developed the proposed spaces have to be set aside for the drainage facilities. In some lowest part of the area, land filling on interior storage with bunding would be inevitable. The selection of proper method should be made after the development scale become clear.

(4) Drainage Basin IV

The entire Butterworth town limit is included in this basin. The northern boundary is the limit of the Air Force base at which existing major drains have their heads. The west border faces to the channel between Penang Island and Province Wellesley and the east to the Prai river. This basin is the most urbanized and densely populated area in the Project Area. It occupies the whole area of Mukim 14 and 15 of Northern District with the population of 141,800 in the year 2000, which is equivalent to 22 percent of the whole population of the Project Area.

The shape of the basin is approximately rectangular to being wide in north and south direction and narrow in east and west. Surface elevations vary from RL +3.8 meters (+12.5 ft) at the basin's northern extremity and RL +1.8 meters (+5.9 ft) at the southern limit near the ferry port.

Existing main drains, called presently "monsoon drain", are named under this Project as is indicated in Figure IV - 4. Those flow in parallel with the shore line of Butterworth from the north to the south and eventually discharge into the Prai river.

Because of topographical situation in which the ground surface forms wave mortion with peaks and troughs running in parallel with the shore line, the stormwaters are not able to gravitate toward the sea. As a result, the length of the drains reaches as long as 4.0 km (2.5 miles) - 6.5 km (4.0 miles), while the distances from the drains to the shore line are between 1.8 km (1.1 miles) and 0.8 km (0.5 miles).

The diversion of runoffs to the sea shore has been investigated as one of alternatives to be considered. (Ref. Appendix J, Volume II) The recommended drainage system consists of mained drains which are improved existing drains and reservoirs to cut peak discharge. This system is termed alternative III in the study in Appendix J, Volume II. It become clear the diversion system is costy and bears engineering difficulties including sand accumulation problems at the outlet of diversion ditches and inconveniences for the traffic during construction period of box culverts under the main roads. Thus the diversion system is not recommended for the area.

Butterworth drains A, B and C (Ref. Figures IV - 2 and 3) are piecemeal improvement of natural water course that existed before the urban development began. They are heavily silted and impaired with vegetation. Generally, these existing drains with meandering alignment of varied widths and depths present the single need for improvement. Because of swamps existed in the area to which the main drains are dispersing at several portions, flooding in the basin is not so serious in spite of the inadequate conditions in drainage systems.

The present situations mentioned above indicate the great contribution of swamps for alleviating floods. Although being preferable to preserve these existing swampy areas, difficulties in land acquisition are expected because Butterworth area is valuable estate.
In this Master Plan, therefore, storage areas to cope with extreme

intense rain of 100-yr frequency is not considered for the basin.

Neverthless, it is emphasized that at the final design the availability of storage area should be investigated carefully and considered to store stormwaters as much as possible. For areas to be developed hereafter, the municipality can impose spaces needed for storage of stormwaters to developers as the basic requirement for approval of the development application.

Areas along the B.D (A) are built-up and the availability of land space in both sides of the drain is limited. Downstream areas of the B.D (B) and (C) have already been developed densely and constitutes industrial, commercial and housing areas.

Accounting those situations above, the reserves assigned for the drains are the least spaces required for open channels having capacity to convey runoff derived from 5-yr frequency storm and the access for maintenance works of 4.0 meters. The recommended channel is rectangular section of reinforced concrete which will result in least land spaces requirement.

The water level in these channels is below the general ground level of much of Butterworth area, it will be possible for stormwater to gravitate into the Prai river. However, if the sea level rises up to the maximum recorded level of RL +1.68 meters (+5.5 ft) some lower swampy areas will be flooded. It is therefore necessary to raise the ground by filling.

The construction of reservoirs is recommended in B.D (B) and (C). Stormwaters derived from the storm with frequency larger than 5-yr will be stored in the reservoirs during heavy rains and released after rain stops. To protect the industrial area of Mak Mandin, the storage of stormwaters in upstream area will be desired and it should be investigated in the feasibility study deeply on the basis of detail data.

When the major storm occurs the water level in the drain will be 0.6 meters (2 ft) higher than the existing ground elevation. At the point just downstream of the reservoir the water level rise as high as 1.2 meters (4 ft) above the ground surface, because the cross section at the point is smaller than that of adjacent portion. Considering topographical feature in this basin, expected damages would be inundation up to the ground floor. The velocity of the flood water would be low and the destruction of premises would be unlikely. To minimize damages, the floor level in new housing scheme and the level of bridges to be constructed newly should be determined on the basis of the major flood level shown in Figures J-6, 7 and 8. Recommended network of smaller drains is shown in Figures J-12 and 13, Appendix J, Volume II. These consists of rectangular shape concrete ditches to conserve valuable real estate.

(5) Drainage Basin V

Basin V, 570 hectares (1,408 acres) in extent, is situated in the east of basin IV and lies exclusively in Mukim 16 of Northern District. Runoff in the area discharges into two sizable irrigation waterways, eventually flowing into the Prai river. Existing ground elevation is less than 0.9 meters (3 ft) and totally flat. Ground cover in the area is mixture of swamps and palm trees.

The basin is studied by the Preventative Master Plan. In Figures IV - 2 and 3, the reserve requirement and storage area to be set aside are indicated.

The water level of the Prai river to which the basin is tributary, will be kept at RL +0.60 meters (+2.0 ft) during dry weather by the barrage to be constructed in the future. According to the Prai river reclamation plan, the water level, at the time of intense storm (40-yr return period) will rise as high as RL +1.37 meters (+4.5 ft). Considering the relation between both levels of the Prai river and ground surface of the basin, the land filling is necessary as has been planned for the new development now applied for the municipality. For that development of housing area, the storage of stormwaters and land filling are adopted as stormwater drainage strategy. As far as the basin is urbanized gradually by piecemeal development, it will be preferable to cope with expected flood with land filling and storage of runoff.

At the time of the final design of main drains proposed, the water quantity discharged from paddy field extended in upstream area of the drains, should carefully be investigated.

(6) Drainage Basin VI

In the extremity of northern position of the Project Area, the Basin VI is situated and occupies portions of Mukim 7 and 9 of Northern district. The area extend 544 hectares (1,344 acres) excluding the Air Base.

Ground cover consists of paddy field and palm trees plantation. Only one sizable community is found in the north-western corner of the basin. Surface elevation is about RL +2.7 meters (+9.0 ft) at the southern limit and RL +3.4 meters (+11.1 ft) in the north. It is possible for stormwaters to gravitate into the Prai river.

Runoff of the area is now discharged together with wastewaters from paddy fields by existing Benggali drain flowing toward south and Addul drain to north eventually discharging the Prai river and the sea respectively.

4.2 Proposed Drainage Facilities

4.2.1 Main Drain

Main drains in built-up areas are studied in accordance with the Design Master Plan requirement and ones in undeveloped areas are under the Preventative Master Plan.

General layout and recommendations are shown in Figures IV - 2 and 3. Criteria used for the decision of reserves are as follows:

a. In built-up areas
Space required for open channel having capacity of conducting stormwater resulted from 5-yr frequency storm plus the maintenance access of 4 meters.

b. In undeveloped areas
Stormwater quantity derived from the major storm with runoff coefficient of 0.65 is initially estimated. Based on the quantity, reserve requirement is determined on the basis of the standard of Drainage and Irrigation Division, Ministry of Agriculture, Malaysia.

Proposed routes of the main drains are based on that of existing major water courses, natural or artificial, which are shown in available topographical map and confirmed by field inspection. In case of Butterworth area, the routes are decided through a comparative study of alternatives.

Flows are estimated on the basis of criteria shown in Section 3.3, Part IV. Considering land availability, the recommended shape of cross section of main drains is a rectangle in densely populated areas and a trapezoid in sparsely populated ones. Reinforced concrete is used for the rectangular drain and stone or earth for the trapezoidal drain. (Ref. Appendix J, Volume II)

4.2.2 Network of Smaller Drain

In Figures J-12 and 13. Appendix J. Drainage System Consideration, the typical network of smaller drains in residential and industrial areas are shown.

Pre-cast "U" shape drains in sizes form 240 x 240 mm to 900 x 900 mm are used, and, for larger sizes, cast-in-place reinforced concrete rectangular channels are adopted because of advantages in which the land space will be conserved and maximum development will be permitted. The network of smaller drains shown in Figures J-12 and 13 are intended to be illustrative for the estimated unit construction cost in terms of M$/ha.

4.2.3 Storage System

The concept of a storage of stormwater is applied in this master plan. The objective of storage is to eliminate damages due to the Major storm (100-yr return period) in undeveloped areas within which land spaces for storage area are available. At the time any development plan is applied the area for storage of stormwaters has to be set aside and increment of stormwater runoff derived from the development should be stored in that assigned area. The area should be gazetted as the zone not to permit any development and to be utilized for green belts or parks. The required storage area in individual sub-basin is shown in Figures IV - 2 and 3. Because of absence of any town or regional plan in those undeveloped areas, the location of storage areas are not clarified at the present stage.

On the other hand, in built-up area, especialy Butterworth in this master plan, reservoirs to cut peak discharge from the Initial Storm are furnished as the economical measure after a comparison of alternative systems (Ref. Section 3.3, Part IV). Because, in built-up areas, land is not available for storage areas to deal with the major storm, the reservoir for the Initial Storm is adopted in Butterworth area. The volumes of these reservoirs are 10,000 cu m and 17,000 cu m as shown in Figures IV - 2 and 3.

The necessary volume of these storage areas and reservoirs are calculated using the criteria described in Section 2.2 and 3.5, Part IV. The gate size of individual storage pond is that with the maximum capacity of being equivalent to stormwater quantity derived from 2-yr frequency storm with runoff coefficient of 0.35. In case of final design the gate size has to be calculated on the basis of the principle mentioned above while accounting situation of the individual reservoir. The level of the base of reservoirs should be higher in any case than that of drains to which stored stormwaters are to be discharged.

Typical profile of the recommended reservoir is shown in Figure J-9, Appendix J. "Drainage System Consideration."

4.2.4 Materials and Methods of Construction

(1) Construction Materails

Cements, sands and gravels are available with adequate quantities in Malaysia. It is able to get stones for construction of masonry channel rather easily and they have been used in Malaysia as favorable materials with less cost.

All materials used for the construction of proposed drainage system would be available locally. It is confirmed that any type of pre-cast concrete channel could be produced by the existing firms in Malaysia.

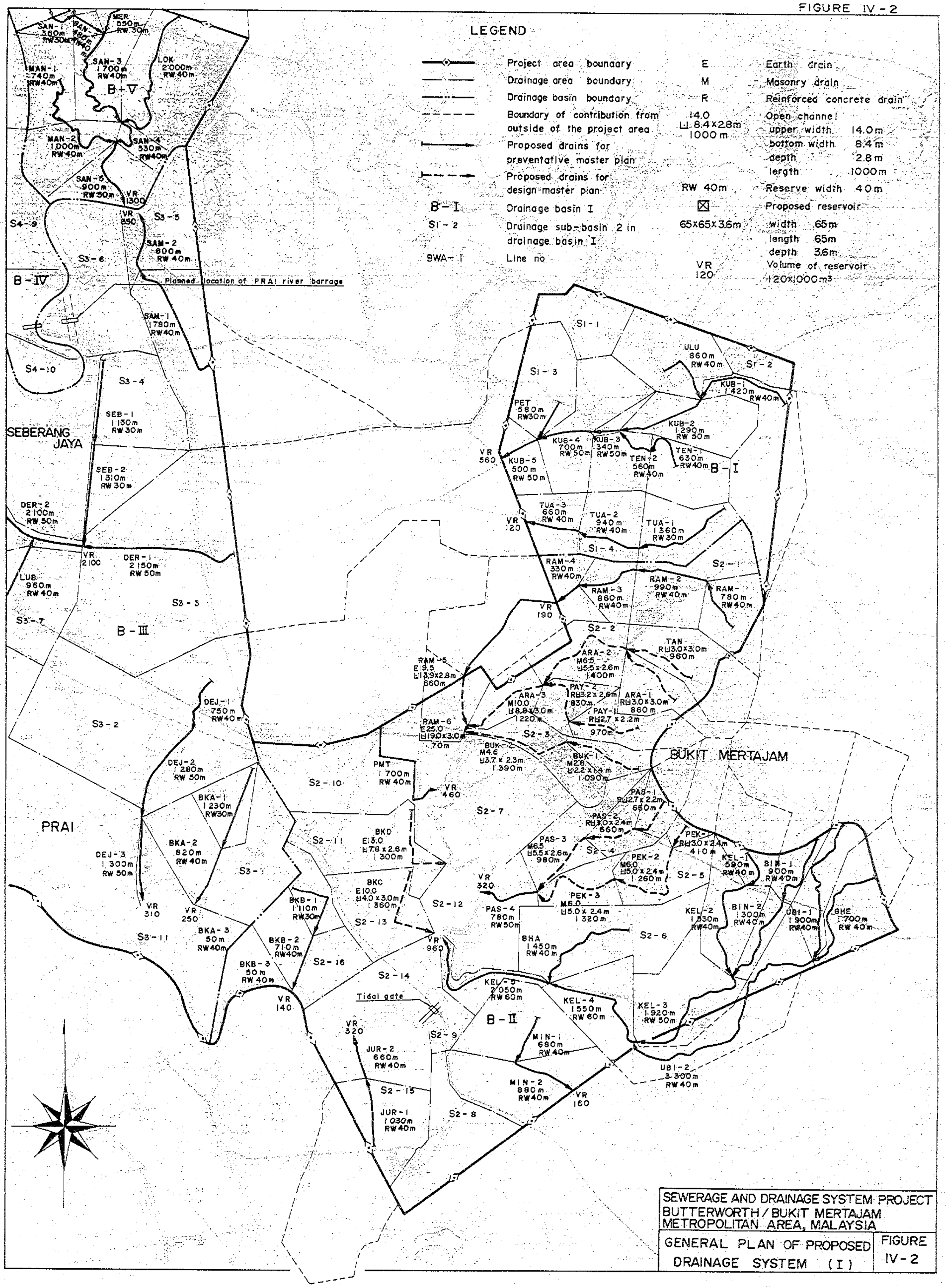
(2) Construction Methods

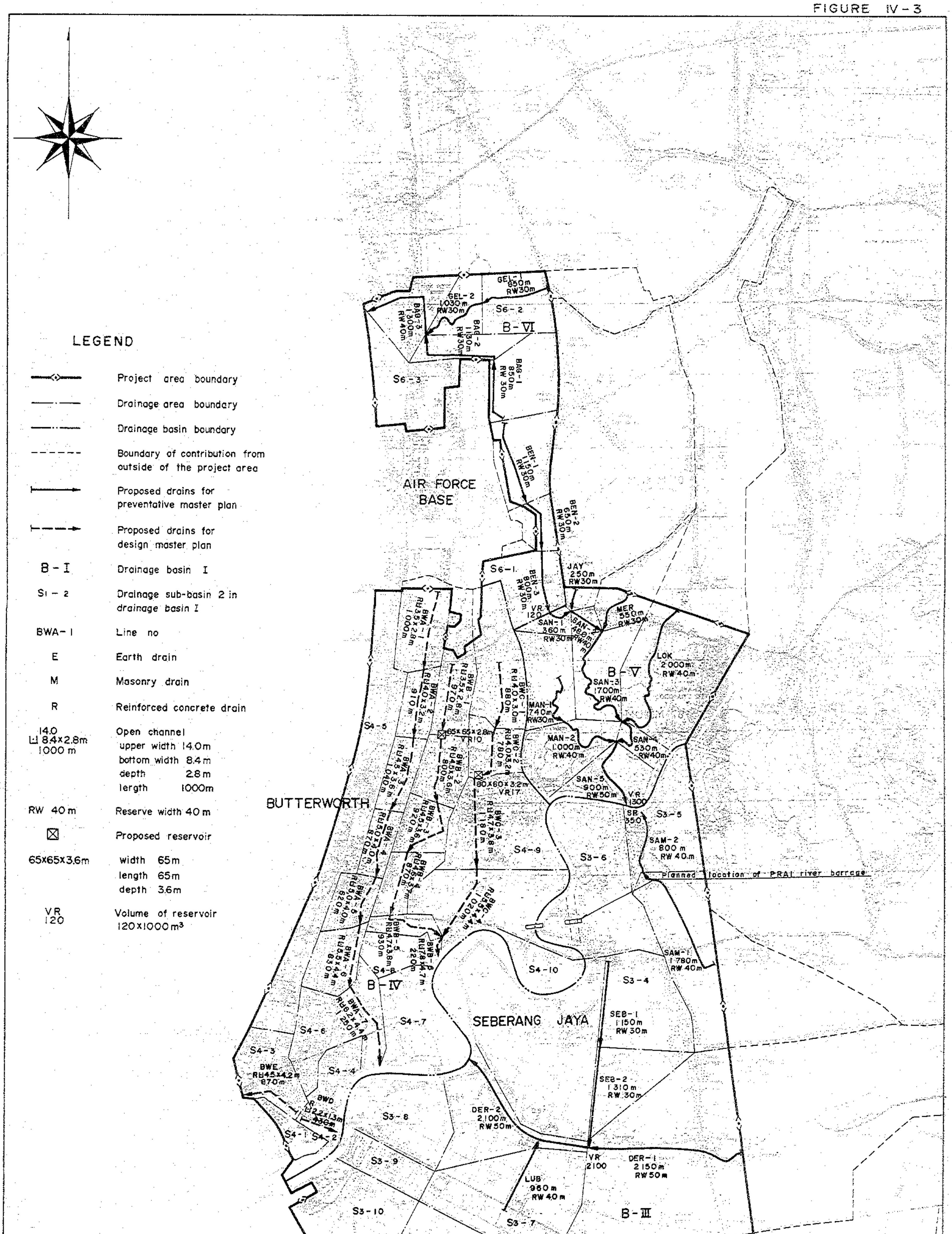
Machine excavation, steel sheet piling and any other mechanical works required for the construction of drainage systems can be done with equipments locally available.

Discussions with government staff and observation on various civil works which are on-going in Penang State convince that any construction method considered most appropriate for the Project would be feasible.

However, availability of land is the another factor to be considered when construction method is to be determined. In the case of areas currently undeveloped, it is possible to consider greater variety of construction methods because of adequate space for works.

On the other hand, in case of built-up area such as Butterworth, constraints will be imposed due to the inadequate space and the traffic problems during the construction period.


LEGEND
Project area boundary
Drainage area boundary
Drainage basin boundary
Boundary of contribution from outside of the project area
Proposed drains for preventative master plan
Proposed drains for design master plan
B-I Drainage basin I
S1-2 Drainage sub-basin 2 in drainage basin I
BWA-1 Line no
E Earth drain
M Masonry drain
R Reinforced concrete drain
14.0 ⊔ 8.4x2.8m 1000 m Open channel upper width 14.0 m bottom width 8.4 m depth 2.8 m length 1000m
RW 40m Reserve width 40 m
☒ Proposed reservoir
65x65x3.6m width 65m length 65m depth 3.6m
VR 120 Volume of reservoir 120x1000m³
Planned location of PRAI river barrage
SEBERANG JAYA
PRAI
BUKIT MERTAJAM
B-I
B-II
B-III
B-IV
B-V
Tidal gate
SEWERAGE AND DRAINAGE SYSTEM PROJECT
BUTTERWORTH / BUKIT MERTAJAM
METROPOLITAN AREA, MALAYSIA
GENERAL PLAN OF PROPOSED DRAINAGE SYSTEM (I)
FIGURE IV-2



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

GENERAL PLAN OF PROPOSED DRAINAGE SYSTEM (II) — FIGURE IV-3

4.3 Staging of Construction

Priorities have to be established in implementing the consturction programme because of the urgency of the work involved, for which initial investment is fully justified. The major factors considered are:

(1) Even the degree of flooding is in the stage of minor "nuisance", the damages due to repetitious pondings to public health can not be ignored, so flood-prone areas are given the high priority.

(2) The priority should be high in the areas within which rapid urbainzation is proceeding, where stormwater runoff quantities are expected to increase and cause deteriorated situations in terms of drainage conditions in the near future.

(3) It is preferable to coincide with the sewerage system staging programme so that the network of smaller drains will be constructed together with the sanitary sewers.

On the basis of the above consideration, following staging programmes are proposed and are shown in Figure IV-4. Tables IV-7 - 14 give construction cost of individual stage.

(1) First Stage Programme

The first stage programme includes the general improvement of drainage situations in two urbanized areas, Butterworth and Bukit Mertajam. Those consists of increasing the capacity of existing main drains by converting them to rectangular channel of reinforced concrete or enlarging cross-sectional area of existing earth drains. The construction of two reservoirs and the extention of B.D. (C) in its upstream portion are also carried out in this stage.

These improvements are necessary for alleviation of local flooding occured at present and coping with the expected increase in stormwater runoff quantities resulted from rapid urbanization which is proceeded now. The improved main drains would function as the back bone of the drainage system in the area. As a result many ponding areas would be dried up and it would contribute to the control of mosquito breeding. Development in the area would be accelerated because of land conditions free from flooding problem. The provision of the network of smaller drains would be carried out along with the development of the area.

The area covered by the first stage programme is shown in Figure IV-4.

(2) Second Stage Programme

The improvement of two main drains in Basin-VI, flowing along the boundary of the Air Force Base, Benggali and Bagan Tambang drains, are to be included in the second stage programme.

By these reinforced drains, the safety of the air field, in terms of flooding due to stormwater runoff from outside of the area, will be guaranteed.

The improvement of network of smaller drains in existing built-up areas including S_{3-7}, S_{3-8}, S_{3-9}, and S_{3-10} of Basin III will be conducted during this stage.

By the end of the second stage programme, the majority of existing built-up areas would be served by adequate drainage systems.

(3) Third Stage Programme

The provision of network of smaller drains to Drainage Basin V, VI and a part of sub-basin S_{3-2} & S_{3-3} is included in the third stage programme.

The improvement of the Sungai Tuan Abdullah, Rambai and Pekan Bharu together with the provision of road-side drains to their tributary will be implemented during this stage.

The construction work will be carried out simultaneously with the sewerage system provision.

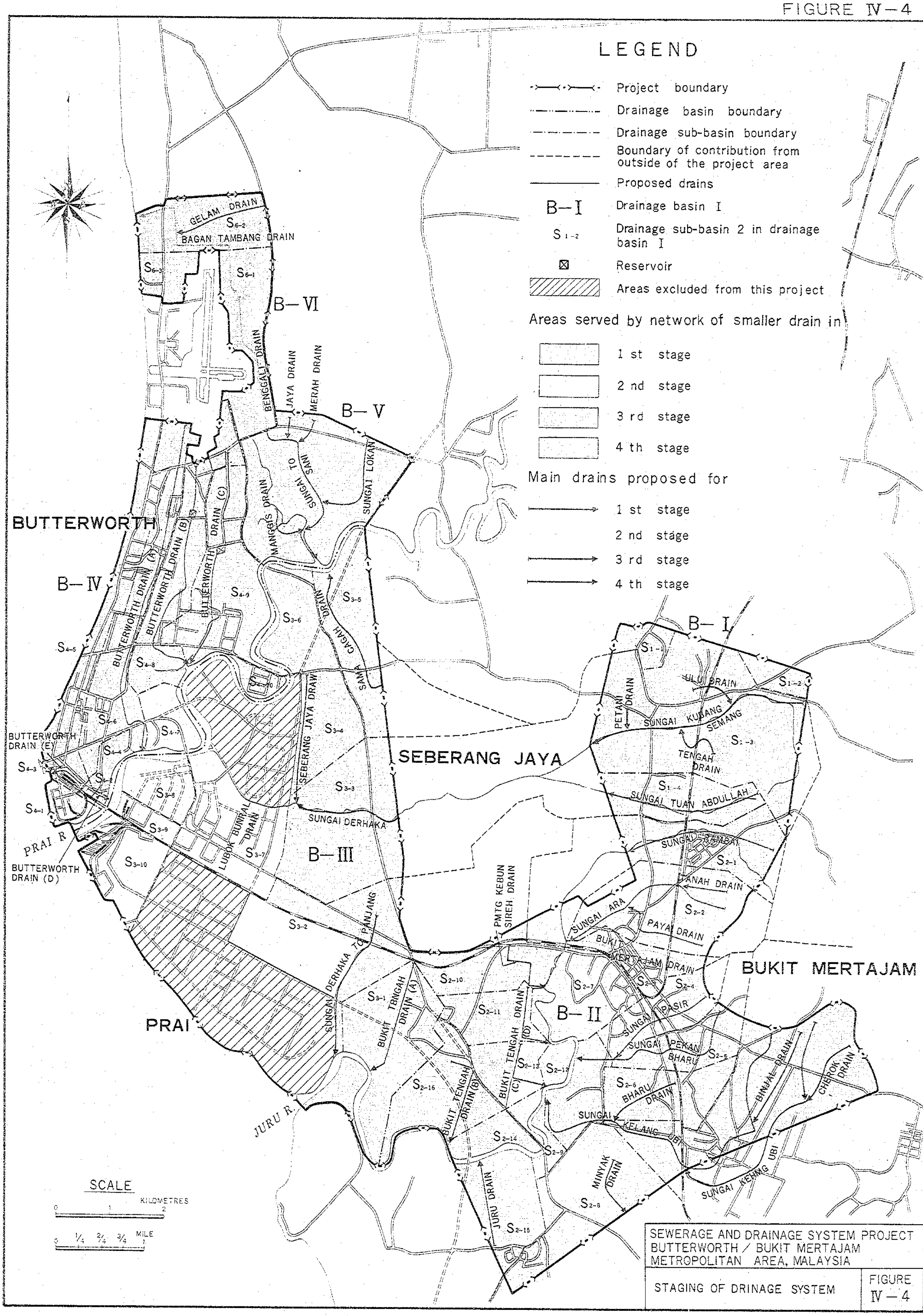
(4) Fourth Stage Programme

In the fourth stage following items will be included.

i) The improvement of Sungai Kubang Semang and Kelang Ubi.

ii) The construction of new drains including the Juru, Bukit Tengah (A), Bukit Tengah (B) and Seberang Jaya drain.

iii) The provision of network of smaller drans in Basin-I, a part of S_{2-4} & S_{2-6}, S_{2-8}, S_{2-9}, a part of S_{2-10}, S_{2-11}, S_{2-13} & S_{2-14}, S_{2-15}, S_{2-16} of Basin II, and S_{3-1}, a part of S_{3-2} & S_{3-3}, S_{3-4}, S_{3-5}, S_{3-6}, and S_{3-11} of Basin III.



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

STAGING OF DRINAGE SYSTEM

FIGURE IV-4

CHAPTER 5

CONSTRUCTION AND MAINTENANCE COST

5.1 Construction Cost

5.1.1 Main Drains

1) Unit Cost

The unit cost estimates used in preparing the drainage programme and presented herein are based on the available unit cost of labour, materials, power, equipment and trensport-ation, as applicable in Penang in 1976 (Ref. Appendix E. Design Data). As is described in Section 3.4, three types of open channels are recommended for this Project. For individual type of drains cost curve is developed, taking into account the available or estimated cost of excavation, sheeting, shoring dewatering, reinforcing, forming, concrete spreading and restoration of paving. They do not include unusual soil and dewatering problems or any other extra costs. In Figure J-10, developed curves of unit cost are presented. (Ref. Appendix J. Drainage System Consideration)

2) Construction Cost of System

Construction cost of main drains are estimated in the basis of designed cross section and unit construction cost mentioned in previous section. The construction cost shown in Table IV-4 consist of direct labour and material cost, over-heads of 20 percent of the direct cost, contingencies of 20 percent and 10 percent engineering fee. Land acquisition cost include that for maintenance roads as shown in Figure J-11.

In Butterworth area, average of 3.0 meters are allocated for maintenance roads. Because the sites through which main drains flow are apart from existing roads in most of the cases, the construction work would involve various difficult consitions with extra cost. Therefore, 20% contingencies are estimated as described aboe.

5.1.2 Network of Smaller Drains

1) Unit Cost

Unit construction cost of network of smaller drains is estimated in the basis of street plan in the housing development area and industrial area. These are shown in Figures J-12 and J-13. The required size of individual road-side drain is calculated and construction cost is estimated depending on cost curves shown in Figure J-10, with assumption that the commercial and densely populated residential areas would have the same characteristics in terms of layout of smaller drains. The cost of industrial area is also estimated. It is considered the cost in sparsely inhabited residential areas with population density of 53 persons per hectare could be approximated by the following equation.

$$C_1 = \frac{53}{120} \times C_2$$

where

C_1 = construction cost in sparsely inhabited residential area with population density 53 persons/ha.

C_2 = construction cost in densely inhabited residential area with population density 120 persons/ha

* Calculated unit construction costs are summarized as follows:

Residential area	
densely populated	32,400 M$/ha
sparsely populated	14,300 "
Commercial area	32,400 "
Industrial area	30,000 "

Table IV-3 of the present document gives construction cost of the network of smaller drains together with other facilities in individual drainage basin.

5.1.3 Reservoir

The Construction cost of reservoirs is estimated depending on cost curve shown in Figure J-10. In Table IV-3, cost required for the reservoir is shown.

TABLE IV-3 Construction Cost of Drainage Basin at 1976 Price Level (Government Contribution)

(1,000 M$)

Description	Basin I	Basin II	Basin III	Basin IV	Basin V	Basin VI	Total	Remarks
a. Main Drains	7,790	48,090	7,480	37,030	5,560	2,340	108,290	
b. Reservoir for Initial Storm	-	-	-	350	-	-	350	
c. Reservoir for Major Storm	5,300	19,700	23,100	-	9,000	1,000	58,100	
d. Land Acquisition	-	2,050	-	3,400	-	-	5,450	
(A) Sub Total	13,090	69,840	30,580	40,780	14,560	3,340	172,190	
(B) Contingency	2,620	13,970	6,110	8,150	2,910	660	34,420	(A) x 0.20
(C) Engineering Fee								
Design	780	4,190	1,830	2,440	870	200	10,310	(A+B) x 0.05
Supervision	780	4,190	1,830	2,440	870	200	10,310	(A+B) x 0.05
Total	17,270	92,190	40,350	53,810	19,210	4,400	227,230	

TABLE IV-4 Construction Cost of Smaller Drain at 1976 Price Level (Private Contribution)

(1,000 M$)

Description	Basin I	Basin II	Basin III	Basin IV	Basin V	Basin VI	Total	Remarks
(A) Network of Smaller Drain	14,110	53,130	44,210	30,140	6,900	7,530	156,020	
(B) Contingency	2,820	10,620	8,840	6,020	1,380	1,510	31,190	(A) x 0.20
(C) Engineering Fee								
Design	850	3,190	2,650	1,800	410	450	9,350	(A+B) x 0.05
Supervision	850	3,190	2,650	1,800	410	450	9,350	(A+B) x 0.05
Total	18,630	70,130	58,350	39,760	9,100	9,940	205,910	

5.2 Maintenance Cost

(1) Unit Cost

Maintenance work for drains consists mainly of removal of desposits from drains and carrying those wastes from the sites to assigned dumping places. Repairing of broken parts of channels are also included in the maintenance work. For the purpose of estimating maintenance cost, it is assumed that the cost for removing deposits from drains is the same as that of excavation. For main drains, machine excavation will be applied and for smaller ones, hand excavation. For the cost of carrying removed materials from the site to planned dumping places, the cost of deposing of excess soil is applied.

On the basis of assumptions above, the unit cost for maintenance is estimated to 5M$/cu m. The average volume of deposits in drains is estimated roughly on the assumption which the part of accumulation of silt to be removed would be 10% of the cross section area. The average cross section area of main drains proposed, is 22 sq m. The deposit volume, therefore, is 22 x 0.1 = 2.2 cu m per one meter of drains.

The unit maintenance cost for smaller drains is expressed Malaysian dollar per one hectare. The average cross section area of smaller drains is 0.50 sq m with the average volume of deposits of 0.05 cu m per unit length.

It is estimated that the drain length per one hectare in densely populated residential area is about 450[1/] meters. The volume of deposits to be removed is 0.05 x 450 =22.5 cu m. It is summarized as follows:

1/: The total length of drains in selected representative residential area (Ref. Figure J-12) is 13,716 meters and the area is 30.57 hectares. The length of drains per hectare, therefore, is 13,716 ÷ 30.57 = 449 m/ha, say 450 m/ha.

Maintenance costs of main drains : 11 M$/m

Maintenance costs of network of smaller drains

(in densely populated area) : 110 M$/ha

(in sparsely populated area)[1/] : 50 M$/ha

(2) Maintenance Cost of System

As a basis of the maintenance cost estimate, the amount of maintenance work has to be clarified.

TABLE IV-5 Amount of Maintenance Work

Stage	Area Served by Smaller Drain		Length of Main Drain (km)
	Densely Populated (ha)	Sparsely Populated (ha)	
1st	2,184	743	53.88
2nd	3,516	1,289	67.62
3rd	4,149	2,998	84.51
4th	4,261	7,192	109.80

Based on practice in Japan, it is assumed that all drains will be cleaned at least every four years. Table IV-6 gives cost required for maintenance work with amounts shown in Table IV-5.

1/: The maintenance cost in sparsely populated area is,

$$22.5 \times 5 \times \frac{53}{120} = 50 \text{ M\$/ha.}$$

TABLE IV-6 Maintenance Cost

(1,000 M$/year)

Stage	Maintenance Cost of Smaller Drains		Maintenance Cost of Main Drains	Total
	In Densely Populated Area	In Sparsely Populated Area		
1st	240	40	590	870
2nd	390	60	740	1,190
3rd	460	150	930	1,540
4th	470	360	1,210	2,040
Total	1,560	610	3,470	5,640

5.3 Stagwise Construction Cost

On the basis of the unit cost described above, and with the proposed facilities for each of the stages recommended, total cost for each of the stages are estimated and expressed in Tables IV-7 - 14.

TABLE IV-7 Drainage Construction Cost by Stage at 1976 Price (Government Contribution)

1st Stage (1981-1985) (Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Main Drains	46,940	-	46,940	
b. Reservoirs for Initial Storms	350	-	-	
c. Reservoirs for Major Storm	-	-	-	
d. Land Acquisition	4,490	-	4,490	
(A) Sub Total	51,780	-	51,780	
(B) Contingency	10,350	-	10,350	(A) x 0.20
(C) Engineering Fee				
Design	3,100	-	3,100	(A+B) x 0.05
Supervision	3,100	-	3,100	(A+B) x 0.05
Total	68,330	-	68,330	

TABLE IV-8 Drainage Construction Cost by Stage at 1976 Price (Private Contribution)

1st Stage (1981-1985) (Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
Network of Smaller Drains	39,840	-	39,840	
(A) Sub Total	39,840	-	39,840	
(B) Contingency	7,960	-	7,960	(A) x 0.20
(C) Engineering Fee				
Design	2,390	-	2,390	(A+B) x 0.05
Supervision	2,390	-	2,390	(A+B) x 0.05
Total	52,580	-	52,580	

TABLE IV-11 Drainage Construction Cost by Stage at 1976 Price (Government Contribution)

3rd Stage (1996-2000) (Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Main Drains	17,080	-	17,080	
b. Reservoirs for Initial STorm	-	-	-	
c. Reservoirs for Major Storm	11,500	-	11,500	
d. Land Acquisition	630	-	630	
(A) Sub Total	29,210	-	29,210	
(B) Contingency	5,840	-	5,840	(A) x 0.20
(C) Engineering Fee				
Design	1,750	-	1,750	(A+B) x 0.05
Supervision	1,750	-	1,750	(A+B) x 0.05
Total	38,550	-	38,550	

TABLE IV-12 Drainage Construction Cost by Stage at 1976 Price (Private Contribution)

3rd Stage (1991-1995) (Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
Network of Smaller Drains	34,230	-	34,230	
(A) Sub Total	34,230	-	34,230	
(B) Contingency	6,840	-	6,840	(A) x 0.20
(C) Engineering Fee	2,050	-	2,050	
Design	2,050	-	2,050	(A+B) x 0.05
Supervision	2,050	-	2,050	(A+B) x 0.05
Total	45,170	-	45,170	

TABLE IV-13 Drainage Construction Cost by Stage at 1976 Price (Government Contribution)

4th Stage (1996-2000) (Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
a. Main Drains	39,220	-	39,220	
b. Reservoirs for Initial Storm	-	-	-	
c. Reservoirs for Major Storm	45,600	-	45,600	
d. Land Acquisition	-	-	-	
(A) Sub Total	84,820	-	84,820	
(B) Contingency	16,960	-	16,960	(A) x 0.20
(C) Engineering Fee				
Design	5,080	-	5,080	(A+B) x 0.05
Supervision	5,080	-	5,080	(A+B) x 0.05
Total	111,940	-	111,940	

TABLE IV-14 Drainage Construction Cost by Stage at 1976 Price (Private Contribution)

4th Stage (1996-2000)

(Cost unit: 1,000 M$)

Description	Local Currency	Foreign Exchange	Total Cost	Remarks
Network of Smaller Drains	62,900	-	62,900	
(A) Sub Total	62,900	-	62,900	
(B) Contingency	12,580	-	12,580	(A) x 0.20
(C) Engineering Fee				
Design	3,770	-	3,770	(A+B) x 0.05
Supervision	3,770	-	3,770	(A+B) x 0.05
Total	83,020	-	83,020	

CHAPTER 6

BENEFITS

6.1 Introduction

Proper construction and operation of drainage systems are expected to result in certain types of benefits towards inhabitants of the areas concerned. These benefits include items, both quantifiable and non-quantifiable as follows:

(a) Prevention of the occurrence of flood damages.

(b) Stimulation of development in the protected areas and increase of land value.

(c) Improvement of comfort and convenience of the individual and community.

(d) Decrease swampy area and mosquito breeding.

The items above are discussed in the following sections.

6.2 Prevention of Occurrence of Flood Damages

In urban areas local flooding can and does cause considerable nuisance and hardship to those affected, which the problem can be alleviated by proper remedial work on the drainage system. The implementation of such works will result in considerable benefit to the community at large, in terms of public road and private properties becoming flood free, and also, in a more significant benefit, to the living condition of people whose houses and business premises were previously flood prone.

The quantifiable benefit expected by preventing flooding is equivalent to the amount of damages due to the flood. In the absence of data concerning flood damages the quantity of benefit is not figured. However, it should be kept in mind that the expenditure to recover flood damages is recurrent cost upon residents or the municipality and will increase unless flood relief measures are undertaken.

6.3 Stimulation of Development in the Protected Areas and Increase of Land Value:

With the provision of infrastructure including drainage system, development programme, both public and private sectors, will be greatly stimulated and land values increased. The value added to the land tends to equal or exceed the pro rata share of the total investment involved.

The added land value will be major economic banefit which will stimulate larger scale of financial transaction, and will cause additional source of taxation for the revenue in favour of the government agencies concerned. (Ref. Part III. Sewerage Master Plan 8.2.3)

6.4 Improvement of Comfort and Convenience of the Individual and Community

Benefits under this item can be understood easily when situations in which certain area is flooded and all kinds of waste waters including sullage, human excreta and discharge from industry, are mixed each other spreading coliforms, disease germs and toxic materials.

It is generally recognized through abundant experiences in the past that after flooding the cases of waterborne disease increase. Together with that of the sewerage system, contribution of the drainage systems to public health improvement can be expected to be very significant, especially in areas where people depend on bucket systems and pit privies for disposal of excreta.

6.5 Decrease Swampy Area and Mosquito Breeding

Considerable part of the Project Area is occupied by swampy areas which raises the problem of mosquito breeding. MPSP has spent a great deal of money every year for spreading chemicals to prevent mosquito breeding. The provision of proper drainage systems will result in the reduction of marshy area and breeding of mosquito. Thus the considerable part of recurrence costs for maintenance on mosquito control is expected to be reduced.

PART V

MANAGEMENT STUDIES

Table of Contents

CHAPTER 1

INTRODUCTION

The managerial arrangements with due consideration on organizational framework, legal supports and financial planning are necessary to bring the planned systems into being and make it viable at a continual base.

With regard to the organizational arrangements, the recommendations are made based on the conception that the too rigid requirements which entail the time consuming efforts in legal modifications and recruiting the personnel of high calibre can best be avoided to encourage the early initiation of the Project.

The above conception coincides with the Government's inclination on stepwise systems construction without any extensive and extravagant systems construction which requires a significant amount of investment. In this context more practicable approach is adopted avoiding drastic evolution and therefore existing organizational framework in the Municipal Council which administers the Project area is recommended to be fully utilized at the initiation of the Project taking account of exemplary organization in an adjacent city and assessment of other alternative organizational arrangement. The basic objectives are presented, however, for the incumbent organization to develop its functions in accordance with the changing requirements with objective to reach ultimately to fullfilment of basic requirements.

The legislative recommendations are also presented based on the similar approach to that of organizational recommendation. The existing legislation of Municipal Ordinance and Street, Drainage and Building Act, 1974 are recommended to be fully apllied with minor modifications which will be minimum requirements to eliminate the obstacles for the implementation of sewerage and drainage system developments. The preliminary consideration on financial arrangement are given to make the estimation of substantial funding requirements and potential revenue plan for the Project by which a detailed financial plan can be projected at the stage of feasibility study for implementation of each staged programme.

CHAPTER 2

ORGANIZATION

2.1 General

There is no organized modern sewerage system in the Project Area presently except for rudimentary sewage disposal system as septic tank, night-soil buckets collection and surface drains, hence no comprehensive sewerage organization to undertake effective planning, construction, operation, maintenance, management, and administration of the sewerage systems.

The existing organizations which are directly concerned with sanitary control including sewage disposal in Project Area are Engineering Department and Health Department of Municipal Council, Province Wellesley, and Drainage and Irrigation Department of State Government. The Engineering Department is mainly responsible for operation and control of existing sanitary system including desludging of septic tanks and Imhoff tanks. The Health Department is generally concerned with administrative control for public health regulating nuisance wholly or partly related to sanitary systems in the Project Area including bucket collection of night-soil and cleaning of drains.

Drainage and Irrigation Department (DID) is responsible mainly for construction and improvement of main drains and reservoirs including irrigation channels.

The completely new organization or a partial modification to existing organization may be necessary to be charged with the functions required when proposed plan is implemented. The new organization is suggested with due consideration on combination of the existing agencies with the standard generally accepted for the sewerage and drainage works. Consideration on some alternatives are attempted as can be seen in Appendix K. "Alternative Organization."

The proposed organizational structure presented in this chapter is, however, the suggested guideline to be followed with appropriate modifications on the basis of the Government's own policy.

2.2 Basic Organization Requirements

The following consideration may serve in considering an administrative organization sufficient to cope with the work for management of the Project, operation and maintenance of the sewerage and drainage system.

Basic Objectives

(1) To establish effective organization with capabilities in financially self-supporting, staffed with sufficient number of qualified personnel available.

(2) To provide a dependable service of sewerage and drainage facilities with efficient system of management preferably at the lowest possible cost.

(3) To coordinate with other agencies, governmental and private, and integrate the sewerage and drainage programme into development programme for the overall improvement of health and sanitation.

Functional Units Required

On the basis of the above consideration, the basic requirement of the services required for the new organization should include the following.

(1) Administration

(a) Personnel

The personnel recruitment and training as well as wage and salary administration would be included.

(b) Procurement

The procurement management of local and imported supplies.

(c) Finance

This function would include budgeting, accounting, payroll, billing, and collection of bills for the services rendered. The financial reports would be prepared to provide adequate information for evaluating and controlling sewerage and drainage operation, and for planning future development of sewerage and drainage system.

(d) Legal

This function would include provision of legal basis for taking appropriate measures to ensure proper operation and maintenance of sewerage and drainage system in compliance with Government ordinances including acquisition of rights-of-way and land.

(2) Engineering

(a) Design

This function would include detailed designing of all new construction including new service connection with cost estimation, the drawing and reproduction of engineering plans, and control of plumbing and service connections through the inspection and permits. The maintenance of engineering records would be also contained.

(b) Construction

This function would include supervision of all construction work connected with repair, improvement and expansion to assure compliance of the plan and designs in accordance with the established regulations.

(3) Operation/Maintenance Division

(a) Operation

This function would include the efficient operation of the treatment plants and pumping stations on a continuous base and monitoring of stream, river, drain and illegal effluent from cesspools and septic tanks as well as industries.

(b) Maintenance

This function would contain keeping entire sewerage and drainage system in good working order, including plants,,pumping,, and piping facilities, drains and house connections, and perform necessary repairs for damaged facilities and equipments.

2.3 Proposed Organization

The advantages and disadvantages of all alternatives as explored in Appendix K."Alternative Organizations"are evaluated taking into account of the background and current situation.

The first alternative is to create new regional organization as Penang Sewerage & Drainage Authority, covering both the Penang Island and Province Wellesley, and the second alternative is to add sewerage and drainage activities into the existing Penang Water Authority in the state wide level. The third alternative calls for expansion and modification of the existing Engineering Department and others in Municipality of Provice Wellesley.

While each of these alternatives has logical sequence to establish well organized agency to cope with the administrative responsibilities, the third alternative is deemed to be more practical for implementation within the organizational framework of existing Municipal Council, Province Wellesley, by adding minimum of the needed staff mainly to the existing Engineering Department. This is further elaborated, therefore, with the description of the responsibilities to be added in the following;

Engineering Department:

The newly added functions for sewerage and drainage system operation in the Engineering Department are to undertake activities, by creating Sewerage and Drainage Division in the Department, in conformance with basic guideline for functional units described in previous paragraph. The new organization as graphically indicated by Figures V-1 and V-2 will have the following functional units in the Division:

Operation & Maintenance Section:

Two sub-sections for each objective are provided under the head of this Section.

Sub-section of Treatment Plant & Pumping Station will be responsible for proper operation and maintenance of treatment plant and pump to achieve desired quality of effluent and target volume of sewage treated and proper disposal of plant effluent as well as uninterrupted conveyance of sewage.

This Section will be also responsible for the maintenance and repair of the treatment plant works and equipments to keep it in good working order including pumps, structures and plant premises.

Sewer & Drain Sub-section will be responsible for proper maintenance of the public sewers and all drains together with pertinent reservoirs and their appurtenances conducting routine inspection for physical damage and obstruction in the sewers and all drains with pertinent reservoirs including control of the illegal discharge from industries, septic tank into main sewers and drains. Any voilation of related regulations established in Municipal Ordinance and/or related By-Laws detected by inspection will be reported to initiate filling of court suits against violators.

Section of Designing:

This section will be responsible for preparation of engineering design and specification necessary to receive tenders for construction of sewerage and smaller drainage systems including service connection with pertinent cost estimation, drawings and reproduction of engineering plans, and the issuance of permits for new service connections requested by owners of buildings. The designing of main drains and reservoirs will be undertaken by existing Drainage and Irrigation Department of State Government.

Section of Construction:

This section will be responsible for supervision of all new construction with attendant surveys and inspections to assure compliance with required specification and standards. The construction of main drains and reservoirs is, however, suggested to be undertaken by Drainage and Irrigation Department of State Government.

Taking into consideration the probable shortage of required staff to be assigned in Design Section and Construction Section which will be a restraint to initiation of the implementation of planned project, the external engineering consultants are suggested to undertake detailed designing and preparation of tender documents and subsequent supervision of construction at initial stage of programme.

Only a few selected key personnel as counterpart staff are required to participate with consultants' work to develop their capability gradually with ultimate objective to undertake designing and construction supervision as well as operation and maintenance of the sewerage and drainage systems on independent base at subsequent stages.

Laboratory Section:

This section will be required to conduct routine laboratory analysis and test for sewage and industrial wastewater as required from time to time.

The following existing functional units already existing in Municipal Council, P.W. (MPSP) are proposed to extend their functions for sewerage and drainage operations.

Secretariat Department:

Under the exising Secretariat Department, the following terms of reference should be added in its respective Sections:

Administration Section:

This section should include to perform personnel administration and control over procurement and supplies of materials for sewerage and drainage operation.

Legal Section:

This section should expand its functions necessary for proper operation of the new systems as specified in (d) of Functional Units in previous page V-7.

Special Task Section:

The public relation services presently undertaken by this section is proposed to undertake an intensive public relations programme to enhance public concerns to environment sanitation and encourage public to avail themselves of the sewerage system.

Finance and Treasurey Department:

This Department is presently undertaking financial control over all activities involved in Municipal Council. However, a separate financial section within the Department exclusively for sewerage and drainage system operation is suggested to perform financial functions as budgeting, accounting, billing and maintenance of financial records separately from other departments in order to ensure sound management practice and accurate operating result of the proposed sewerage and drainage systems.

Drainage and Irrigation Department (DID), Penang State Government

This department is presently providing engineering services on planning designing and construction of major drainage and irrigation systems in State of Penang including Project Area. It is suggested that proposed construction of the main drains and reservoirs would be undertaken by this department providing Engineering Department of MPSP take care of smaller drains.

Health Department:

While the proposed sewerage and drainage project will eventually replace night soil collection and septic tank systems with complete sewerage systems, there will be a continuing need to collect and dispose of night soil and septic tank deposits and clean the drains, which are presently undertaken by the Health Department. There is an apparent need for Health Department to continue its present service and coordination between the new sewerage and drainage organization and the Health Department for the foreseeable future until the complete sewerage system is implemented.

FIGURE V-1 Municipal Council, Province Wellesley

Added Functional Unit in Existing Organization

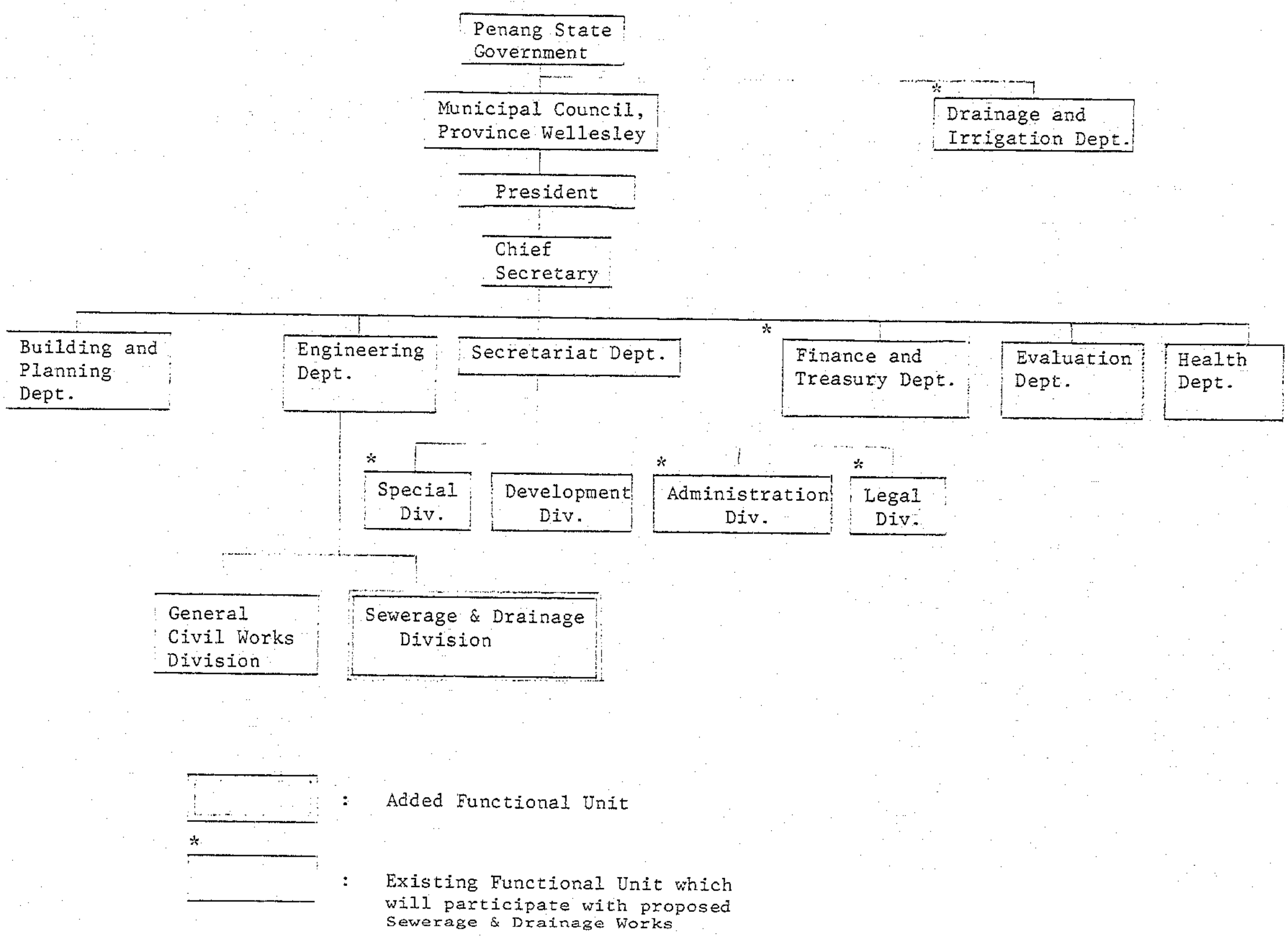


FIGURE V-2 Sewerage & Drainage Works Organization

Suggested Functional Units