3. Time of Concentration

An estimation of the time for the flow to concentrate at the point under consideration must be made, in using the national method. For urban storm sewers, the time of concentration consists of inlet time plus time of flow in the sewer from the most remote inlet to the point under consideration.

The time of flow in the sewer is dependent upon the distance, slope and type of conduits or channels, and is calculated in individual sewer line when it is designed. However, the inlet time is in similar range in areas in which surface slope, nature of surface cover, and length of path of surface flow are in the same charactor. Therefore it is general practice to use the fixed inlet time in areas with similar characteristics.

In this project the inlet time has been estimated as follows.

3-1 Inlet Time

An equation which represents the inlet time for urban sewer design was originally proposed by Horton[1] and later modified and formulated by Kerby [2] in the form:

$$T_i = \left[\frac{2}{3} \times 3.28 \times L \times \left(\frac{n}{\sqrt{s}} \right) \right] 0.467$$

where T_i = inlet time, in minutes

L = distance from the most remote point to the point of inlet, in metres

n = coefficient of roughness, similar to runoff coefficient, as given in table below

Table G-6 Coefficient of Roughness in Kerby's Equation

Character of Surface	Coefficient of Roughness
Smooth pavement	0.02
Bare, packed soil, free of stone	0.10
Poor grass cover	0.20
Moderately rough bare surface	0.20
Average grass cover	0.40
Forest (deciduous tree)	0.60
Dense grass cover	0.80
Forest (deciduous tree, with deep dead leaves)	0.80
Forest (needle-leaved tree)	0.80

1/ R.E. Horton, The Role of Infiltration in the Hydrologic Cycle. Trans. AGU, Vol. 14, 1933.

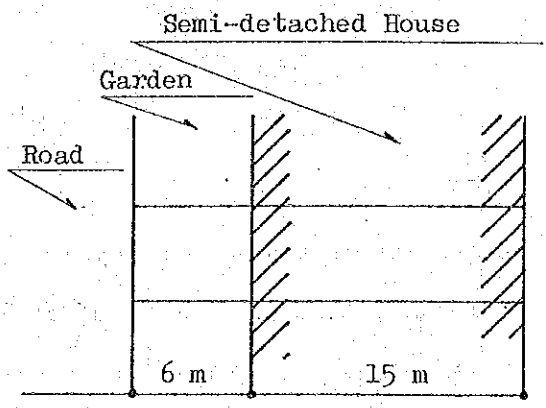
2/ W.S. Kerby, Civil Engineering 29,174 (1959).

The surface slope in the Project Area except Bukit Mertajam area is around 0.3/1000 and length of path of surface flow was decided for individual type of land use. The inlet time of individual land are has been estimated as described below.

3-1-1 Inlet Time of Individual Land Use

1) Residential Area

From the layout plan of a new housing development area the distance from the remote point of the premise was estimated as shown in the figure below.



The inlet time can be calculated as:

= 6.0 m n = 0.2

$$t = \left[\frac{2}{3} \times 3.28 \times 6 \times \frac{0.2}{\sqrt{0.0003}} \right]^{0.467}$$

= 10.4 minutes

2) Commercial Area

The commercial area in Butterworth and Bukit Mertajam are served with roads which run in parallel in every about 50 metres or so. The average width of these roads is approximately 10 metres.

Based on the condition above, the distance from the center of an area between two roads is assumed to be 20 metres. The inlet time of 6.2 minutes was calculated when the distance of surface flow is 20 metres and n = 0.02.

3) Industrial Area

In case of industrial area, Macmandin area was investigated and the average distance of the surface flow is defined to be 15 metres. When coefficient n is 0.2, the inlet time is 16.0 minutes.

4) Mountainous Area

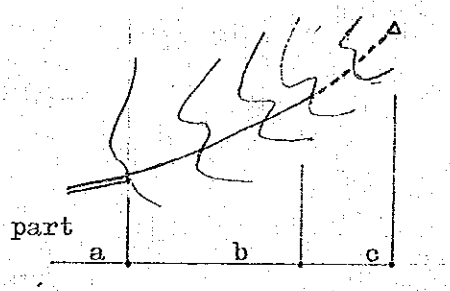
The path of surface flow consists of three parts with different characteristics as shown in the figure below.

part a: established surface drainage channels

part b: natural water way

part c: path of overland flow

The inlet time consists of the time of flow of part b plus part c.



For the purpose of estimation of the inlet time Rziha formula was used for the part "b" and Kerby formula for the part "c". The Rziha formula is in the current use for the estimation of the average velocity in mountainous area and expressed as;

$$v = 20\,(h/\ell)\,0.6$$ ----------

v = velocity of flood (m/sec)

ℓ = horizontal distance of the part "c"

h = head in the part "c"

The time of flow in the part "b" is, therefore, calculated as follows.

$$\alpha = \frac{b}{v} \times 60 \text{ (minutes)} \text{ -------}$$

where

α = inlet time in minute

By applying Kerby formula, the time of flow in the part "b" has been investigates in eight existing major streams in the Project Area. The range of results is 17 ~ 21 minutes with the average of 19.5 minutes. It was concluded that the use of 20 minutes for the inlet time would yield the satisfactory results.

The inlet time discussed is summerized as follows:

Residential area -------- 10 minutes

Commercial areas -------- 5 "

Industrial area -------- 15 "

Mountainous area -------- 20 + α "

In order to simplify the application of the inlet time an comparison of results derived by using 5, 10 and 15 minutes, was carried out. The ratio $\frac{Q5}{Q10} = R.1$, $\frac{Q15}{Q_{10}} = R.2$ were calculated and is shown in Table 6·7 .

The subscripts denote the inlet time, so Q5 represents the stormwater runoff quantity, of any rainfall, which will be expected in the drainage systems with the inlet time of 5 minutes.

Table G.7 Ratio of Stormwater Quantities with Different Inlet Time

Time of Concentration	2-yr frequency		5-yr frequency	
	Q_5 / Q_{10}	Q_{15} / Q_{10}	Q_5 / Q_{10}	Q_{15} / Q_{10}
T= 10	R1= 1.081	R2= 0.931	R3= 1.068	R4= 0.940
T= 15	R1= 1.003	R2= 0.970	R3= 0.992	R4= 0.979
T= 20	R1= 1.003	R2= 0.978	R3= 0.993	R4= 0.986
T= 25	R1= 1.007	R2= 0.980	R3= 0.999	R4= 0.987
T= 30	R1= 1.010	R2= 0.981	R3= 1.003	R4= 0.987
T= 35	R1= 1.013	R2= 0.981	R3= 1.006	R4= 0.987
T= 40	R1= 1.015	R2= 0.981	R3= 1.009	R4= 0.986
T= 45	R1= 1.016	R2= 0.981	R3= 1.011	R4= 0.986
T= 50	R1= 1.017	R2= 0.981	R3= 1.012	R4= 0.985
T= 55	R1= 1.017	R2= 0.981	R3= 1.013	R4= 0.985
T= 60	R1= 1.017	R2= 0.981	R3= 1.013	R4= 0.985
T= 65	R1= 1.018	R2= 0.981	R3= 1.014	R4= 0.985
T= 70	R1= 1.018	R3= 0.982	R3= 1.014	R4= 0.985
T= 75	R1= 1.017	R2= 0.982	R3= 1.014	R4= 0.985
T= 80	R1= 1.017	R2= 0.982	R3= 1.014	R4= 0.985
T= 85	R1= 1.017	R2= 0.983	R3= 1.014	R4= 0.985
T= 90	R1= 1.017	R2= 0.983	R3= 1.014	R4= 0.985
T= 95	R1= 1.017	R2= 0.983	R3= 1.014	R4= 0.986
T=100	R1= 1.016	R2= 0.984	R3= 1.014	R4= 0.986
T=105	R1= 1.016	R2= 0.984	R3= 1.014	R4= 0.986
T=110	R1= 1.016	R2= 0.984	R3= 1.014	R4= 0.986
T=115	R1= 1.015	R2= 0.985	R3= 1.013	R4= 0.986
T=120	R1= 1.015	R2= 0.985	R3= 1.013	R4= 0.987
T=125	R1= 1.015	R2= 0.985	R3= 1.013	R4= 0.987
T=130	R1= 1.015	R2= 0.985	R3= 1.013	R4= 0.987
T=135	R1= 1.014	R2= 0.986	R3= 1.013	R4= 0.987
T=140	R1= 1.014	R2= 0.986	R3= 1.013	R4= 0.987
T=145	R1= 1.014	R2= 0.986	R3= 1.012	R4= 0.988
T=150	R1= 1.014	R2= 0.987	R3= 1.012	R4= 0.988
T=155	R1= 1.013	R2= 0.987	R3= 1.012	R4= 0.988
T=160	R1= 1.013	R2= 0.987	R3= 1.012	R4= 0.988
T=165	R1= 1.013	R2= 0.987	R3= 1.012	R4= 0.988
T=170	R1= 1.013	R2= 0.987	R3= 1.012	R4= 0.989
T=175	R1= 1.012	R2= 0.988	R3= 1.011	R4= 0.989
T=180	R1= 1.012	R2= 0.988	R3= 1.011	R4= 0.989

From Table G·7 , it is understand that the difference between stormwater quantities yielded with the inlet time of 5, 10 and 15 minutes is not noticeable.

It was concluded, therefore, the same inlet time of 20 minutes is used for residential, commercial and industrial areas in this project.

3.1.2 Comparison with Practice in Other Areas

The inlet time recommended for this project is compared with practices is USA and Japan as shown in Table G·8 .

Table G·8 Comparison of Inlet Time

(in minute)

Definition of Area	Recommendations for this Project	Practice in Japan	Standards in ASCE
Densely populated area with paved roads and drainage systems	10	5	5
Sparsely populated area	10	10	10 ~ 15

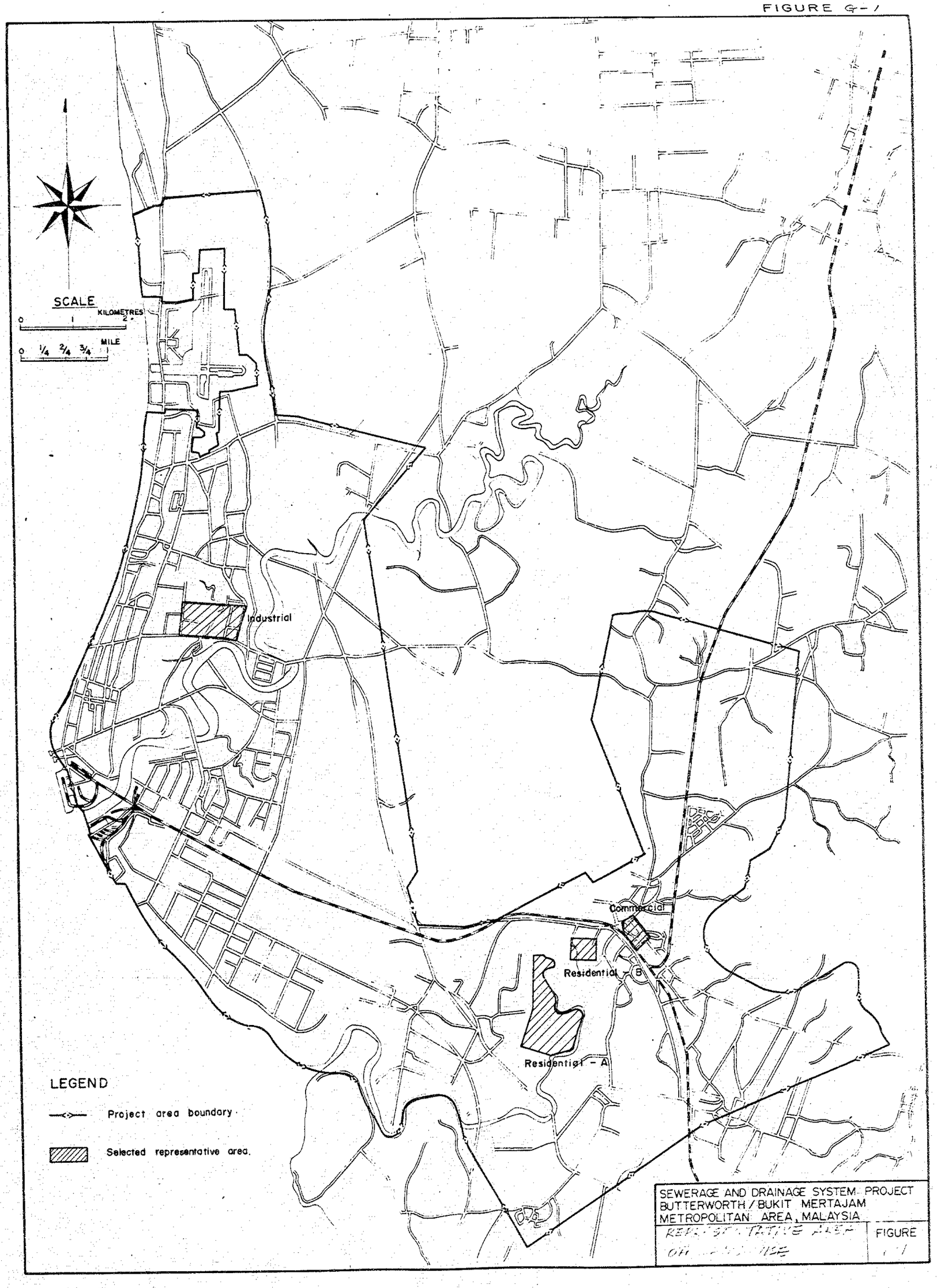
3.1.3 Recommended Inlet Time

The recommended inlet time is shown in Table.

Table G·9 Inlet Time

(in minute)

Area	Inlet time
Urban area	10
Mountainous area	20 + α



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REPRESENTATIVE AREA
OF LAND USE

FIGURE G-1

APPENDIX H

STAGING OF CONSTRUCTION

Table of Contents

CHAPTER 1
INTRODUCTION

The provision of a complete wastewater and stormwater sewerage system for an area of the size of the proposal Project Area with its large and expanding population, is a task of tremendous magnitude.

However, it is only prudent and sound to build the required facilities in stages, according to the urgency of need and benefits to be derived. Stage construction will spread capital expenditure over an extensive period of years, as well as saving interest on borrowed capital and reducing initial costs. In addition, experience gained in the early construction programme will permit necessary review and re-evaluation of the plan for any continuing construction programme.

A study has therefore been made to determine the desirable stages of sewerage construction, taking into account the various important elements which affect sanitary conditions in the Project Area, based on use of a reasonable rating procedure.

CHAPTER 2
RATING OF SANITARY CONDITIONS

2.1 Basic Considerations for Rating

The elements considered in selecting the priority of sewerage districts for implementation of sewerage construction up to the year 2000 include the following seven items, each of which has impacts on environmental sanitation in the Project Area.

(1) Population Density
(2) Waste Load Production Aspect
(3) Excreta Disposal System
(4) Flooding
(5) Housing and Industrial Development Programmes
(6) Availability of Water Supply
(7) Incidence of Water-borne Diseases

The above-mentioned seven elements are each assigned by the different evaluation points to reflect their relative importance to the sanitation, and each of the twenty sewerage zones, dirided out of Butterworth, Seberang Jaya, Prai, and Bukit Mertajam districts, is evaluated carefully and graded according to the rating for each element for the purpose of establishing sewerage priority for implementation.

2.2 Application of Rating System

As already noted, for purpose of provision of sewerage system, improvement of health condition and social welfare must be regarded as all-important forget, on the basis of impact on (1) the communicable diseases hazard, (2) water pollution control in the waterways and (3) the community aesthetics.

For the purpose of rating system, a total of 1000 points was assigned to each of seven major elements, according to order of important, as described below.

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

(2) Second highest point was assigned for the waste load production aspects.

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

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

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

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

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

In view of these factors, the seven elements which affect sanitary conditions were assigned points arbitarary for the rating, as given below:

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

The importance of these factors are discussed as following paragraphy, including various intangible matters.

2.2.1 Population Density

Population densities, both present and future, by sewerage zones, range approximately from 0 persons per hectare in zone 2 of Seberang Jaya district and zone 1 of Prai district to 124 persons per hectare in zone 1 of Butterworth district, as presented in Table H-1 and Figures H-1 & 2. For purpose of rating, 200 points given both to present and future population densities as follows:

Assigned Points	Present and/or Future population density
200	100 p/ha or more
150	75 - 100 p/ha
100	50 - 75 "
50	25 - 50 "
0	0 - 25 "

As shown in Table H-2, the highest rating zone is 1 of Butterworth district, which is assigned as full 400 points, followed by the zones 3 and 4 of Butterworth, and zone 1 of Seberang Jaya district.

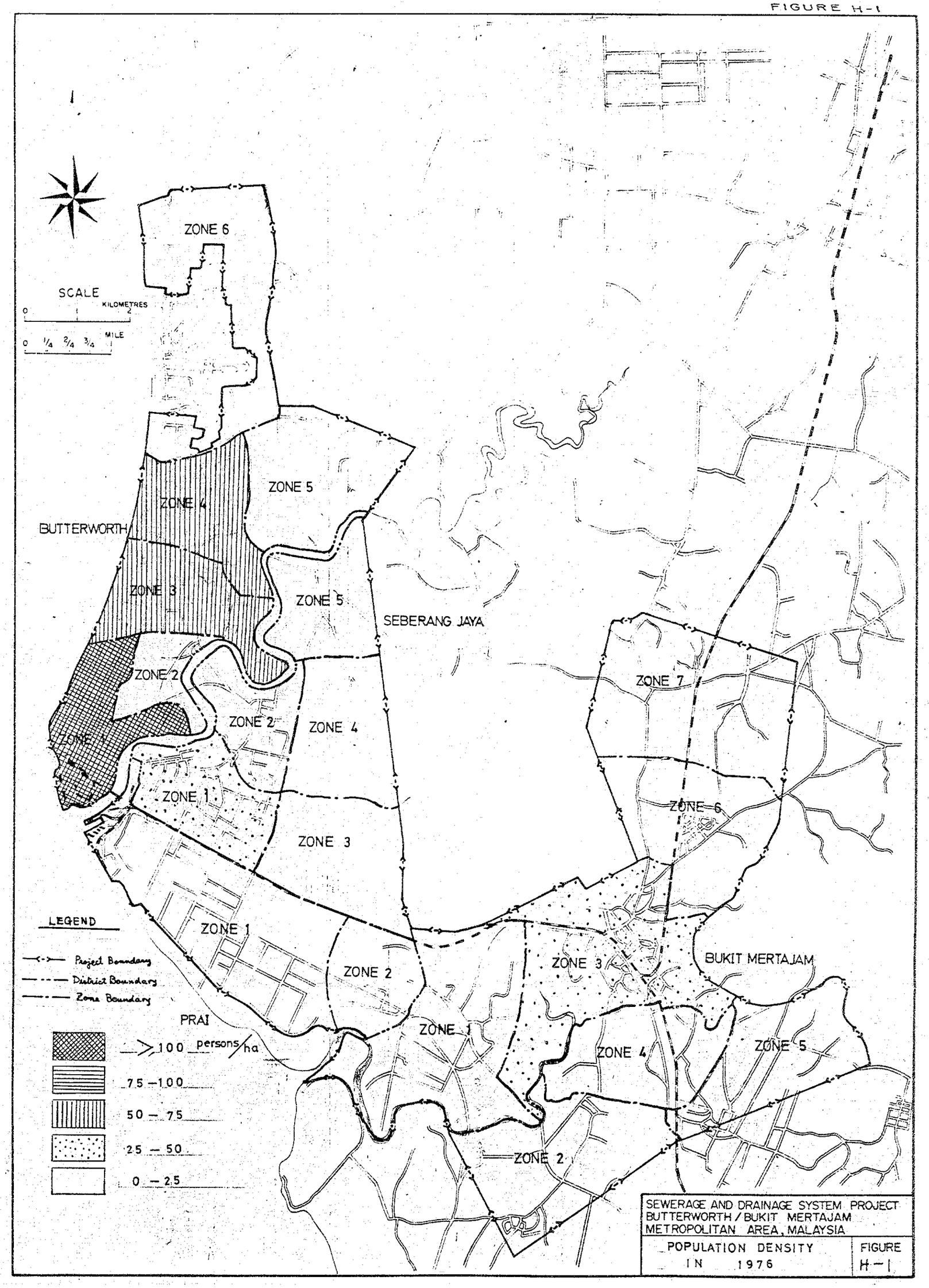
TABLE H-1 Population Density by Sewerage Zones

District	Zone	Sewerage Area Considered	1976		2000	
			Population	Population Density	Population	Population Density
		※ (ha)	(persons)	(persons/ha)	(persons)	(person/ha)
Butter worth	1	367	37,920	103.3	45,440	123.8
	2	182	3,585	19.7	21,840	120.0
	3	457	28,255	61.8	37,039	81.0
	4	444	26,332	59.3	37,514	84.5
	5	551	3,961	7.2	33,705	61.2
	6	670	8,902	13.3	37,316	55.7
Seberang Jaya	1	438	13,657	31.2	46,748	106.7
	2	305	69	0.2	25,178	82.6
	3	510	2,991	5.9	26,543	52.0
	4	430	7,518	17.5	20,818	48.4
	5	368	4,369	11.9	19,152	52.0
Prai	1	1,063	1,860	1.7	0	0
	2	268	1,974	7.4	13,948	52.0
Bukit Meltajan	1	892	7,559	8.5	47,512	53.3
	2	715	6,387	8.9	39,794	55.7
	3	927	45,540	49.1	73,729	79.5
	4	467	6,077	13.0	24,917	53.4
	5	459	7,257	15.8	23,889	52.0
	6	573	13,840	24.2	32,948	57.5
	7	768	9,947	13.0	39,970	52.0
Total		10,854	238,000	21.9	648,000	59.5

※ These figures do not include areas of mountain, rivers and ponds.

TABLE H-2 Results of Assessment Points for Population Density Aspect

District	Zone	Assessment Points		
		1976	2000	Total
Butter worth	1	200	200	400
	2	0	200	200
	3	100	150	250
	4	100	150	250
	5	0	100	100
	6	0	100	100
Seberang Jaya	1	50	200	250
	2	0	150	150
	3	0	100	100
	4	0	50	50
	5	0	100	100
Prai	1	0	0	0
	2	0	100	100
Bukit Mertajam	1	0	100	100
	2	0	100	100
	3	50	150	200
	4	0	100	100
	5	0	100	100
	6	0	100	100
	7	0	100	100



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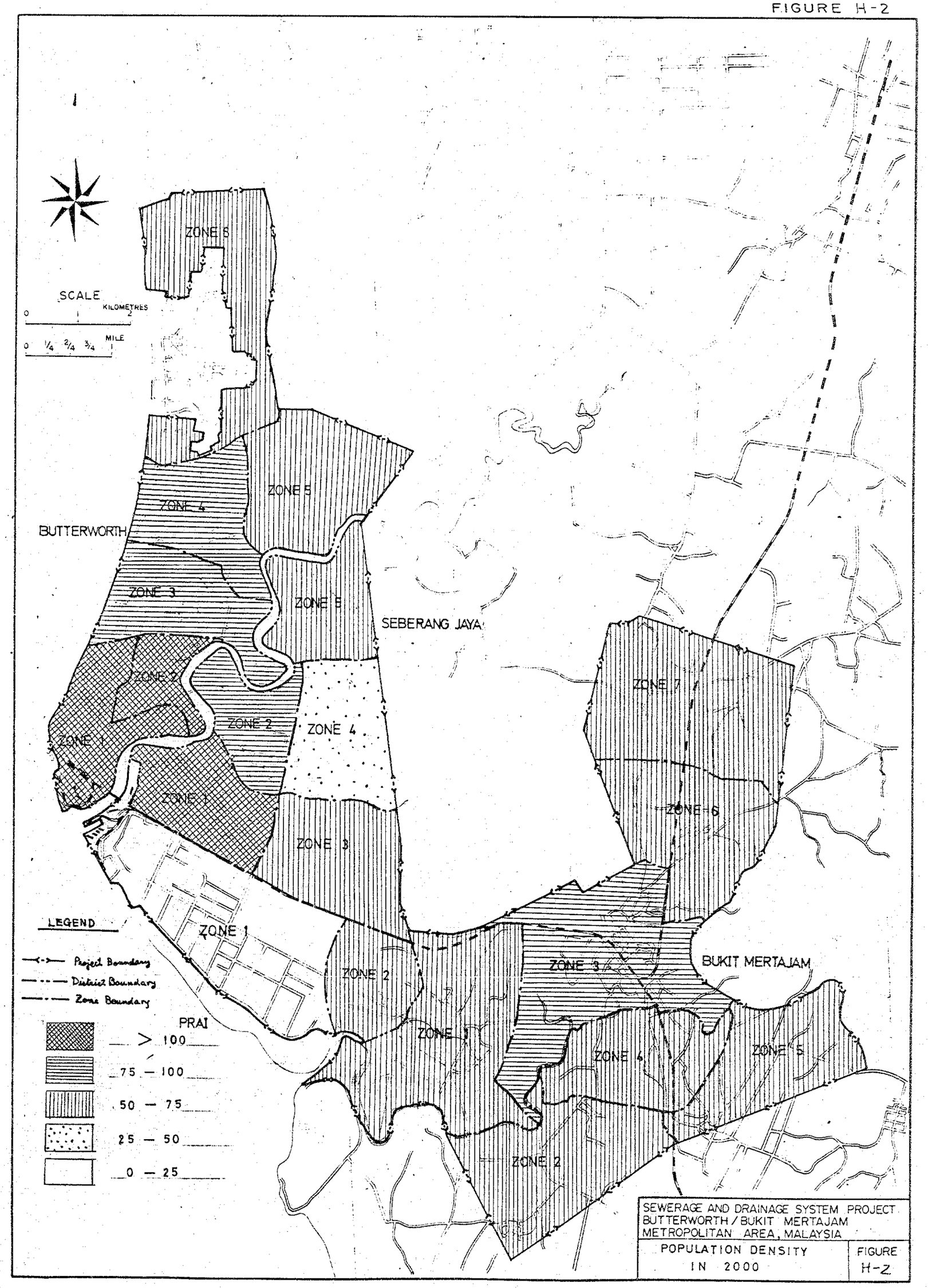
POPULATION DENSITY IN 1976 — FIGURE H-1

FIGURE H-2



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POPULATION DENSITY IN 2000	FIGURE H-2

2.2.2 Waste Load Production Aspects

According to the investigation on present project carried out in the Project Area, streams are generally polluted by the depositary of right soil sewage, industrial waste and garbage generated, hence it is necessary to control the waste load discharging into waterways. For the purpose of rating, waste load originating within the area of each sewerage zone is estimated from two view points considered, namely per hectare waste load production and per capita burden aspect, and then calculation of waste load was made both the present and the year 2000 projections.

Table H-3 indicats the result of the per hectare waste load produced. The calculation of waste load within the residential area was made by served population, water consumption of 230 l/cap and waste load production of 200 mg/l./cap in terms of BOD. For the industrial area, calculation also was made by multipling waste water production of 100 cum/ha/day to the waste load production of BOD of 150 mg/l.

On the other hand, in view of the environmental protection of population, Table H-4 indicats the result of the per capita waste burden who will be of benefit by the sewerage facilities, in terms of BOD throughout residential and industrial.

However, figures in which are Tables H-3 and H-4, have not been taken into account the effects of waste load which should be alternable by the existing and staging sewerage facilities both of residential and industrial area in the Project Area.

As may be seen from Table H-3, zone 1 of Prai district of industrial area, is the most heavily produced waste load on the basis of per hectare production, both the present and the year 2000 to be expected the extending development of industrial area. While there is no waste load production on the year 2000, as indicated in Table H-4, in term of per capita waste burden, because of this sewerage zone is an industrial area which have no served population. Therefore, an assessment for this sewerage zone will be given to the lower priority.

In this rating, a total of 250 points were assigned to the waste load production aspects, divided into an assessment from two viewpoints which are evaluated by the per hectare production is given to the points of 100, and per capita burden aspect is given to the points of 25, in both the present and the year 2000 respectively, and then an evaluation was made of each of sewerage zones with respect to the point of waste load produced in the project area in terms of BOD level, as presented in Table H-5 and H-6. As shown in Tables H-5 and H-6, the calculation of evaluated numbers on the basis of per hectare production and per capita burden was made by the percentage of the waste loads to be produced in each of sewerage zone, to the total waste loads in Project Area.

Then, an assessment for rating of each of sewerage zone is given the following points both for the present and the year 2000, according to the above mentioned, and calculated numbers:

(1) Based on Per hectare production

Assessment points	Evaluation Numbers	
	1976	2000
100	20 more	15 more
75	15 - 20	10 - 15
50	10 - 15	5 - 10
25	5 - 10	3 - 5
0	0 - 5	0 - 3

(2) Based on Per Capita burden

Assessment Points	Evaluation Numbers	
	1976	2000
25	40 more	10 more
15	20 - 40	5 - 10
5	10 - 20	3 - 5
0	0 - 10	0 - 3

The results of the assessment is indicated in Table H-7

TABLE - H-3 Estimated Waste Load on the basis of per Hectare Production

District	Zone	1976 (Kg/ha.day)	2000
Butterworth	1	8.6	8.4
	2	1.8	4.2
	3	7.2	7.2
	4	2.8	3.9
	5	0.6	2.8
	6	0.6	2.6
Seberang Jaya	1	1.8	5.0
	2	1.7	6.3
	3	0.3	2.4
	4	0.9	2.2
	5	0.8	2.4
Prai	1	11.7	15.0
	2	0.4	2.4
Bukit Mertajam	1	0.5	2.5
	2	0.4	2.6
	3	3.0	3.7
	4	0.6	2.5
	5	0.7	2.4
	6	1.1	2.6
	7	0.6	2.4
Total		46.1	83.5

TABLE - H-7 Estimated Waste Load Production on the basis of per Capita Burden

District	Zone	1976 (g/cap.day)	2000
Butter worth	1	73	68
	2	46	46
	3	103	89
	4	46	46
	5	46	46
	6	46	46
Seberang Jaya	1	48	47
	2	6,350	77
	3	46	46
	4	46	46
	5	46	46
Prai	1	5,199	0
	2	46	46
Bukit Mertajam	1	46	46
	2	46	46
	3	46	46
	4	46	46
	5	46	46
	6	46	46
	7	46	46
Total		12,415	924

TABLE - H-5 Evaluation Numbers on the basis of per Hectare Production

District	Zone	1976	2000
Butter worth	1	19	10
	2	4	5
	3	16	9
	4	6	5
	5	1	3
	6	1	3
Seberang Jaya	1	4	6
	2	4	8
	3	1	3
	4	2	3
	5	2	3
Prai	1	25	18
	2	1	3
Bukit Mertajam	1	1	3
	2	1	3
	3	7	4
	4	1	3
	5	2	3
	6	2	3
	7	1	3

TABLE - H-6 Evaluation Numbers on the basis of per Capita Burden

District	Zone	1976	2000
Butter worth	1	1	7
	2	0	5
	3	1	10
	4	0	5
	5	0	5
	6	0	5
Seberang Jaya	1	0	5
	2	51	8
	3	0	5
	4	0	5
	5	0	5
Prai	1	42	0
	2	0	5
Bukit Mertajam	1	0	5
	2	0	5
	3	0	5
	4	0	5
	5	0	5
	6	0	5
	7	0	5

TABLE - H-7 Results of Assessment Points for Waste Load Production Aspect

District	Zone	Per hectare production 1976	Per hectare production 2000	Per capita burden 1976	Per capita burden 2000	Total Points
Butterworth	1	75	75	0	15	165
	2	0	50	0	15	65
	3	75	50	0	25	150
	4	25	50	0	15	90
	5	0	25	0	15	40
	6	0	25	0	15	40
Seberang Jaya	1	0	50	0	15	65
	2	0	50	25	15	90
	3	0	25	0	15	40
	4	0	25	0	15	40
	5	0	25	0	15	40
Prai	1	100	100	25	0	225
	2	0	25	0	15	40
Bukit Mertajam	1	0	25	0	15	40
	2	0	25	0	15	40
	3	25	25	0	15	65
	4	0	25	0	15	40
	5	0	25	0	15	40
	6	0	25	0	15	40
	7	0	25	0	15	40

2.2.3 Excreta Disposal System

For the recommendable consideration of sewerage system including excreta disposal within municipal and rural area of Project Area, the existing excreta disposal system shall be essential before a new or modified system can be proposed, and for a while, the existing system usually will be incorporated into any new system, since the new system are required a tremendous capital investment.

The existing exreta disposal system in project area is represented generally by two systems, namely septic tank and bucket systems. Most of the population in the new housing development areas use the flush toilets with communal septic tank, while most of the rural population use the bucket system, and built-up unbarrized area in used by the system incorporated into the septic tank and bucket system.

Figure II-2 shows location of the present excreta disposal system covered by the septic tank and bucket systems. But, no information was available on the exact number of these excrete disposal systems and its serving population throughout the sewerage zones.

However, according to the population and housing census in Malaysia on 1970, excreta disposal conditions relative to the sewerage district are presented in proportion to the depending upon the type of toilet as followsing.

Name of local council area	Type of Toilet in Percentage					
	Flush	Bucket	Pit	River	None	Total
Butterworth	31	60	6	1	2	100
Prai	24	67	3	4	2	100
Bukit Mertajam	28	69	2	-	1	100
Other *	7	64	16	5	8	100

* Other was estimated by the weighted ratio of population density in the rural area of various Kampong.

For the purpose of rating, proportion of toilet systems in each sewerage zone was determined arbitrarily to be distributed as same as above percentages presented in local council areas, and then a full 100 points are given to the sewerage zones where no excreta disposal system exists, but the areas where septic tank are generally functioning reasonably satisfactorily, based on minimum sanitation levels covered.

As indicated in Table H-8, the evaluation in each sewerage zone was made by the proportion of unsatisfactory excreta disposal system to the population density, and the following points were given by the number estimated

Assessment Point	Evaluation Number
100	60 more
50	30 - 60
0	0 - 30

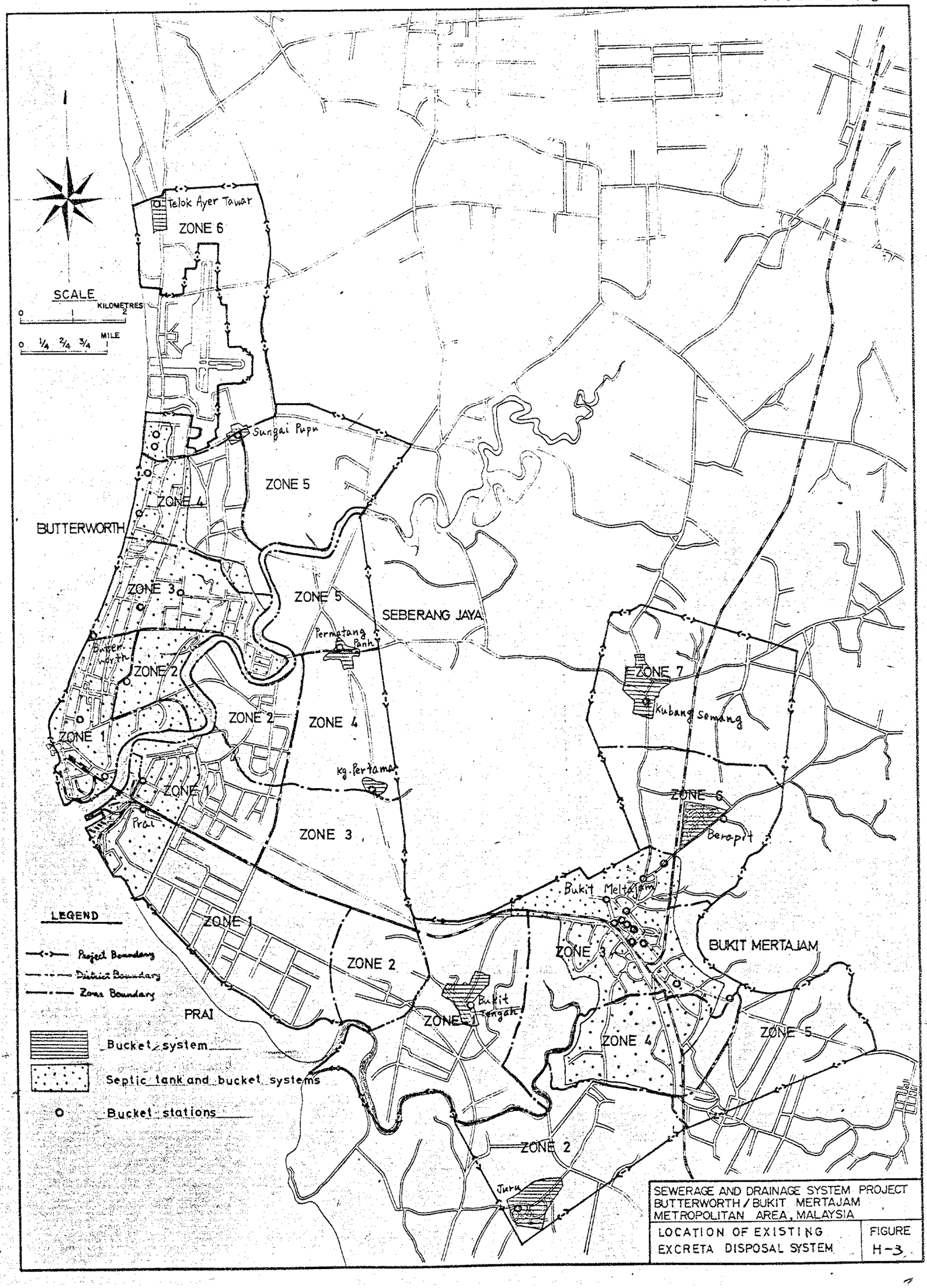
For all the sewerage zones, rating was estimated to be given the points as summarized in Table H-9.

TABLE - H-8 Evaluation Number by Excreta Disposed System

District	Zone	Percentage of unsatisfactory excreta disposal system (%) (a)	Population density on 1976 (b)	Evaluation Number by population density (a)x(b)×100
Butter worth	1	69	103.3	71
	2	69	19.7	14
	3	69	61.8	43
	4	69	59.3	41
	5	93	7.2	7
	6	93	13.3	12
Seberang Jaya	1	76	31.2	24
	2	93	0.2	0
	3	93	5.9	5
	4	93	17.5	16
	5	93	11.9	11
Prai	1	76	1.7	1
	2	93	7.4	7
Bukit Mertajam	1	93	8.5	8
	2	93	8.9	8
	3	72	49.1	35
	4	72	13.0	9
	5	93	15.8	15
	6	93	24.2	23
	7	93	13.0	12

TABLE-H-9 Result of Assessment Points for Excreta Disposal System

District	Zone	Points
Butter worth	1	100
	2	0
	3	50
	4	50
	5	0
	6	0
Seberang Jaya	1	0
	2	0
	3	0
	4	0
	5	0
Prai	1	0
	2	0
Bukit Mertajam	1	0
	2	0
	3	50
	4	0
	5	0
	6	0
	7	0



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

LOCATION OF EXISTING EXCRETA DISPOSAL SYSTEM	FIGURE H-3

2.2.4 Flooding

As shown in Figure H-4, in the areas marked, flooding has occurred most frequently.

For the purpose of rating, only the areas marked of Butterworth and Bukit Mertajam district are considered, because of the other marked areas in Seberang Jaya, Prai and some areas of Bukit Mertajam district are confined to be area of wet land, and these areas have yet developed with the ponding in each of districts occurs when there's a coincidence of high-rainfall, hightides and/or poor drainage.

Therefore, following sewerage zones are given arbitrarily to be considered for the rating. While there are no available records with regard to flood incidence on damage caused in these areas.

District	Zone	Flooded Area (ha)
Butterworth	1	7.9
	3	70.8
	4	4.1
Mukit Mertajam	3	70.0

In view of there conditions a total of 100 points were assigned to the flooding aspect, and the ratio of extent of flooding to the total area of each sewerage zones, was calculated for the assessment point as follows:

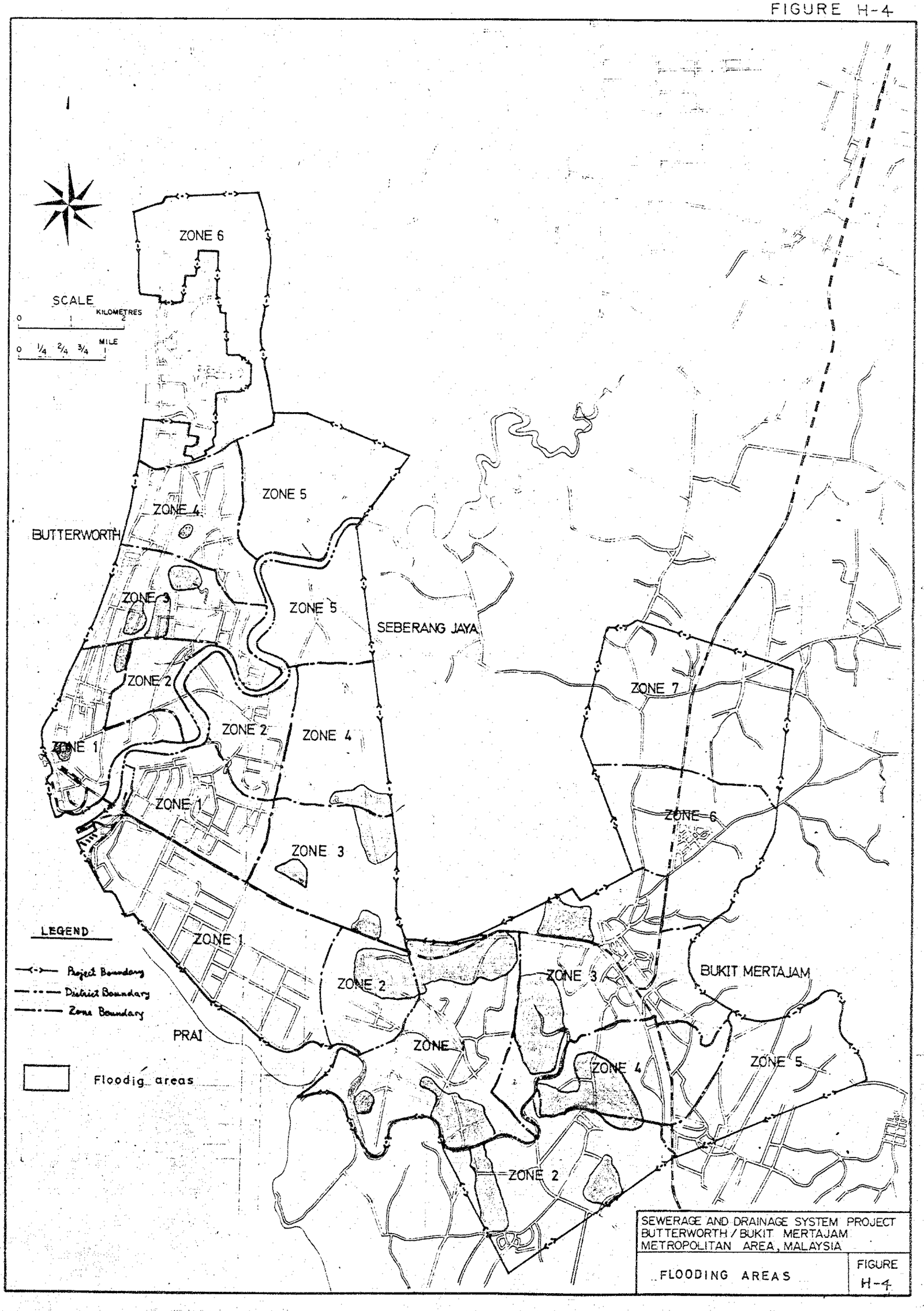
District	Zone	Area(ha)	Flooded area(ha)	Ratio
Butterworth	1	390	7.9	2
	3	490	70.8	14
	4	450	4.1	1
Bukit Mertajam	3	980	70.0	7

Then, an assessment point for rating was given the following points according to the ratio of extent of flooding.

Assessment points	Ratio
100	5 more
50	1 - 5

The results of the rating are as follows:

District	Zone	Point
Butterworth	1	50
	3	100
	4	50
Bukit Mertajam	3	100



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

FLOODING AREAS — FIGURE H-4

2.2.5 Housing and Industrial Development Programmes

Butterworth/Bukit Mertajam Metropolitan Area has been carring out a development programme for construction of housing and industries in the permeter built up area, to meet the needs of the rapidly expanding city.

The major development programmes are, zone 2 and 5 of Butterworth district located in the North Mukim of 14, 15 and 16 to the constructior of housing, zone 1, 2 and 4 of Seberang Jaya district located in the Central Mukim of 1 and 6 to the construction of housing and industries, zone 3 of Bukit Mertajam district located in the Central Mukim of 11 to the construction of housing, and zone 1 of Prai district located in the Central Mukim of 1 and 6 to the construction of industries. These numbers of Mukim located are referred in Fig. . Some of areas of these programmes have been filled up to develop the construction including housing and industries.

Figure H-5 shows the locations of these major projects. Other development projects scattered throughout the project area will be mostly located neighbouring existing built-up urban area, and represent relatively minor problems, hence they have not been considered for purpose of sewerage planning.

All the project described above are expected to be completed by the year 2000, and by being built progressively in stages should be able to provide sewerage services to keep pace with the growing population and industry.

For the rating, the sewerage zones for these development programme areas, as presented in table H-10, were given 50 points. Other zones, for which no specific development is planned, were given zero points.

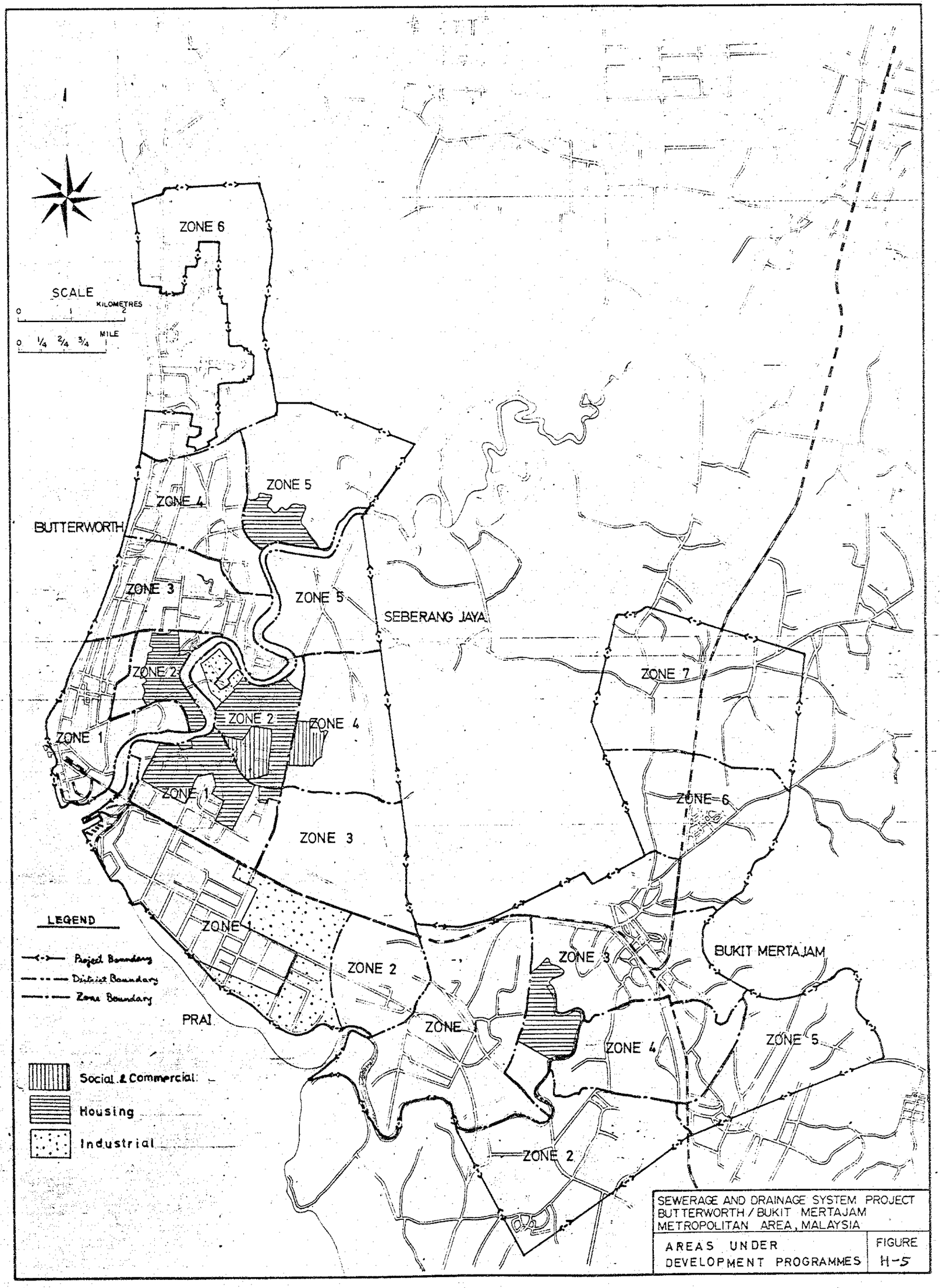
The result of the assessment is as follows:

District	Zone	Point
Butterworth	2	50
	5	50
Seberang Jaya	1	50
	2	50
	4	50
Prai	1	50
Bukit Mertajam	3	50

TABLE - II-10 Housing and Industrial Development Programmes by Sewerage Zone

District	Zone	Area (ha)	Development Area (ha)		(ha)
			Housing	Industrial	
Butterworth	2	182	120		
	5	551	74		
Seberang Jaya	1	438	170		
	2	305	207	21	
	4	430	30		
Prai	1	1,063		424	
Bukit Mertajam	3	927	100		

FIGURE H-5



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

AREAS UNDER DEVELOPMENT PROGRAMMES | FIGURE H-5

2.2.6 Availability of Water Supply

Since the water supply system in state of Penang has been operated by the Penang Water Authority (PWA) from the 1st January 1973.

The master plan of water supply for the state of Penang covering Project Area with Province Wellesley, prepared by Binnie & Partners, was programmed to be implemented by stages followed by the first, second and third stage projects.

The first stage was planned to construct the barrage, canal, pumping stations, pipelines to Penang Island, Butterworth and Prai which are covering project area, and 22,727 m^3 (5mg) reservoirs at Bukit Dumbar and Bukit Indira Mudu to be completed during the years from 1968 to 1977.

The second and third stages is planned to extend in predicting future water requirement up to the year 2000, and will be covered 100 percents to the served population area. Figure H-6 shows the existing water supply service area in Project Area, covering the main pipes of water supply.

On the basis of the reviewing of existing water supply and master plan, the entire area of sewerage zones, were evaluated to determine their ratio of water supply service area to the sewerage zone area at present, and the year 2000, as presented in Table H-11, and multiplied by the assigned points, 25 points for the sewerage zones where water supply system is available in 1976, 25 points for the sewerage zones to be provided by the year 2000. The result of rating is indicated in Table H-12.

TABLE - H-11 Water Service Areas by Sewerage zone

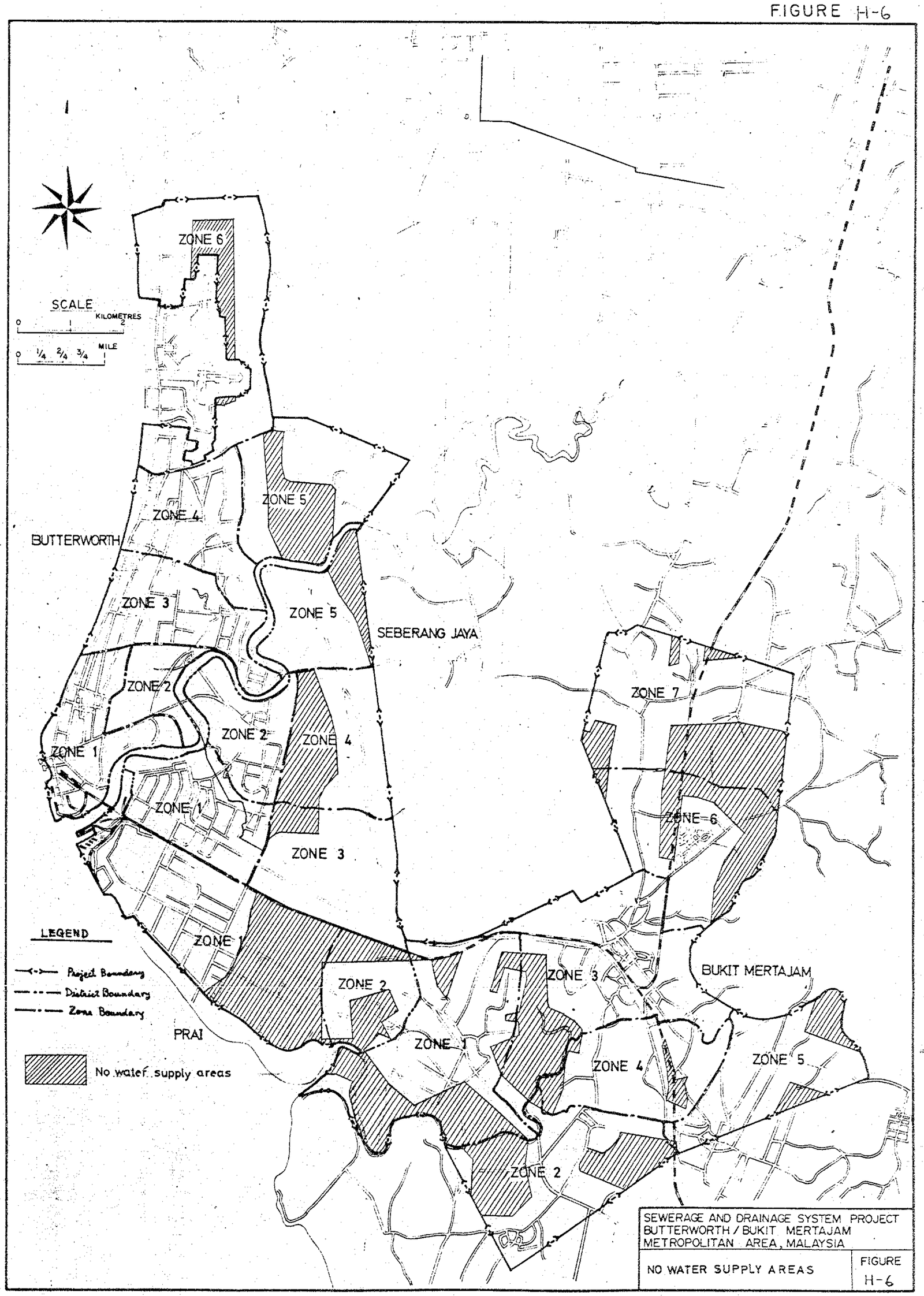
District	Zone	Area	Served Area at 1976 (%) *		at 2000 (%)
Butterworth	1	367	367	(100)	(100)
	2	182	182	(100)	(100)
	3	457	457	(100)	(100)
	4	444	444	(100)	(100)
	5	551	~~551~~ 375	(68)	(100)
	6	670	570	(85)	(100)
Seberang Jaya	1	438	~~438~~ 387	(87)	(100)
	2	305	305	(100)	(100)
	3	510	474	(93)	(100)
	4	430	254	(59)	(100)
	5	368	298	(81)	(100)
Prai	1	1063	617	(58)	(100)
	2	268	~~298~~ 161	(60)	(100)
Bukit Mertajam	1	892	580	(65)	(100)
	2	715	458	(64)	(100)
	3	927	751	(81)	(100)
	4	467	425	(91)	(100)
	5	459	399	(87)	(100)
	6	573	350	(61)	(100)
	7	768	507	(66)	(100)

* (The Numbers put in parentheses show the percentage of served water supply area.)

TABLE H-12. Results of Assessment Points for Availability of Water Supply

District	Zone	at 1976	2000	Total points
Butterworth	1	25	25	50
	2	25	25	50
	3	25	25	50
	4	25	25	50
	5	17	25	42
	6	21	25	46
Seberang Jaya	1	22	25	47
	2	25	25	50
	3	23	25	48
	4	15	25	40
	5	20	25	45
Prai	1	15	25	40
	2	15	25	40
Bukit Mertajam	1	16	25	41
	2	16	25	41
	3	20	25	45
	4	23	25	48
	5	21	25	46
	6	15	25	40
	7	17	25	42

FIGURE H-6



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

NO WATER SUPPLY AREAS | FIGURE H-6

2.2.7 Incidence of Water Borne Diseases

Water has always been a medium for the transmission of human microbial diseases, and are the bacterial caused disease of typhoid fever, paratyphoid fever, bacillary dysentery, and cholera, and non-bacterial diseases such as anoebic dysentery and infectious hepatitis.

Especially cholera is expressed as an excellent indicator of water borne contamination hazards in tropical countries. According the the data investigated by the Medical and Health Department of Penang, from the year 1970 through 1975, the yearly disease by water in the Province Wellesley covering the sewerage project area, was indicated as Table H-13.

For the purpose of rating, the number of diseaser on the year 1974 occurred was assigned for the whole Project Area, and then the number of diseases occurred in each sewerage zone was estimated by the ratio of served population to the total population of Project Area, as indicated in Table H-14.

For an assessment, 50 points were assigned to each of sewerage zones according to the level of incidence estimated as follow:

Assessment Point	Number of Incidence of Diseases
50	10 more
25	5 - 10
0	0 - 5

Then, the results of the assessment point for each of sewerage zones are indicated in Table H-15.

TABLE - H-13 Numbers of Patient of Water Borne Disease

Disease	1970	1971	1972	1973	1974	1975
Cholera	62	-	7	-	10	-
Dysentery	1	6	11	35	19	11
Infectious Hapatitis	-	-	-	67	49	53
Leptospiral Infectious	-	-	-	1	-	-
Typhoid fever	3	18	51	58	11	13
Total	66	24	69	161	89	77

Data obtained from Medical and Health Department of Penang.

TABLE - H-14 Distribution of Water Borne Disease in 1974 by Sewerage Zone

District	Zone	Population at 1976	ratio of population (a) (%)	Incidence of disease presumed (persons) (a) x 89
Butterworth	1	37,920	16	14
	2	3,585	1	1
	3	28,255	12	10
	4	26,332	11	10
	5	3,961	2	2
	6	8,902	4	3
Seberang Jaya	1	13,657	6	5
	2	69	0	0
	3	2,991	1	1
	4	7,518	3	3
	5	4,369	2	2
Prai	1	1,860	1	1
	2	1,974	1	1
Bukit Mertajam	1	7,559	3	3
	2	6,387	3	3
	3	45,540	19	17
	4	6,077	2	2
	5	7,257	3	3
	6	13,840	6	5
	7	9,947	4	3
Total		238,000	100	89

TABLE - H-15 Results of Assessment Points for Incidence of Water Borne Disease

District	Zone	Assessment Points
Butterworth	1	50
	2	0
	3	50
	4	50
	5	0
	6	0
Seberang Jaya	1	25
	2	0
	3	0
	4	0
	5	0
Prai	1	0
	2	0
Bukit Mertajam	1	0
	2	0
	3	50
	4	0
	5	0
	6	25
	7	0

CHAPTER 3

EVALUATION AND SUMMARY OF RATING SYSTEM

The study on rating the seven elements in determining construction stages of sewerage systems of Butterworth/Bukit Mettajam Metropolitan Area is summarized in Table H-16, with the following findings and conclusion.

(a) The densely populated areas exist in the Project Area and undoubtedly increase by the year 2000. As such area will have greater in pact of the environmental sanitation and populetion in the areas will be the beneficiaries of the satisfactory sewerage system, higher rating is justified.

(b) Sewerage zones which make the heaviest contributions to the waste load production are surrounded by the area of industrial estate and combination of residential and industrial area. It is found that zone 1 of Prai district most heavily produces the waste load, and, accordingly, the assessment points is higher than other zones of districts. Even the high points are assessed for this sewerage zone, the priority will be lower due to the fact that this is industrial area and has no served population. In our opinion, industrial waste control should have special consideration for itself instead of relying on the municipal sewerage system.

(c) In view of lack of exact data on existing excreta disposal systems, an assessment of urban and rural area has been given arbitrarily 100 and 50 points in proportion to the population who have no served excreta disposal system in each of sewerage zones.

High ratings are given to each of the sewerage districts where the existing excreta disposal system is not functioning well or does not exist. The rating reflects the actual sanitary conditions in the project area.

(d) With respect to flooding, the rating is considered according to the extent of flood in connection with drainage facilities. Inclusion of flooding in the evaluation appears to be appropriate in that areas without adequate facilities for storm drainage usually have much more urgent need for sanitary facilities.

(e) Other factors considered in the rating namely, housing and industrial development programmes and availability of water supply are given fewer assessment points than other factors because they are deemed less meaningful in determining the priority of sewerage system construction.

(f) The results of the rating on incidence of water borne disease indicates that the congested and high population density zones get higher assessment points. Generally speaking, rate of incidence of such diseases are low in the Project Area.

The results of the rating indicate that the zone 1 of Butterworth District has the highest total number of points, representing the combined ratings for all seven elements, followed by the zone 3 of Butterworth and zone 3 of Bukit Mertajam Districts as listed below.

Priority of Construction	District	Zone	Assigned Points
1	Butterworth	1	815
2	"	3	650
3	Bukit Mertajam	3	560
4	Butterworth	4	540
5	Seberang Jaya	1	437
6	Butterworth	2	365
7	Seberang Jaya	2	340
8	Prai	1	315
9	Butterworth	5	232
10	Bukit Mertajam	6	205
11	Seberang Jaya	3	188
11	Bukit Mertajam	4	188
13	Butterworth	6	186
13	Bukit Mertajam	5	186
15	Seberang Jaya	5	185
16	Bukit Mertajam	7	182
17	"	1	181
17	"	2	181
19	Seberang Jaya	4	180
19	Prai	2	180

It is concluded that the rating system adopted in this study, while arbitrary in many respects, nevertheless resonably reflects and quantities both present and future conditions of the project area with respect to need for sanitary sewerage. The results are considered as a good indication of the overall needs of the various zones and should be taken into consideration in determining the staging of the sewerage construction programme.

TABLE - H-16 Results of Rating for Overall Aspects

District	Zone	Population Density	Waste Load Population Aspects	Excreta Disposal System	Flooding	Housing & Industrial Develop. Prog.	Availability of Water Supply	Incidence of Water-Borne Diseases	Total
Butterworth	1	400	165	100	50	0	50	50	815
	2	200	65	0	0	50	50	0	365
	3	250	150	50	100	0	50	50	650
	4	250	90	50	50	0	50	50	540
	5	100	40	0	0	50	42	0	232
	6	100	40	0	0	0	46	0	186
Seberang Jaya	1	250	65	0	0	50	47	25	437
	2	150	90	0	0	50	50	0	340
	3	100	40	0	0	0	48	0	188
	4	50	40	0	0	50	40	0	180
	5	100	40	0	0	0	45	0	185
Prai	1	0	225	0	0	50	40	0	315
	2	100	40	0	0	0	40	0	180
Bukit Mertajam	1	100	40	0	0	0	41	0	181
	2	100	40	0	0	0	41	0	181
	3	200	65	50	100	50	45	50	560
	4	100	40	0	0	0	48	0	188
	5	100	40	0	0	0	46	0	186
	6	100	40	0	0	0	40	25	205
	7	100	40	0	0	0	42	0	182

APPENDIX I

WATER SUPPLY SYSTEM

Table of Contents

CHAPTER 1

EXISTING WATER SUPPLY SYSTEM

1.1 Water Agency

The water supply system of the State of Penang is operated by the Penang Water Authority (PWA).

The Penang Water Authority was established on the 1st of January 1973 in accordance with the Penang Water Authority Enactment, 1972.

On the date of commencement the former City Water Department of the City Council of George Town and the former Water Supply Section of the State Public Works Department were analgamated into one Authority to supply a potable water supply to the State of Penang.

1.2 Water Service Area, Water Production, and Use

The existing supplies in Province Wellesley is administratively divided into three zones - NORTH, CENTRAL, SOUTH.

The Data of the water service area, the water service population and the quantity of water supplied are shown in Table I-1 - I-2. Monthly analysis of water consumption in Province Wellesley is shown in Table I-3.

TABLE I-1 Distribution Data in Province Wellesley

Item	1969	1970	1971	1972	1973	1974	1975	
Area Served (ha)	27,213	27,516	27,658	27,956	28,184	28,434		
Population Served	232,470	238,170	244,010	249,990	263,180	273,470		
Water Supplied (cu m/day)	41,958	46,393	58,474	61,118	68,698	83,218		
Water Sold (cu m/day)	37,555	36,485	40,634	43,379	49,991	62,927	64,490	
% Unaccounted-for	10.5	21.4	30.5	29.0	27.2	14.1		
Consumption (l/cap/day)	162	153	167	174	190	230		

Data Source: PWA

TABLE I-2 Distribution Data by Water Supply Zone in Province Wellesley

	Item	1969	1970	1971	1972	1973	1974
NORTH	Area Served (ha)	12,290	12,380	12,414	12,473	12,590	12,717
	Population Served	125,510	128,590	131,740	134,970	141,200	145,880
	Water Supplied (cu m/day)	32,950	36,816	48,685	52,234	58,163	64,125
	Water Sold (cu m/day)	24,025	23,333	26,406	27,374	31,383	44,020
CENTRAL	Area Served (ha)	8,109	8,311	8,412	8,599	8,684	8,752
	Population Served	69,120	70,810	72,550	74,330	78,850	83,380
	Water Supplied (cu m/day)	4,112	4,855	4,350	4,441	4,443	4,615
	Water Sold (cu m/day)	8,767	8,837	9,423	10,624	12,435	12,078
SOUTH	Area Served (ha)	6,814	6,825	6,832	6,884	6,910	6,965
	Population Served	37,840	38,770	39,720	40,630	43,130	44,210
	Water Supplied (cu m/day)	4,896	4,722	5,440	4,443	6,092	4,478
	Water Sold (cu m/day)	4,763	4,315	4,805	5,381	6,173	6,829

Data Source: PWA

TABLE I-3 Monthly Analyses of Water Consumption in Province Wellesley

Unit: 1,000 cu m per month

	1974			1975			1976		
	Domestic	Trade	Total	Domestic	Trade	Total	Domestic	Trade	Total
n.				1,190	591	1,781	1,333	920	2,253
b.				1,186	663	1,849	1,293	799	2,092
r.				1,124	615	1,739	1,224	768	1,992
r.				1,219	732	1,951	1,313	838	2,151
y				1,287	763	2,050	1,292	814	2,106
n.	1,165	479	1,644	1,206	750	1,956	1,266	841	2,107
l.	1,115	523	1,638	1,200	787	1,987	1,274	904	2,178
g.	1,136	504	1,640	1,256	883	2,139	1,289	925	2,214
pt.	1,130	535	1,665	1,240	849	2,089	1,328	967	2,295
t.	1,122	572	1,694	1,292	874	2,166			
v.	1,108	610	1,718	1,138	865	2,003			
c.	1,097	610	1,707	1,149	844	1,993			
tal	7,873	3,833	11,706	14,487	9,216	23,703	11,612	7,776	19,388
	67.3	32.7	100.0	61.1	38.9	100.0	59.9	40.1	100.0

Data Source: PWA

1.3 Outline of the Existing Water Supply Facilities

The existing supplies in Province Wellesley is divided three zones - North, Central, South.

The north zone supplies rural areas in the north of Province Wellesley and the town of Butterworth. Water is derived from a lowland catchment area of about 12,950 hectare (32,000 acres) above an intake on the Sungai Kulim and flows along a channel to the Bukit Toh Allang treatment plant. The works and the existing mains to Butterworth and Bukit Mertajam have a capacity of 40,914 cu m/day (9 m.g.d.), but when the new scheme is brought into operation the presure at Butterworth will be raised. The mains will then only have sufficient capacity to supply peak demand corresponding to a yield of 30,913 cu m/day (6.8 m.g.d.). The excess output will be available for supply to Lunas and Kulim in State of Kedah.

The central zone supplies the town of Bukit Mertajam and Prai. The water is obtained from three small streams on the slope of Bukit Mertajam hill with a combined catchment area of about 243 hectare (600 acres). There is a storage reservior on each stream, their combined capacity being 218,210 cu m (48 m.g.) and reliable yield 4,546 cu m/day (1.0 m.g.d.). The sources can not be expanded and the water requirements for the zone are being supplemented from an 457 mm (18 in.) diameter pipeline from the Bukit Toh Allang treatment works in the north zone.

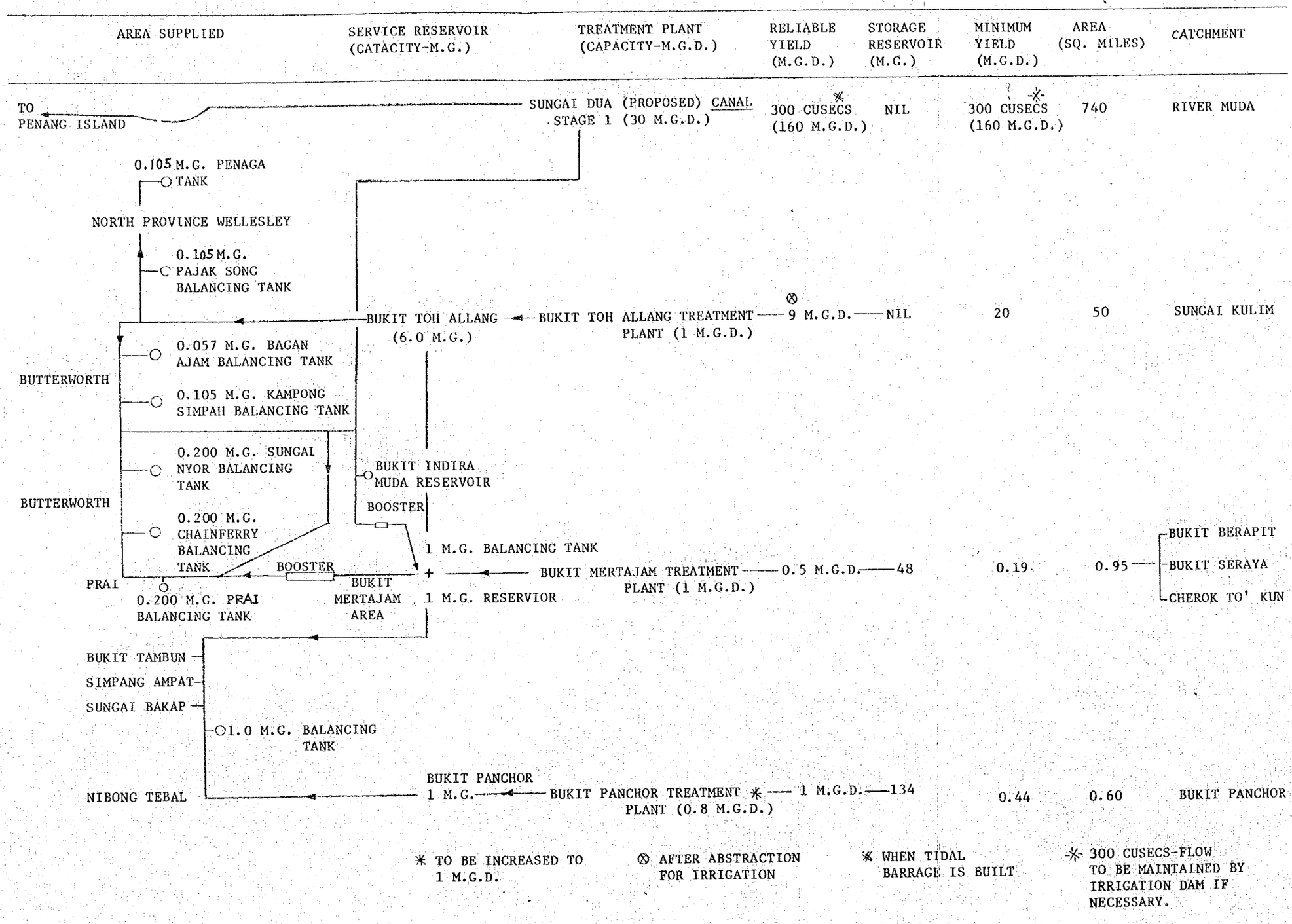
In the south zone the principal areas supplied are Nibong Tebal and Sungai Bakap. Water is obtained from a 609,164 cu m (134 m.g.) capacity impounding reservoir and is treated in the 3,637 cu m (0.8 m.g.d.) treatment works at Bukit Panchor. The reliable yield of the reservoir is estimated to be 4,546 cu m/d (1.0 m.g.d.) and there aye plants to modify the filters to increase the output of the works to this amount. In the meanwhile the supply is being supplemented by drawing water from the Bukit Toh Allang treatment works through Bukit Mertajam.

The Muda River Waterworks Project was completed partially and enabled extra water to be distributed into the Water Supply System through improvised measures at the work site and the State.

The Muda River is the largest single source of water in the State and flows into the sea about 12 miles north of Butterworth. The river flows into the State from Kedah and its northern bank forms the State boundary.

The outline of the existing water supply facilities described above are illustrated in Figure I-1.

FIGURE I-1 Existing and Proposed Water Supply System in Province Wellesley



✳ TO BE INCREASED TO 1 M.G.D.

⊗ AFTER ABSTRACTION FOR IRRIGATION

✳ WHEN TIDAL BARRAGE IS BUILT

-✳- 300 CUSECS-FLOW TO BE MAINTAINED BY IRRIGATION DAM IF NECESSARY.

CHAPTER 2

WATER SUPPLY PROJECT FOR THE PROJECT AREA

2.1 Outline Water Supply Projection

The report "Penang State Water Supply", prepared by Binnie & Partners (MALAYSIA), and submitted to the Government of Penang in September 1967, presents a long-term projection for water supply system of the State of Penang up to the year 2000. However, PWA reviews the water demand curves for Province Wellesley and compares present figures and projections with the curves derived in Volume 1 Appendix 3 of Binnie's Report of 1967 in 1976.

The existing and proposed water supply system in Province Wellesley is shown in Figure I-1.

2.2 Water Requirements

In Province Wellesley the PWA operates installations with a combined yield of 50,000 cu m/day (11 m.g.d). Existing mains will be able to distribute 40,000 cu m/day (8.8 m.g.d) in the State leaving 10,000 cu m/day (2.2 m.g.d) available for distribution to towns in Kedah if required. It is estimated that demand, including the requirements of industry, will have increased to 305,000 cu m/day (67.1 m.g.d) in maximum by the year 2000 leaving a deficit of 264,000 cu m/day (58.1 m.g.d).

Therefore, the River Muda Water Works should be capable of development in Province Wellesley to yield 264,000 cu m/day (58.1 m.g.d) to meet the maximum predicted demand.

The further details of future water requirements on referred in paragraph 2-1 is shown in Table I-4.

TABLE I-4 Water Requirements in Province Wellesley

		Popula-tion -urban	Demand (l/c/d)	Quantity (cu m/d)	Popula-tion -rural	Demand (l/c/d)	Quantity (cu m/d)	Total Domestic Demand (cu m/d)	Rate (l/c/d)	Q'ty (cu m/d)	Total Quantity (cu m/d)	Maximum Quantity (cu m/d)	Existing Quantity (cu m/d)	River Muda Quantity (cu m/d)
Upper growth limit	1965	96,300	182	17,700	202,200	91	13,200	30,900	14	1,400	32,300	35,500	40,000	-
	1975	151,000	200	30,000	258,900	100	25,900	(51,800) 55,900	23	(30,000) 3,600	(81,800) 59,500	(96,800) 65,000	40,000	(56,700) 25,000
	1980	189,100	209	39,500	292,900	105	30,500	(65,900) 70,000	27	(45,500) 5,000	(111,400) 75,000	(122,700) 81,800	40,000	(82,700) 41,800
	1990	296,400	223	65,900	374,900	114	42,700	(103,200) 108,500	41	(80,000) 12,300	(183,200) 120,800	(201,400) 131,800	40,000	(161,400) 91,800
	2000	464,800	227	105,500	479,800	123	54,500	(150,900) 160,000	45	(126,400) 20,900	(277,300) 180,900	(305,000) 196,800	40,000	(265,000) 156,800
Lower growth limit	1965	88,400	182	15,900	194,600	91	12,300	28,200	14	1,400	29,600			
	1975	124,800	200	25,000	237,200	100	23,600	48,600	18	2,300	50,900			
	1980	148,200	209	30,900	261,900	105	27,300	58,200	20	3,200	61,400			
	1990	209,000	223	46,400	319,200	114	36,400	82,800	25	5,000	87,800			
	2000	294,800	227	66,800	389,100	123	47,700	114,500	27	8,200	122,700			

Note: Maximum quantity includs 10% addition to average domestic consumption
( ) is the figure reviewed by P.W.A in 1976.

Data Source: "Penang State Water Supply" by Binnie & Partners of 1967 and P.W.A study of 1976.

2.3 Results of Water Analyses

Results of water analyses at the D.I.D canal near Sungai Dua and the River Muda are shown in Table I-5 - I-9.

TABLE I-5 Results of Water Analyses

Location: DID Canal near Sungai Dua

Sample taken on: Month (1967)	June	July		August		
Day	25	2	7	4	23	29
Time	–	–	–	1415	1525	1600
CHEMICAL ANALYSIS (mg/l)						
Salinity	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15
Chlorides as Cl.	7	9	9	12	3	4
Total solids dried at 105° - 110°C	100	135	355	165	75	115
B.O.D. (5 days)	2.0	2.0	3.0	3.0	1.0	5.0
Oxygen absorbed from $KMnO_4$, 4 hrs., 27° - 30°C.	5.05	5.5	6.55	7.7	2.75	3.2
Ammoniacal Nitrogen	0.27	0.05	0.02	0.13	0.09	0.21
Albuminoid Nitrogen	0.10	0.13	0.33	0.23	0.12	0.12
Oxidised Nitrogen	< 0.05	0.10	0.05	Nil	Nil	< 0.05
Nitrite Nitrogen	< 0.001	Nil	< 0.001	< 0.001	Nil	< 0.001
Iron expressed as Fe	0.35	0.75	0.90	1.30	0.75	0.75
Sulphate as SO_4	1.0	< 1.0	2.0	7.0	< 1.0	2.0
Manganese as Mn	–	–	–	0.03	0.02	0.02
Arsenic as As	–	–	–	< 0.005	< 0.005	< 0.005
PHYSICAL EXAMINATION						
Turbidity	T	STS	ST	ST	ST	STS
Odour	Nil	Nil	Nil	Nil	Nil	Nil
Colour (Hazen) on filtered sample	> 70	50	> 70	> 70	30	20
pH	7.2	7.1	7.8	7.4	6.6	7.6

Data Source: "Penang State Water Supply Development Plan" by Binnie & Partners

T = Turbid

ST = Slightly turbid

STS = Slightly turbid with sediment

VTS = Very turbid with sediment

TABLE I-6 Results of Water Snalyses

Location: DID Canal at the junction between the main canal and the branch leading to Sungai Dua

Sample taken on: Month (1967) Day Time	June 25 –	July 2 –	July 7 –	August 4 1400	August 23 1550	August 29 1620
CHEMICAL ANALYSIS (mg/l)						
Salinity	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
Chlorides as Cl.	5	7	9	3	3	7
Total solids dried at 105° - 110°C	140	100	460	80	85	630
B.O.D. (5 days)	1.0	2.0	3.0	<1.0	<1.0	3.0
Oxygen absorbed from $KMnO_4$, 4 hrs., 27° - 30°C.	2.85	4.45	7.0	2.1	2.35	12.1
Ammoniacal Nitrogen	0.17	0.07	0.99	0.14	0.04	0.30
Albuminoid Nitrogen	0.06	0.09	0.84	0.07	0.08	1.25
Oxidised Nitrogen	0.10	0.10	1.05	<0.05	0.10	<0.05
Nitrite Nitrogen	<0.001	Nil	2.40	0.001	<0.001	<0.001
Iron expressed as Fe	0.30	0.65	1.10	0.75	0.90	0.90
Sulphate as SO_4	1.0	<1.0	2.0	1.0	<1.0	5.0
Manganese as Mn	–	–	–	0.02	<0.01	0.10
Arsenic as As	–	–	–	<0.005	<0.005	0.01
PHYSICAL EXAMINATION						
Turbidity	T	STS	VTS	STS	ST	VT
Odour	Nil	Nil	Nil	Nil	Nil	Nil
Colour (Hazen) on filtered sample	>70	40	>70	20	30	>70
pH	7.3	7.1	7.6	7.5	7.0	7.3

Date Source: "Penang State Water Supply Development Plan" by Binnie & Partners

T = Turbid

ST = Slightly turbid

STS = Slightly turbid with sediment

VTS = Very turbid with sediment

TABLE I-7 Results of Water Analyses

Location: The Muda River at Merdeka Bridge at low tide.

Sample taken on: Month (1965) Day Time	Jan 9 1115	Feb 20 1010	Mar 20 0843	Apr 17 0741	May 15 0638	June 12 1833	July 17 0833	Aug 14 0750
CHEMICAL ANALYSIS (mg/l)	Nil	Is	Is	Is	Is	Is	Is	Is
Salinity	Nil	Is	Is	Is	Is	Is	Is	Is
Chlorides as Cl.	6	7	5	5	6	4	4	5
Total solids, dried at 100°C	60	100	115	140	85	75	70	80
Oxygen absorbed from $KMnO_4$, 4 hrs., 27° - 30°C	1.10	1.50	1.40	3.70	2.70	1.60	1.85	2.90
Ammoniacal Nitrogen	0.02	0.02	0.07	0.02	0.03	0.02	0.05	0.08
Albuminoid Nitrogen	Tr	0.08	0.03	0.06	0.04	0.04	0.02	0.04
Oxidised Nitrogen	0.10	0.15	0.15	0.15	0.15	0.10	0.15	0.10
Iron as Fe	0.60	1.30	1.20	1.30	0.70	0.70	0.85	1.20
Sulphate as SO_4	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Nitrites	Tr	0.01	Tr	0.01	Tr	Tr	Tr	Tr
Manganese as Mn	Is	Tr	Nil	0.10	0.07	0.05	0.04	Tr
Arsenic as As	0.01	Tr	Tr	Tr	Tr	Tr	Tr	Tr
PHYSICAL EXAMINATION								
Turbidity	TS	TS	SCS	SCS	SCS	SCS	SCS	SCS
Odour	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Colour (Hazen)	15	25	15	>70	>70	65	30	35
pH	7.4	8.4	7.5	7.0	6.9	7.4	7.3	7.1

Data Source: "Penang State Water Supply Development Plan" by Binnie & Partners

Tr = Trace

Is = Insignificant

TS = Turbid with sediment

SCS = Straw coloured with sediment

TABEL I-8 Results of Water Analyses

Location: The Muda River at Merdeka Bridge at hight tide.

Sample taken on: Month (1965) Day Time	Jan 9 1956	Feb 20 1605	Mar 20 1434	Apr 17 1332	May 15 1232	June 12 1136	July 17 1433	Aug 14 1344
CHEMICAL analysis (mg/l)								
Salinity	Nil	Is	Is	Is	Is	Is	Is	Is
Chlorides as Cl	9	7	14	5	5	5	5	5
Total solids, dried at 100°C	50	115	125	110	85	80	60	90
Oxygen absorbed from $KMnO_4$, 4 hrs., 27° - 30°C	1.20	1.95	1.25	3.45	2.60	1.65	1.85	2.90
Ammoniacal Nitrogen	0.03	0.03	0.03	0.17	0.03	0.05	0.02	0.04
Albuminoid Nitrogen	0.02	0.10	0.15	0.08	0.07	0.03	0.03	0.03
Oxidised Nitrogen	Tr	0.10	0.15	0.05	0.10	0.15	0.10	0.10
Iron as Fe	0.90	1.50	1.10	1.50	0.70	0.80	0.90	0.65
Sulphate as SO_4	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Nitrites	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Manganese as Mn	Is	Tr	Tr	0.10	Tr	0.06	0.04	Tr
Arsenic as As	0.01	Tr	Tr	Tr	0.02	Tr	Tr	Tr
PHYSICAL EXAMINATION								
Turbidity	TS	TS	SCS	SCS	SCS	SCS	SCS	SCS
Odour	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Colour (Hazen)	20	25	25	>70	>70	65	30	35
pH	7.3	7.4	7.7	6.8	6.9	7.3	7.3	6.8

Data Source: "Penang State Water Supply Development Plan" by Binnie & Partners

Tr = Trace

Is = Insignificant

TS = Turbid with sediment

SCS = Straw coloured with sediment

TABLE I-9 Results of Water Analyses

Location: The Muda River at Penang Tunggal, 7 1/4 upstream of Merdeka Bridge at low tide.

Sample taken on: Month (195) Day Time	Jan 9 1050	Feb 20 0950	Mar 20 0903	Apr 17 0805	May 15 0700	June 12 0705	July 17 0900	Aug 14 0815
CHEMICAL ANALYSES (mg/l)								
Salinity	Nil	Is	Is	Is	Is	Is	Ia	Is
Chlorides as Cl	6	6	5	6	5	4	4	5
Total solids, dried at 100°C	60	55	75	105	110	75	90	95
Oxygen absorbed from $KMnO_4$, 4 hrs., 27° - 30°C	1.00	1.10	1.35	3.65	3.05	1.70	2.00	2.85
Ammoniacal Nitrogen	0.07	0.02	0.03	0.04	0.03	0.02	0.11	0.03
Albuminoid Nitrogen	0.03	0.06	0.03	0.03	0.05	0.03	0.07	0.05
Oxidised Nitrogen	Tr	0.10	0.15	0.15	0.15	0.10	0.20	0.10
Iron as Fe	1.50	0.65	0.85	1.60	0.90	0.90	1.30	0.50
Sulphate as SO_4	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Nitrites	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Manganese as Mn	Is	Tr	Tr	0,10	0.05	0.04	Tr	Tr
Arsenic as As	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
PHYSICAL EXAMINATION								
Turbidity	TS	TS	TS	SCS	SCS	SCS	SCS	SCS
Odour	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Colour (Hazen)	25	20	25	> 70	> 70	70	35	40
pH	7.5	7.3	7.7	6.9	7.1	7.4	7.4	6.5

Data Source: "Penang State Water Supply Development Plan" by Binnie & Partners

Tr = Trace

Is = Insignificant

TS = Turbid with sediment

SCS = Straw coloured with sediment

TABLE I-10 Results of Water Analyses

Location: The Muda River at Penang Tunggal, 7 1/4 upstream of Merdeka Bridge at high tide.

Sample taken on: Month (1965) Day Time	Jan 9 1725	Feb 20 1545	Mar 20 1500	Apr 17 1405	May 15 1300	June 12 1205	July 17 1500	Aug 14 1410
CHEMICAL ANALYSIS (mg/l)								
Salinity	Nil	Is	Is	Is	Is	Is	Is	Is
Chlorides as Cl	6	7	5	4	5	4	5	5
Total solids, dried at 100°C	60	65	80	120	85	65	70	115
Oxygen absorbed from $KMnO_4$, 4 hrs., 27° - 30°C	1.00	1.35	1.20	3.65	2.65	1.70	1.90	2.85
Ammoniacal Nitrogen	0.07	0.16	0.08	0.04	0.06	0.02	0.12	0.06
Albuminoid Nitrogen	0.03	0.07	0.04	0.08	0.07	0.04	0.06	0.05
Oxidised Nitrogen	Tr	0.15	0.10	0.15	0.15	0.15	0.10	0.10
Iron as Fe	1.50	0.85	0.65	1.50	1.20	0.80	1.30	1.30
Sulphate as SO_4	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Nitrites	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
Manganese as Mn	Is	0.10	Nil	0.10	0.02	0.04	Tr	Tr
Arsenic as As	Tr	Tr	Tr	Tr	Tr	Tr	Tr	Tr
PHYSICAL EXAMINATION								
Turbidity	TS	TS	TS	SCS	SCS	SCS	SCS	SCS
Odour	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Colour (Hazen)	25	25	25	> 70	> 70	55	35	45
pH	7.5	7.6	7.6	6.7	7.2	7.4	7.4	6.8

Data Source: "Penang State Water Supply Development Plan" by Binnie & Partners

Tr = Trace

Is = Insignificant

TS = Turbid with sediment

SCS = Straw coloured with sediment

APPENDIX J

ALTERNATIVE ORGANIZATIONS

Appendix J

Alternative Organizations

In conjunction with the implementation of sewerage and drainage systems programmed in Master Plan. The organization well conceived to achieve required objectives and functions is prerequisite. Three alternatives are considered taking into account the site-bound nature and presented as follows with conceivable advantages and disadvantages.

1. Creation of new regional organization as Penang Sewerage Authority

As mentioned in previous chapter there are twin local government council under State of Penang Authority, i.e., Municipal Council, Penang Island and Municipal Council, Province Wellesley.

While no midern sewerage systems exist in Province Wellesley, the more developed sewage disposal systems exist in urban area of Penang Island with corresponding organization responsible for operation of these systems in the Council of Penang Island.

This alternative is considered based on the concept to create a new organization amalgamating already developed organization responsible for existing sewerage works in Penang Island and recruiting available sanitary engineers in charge of sanitary systems operation and management.

The entire status of this new organization is to be similar to Penang Water Authority, the fully autonomous statutory body authorized by Federal Constitution.

This organization would promote uniformed technical standards and administrative controls on sewerage systems through the combined area of Penang Island and Province Wellesley.

The strong capability and centralized enforcement for overall performance and direct control will be enhanced by this empowered authority as opposed to two signle organizations to be provided separately in two municipal councils.

The possible disadvantage of this approach is, however, that it may require tremendous initial efforts as lengthy political debate and legislative review before the creation of new organization. Secondaly many controvercial cumbersome matters have to be settled as taking over the control of various authorities for sewerage works vested in each existing municipal councils.

On the other hand, the existing department responsible for sewerage works in Municipal Council, Penang Island is not fully financially self-supporting, not to mention that of Province Wellesley, as they incorporate other civil works and operating expenses are provided from council's fund.

This poses an additional problem as it is foreseen that difficulties will be faced in the recruitment of qualified personnel experienced in managing sewerage works on financially viable base.

2. Combined Penang Water Supply and Sewerage Authority

This alternative is the expansion of the function of existing Penang Water Authority to include the sewerage functions. The development of the sewerage system will need to be coordinated with the growth of infrastructure, particularly water for residential and commercial use and demand for sewerage service is closely related to the consumption of water as sewerage facilities carry away used water, thus completing the cycle created by the processing of water resources and returning to the nature.

The project areas in this Master Plan is the urban areas of Butterworth and Bukit/Mertajam receiving water supply services from Penang Water Authority (PWA).

PWA has been demonstrating its capabilities in the operation and maintenance of a major utility systems and financial management for its debt obligations for both local and foreign currency loans since its formation on 1st, January 1977.

A practice generally followed as an equitable method to generate the revenue for sound operation of sewerage works is to impose a sewer charge based on the quantity of water used.

By combining water supply and sewerage works into an unified organization, sewer charge can be collected utilizing a single meter reading with combination of water supply billing procedure. The delinquent users of sewerage service can be easily penalized by cutting off the water supply.

The additional advantage is that existing engineering and administrative key personnel in the established functional units are utilized to avoid the problem to recruite the experienced and qualified engineering and administrative man-power which are generally shorted.

In contrast to the overwhelming advantages as mentioned above, there exist significant disadvantages in this approach. One of the most important disadvantage is the difficulties in political and jurisdictional arrangements required to form a combined organization as similar to the disadvantage enumerated in the first alternative.

The combined authority will face the necessity to generate the revenue in addition to surcharge on water consumption, and operation cost for sewerage and drainages works by imposing the levy on properties vested in Municipal Council of Province Wellesley.

3. Expansion and Modification of existing Engineering Department, Province Wellesley

The all sanitary systems in the Project Area except for sewerage systems which are to be constructed and the proposed Master Plan are under the control of Municipal Council, P.W. in accordance with Municipal Ordinance enacted as chapter 133 of the Straits Settlements in 1913 with its subsequent amendments.

This ordinance empowers the Municipal Council to construct and maintain the sewerage and sewage disposal systems as well as all other sanitary systems within the council's boundary.

The Ordinance also granted the power to the Council to raise the revenue for the sewerage works by levying the annual rate and other charges for sewage removal.

Under this ordinance the Municipal Council would be able to undertake the sewerage and drainage development programme expanding the existing func-

tions suited to meet planned sewerage systems without drastic jurisdisctional reformation as required in the first and second alternatives.

Further the administrative authority of this has recently been unified and enhanced as indicated by the amalgamation of previous three district councils into one local council "Lembaga" and subsequent status promotion to Municipal Council from Local Council in December, 1976.

The further expansion and development of administrative authority is expected in accordance with urban and industrial development encouraged in line with the national policy.

The major disadvantage is a difficulty pertinent to the creation of new functional units required for viable management of proposed sewerage and drainage systems. The shortage of qualified and experienced personnel will impose a restraint for early implementation of unexperienced new public utility services especially in case the self-sufficiency is required in operation of the services.