CHAPTER 4

DESIGN CONSIDERATION

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4.1. Sewerage Districts, Zones and Sub-zones

4.1.1. General Description

The physical characteristics of the Project Area are: (1) Flat and low-lying, except for a small portion of hilly areas in Kelang North and Kelang South, (2) limited areas of dense population and (3) large rural areas as yet to be developed. These will be important factors to be considered in developing a sewerage system to cover the entire area under a Master Plan.

It is obvious that the alternatives to be considered for system development would either be: (a) a single comprehensive sewerage system for the whole Area or (b) decentralized system properly identified according to the topographical condition and local needs of each of the areas concerned. As mentioned in the previous Chapter 2, the previous study prepared by the consulting firm, Procter and Redfern International Ltd., 1968, recommends a single comprehensive system, which will inevitably require large-size deep main of considerable length and siginificant number of pumping stations to convey sewage to the disposal point. High initial investment will thus be required and operation and maintenance will pause problems. Since substantial land development and significant population increase are evident in the future in the Area, difficulties of future modification of the facilities according to the requirement should also be taken into account. Disposal to sea without treatment as proposed is not advisable due to the words and spirit of the Regulations embodied in Environmental Quality Act, 1974, which encourages proper treatment even in case of off-shore disposal. Consequently, such an alternative is not preferable for Master Plan consideration.

Taking into account the above-mentioned observation, it is considered practical that, by adopting decentralised system, the Project Area be properly divided into districts, zones and sub-zones to be dealt with separately. The advantages of such a decentralized, sub-divided sewerage system are:

a) It will be possible to design sewerage facilities according to the characteristics of each zone or sub-zone.
b) Implementation of construction plan will be flexible for adjustment according to the future development requirement together with the availability of financial resources.
c) Plan for rural areas, in which urbanization plan is yet to be developed, will remain flexible for future consideration.

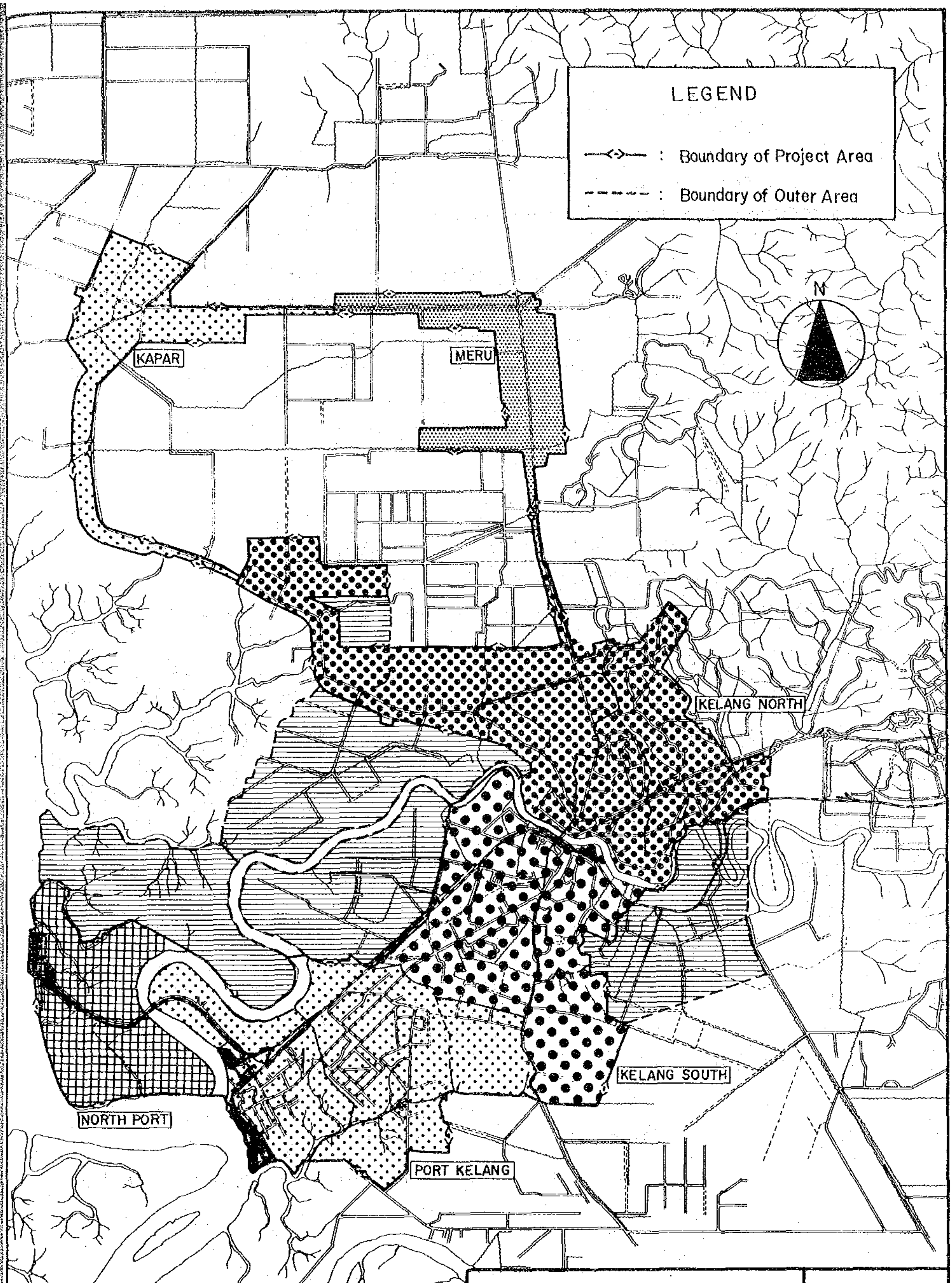
The procedure, methodology and resulting identification of the district, zone and sub-zone division are as follows:

1) Districts

For convenience of planning, the Project Area is initially divided into districts, mainly based on geographical conditions. (Ref. Fig. 4.1.) The Kelang River which runs through the Project Area from east to west, forms a natural district boundary. In south of the Kelang River, two urban centers are located at the eastern and western ends of the Area; namely, Kelang South and Port Kelang. These two urban centers are connected by the federal highway and their boundary is not necessarily clear. However, it is considered reasonable to divide this part of the Area into two districts from the planning viewpoint.

The area north of the Kelang River is divided into four districts. These are Kelang North district, the two small towns of Kapar and Meru, and North Port district at the western end of the Project Area.

Consequently, six sewerage districts are planned in the Project Area: (1) Kelang North, (2) Kelang South, (3) Port Kelang, (4) North Port, (5) Kapar and (6) Meru.



Sewerage Districts

Fig. 4.1.

2) <u>Zones</u>

The districts will be further divided into zones for the purpose of planning sewerage facilities. (Ref. Fig. 4.2.)

The basic approach for zoning is to collect sewage within each zone and to convey it to its own treatment plant. Identification of zones is based on topographic condition including existence of federal highway, railways, rivers, drains and others which will cause difficulty for pipe laying work. Availability of adequate land for wastewater treatment plant within the zone boundary is also important to identify sewerage zones.

3) <u>Sub-zones</u>

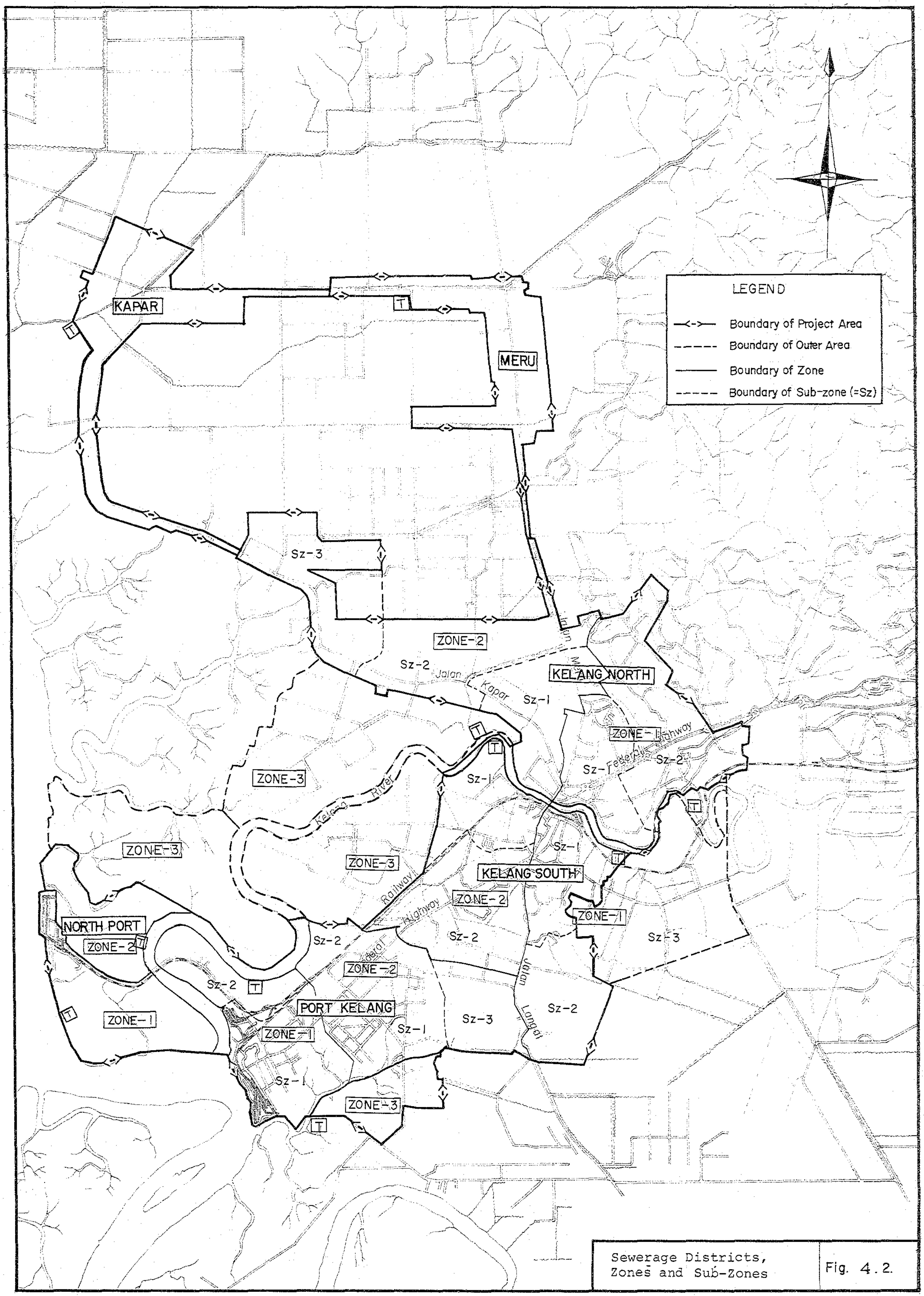
Zones will also be divided into sub-zones for implementation purpose. Three factors are taken into account; namely, (1) population density, (2) existing and future land use pattern and (3) characteristics of urbanization.

The proposed zones and sub-zones thus established are shown in Table 4.1 and Fig. 4.2.

Table 4.1. Sewerage Districts, Zones and Sub-zones

District	Zone	Sub-zone	Acreage (ha)
Kelang North	Zone - 1	Sub-zone - 1	338
		Sub-zone - 2	589
	Zone - 2	Sub-zone - 1	401
		Sub-zone - 2	458
		Sub-zone - 3	418
Kelang South	Zone - 1	Sub-zone - 1	306
		Sub-zone - 2	353
	Zone - 2	Sub-zone - 1	315
		Sub-zone - 2	512
Port Kelang	Zone - 1	Sub-zone - 1	410
		Sub-zone - 2	225
	Zone - 1	Sub-zone - 1	445
		Sub-zone - 2	186
		Sub-zone - 3	248
	Zone - 3		230
North Port	Zone - 1		461
	Zone - 2		349
Kapar			621
Meru			573
Total			7,438

Note: Surface area of the Kelang River is excluded.



Sewerage Districts, Zones and Sub-Zones

Fig. 4.2.

4.1.2. Present Condition of Districts and Zones

The followings are the description of the present condition in the districts, zones and sub-zones as identified.

1) Kelang North District

Kelang North district is located on the right bank of the Kelang River. The highest point of the Project Area is the north-eastern portion of this district, where the altitude extends above 90m. Low hills stretch in a north-south direction on the east side. This range of hills provides a gentle undulation in the eastern part of this district. On the other hand, the western portion forms a flat and low-lying area.

The entire district lies in the Kelang River basin. Sullage water generated in this district flows into the Kelang River by tributaries or monsoon drains, which divide the district into small tributary areas.

Three major roads; i.e., the federal highway, Jalan Meru and Jalan Kapar, become confluent near the Kelang River in this district. A rapidly growing commercial area surrounds the conjunction of these three roads. The riverside, which forms the southern boundary of this district, is therefore occupied by a fully developed area. Consequently, this portion cannot possibly be used as site for a wastewater treatment plant.

Under the condition stated above, the district is divided into two zones. However, possible sites for the wastewater treatment plants for these two zones are planned at the east and west ends outside the Project Area owing to the availability of necessary land space.

a) Zone-1

The east portion of Kelang North district forms Zone-1. Approximately half of the Kelang North commercial area is included in this zone. Many housing schemes have already been developed and/or now in progress. In addition to these developments, huge industrial and housing developments are now being undertaken by SEDC in the north-east portion of this zone, which was previously called Bt. Raja Estate. The east end of this zone has been designated as an industrial area, where several modern factories have been constructed and are in operation.

Zone-1 is further divided into two sub-zones for the implementation purpose. Sub-zone-1 is more developed than the other areas and consists of 338 ha with a population (1980) of 20,000, including a commercial area and high- and medium-density residential areas according to future land use planning.

Sub-zone-2 is the rest of the Zone-1 area, consisting of 589 ha, with a population of 14,966 in 1980. Some areas in Sub-zone-2 have recently been developed into housing schemes. However, a major portion still remains for future development. Bt. Raja development area and the east industrial area are also included in this sub-zone. Future land use pattern in this sub-zone consists of medium-density residential and industrial areas.

b) Zone-2

The west portion of Kelang North district forms Zone-2. This zone is a generally flat and low-lying area. The proposed new highway, which will connect North Port with the existing federal highway, crosses in an east-west direction through the center of this zone. This new highway will form a natural boundary under the present development plan. The southern portion of the zone consists mostly of developed areas, including a commercial area. On the other hand, the northern portion mostly consists of undeveloped areas and development is limited to dispersed areas along the Jalan Kapar.

Zone-2 is further divided into three sub-zones. Sub-zone-1 consists of the part south of the proposed highway which is the developed area of 401 ha, with a population of 20,970 in 1980. Some factories also exist along the Jalan Kapar and Jalan Goh Hock Huat.

Future land use in this sub-zone are categorized as commercial, medium-density residential and industrial areas.

Sub-zone-2 and Sub-zone-3 consist mostly of undeveloped areas. The area and 1980 population of these two sub-zones are 458 ha and 5,732 residents, and 418 ha and 1,233 residents respectively. Industrial development is planned in Sub-zone-3, which has also been earmarked as a low-density residential area. However, these two sub-zones are not expected to be developed fully by the year 2000.

2) Kelang South District

Kelang South district is located on the left bank of the Kelang River facing Kelang North district. A small range of hills runs through this district in a north-south direction. The highest point of this range of hills is Bt. Lipat Kajang, which has an elevation of about 63 m. The rest of the district consists of flat areas.

Approximately three-fourths of this district lies in the Kelang River basin. The remaining one-quarter, which is in the southern part, lies in the Aur River basin. Sullage water generated in this portion flows into the Aur River which flows directly into the sea.

Gorvernment offices and public institutions are mostly located in this district, including the Kelang Municipal Hall and the district office of Selangor State. The neighboring area forms the town center of Kelang municipality.

Many housing developments have been implemented along the two main roads; i.e., the federal highway and Jalan Langat. Among them, the largest is the one being constructed by SEDC south of Bt. Lipat Kajan.

No industrial development is expected in this district. Therefore, Kelang South district consists mainly of the town center and residential areas.

This district is divided into two zones, based on its topography.

a) Zone-1

Zone-1 is in the eastern portion of Kelang South district and it consists of hilly areas, which is further divided into two sub-zones by Bt. Lipat Kajan.

Sub-zone-1 is in the northern portion of this zone and includes commercial and institutional areas. Also this sub-zone includes a large open space on the north side of Bt. Lipat Kajan where a cemetery is located. Sub-zone-1 covers 306 ha and its population (1980) is 9,478.

Sub-zone-2 is in the southern portion of Zone-1 which is a part of the Aur River basin. Housing developments are now being carried by SEDC and a private firm. The sub-zone-2 area is 353 ha and its population (1980) is 6,842.

b) Zone-2

Zone-2 is in the western part of Kelang South district and is generally flat, except a small hill located at the northeast corner of the zone.

The federal highway crosses the center of this zone in a northeast-southwest direction. North of the federal highway and Kelang-Kuala Lumpur railway also crosses the zone in the same direction.

In the northern part up to the railway, there are some *kampung* areas with scattered small-scale housing developments. On the other hand, from the railway to the south end of this zone, housing developments are spreading extensively along the federal highway and Jalan Langat, which forms the eastern boundary of this zone.

Zone-2 is further divided into two sub-zones for the implementation purpose. Sub-zone-1 is the northern portion with an area of 315 ha and population of 12,706 in 1980. The area of Sub-zone-2 is 512 ha and its population (1980) is 23,906.

3) Port Kelang District

The entire area of Port Kelang district is flat. In some areas, the elevation is lower than the highest sea level.

This district is divided into three natural watercourse basins; namely, the Kelang River basin, the Aur River basin and the drainage basin to the sea.

The old port, which was formerly called Port Swettenham, is situated in the district. Recently, North Port was constructed on the west coast of Tanbahan Hutan Simpan Kapar and progressing port activity function has shifted to North Port. However, the old port is still providing both passenger and cargo services.

The old commercial area and newly-built factories surround the port facilities. Pendamaran Industrial Estate has been developed in the vicinity of the old port. Many export-oriented industries, as well as domestic industries, are located in this estate.

Some squatter areas mingle among these commercial and industrial areas. The congested commercial area and existence of these squatter areas result in high population density.

Close to the industrial estate, an old housing estate is situated. However, large areas still remain undeveloped. There also exist Highland Estate, which occupies the east portion of this district, and swamp areas in the Aur River vicinity and north-western section.

The district is divided into three zones, based on topographic condition.

a) Zone-1

Zone-1 consists of the old port and its surrounding areas. Commercial and industrial areas, such as Pendamaran Industrial Estate, are included in this zone. An undeveloped swamp area, located on the north-western tip of this district, is also included.

This zone is further divided into two sub-zones, based on development condition.

Sub-zone-1 consists of developed areas and Sub-zone-2 is an undeveloped area. The area of Sub-zone-1 is 410 ha and its population (1980) is 40,589. This population density of 99 persons per ha. which is the highest among the zones and sub-zones in the Project Area, is the result of the congested commercial area and squatter areas.

The area of Sub-zone-2 is 226 ha and its population is 766 (1980).

b) Zone-2

The area of Zone-2 is entirely flat. The Gadong Besar River and the Aur River form the northern and southern boundaries of this zone respectively. The central portion of this zone consists of both developed and developing areas. On the other hand, the eastern portion consists of a palm and rubber estate. The western portion near the Kelang River is the *kampung* areas.

Taking into account the above-mentioned conditions, Zone-2 has been divided into three sub-zones. Sub-zone-1 consists of developed areas, which include Pendamaran Housing Estate and industrial and other housing areas planned in the surroundings of developed areas. The area of Sub-zone-1 is 445 ha with a population (1980) of 16,208.

Sub-zone-2 is in the north-western portion which is divided from Sub-zone-1 by the federal highway. This Sub-zone consists of developed residential areas and *kampung* areas. The area is 186 ha, with a population of 6,447 (1980).

Sub-zone-3 consists of a palm and rubber estate and *kampung* areas with 248 ha and a population of 5,561 (1980).

c) Zone-3

Zone-3 located on the left bank of the Aur River, consists of a palm estate and a swamp area. Housing and industrial development is also planned. However, some open space will remain undeveloped in the year 2000.

This zone, with an area of 230 ha., is too small to be divided into sub-zones. Its population (1980) is 1,197.

4) North Port District

North Port district, which is divided from Port Kelang district by the Kelang River, faces the sea along its west and south boundaries. Formerly a swamp area, the construction of port facilities was made possible by land reclamation. Approximately three-fourths of the port facilities have been completed and construction of additional facilities is being undertaken in the north portion of the area.

At present, North Port handles the largest cargo shipments in Malaysia. However, as the planned capacity of this port is considered to be insufficient to cope with growing future demand, another port has been planned for construction at Pulau Lumut as extension of North Port is not feasible.

Huge industrial development is planned surrounding North Port. Land reclamation has been carried out by SEDC and Phase-1 of the development work has been completed. Large-scale heavy industry is expected to be established in this area, and several factories are now under construction.

North Port district is divided into two zones by the existing federal highway and railway which run parallel to each other in this district. Zone-1 consists of existing port facilities and SEDC's Phase-1 area. Zone-2 in the northern portion of this district consists of developing area.

The area of Zone-1 covers 461 ha. with a population of 2,010 (1980), while the area of Zone-2 is 349 ha with zero population (1980). Neither zones have been divided into sub-zones.

5) Kapar District

Kapar district is a flat area in an isolated north-western portion of the Project Area, outside of the Kelang River basin. Its area covers 621 ha, with a population of 10,532 in 1980. There is no division of this district into zones or sub-zones.

In the west of Kapar district, a new electric power generation station has been planned on the sea coast. However, development of this district is expected to be slower than those districts previously mentioned.

Kapar district and the following Meru district, which were formerly villages under jurisdiction of the state government, have recently come under the jurisdiction of the Kelang Municipality.

6) Meru District

Meru district is also an isolated flat area in the north-eastern portion of the Project Area, completely outside of the Kelang River basin. Its area covers 573 ha, with a population of 6,487 in 1980. There is no division of this district into zones or sub-zones.

Construction of a small housing scheme is underway near the existing village center, while the southern portion of this district has been earmarked as an industrial area. However, a major part of this district is still occupied by *kampung* and agricultural areas.

Neither Meru nor Kapar district is expected to develop in the immediate future.

4.2. Population Distribution in Sewerage Zones and Sub-zones

Population distribution in each sewerage zone and sub-zone in the year 2000 is estimated on the basis of future land use plan and estimated population projection of 380,000 for the Project Area out of the total of 500,000 for Urban Area. Population density forecasts in Section 3.5. (Population Distribution) are used to arrive at the estimations.

Employed population distribution is also estimated on the same basis of future land use plan in order to calculate sewage flow generated by them.

Results of the estimation both for resident population and employed population are shown in the following Table 4.2.

Table 4.2. (1) Projected Population in the Year 2000 by Sewerage Zones

Sewerage District	Zone	Sub-Zone	Item	Type of Area								Total
				Residential			Commercial	Industrial	Port Area	Institutional	Open Space	
				High	Medium	Low						
Kelang North	1	1	a	145.0	65.0		57.0			22.0	49.0	338
			b	21,750	7,410		6,840			-	-	36,000
			c	-	-		17,100			717	32	17,849
	1	2	a	0.6	404.0		2.7	92.7		15.6	73.4	589
			b	90	40,400		324	-		-	-	40,814
			c	-	-		750	3,876		255	30	4,911
	2	1	a		255.0	11.2	48.4	77.0		4.1		401
			b		25,500	672	5,808	-		-		31,980
			c		-	-	13,800	3,219		101		17,122
	2	2	a			236.9		35.0		38.1	148.0	458
			b			14,214		-		-	-	14,214
			c			-		1,463		943	67	2,473
	2	3	a			23.5		171.7			222.8	418
			b			1,410		-			-	1,410
			c			-		6,626			100	6,726
Kelang South	1	1	a		45.4		36.9			47.5	176.2	306
			b		4,540		4,428			-	-	8,968
			c		-		10,500			1,175	79	11,754
	1	2	a		275.7		3.6			4.6	69.1	353
			b		27,570		432			-	-	28,002
			c		-		1,050			114	31	1,195
	2	1	a	3.8	233.9		2.3			19.0	56.0	315
			b	570	23,390		276			-	-	24,236
			c	-	-		675			471	25	1,171

Items: a: Area (ha), b: Population (person), c: Employed population (person)

Table 4.2. (1) (Cont.)

Sewarage District	Zone	Sub-Zone	Item	Type of Area: Residential High	Residential Medium	Residential Low	Commercial	Industrial	Port Area	Institutional	Open Space	Total
Kelang South	2	2	a	169.4	288.5		29.4			20.9	3.8	512
			b	25,410	28,850		3,528			-	-	57,788
			c	-	-		8,325			516	2	8,843
Port Kelang	1	1	a	100.0	0.8		45.5	141.7	75.6	34.6	11.8	410
			b	15,000	80		5,460	-	-	-	-	20,540
			c	-	-		13,650	5,924	2,725	857	5	23,161
	1	2	a					197.9		27.1		225
			b					-		-		-
			c					8,274		670		8,944
	2	1	a	143.4	171.2		9.1	50.1		45.4	25.8	445
			b	21,510	17,120		1,092	-		-	-	39,722
			c	-	-		2,625	2,095		1,123	12	5,855
	2	2	a	57.3			10.8	66.1		8.4	43.4	186
			b	8,595			1,296	-		-	-	9,891
			c	-			3,075	2,764		208	20	6,067
	2	3	a		229.2		2.0			16.8		248
			b		22,920		240			-		23,160
			c		-		600			416		1,016
	3		a		50.8			75.2			104.0	230
			b		5,080			-			-	5,080
			c		-			3,144			47	3,191

Items: a: Area (ha), b: Population (person, c: Employed population (person)

Table 4.2. (1) (Cont.)

Sewarage District	Zone	Sub-Zone	Item	Type of Area								Total
				Residential			Commercial	Industrial	Port Area	Institutional	Open Space	
				High	Medium	Low						
North Port	1		a		14.5		29.4	242.1	75.6	24.6		461
			b		1,450		3,288	-	-	-		4,738
			c		-		8,820	10,122	2,725	609		22,310
	2		a	36.5			2.1	137.7	135.4	6.8	30.5	349
			b	5,475			252	-	-	-	-	5,475
			c	-			630	5,757	4,887	168	14	11,451
Kapar			a		37.3	205.6	8.4			23.9	345.8	621
			b		3,730	12,336	1,008			-	-	17,074
			c		-	-	2,400			592	155	3,147
Meru			a		22.7	130.4	2.3	156.1		6.5	255.0	573
			b		2,270	7,824	276	-		-	-	10,370
			c		-	-	675	6,526		161	115	7,477
TOTAL			a	656.0	2,094.0	607.6	289.9	1,443.3	286.6	365.9	1,694.9	7,438
			b	98,400	210,310	36,456	34,548	-	-	-	-	379,714
			c	-	-	-	84,675	60,343	10,332	9,096	770	165,216

Items: a: Area (ha), b: Population (person), c: Employed population (person)

Table 4.2. (2) Projected Population in the Year 2000 by Sewerage Zones (Out-of-Project Area)

Sewarage District	Zone	Sub-Zone	Item	Type of Area								Total
				Residential			Commercial	Industrial	Port Area	Institutional	Open Space	
				High	Medium	Low						
Kelang North	2	3	a					109.0				109
			b					-				-
			c					4,557				4,557
	3		a			685.4				19.6	268.0	973
			b			41,124				-	-	41,124
			c			-				485	120	605
Kelang South	1	3	a			547.0	1.8			42.1	98.1	689
			b			32,820	216			-	-	33,036
			c			-	525			1,043	44	1,612
	3		a			470.9				28.6	231.5	731
			b			28,254				-	-	28,254
			c			-				708	104	812
North Port	1		a						12.0			12
			b						-			-
			c						433			433
	2		a						8.0			8
			b						-			-
			c						288			288
	3		a	22.9		229.6	3.5	385.1	106.8	20.3	55.8	824
			b	3,435		13,776	420	-	-	-	-	17,631
			c	-		-	975	16,100	3,850	503	25	21,453
TOTAL			a	22.9		1,932.9	5.3	494.1	126.8	110.6	696.4	3,346
			b	3,435		115,974	636	-	-	-	-	120,045
			c	-		-	1,500	20,657	4,571	2,765	293	29,760

Items: a: Area (ha), b: Population (person, c: Employed population (person)

4.3. Wastewater Quantity and Quality

Estimation of volume and nature of wastewater in the year 2000 is undertaken by taking into account the type of waste origin.

Sources of wastwater are mainly from domestic with human excreta and industrial of various elements. Wastewater from commercial areas and institutional buildings is basically the same nature with domestic sewage, and therefore, domestic wastewater is defined to include wastewater from the commercial and institutional buildings in this report.

Industrial wastewater is generated from various processes in various types of factories. Quantity and quality of industrial wastewater vary greatly according to the types of and processes used by the factories.

To estimate wastewater quantity and quality, data from the WWD were collected and analyzed. At the same time, field studies of domestic wastes from two typical housing areas, including sampling of industrial wastewaters and interviewing in fourteen major factories were carried out by the Study Team. Supplementary data on industrial wastewater were also obtained from the Environmental Division of the Ministry of Science, Technology and Environment.

4.3.1. Domestic Wastewater

1) Water Consumption Per Capita

Present per capita water consumption in urban area is estimated at 230 ℓ/cap./day, as discussed in a previous section (2.5. Water Supply).

Two typical housing areas were selected for investigation of per capita water consumption, as well as per capita BOD load. Results of the individual water meter readings showed per capita water consumption of the two areas to be 210 and 251 ℓ/cap./day, which are very close to figures obtained from WWD records.

Per capita water consumption in individual household varied from 90 to 450 ℓ/cap./day. An analysis of the interrelation between per capital water consumption and income or number of persons per household was made based on the results obtained from questionnaires. However, no significant interrelation was evident, either in comparison with income and persons per household (Ref. to Appendix C).

2) <u>BOD Concentration in Raw Sewage</u>

Regarding BOD concentration, a varied range of 20 to 145 mg/ℓ in an open drain which drains sullage and septic tank effluent from each housing area was obtained from field surveys. The fluctuation pattern of BOD concentration was observed to be identical to that of the discharge flow rate.

It is recognized that BOD concentration was diluted by infiltration of groundwater. Furthermore, as every house is installed with its own septic tank, excreta is treated before being discharged into the drain. Taking into account the volume of groundwater infiltration and BOD reduction in the septic tank, BOD concentration in raw sewage is estimated at 168-218 mg/ℓ (Ref. to Appendix C).

3) <u>Wastewater Flow Rate</u>

An attempt was made to determine wastewater flow rate by using the field survey results covering the typical housing areas. However, an exact figure could not be worked out due to inability to determine the exact amount of infiltration. Assuming that the minimum flow rate recorded at 5:00 am is due to groundwater infiltration, wastewater flow rate is considered to be 77 percent of water consumption.

This percentage is, however, considered to be lower than the actual amount because the low flow rate includes some domestic wastewater.

Taking into account the above-mentioned condition, as well as similar situations in other Malaysian cities, the wastewater estimation for 1980 is calculated to be approximately 90 percent of water consumption or 210 ℓ/cap./day.

In order to determine future per capita wastewater flow rate, the prediction of per capita water consumption in Water Supply Master Plan is used as a basis. In the Master Plan, the estimation of 273 ℓ/cap./day was used as per capita water consumption for urbanized population in 1995.

Using this projected estimation, 290 ℓ/cap./day is obtained as the per capita water consumption in the year 2000. Based on this extrapolation, the per capita wastewater flow rate, i.e. 90 percent of per capita water consumption, is projected up to 2000 as follows:

Table 4.3. Domestic Wastewater Flow

Year	ℓ/capita/day
1980	210
1990	240
1995	250
2000	260

4) BOD Load Per Capita

BOD concentration in raw sewage is estimated to range from 168 to 218 mg/ℓ based on field surveys. For design purpose, the adoption of 200 mg/ℓ is considered to be a reasonable estimation. The same concentration of 200 mg/ℓ is adopted for SS. BOD and SS per capita loads up to the year 2000 are as follows:

Table 4.4. BOD, SS Concentration and Per Capita Load

Year	BOD and SS Concentration (mg/)	BOD and SS Per Capita Load (g/capita/day)
1980	200	42
1990	200	48
1995	200	50
2000	200	52

5) Wastewater Flow Rate and BOD Load Per Capita for Employed Population

The nature of raw sewage generated in commercial and institutional areas is basically the same as that of domestic sewage. Per capita water consumption by employed population in commercial and institutional areas is almost identical to domestic per capita water consumption as discussed in a previous section (2.5. Water Supply). Therefore, the same per capita wastewater flow rate, BOD load and SS load are adopted for employed population.

4.3.2. Industrial Wastewater

1) Quantity of Industrial Wastewater

In the Water Supply Master Plan, the basic rate of water consumption for the industrial area is considered to be 34 m^3/day/ha, while in the industrial estate in the vicinity of North Port, the rate of 54 m^3/day/ha is adopted because this estate is expected to attract heavier type of industries.

According to a survey conducted by the Study Team to examine pollutant load of industrial wastewater, average water consumption per lot space is 60.7 m^3/day/ha. Assuming that two-thirds of the industrial area is occupied by factory lots, an adjustment was made to arrive at a figure of 40.4 m^3/day/ha per total industrial area. This rate is considered sufficiently close to the above-mentioned rates. Results of the questionnaires are shown in Tables 4.5. and 4.6.

The rates adopted in the Water Supply Master Plan are used for estimation of industrial wastewater quantity for the following reasons:

1) Rates used in the Water Supply Master Plan are considered more realistic
2) Expected establishment of new types of factories in the Project Area
3) Insufficient replies to the questionnaire survey

Table 4.5. Industrial Data Concerning Water Consumption

(Compiled from Questionnaires)

Name of Factory	Space (ha)		Number of Employees	Water Consumption (m^3/d)	Major Products	Remarks
	Lot	Floor				
Malaysia International Palm Oil	8.09	1.62	164	430	Cooking Oil, Refined deodorized Palm Oil, Refined deodorized Palm Olein, Crude Palm Stearin, Ghee, Shortening	48-195 m^3/d (DOE)*
IPI			40		Printing ink	
Lee Rubber	4.13	1.62	42	911.5	Standard Malaysian Rubber	1,000 m^3/d (DOE)* 910 m^3/d (River Water)
Fung Keong Rubber	6.35	3.99	2,062	202	Bicycle & Motorcycle Tires, Car and Truck Tube, Shoes, Rubber Sundries	
Chemetics-Mega	0.61	0.44	33	52.7	Sodium Chlorate	32 m^3/d (DOE)*
Fusan Fishing Net	4.65		497	142	Netting, Rope	123 m^3/d (from well)
Federal Flour Mills	3.24		221	52	Wheat Flour, Pollard, Bran	
Socoil Corporation	4.05	4.05	268	48	Refined Palm Oleine, Refined Palm Oil, Crude Palm Kernel Oil, Neutralized Palm Oil, Crude Palm Kernel Stearine Crude Palm Kernel Olein, Acid Oil, Fatty Acid Distillate	
Amoy Canning	0.79	0.29	38	13	Canned Vegetables, Canned Meat, Canned Seafood, Canned Jams	125 m^3/d (DOE)*
FMC	0.11		15	91	Liquid Detergent, Powder Detergent, Shampoo	

Note: * Water consumption data obtained from Division of Environment.

Table 4.6. Characteristics of Industrial Wastewater

Name of Factory	Source	Temperature (°C)	pH	COD (mg/ℓ)	BOD (mg/ℓ)	SS (mg/ℓ)	TS (mg/ℓ)	Transparency (cm)	Conductivity (μΩ/cm)	DO (mg/ℓ)	NH_3-N (Total-N) (mg/ℓ)	PO_4-P (Total-P) (mg/ℓ)	Oil/Grease (mg/ℓ)
Malaysian International Palm Oil	ST	32.0	6.9	110	25			0.6		0	8.23	0.12	
	DOE	30-40	3.1-6.2	810-1,899	300-702	100-600	1,572-3,803				3-12.5	(350-700)	20-1,288
Lee Rubber	ST	29.4	7.0	765	325			1.3	6,000	3.0	168	10.8	
	DOE		6.75	762	210*	212	712				19		
	F		6.45	595	259*	135	705				39		
Fung Keong Rubber	ST	34.2	>8.0	65.0	16.0			14.0	550	12.7	0.99	0.1	
Chemistic-Mega	DOE	32	8.6	50	20	50					(0.3)	5	
Mega-Chemicals	DOE	32	1.9	950	70	2							
Fusan Fishing Net	ST		>12	2,345	885						1.27	<0.01	
Socoil 1981 (Jan.)	F	44.7	7.4	6,655		1,686	1,947						42,537
1981 (Feb.)	F	41.9	7.4	1,556		829	1,144.5						3,345
1981 (Mar.)	F	45.8	7.2	1,667		753	925						3,118
1981 (Apr.)	F	46.1	7.2	2,614	997	1,778	1,755						5,261
1980 (6 months av.)	F	44.9	6.4	6,963	4,115	3,769	3,717						3,100-3,300
	DOE		6.4	1,720	880*	547	1,260				(100)		
Amoy Canning	F		6.3	848	442	919	1,064				(31)	(6)	9
	DOE		8.4	396	200	510	617				(11.7)	(4.4)	26
Lee Oil	ST	29.0	6.9	5,445	3,600			11.5	6,500	1.6	1.65	4.9	
Asian Marine Product	ST	24.7	6.2	2,540	1,960			1.3	800	3.9	2,590	9.8	

Note: Under Source ST = Study Team, DOE = Division of Environment, F = Factory

* 3 day BOD at 30°C

2) BOD and SS concentration in Industrial Wastewater

The type of factory is classified into 13 categories as shown in Table 5.7. in order to calculate BOD and SS concentration. BOD and SS concentration for each category is determined on the basis of field studies and various available data in Malaysia and Japan as well.

Table 4.7. BOD and SS Concentration in Industrial Wastewater by Category in 2000

Category of Factory		BOD (mg/ℓ)	SS (mg/ℓ)
1	Food Products	400	400
2	Oils and Fats	400	400
3	Textiles	120	400
4	Wood and Wood Products	70	130
5	Chemicals	70	130
6	Petroleum Products	70	130
7	Rubber Products	400	400
8	Cement and Non-Metals	70	130
9	Basic Metals	70	130
10	Fabricated Metals	70	130
11	Electrical Machinery	70	130
12	Transport Equipment	70	130
13	Other Manufactured Products	70	130

In the "Environmental Quality (Sewerage and Industrial Effluents) Regulations 1979", limits of pollutant concentration are prescribed for permissible discharge into the sewerage system. The limit for both BOD and SS concentration prescribed in the Sixth Schedule of the Regulations is 400 mg/ℓ, while stricter limits are applied for direct discharge into the watercourse. Therefore, 400 mg/ℓ limit is used.

Since many industrial areas are under development or still remain undeveloped, data for the calculation of industrial waste load in those areas is not available. Hence, the following method is adopted to estimate the quantity of industrial waste load.

Existing factories and planned factories which have submitted applications for lot allocation are classified according to category. Then, the factory lot area in each category is summed up and weighted the average concentration calculated on the basis of area.

The lot space of existing and planned factories in Pendamaran and North Port industrial estates is used to work out average concentration which is 160 mg/ℓ for BOD concentration and 198 and 199 mg/ℓ for SS concentration. Based on this result, BOD and SS concentration in industrial wastewater are estimated as follows:

Table 4.8. BOD and SS Concentration in Industrial Wastewater in 2000

BOD	SS
160 mg/ℓ	200 mg/ℓ

3) Possible Toxic Waste in Industrial Wastewater

Some of the effluent from the factories may include toxic materials such as mercury, cadmium etc. These materials are originated from raw materials used and/or from products or by products of the factories. Excess concentration of these materials may cause contamination in the receiving waters into which wastewater is discharged resulting in sometimes serious health problem.

Discharging industiral wastewater in excess of a certain concentration limit of a toxic material into sewerage system is prohibited by the following two reasons: 1) Most of the materials can not be reduced efficiently by sewerage system, thus cause contamination in the receiving water and 2) these materials are harmful to the sewerage system, especially to biological treatment process.

Possible sources of each toxic material are limited to types or processes of the factories. Following Table 4.9. shows toxic materials and their sources grouped by the same categories used in the previous Table 4.7.

Table 4.9. Possible Toxic Waste in Industrial Wastewater

Toxic Material \ Category	1	2	3	4	5	6	7	8	9	10	11	12	13
Mercury					○						○		
Cadmium					○				○				
Chromium, Heavalent					○					○	○	○	
Arsenic					○								
Cyanide										○	○	○	
Lead					○				○				
Chromium, Trivalent					○					○	○	○	
Copper					○				○	○	○	○	
Managanese					○								
Zinc					○				○	○	○	○	
Iron (Fe)					○								
Phenol													
Oil and Grease	○	○			○	○			○	○			

Category

1: Food Products
2: Oils and Fats
3: Textiles
4: Wood and Wood Products
5: Chemicals
6: Petroleum Products
7: Rubber Products
8: Cement and Non-Metals
9: Basic Metals
10: Fabricated Metals
11: Electrical Machinery
12: Transport Equipment
13: Other Manufactured Products

4.3.3. Wastewater from Port Facilities

There are two ports in the Project Area and the water used in the port facilities is supplied by WWD. In 1980, the daily average water consumption in these two ports was as follows:

Table 4.10. Water Consumption in Port Facilities

North Port	
Total Consumption	1,480 m^3/day
Supply to Ships	70 m^3/day
Wastewater	1,410 m^3/day
South Port	
Total Consumption	340 m^3/day
Supply to Ships	-
Wastewater	340 m^3/day

It is assumed that wastewater from port facilities will not change in South Port by the year 2000 because the port area is presently fully developed. On the other hand, the amount of wastewater in North Port is assumed to double by 1990 but will not increase thereafter, taking into account the present development condition and future development plan.

Although no data is available concerning the nature of wastewater from port facilities, it is considered to be reasonable to assume similar to that of industrial wastewater.

4.3.4. Infiltration

Sanitary sewer design quantities must include an allowance for non-waste component which inevitably become a part of the total flow through cracked pipes, defective joints, faulty manholes, and submerged manhole covers, together with infiltration from improper house connections, illegal connections, or other defects on private property.

Since no applicable data on infiltration is immediately available for the Project Area, various cases in other Malaysian cities, as well as in industrialized countries such as Japan and the United States[1/], are studied. As a result, infiltration rate of 45 m^3/day per km of sewer length is adopted.

Based on the above-mentioned infiltration rate and estimated average sewer length in the Project Area, infiltration rate per area is estimated as 7 m^3/day/ha.

It should be noted that infiltration rate depends on design and construction of sewers, together with groundwater condition. Therefore, careful consideration needs to be given to the design for each sewer system.

4.3.5. Wastewater and Waste Load in the Year 2000

Based on the studies and consideration stated in proceeding chapters, amount of wastewater, BOD load and SS load generated in each sewerage zone in the year 2000 are tabulated in Tables 4.11, 4.12 and 4.13 respectively.

Total amount of wastewater in the Project Area is estimated as 255,000 m^3/day, which is approximately 4.0 times the present volume of wastewater. About half is domestic wastewater and the remaining half consist of industrial wastewater and infiltration.

1/ WPCF Manual of Practice No. 9 "Design and Construction of Sanitary and Storm Sewers", Fourth Printing, 1976

Table 4.11. Wastewater Quantity by Sewerage Zones

Sewerage Division			Wastewater Flow (m^3/day)			
District	Zone	Sub-zone	Domestic	Industrial	Infiltration	Total
Kelang North	Z-1	S-1	14,000	-	2,023	16,023
	"	S-2	10,881	3,152	3,609	17,642
	Sub-total		24,881	3,152	5,632	33,665
"	Z-2	S-1	11,930	2,618	2,807	17,355
	"	S-2	3,958	1,190	1,085	6,233
	"	S-3	393	5,838	1,366	7,597
	"	S-3*	-	3,706	763	4,469
	Sub-total		16,281	13,352	6,021	35,654
Kelang South	Z-1	S-1	5,388	-	909	6,297
	"	S-2	7,591	-	1,987	9,578
	"	S-3*	9,008	-	4,136	13,144
	Sub-total		21,987	-	7,032	29,019
"	Z-2	S-1	6,606	-	1,813	8,419
	"	S-2	17,324	-	3,557	20,881
	Sub-total		23,930	-	5,370	29,300
Port Kelang	Z-1	S-1	9,114	5,157**	2,787	17,058
	"	S-2	174	6,729	1,575	8,478
	Sub-total		9,288	11,886	4,362	25,536
"	Z-2	S-1	11,305	1,703	2,934	15,942
	"	S-2	3,430	2,247	998	6,675
	"	S-3	6,286	-	1,736	8,022
	Sub-total		21,021	3,950	5,668	30,639
"	Z-3		1,333	2,557	882	4,772
North Port	Z-1		3,692	14,628**	3,227	21,547
"	Z-2		1,633	9,461**	2,230	13,324
Kapar			5,257	-	1,926	7,183
Meru			2,943	5,307	2,226	10,476
TOTAL			(123,238)*** 132,246	(60,587)*** 64,293	(39,677)*** 44,576	(223,502)*** 241,115

Note: * Sub-zone is located outside of the Project Area.

** Wastewater from port facilities is included.

*** Project Area only.

Table 4.12. Wastewater BOD Load and Concentration by Sewerage Zones

Sewerage District	Sewerage Zone	Wastewater BOD					
		Domestic**		Industrial		Total	
		Load (kg/day)	Concen. (mg/ℓ)	Load (kg/day)	Concen. (mg/ℓ)	Load (kg/day)*	Concen. (mg/ℓ)*
Kelang North	Zone-1	4,976	200	504	160	5,480	163
	Zone-2	3,256	200	(1,543)* 2,136	160	(4,799)* 5,392	151
Kelang South	Zone-1	(2,596)* 4,397	200			(2,596)* 4,397	152
	Zone-2	4,786	200			4,786	163
Port Kelang	Zone-1	1,857	200	1,902	160	3,759	147
	Zone-2	4,204	200	632	160	4,836	158
	Zone-3	267	200	409	160	676	142
North Port	Zone-1	738	200	2,340	160	3,078	143
	Zone-2	327	200	1,514	160	1,841	138
Kapar		1,051	200			1,051	146
Meru		589	200	849	160	1,438	137
Total		(24,647)* 26,448		(9,693)* 10,286		(34,340)* 36,734	

Note: * Project Area only.

Table 4.13. Wastewater SS Load and Concentration by Sewerage Zones

Sewerage District	Sewerage Zone	Wastewater SS					
		Domestic**		Industrial		Total	
		Load (kg/day)	Concen. (mg/ℓ)	Load (kg/day)	Concen. (mg/ℓ)	Load (kg/day)*	Concen. (mg/ℓ) *
Kelang North	Zone-1	4,976	200	630	200	5,606	167
	Zone-2	3,256	200	(1,929)* 2,670	200	(5,185)* 5,926	166
Kelang South	Zone-1	(2,596)* 4,397	200			(2,596)* 4,397*	152
	Zone-2	4,786	200			4,786	163
Port Kelang	Zone-1	1,857	200	2,377	200	4,234	166
	Zone-2	4,204	200	790	200	4,994	163
	Zone-3	267	200	511	200	778	163
North Port	Zone-1	738	200	2,926	200	3,664	170
	Zone-2	327	200	1,892	200	2,219	167
Kapar		1,051	200			1,051	146
Meru		589	200	1,061	200	1,650	158
Total		(24,647)* 26,448		(12,116)* 12,857		(36,763)* 39,305	

Note: * Project Area only

BOD and SS concentration in zones vary according to the proportion of three components, i.e., domestic, industrial (including wastewater from port facilities) and infiltration. The ranges of BOD and SS concentration are estimated as 140-160 mg/ℓ and 150-170 mg/ℓ respectively.

4.4. Industrial Wastewater Treatment

4.4.1. Environmental Quality Regulations

Three regulations enforced to control industrial wastewater effluent in Malaysia are: (1) Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977, (2) Environmental Quality (Prescribed Premises) (Rubber) Regulations, 1977 and (3) Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979. The first set of regulations applies to discharges of effluent from factories which process palm-oil fruit into crude palm oil. The second set of regulation applies to discharge of effluent from factories which process natural rubber. The last set of regulation applied to discharge of effluent from any type of factories and sewerage facilities, other than palm oil and rubber factories, if the amount of effluent exceeds 60 m^3 /day and the amount of BOD load exceeds 6 kg/day.

Any factory which discharges wastewater into a watercourse in excess of the specified amount of wastewater or BOD load must comply with the requirements of the above-mentioned. The Regulations prescribe the limits for industrial wastewater components according to harmful, hazardous or other aspects. Two sets of limits are provided according to the condition of the receiving water. In the catchment areas upstream to any kind of water supply intake, more stringent limits are applied. However, less stringent limits are applicable throughout the Project Area, as prescribed in Standard B in the Third Schedule of said Regulations, since upstream catchment areas are not included in the Area.

Standard B parameter limits are quoted in Table 4.14.

Table 4.14. Parameter Limits of Effluent of Standard "B"

	Parameter	Unit	Limits
1	Temperature	°C	40.0
2	pH Value	-	5.5-9.0
3	BOD at 20°C	mg/ℓ	50.0
4	COD	mg/ℓ	100.0
5	Suspended Solids	mg/ℓ	100.0
6	Mercury	mg/ℓ	0.05
7	Cadmium	mg/ℓ	0.02
8	Chromium, Hexavalent	mg/ℓ	0.05
9	Arsenic	mg/ℓ	0.10
10	Cyanide	mg/ℓ	0.10
11	Lead	mg/ℓ	0.5
12	Chromium, Trivalent	mg/ℓ	1.0
13	Copper	mg/ℓ	1.0
14	Manganese	mg/ℓ	1.0
15	Nickel	mg/ℓ	1.0
16	Tin	mg/ℓ	1.0
17	Zinc	mg/ℓ	1.0
18	Boron	mg/ℓ	4.0
19	Iron (Fe)	mg/ℓ	5.0
20	Phenol	mg/ℓ	1.0
21	Free Chlorine	mg/ℓ	2.0
22	Sulphide	mg/ℓ	0.5
23	Oil and Grease	mg/ℓ	10.0

4.4.2. General Policy for Handling Industrial Wastewater

The nature of industrial wastewater varies greatly depending on the type of the factory and the processes involved. Industrial wastewater contains various kinds of material which are contained in raw materials or are used in the processes.

Large-scale factories are expected to be constructed in the industrial estates, particularly in the North Port district. While not necessarily all of them, these factories will produce wastewater and /or waste load in excess of the amount prescribed in the Environmental Quality Regulations, which have to treat their wastewater before discharging into the watercourse to meet set standards . Provision of wastewater treatment facilities which may be required mostly by large-scale factories is considered to be possible, both physically and economically, but small-scale factories, which are expected to produce less than prescribed limit, would have no need for such facilities.

General policy for handling industrial wastewater is considered as follows, based on the above-mentioned considerations:

1) Industrial wastewater which contains hazardous materials should not be accepted into the sewerage system.

2) Effluent from the factories, which produce wastewater and/or waste load in excess of prescribed limits, should be excluded from the sewerage system, since they are required to treat them, under the Regulations, to the level permissible for discharge into the watercourse, and acceptance of such effluent after required treatment would simply mean increase of sewage flow of the system, affecting economy of the Project.

3) Industrial wastewater from small-scale factories is to be accepted into sewerage system under the assumption stated above, after reduction of hazardous materials.

Careful review should be undertaken periodically concerning proper identification of each factory according to the foregoing principles as regards the need of the treatment before discharge.

4.4.3. Industrial Wastewater Treatment According to Districts

1) Kelang North District

Clusters of factories are located along Jalan Batu Tiga, along Jalan Kapar and near the Kelang River. These factories process various food, rubber, chemical and other products.

Along the proposed North Kelang Straits Expressway, Bt. Raja Industrial Estate has been developed and steel mills and other factories are under construction. The north-western portion of this district has been earmarked for industrial land use. However, this area is presently the agricultural land and development has not commenced yet.

Among the existing factories in this district, two factories, located in Zone-1, Sub-zone-2, are planning to install wastewater treatment facilities. Effluent from these two factories can be discharged into the drain or river rather than into the sewerage system.

The total amount of industrial wastewater estimates to be generated in this district in the year 2000 is 16,500 m^3/day or 40 percent of domestic wastewater. Joint treatment of the domestic and industrial wastewater except those required treatment at the factory sites can be conducted because of the comparatively small amount involved.

2) Kelang South District

There is no industrial estate in this district. Therefore, industrial wastewater is almost negligible.

3) Port Kelang District

The large-scale Pendamaran Industrial Estate is located in this district. Moreover, large areas in the vicinity of Pendamaran and in the north-western portion along the Kelang River are earmarked as industrial areas.

Therefore, the amount of industrial wastewater expected to be generated in this district will be large, compared with domestic wastewater. The total amount of industrial wastewater is estimate to be 18,400 m^3/day or 58 percent of domestic wastewater.

Large-scale industries are expected to be constructed in the north-western portion of the district because of its proximity to North Port. Industrial wastewater in this area will not be included from the sewerage system, assuming proper treatment according to the requirement by each factory will be performed before discharging into watercourse or open sea.

In Pendamaran Industrial Estate, two palm oil factories are constructing wastewater treatment facilities, and therefore they will also be excluded from the sewerage system.

4) North Port District

A great portion of North Port district will be occupied by port facilities and large-scale industries. Residential areas for the workers are comparatively smaller than the port and industrial areas. Therefore, the amount of industrial wastewater of 24,100 m^3/day is as much as 4.5 times that of domestic wastewater.

Taking into account the above-mentioned conditions, three possible alternatives are considered for the sewerage system in this district in the following.

a) One sewerage system for joint treatment of domestic wastewater and industrial wastewater.

b) Separate sewerage systems for domestic wastewater in the residential areas and for industrial wastewater in the rest of the district.

c) One sewerage system only for domestic wastewater, with industrial wastewater to be treated by each factory.

Taking into account the present development conditions in this district, alternative c) is considered most appropriate among the three alternatives because of the following reasons.

a) Large scale factories are expected to establish in the industrial estate, and large lot spaces are allocated to these factories according to the development plan obtained from SEDC. Therefore, provision of wastewater treatment facilities by the factories considered to be possible.

b) In a development plan of the residential area in Zone-2, a space for stabilization pond for domestic wastewater treatment is allocated.

5) Kapar District

No industrial area is earmarked in Kapar District. Therefore, industrial wastewater is almost negligible in this district.

6) Meru District

The southern portion of Meru district is earmarked as an industrial area. At present, however, it still remains to be *kampung* and agricultural areas, and development has not commenced yet.

Since a large portion of this district still is undeveloped, sewerage facilities are expected to be constructed by the development authorities concerned. Individual treatment or a joint treatment sewerage system should be considered for the industrial wastewater in this district, according to the size of industries to be established.

4.5. Design Criteria

The design criteria necessary for planning of the main sewerage facilities, such as sewers, pumping stations, treatment plants, etc. are stated as follows.

4.5.1. Sewers

1) Flow Friction Formula

The Manning formula is adopted for design of sewers and conduits in the following formula:

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

Where

V : Velocity of flow, in m/sec

n : Coefficient of roughness, 0.013

R : Hydraulic radius, in m

S : Slope

2) Peak Flow Rate

Peak flow rate to average daily domestic wastewater flow is given in the following formula:

$$Md = \frac{5}{P^{1/7}}$$

Where

Md : Peak flow rate for domestic wastewater

P : Design population, in 1,000

Peak flow rate for industrial wastewater used in the design of sewers and pumping stations is as follows:

Mi = 2

where

Mi : Peak flow rate for industrial wastewater

3) Minimum and Maximum Velocity

All sewers shall be designed to maintain minimum velocity, when flowing full or half full, of not less than 0.6 m/sec for vitrified clay pipe or 0.75 m/sec for centrifugally-cast reinforced concrete pipe or any other cement-based pipe.

Maximum velocity shall not exceed 3.0 m/sec in any type of sewer to prevent erosion. Where ground surface slope is steep with velocity of more than 3.0 m/sec, special consideration shall be given for protection of the pipe against erosion and shock.

4) Sulfide Build-up Control

To protect sewer pipes from corrosion caused by sulfide build-up, minimum velocity described in part 3) shall be maintained.

5) Minimum Size of Sewer

For public sanitary sewers, a minimum size of 225 mm in diameter is recommended and house connection pipes shall not be less than 150 mm in diameter.

6) Sewer Pipe Materials

Asbestos cement, centrifugally-cast reinforced concrete, vitrified clay, and various other pipes conforming to internationally accepted standards are currently available in Malaysia. (Ref.: Appendix K, Vol. IV)

Because of its resistance to corrosion from acids, alkalies and virtually all corrosive substances, as well as resistance to erosion and scouring, vitrified clay pipe is recommended for smaller sizes up to 300 mm in diameter.

For main and submain sewers from 375 mm in diameter, centrifugally-cast reinforced concrete pipes are recommended. Where sulfide corrosion is expected, coating or lining may be used on the centrifugally-cast reinforced concrete pipes. (Ref: Appendix K, Vol. IV)

Use of sulphate-resisting concrete pipe is recommended where groundwater contains alkali sulphates in considerable amounts.

7) Depth of Sewer

The depth of earth covering public sewer pipes shall not be less than 1.0 m, except for specific situations that prove shallower depths are preferable. Main and submain sewers shall be sufficiently deep for receiving sewage from branch and lateral sewers.

8) Manholes

Manholes shall be provided at each change in direction, in sewer diameter, or wherever there is a considerable change in grade generally with the following maximum spacing.

Table 4.15. Maximum Manhole Spacing

Sewer Diameter (mm)	Maximum Manhole Spacing (m)
1,050 or less	100
1,500 or less	150
1,650 or more	200

Except for very shallow sewers, all manholes shall have adequate dimensions for entry and for operation of cleaning equipment. The minimum diameter of manholes shall be as follows:

Table 4.16. Minimum Diameter of Manhole

Pipe Diameter (mm)	Minimum Diameter of Manhole (mm)
825 or less	1,200
1,200 or less	1,500
1,350 or less	1,800

Watertight manhole covers of either cast iron or concrete shall be used wherever the manhole top is subject to flooding by street runoff or high water. Manholes of brick or segmented block shall have waterproofed exterior walls with plaster coatings where necessary. Manhole steps shall be of sulfide corrosion-resistant material, such as cast iron or its equivalent, provided at 30 cm intervals and embedded in the wall to reach the dome.

9) Siphons

The purpose of siphon installation is to carry the flow under an obstruction such as a stream or depressed highway and to regain as much elevation as possible after the obstruction has been passed.

To prevent mud and grit deposit, velocity in siphons should be designed higher than that in the upper stream sewer by 20-30 percent. A multiple-barrel siphon is recommended to provide a spare barrel for maintenance work and/or for emergency use. It is also common practice, at least on large sewers, to construct multiple-barrel siphons to provide adequate self-cleaning velocity during the early years of operation.

Siphons may need cleaning oftener than gravity sewers. For ease in cleaning by modern methods the siphon should not have any sharp bends, either vertical or horizontal; only smooth curves of adequate radius should be used. The rising leg should not be so steep as to make it difficult to remove heavy solids with cleaning tools that operate on the hydraulic principle.

To calculate head loss in siphons, the following formula should be used:

$$H = i \cdot \ell + 1.5 \frac{v^2}{2g} + \alpha$$

Where

H : Head loss (m)
i : Hydraulic gradient
ℓ : Length of barrel (m)
v : Velocity in barrel (m/sec)
g : Acceleration of gravity (= 9.8 m/sec^2)
α : Margin (3-5 cm in general)

4.5.2. Pumping Station

For the provision of pumping stations, basic considerations are given to location, layout, type of equipment and structure. Following are the major elements to be considered for the proper design of pumping stations.

1) Design Flow

The design of pumping station is based on the peak flow of the sewage unless special conditions justify the use of a lower rate. All piping and conduits are also designed to carry the expected peak flow, with some allowances for abnormal sewage increases. Enough storage capacity is to be provided in wet wells, especially where automatic controls and variable speed drives are not furnished, to balance pumping rates within flow rates.

2) Type

Types of pumps suitable for transmitting sewage are considered to be as follows:

a) Submersible pump
b) Centrifugal pump
c) Screw pump

Selection of type depends on the condition of each individual pumping station, such as peak flow, total head, etc. Studies should be carried out on both technical and economical aspects. The following Table 4.17. presents the characteristics of each pump in general.

Table 4.17. Characteristics of Pumps

Item \ Type of Pump	Submersible	Centrifugal	Screw
Power Efficiency	Good	Good	Inferior to other two types
Total Head	More than 5 m	More than 10 m	Depends on flow rate, mostly less than 8 m
Diameter	Less than 500 mm Electric motor less than 132 kW	Less than 2,000 mm	Less than 3,000 mm
Required Space	Small Wet well only	Large Wet well and dry well	Large Inclined shaft
Maintenance	Easy	Easy	Very easy
Preliminary Treatment	Screen Better to remove grit	Screen Better to remove grit	not required

3) Structure

Wet and dry wells, including their structures, shall be separate. Provision to facilitate removing pumps and motors shall also be considered in design. Suitable and safe means of access shall be provided for dry wells and wet wells containing either bar screens or mechanical equipment requiring inspection or maintenance.

4) Pumps

At least two pumps should be provided for each required station. The number of pump is to be determined on the basis of flow quantities and variations. Where possible, pumps should have the same capacity and design, with interchangeable parts. Each should be capable of handling flows in excess of the expected maximum flow. Where three or more units are provided, they should be of such capacity that with one unit out of order, the remaining units will have the capacity to handle maximum flow.

In addition to the capacity of pump, careful consideration shall be given to the selection of pump having the proper head rating, considering fluctuations of the wet well water level and the discharge level. Due to diameter restrictions, small-capacity pump should always be of the non-clog type.

5) Pump Drive

In selecting the type of pump drive, careful consideration should be given to the frequency and duration of electrical power suspension, as well as to cost comparison of an electric motor and diesel engine. Past experience indicates that the use of motor is generally more economical and reliable than engine.

Furthermore, electricity has been used for years in Malaysia without serious problems. Therefore, it is recommended that the pumps for all pumping stations be driven by electric motor.

6) Ventilation and Prevention of Odor and Noise

Pumping stations shall be enclosed in a concrete structure to prevent the diffusion of order and noise to the near-by residences. Proper ventilation and lighting shall be provided for all stations to ventilate the screening room and any other portion of the station.

4.5.3. Treatment Plant

1) Necessity and Degree of Treatment

According to the sampling and measuring results of domestic and industrial wastewater, and drain and river water, the pollution condition warrants proper treatment in order to improve present condition and prevent further deterioration to comply with the existing regulation.

Various kinds of processes are adopted for wastewater treatment according to the nature of the wastewater and the required level of effluent. These processes are categorized into three groups according to the degree of treatment; namely, primary, secondary and tertiary treatment.

Primary treatment is the first major phase of sewage treatment and usually consists of a physical process to remove a substantial amount of suspended matters and some colloidals, but not dissolved matters. The sedimentation process is used in primary treatment, which is the gravitational separation of a suspension into its component, solid and liquid phases. In the primary sedimentation of sewage, there are two aims, i.e., to produce a high degree of clarification and of thickening. Clarification is the removal of solids from the liquid phase, and thickening is the removal of the liquid from the solid or suldge phase.

Generally, secondary treatment consists of biological and chemical processes, following primary treatment. The biological processes involve the interaction of bacteria and algae with oxygen and constitute by far the most important methods of sewage treatment, particularly in hot climates. Several biological processes are in common use, such as conventional activated sludge, bio-filtration, stabilization pond, aerated lagoon and oxidation ditch. Chemical processes are not currently in common use for the secondary treatment process even in the industrialized countries.

In order to comply with the requirement in the "Environmental Quality (Sewage and Industrial Effluent) Regulations, 1979", it is recommended that planning for the treatment facilities be based on the secondary treatment processes.

Among the secondary treatment processes, conventional activated sludge and bio-filtration processes require higher construction costs and a higher degree of operational skill than the other processes. Therefore, stabilization pond, aerated lagoon and oxidation ditch processes are considered suitable for the Project.

There are several types of stabilization pond and basically these are classified into three categories, namely facultative, aerobic and anaerobic. Among the three categories, anaerobic pond is not considered to be suitable for the Project because of the following reasons:

a) Anaerobic pond system has been developed mainly for treatment of strong (high BOD concentration) effluent. Therefore, application of anaerobic pond for municipal sewerage has not yet been common.

b) Anaerobic pond may cause order problem. To avoid influence of this problem, some buffer zone should be provided between treatment plant and residential area, and it may cause a additional difficulty to acquire land.

c) In a sewerage study conducted for a Malaysian city, required land space for anaerobic pond is estimated as well as for other treatment processes. Anaerobic pond requires less land space than facultative pond but requires more than aerated lagoon.

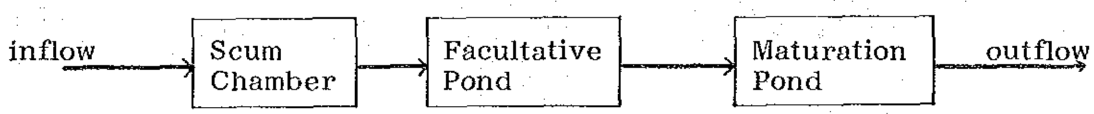
Tertiary treatment usually follows secondary treatment and consists of various types of processes, such as biological, physical and chemical processes. The purpose of tertiary treatment is, (1) to remove organic matter to meet higher degrees of environmental requirement, (2) to remove nutrients, such as nitrogen and phosphate, to avoid eutrophication and (3) to remove inorganic dissolved materials for reuse of wastewater. Under present circumstances, tertiary treatment is unlikely to be required in the foreseeable future in the Project Area.

2) Unit Process

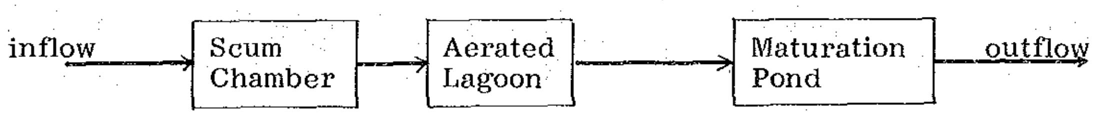
Unit process components of the above-mentioned three methods are shown as schematic plans in the following Fig. 4.3. A scum chamber is provided for either stabilization pond or aerated lagoon system prior to biological treatment. Maturation pond is also provided following stabilization pond and aerated lagoon to polish effluent from these ponds. No sludge treatment facility is required for the two systems because of the digestion expected in the lower layer of the ponds. On the other hand, oxidation ditch system needs sludge treatment, which is considered to be operated by sludge drying beds. Chlorination tank for coliform reduction is installed before discharging effluent into a watercourse, since such reduction can not be expected in either oxidation ditch or sedimentation basin because of the short retention time.

Fig. 4.3. Schematic Plan of Stabilization Pond, Aerated Lagoon and Oxidation Ditch

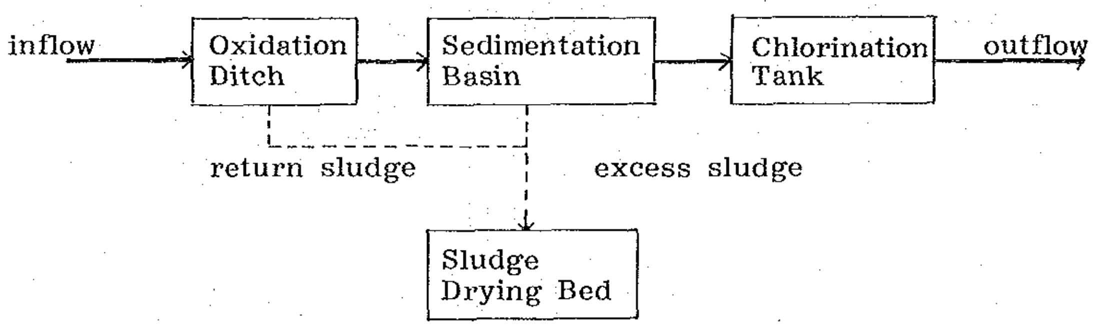
1) Stabilization Pond



2) Aerated Lagoon



3) Oxidation Ditch



3) Design Parameters for Treatment Process

Various parameters to be used for design of the above-mentioned three methods and environmental conditions of the Project Area which affect the parameters are discussed in this section.

a) Facultative Pond

Major parameter to determine the dimension of the pond is BOD loading per pond area and depth of pond. Since biological reaction is highly dependent on the temprature, this parameter is greatly affected by temperature. Thus, selection of proper design temperature is of importance. In the Project Area, mean temperature of the coldest month is around 22°C based on the data obtained from Meteorological Department. (Ref. to Section 2.1.3. Climate) Taking into account the minimum fluctuation of temparature through a year, temperature of 22°C is considered to be appropriate and conservative figure as a design base. A simple empirical equation to calculate BOD loading is proposed by McGarry and Pescod 1/ as follows:

$$L = 20T - 120$$

where

L : BOD loading (kg/ha.day)

T : Temperature (°C)

According to the equation and design temperature of 22°C, BOD loading of 320 kg/ha.day is obtained.

In respect to BOD loading a study was carried out based on data obtained at Wardieburn Waste Stabilization pond in Kuala Lumpur. An analysis of BOD loading and BOD concentration in final effluent revealed no distinct interelation. However, it should be noted that low BOD concentrations in final effluent have recently been recorded under comparatively high BOD loading, for instance more than 400 kg/ha.day, indicating that stabilization pond can be operated satisfactorily under high BOD loading. Details of this study are contained in Appendix E.

1/ Mara, David Duncan, "Sewage Treatment in Hot Climate"

The range of depths most commonly used for facultative pond is 1 to 1.5 m. Depths less than 1 m do no prevent the emergence of vegetation. This must be avoided to prevent pond from becoming a breeding ground for mosquitos and midges. Pond becomes predominantly anaerobic rather than predominantly aerobic if the depth is more than 1.5 m. This condition is also undesirable for the nomal function of the facultative pond. Sharrow depth of pond requires more surface area in a certain necessary retention time. Therefore, maximum allowable depth of 1.5 m is considered to be appropriate.

b) Aerated Lagoon

There are two types of aerated lagoon, namely aerated facultative (partial mix) ponds and aerated aerobic (complete mix) ponds. In aerated facultative ponds, only upper zone is aerated by diffusers or mechanical aerators, and the lower facultative and/or anaerobic zones are relatively undisturbed. On the other hand, aerated aerobic ponds keep all of the solids in suspension by the same mechanical equipment as in the former one.

The facultative type of aerated lagoon is more commonly used than the aerobic for several reasons:

i) Separate sludge handling facilities are not required for aerated facultative ponds.
ii) Aeration equipment is much smaller because complete mix scouring velocities are not required in aerated facultative ponds.
iii) Less operational control is required in aerated facultative ponds.
iv) Less oxygen is required because some of the BOD is satisfied anaerobically in aerated facultative ponds.
v) Extended-aeration, activated sludge or oxidation ditch systems are usually more cost effective than the aerobic aerated system, which requires clarification and sludge handling facilities.

Aerated lagoon system for the Project is recommended to be the aerated facultative ponds, taking the foregoing advantages into account.

Detention time in the aerated facultative ponds should be about 3 to 10 days in warm weather, since the soluble BOD at 20°C is synthesized into cellular material in 2 days and more than 10 days detention time may cause the growth of single cell green algae which have poor settleability. It is advisable to adopt 3 day retention time because of the most suitable temperature for efficient functioning of bacteria and algae in the Project Area.

BOD loading per pond area is usually 5 to 10 times that of non-aerated pond, that is approximately 1,500 to 3,000 kg/ha.day based on the recommended BOD loading of 320 kg/ha.day for the non-aerated facultative ponds. Depth of the ponds most commonly used is 3 to 5 m.

At Pantai Wastewater Treatment Plant, in Kuala Lumpur, a pilot plant of aerated lagoon is under construction. After completion of construction, this pilot plant is expected to be operated for various experimental purposes. Therefore, more accurate design paramenters for the aerated lagoon will be obtained for the Project, since the climate and other conditions, such as the nature of sewage, are considered to be identical with that in Kuala Lumpur.

C) Oxidation Ditch

The oxidation ditch is a modification of the conventional activated sludge process and usually serves for relatively small community. Designs of the oxidation ditch are purely empirical at the present time. The depth is in the range of 1 - 2 m and volume is dependant on the retention time which in tern is based on the sludge loading factor Ls. Sludge loading factor is calculated by the following equation.

$$Ls = \frac{LiQ}{SV}$$

or

$$Ls = \frac{Li}{St}$$

where

Ls : Sludge loading factor (day^{-1})

Li : Influent BOD concentration (mg/ℓ)

Q : Flow rate (m^3/day)

S : Ditch liquor suspended solids concentration (mg/ℓ)

V : Ditch volume (m^3)

t : Retention time (day)

Design values commonly used in Europe are Ls = 0.05 day^{-1} and S = 4,000 mg/ℓ. However, in the tropics, much higher loadings can be applied resulting in smaller volume of the ditch. BOD loading to 0.1 - 0.3 day^{-1} is proposed for India by Duncan Mara.2/ Taking into account the similarity of temperature, higher BOD loading can be adopted in the Project Area.

The main items, those discussed above and other items, on which design of treatment facilities in the Project Area is based are tabulated in Tables 4.18 through 4.20.

2/ Mara, David Duncan, "Sewage Treatment in Hot Climate"

Table 4.18. Design Basis of Stabilization Pond

Items	Design Value
Scum Chamber	Depth = 1.5 - 2.5 m
Retention Time	= 5 min
Facultative Pond	
Surface BOD Loading	= 320 kg/ha/day
Depth	= 1.5 m - 2.0 m
Maturation Pond	
Retention Time	= 3 days
Depth	= 1.5 m - 2.0 m
Expected Effluent Quality	
BOD	less than 50 mg/ℓ
Fecal Coliform	less than 100,000 N/100 mℓ

Table 4.19. Design Basis of Aerated Lagoon

Items	Design Value
Scum Chamber	Depth = 1.5 m
Retention Time	= 5 min
Aerated Lagoon	
Surface BOD Loading	= 1,500 kg/ha/day
Depth	= 3.0 m - 5.0 m
Maturation Pond	
Retention Time	= 3 days
Depth	= 1.5 m - 2.0 m
Expected Effluent Quality	
BOD	less than 50 mg/ℓ
Fecal Coliform	less than 100,000 N/100 mℓ

Table 4.20. Design Basis of Oxidation Ditch

Items	Design Value
Sludge Loading Factor	= 0.2 d^{-1}
Suspended Solids Concentration	= 4,000 mg/ℓ
Depth	= 1.5 m - 2.0 m
Sedimentation Basin	
Retention Time	= 2 hr
Chlorination Tank	
Retention Time	= 15 min
Area of Drying Beds	= 0.10 m^2/m^3/day
Expected Effluent Quality	
BOD	less than 50 mg/ℓ
Fecal Coliform	less than 100,000 N/100 mℓ

4.6. Basis of Cost Estimates

4.6.1. Unit Cost

Information and data on basic costs, including labor and material costs, as well as some unit construction cost, have been collected from various sources such as MPK, DID, JKR, manufacturers, suppliers of equipment and materials and contractors. All cost obtained from the sources referred to above are expressed at 1981 price level in Malaysia. Using these basic cost, unit construction cost have been developed with due consideration for the suitability of materials and construction methods, including availability of local materials and ability of local contractors.

The labor cost and the prices of basic materials are presented in Table 4.21 and 4.22 respectively. Unit construction cost estimates, including contractor's profit, overhead, relevant customs tax, surtax and sales tax, are presented in Table 4.23.

Table 4.21. Labor Cost

Type of Labor	Labor Cost per Day (8 hours) (M$/day)
Common Laborer	17.0
Skilled Laborer	24.0
Welder	27.0
Mason	27.0
Carpenter	27.0
Mechanic	27.0
Brick Layer	28.0
Concrete Worker	28.0
Steel Bender and Fixer	28.0
Painter	28.0
Lorry Driver	30.0
Equipment Operator	35.0
Foreman	45.0

Table 4.22. Price of Basic Materials

Item	Description	Unit	Price (M$)
Cement		t	196.18
Sand		m^3	11.00
Laterite		"	3.00
Aggregate	9-13 mm	"	35.00
"	25-38 mm	"	31.00
Crusher-run		"	25.00
Diesel Oil		litre	0.46
Light Oil		"	0.50
Timber	Grade A	m^3	210.00
"	" B	"	260.00
H-shape Beam		t	1,100.00
Sheet Pile		"	1,034.43
V.C. Pipe	ϕ 225 mm	m	43.40
" "	ϕ 300 "	"	109.42
Concrete Pipe	ϕ 375 "	"	90.81
" "	ϕ 450 "	"	115.38
" "	ϕ 525 "	"	131.40
" "	ϕ 600 "	"	149.31
" "	ϕ 675 "	"	220.95
" "	ϕ 750 "	"	244.70
" "	ϕ 900 "	"	313.70
" "	ϕ 1,050 "	"	401.93
" "	ϕ 1,200 "	"	460.00

Table 4.23. Unit Cost

Item	Description	Unit	Rate (M$)
Excavation	Backhoe	m^3	1.61
"	Clamshell	"	7.08
"	Manual	"	9.89
Soil Trans-portation	Dump Truck 11 t	"	3.91
Backfilling	Sand	"	36.60
"	Excavated Soil	"	5.04
Spreading & Compaction of Soil	Bulldozer	"	1.36
Timber Sheeting	ℓ = 2.0 m	m	5.67
" "	ℓ = 2.5 m	"	7.62
" "	ℓ = 3.0 m	"	9.57
" "	ℓ = 3.5 m	"	11.49
Steel Sheet Piling Work	LSP II ℓ = 3.5 m	"	118.92
" " " "	" " ℓ = 4.0 m	"	129.12
" " " "	" " ℓ = 4.5 m	"	137.61
" " " "	SP II ℓ = 5.0 m	"	172.61
" " " "	" " ℓ = 6.0 m	"	200.22
" " " "	" " ℓ = 7.0 m	"	225.51

Table 4.23. (cont.)

Item	Description	Unit	Rate (M$)
Steel Sheet Piling Work	SP II ℓ = 8.0 m	m	250.84
" " " "	" " ℓ = 9.0 m	"	280.76
" " " "	SP III ℓ = 15.0 m	"	475.00
Attaching & Detaching of Steel Work		t	256.55
Redemption of Steel Materials	H-shape	t/day	11.48
" " " "	LSP	"	2.05
" " " "	SP	"	0.95
Maintenance Cost for Steel	H-shape	t	88.95
" " " "	LSP-II	"	54.62
" " " "	SP-II	"	84.61
" " " "	SP-III	"	80.37
Steel Bars	φ 13 mm and below	"	1,735.81
" "	φ 16 mm and above	"	1,653.16
Concrete	1 : 1½ : 3	m^3	243.51
"	1 : 2 : 4	"	233.11
"	1 : 3 : 6	"	218.81
Timber Forming		m^2	14.28

Table 4.23. (cont.)

Item	Description	Unit	Rate (M$)
Bedding	Sand	m^3	36.60
"	Crusher-run	"	81.54
Restoring	Asphalt Paving	m^2	48.12
Masonry	Granite 30 cm	"	38.08
Pile Driving	18"x18", 30 m	No	224.58
Dewatering	5.5 kW, ϕ100 mm	day	58.54

4.6.2. Sewer Construction Cost

Taking into account the soft foundation, which is composed of soft or very soft silty-clay, and the high groundwater level encountered in most parts of the Project Area, sheet piling may be required for the excavation work. In this case, the following types of sheeting are assumed, depending on the excavation depth, in order to estimate construction cost.

Excavation	Type of Sheeting
Down to 3 m	Timber Sheeting
3 m - 5 m	Light-weight Steel Pile
5 m and below	Steel Pile

The average gravity sewer construction cost per meter is estimated, depending on pipe size and depth to invert as shown in Table 4.24, including the cost for pipes, excavation, sheeting, dewatering, bedding, restoration of paving, along with contractor's profits and overhead. These costs also include cost for manholes, on the assumption that the cost of manholes is 15 percent of that of sewers.

Table 4.24. Unit Sewer Construction Cost

(Unit: M$/m at 1981 price level)

Diameter (mm)	Depth to Invert (m)						
	2.0	3.0	4.0	5.0	6.0	7.0	8.0
225	150	166	797	1,111	1,413	1,701	1,976
300	268	286	902	1,250	1,577	1,885	2,176
375	236	242	828	1,149	1,466	1,779	2,088
450	273	281	876	1,214	1,546	1,874	2,197
525	316	326	926	1,282	1,631	1,975	2,312
600	365	378	979	1,354	1,721	2,081	2,433
675	422	438	1,036	1,430	1,815	2,192	2,560
750	488	508	1,095	1,510	1,915	2,310	2,694
900	653	683	1,225	1,685	2,131	2,564	2,984
1,050	874	918	1,370	1,880	2,372	2,847	3,304
1,200	1,169	1,235	1,532	2,097	2,640	3,160	3,659

CHAPTER 5

PROPOSED SEWERAGE SYSTEM AND CONSTRUCTION COST

CHAPTER 5 PROPOSED SEWERAGE SYSTEM AND CONSTRUCTION COST

5.1. Comparison of Alternative Treatment Processes

Taking into account the advantages and disadvantages of the secondary treatment processes discussed in the last chapter, comparison of construction cost and operation and maintenance cost for three processes is considered.

In order to compare the cost of the three alternative treatment processes proposed, the design of the treatment plant is based on daily average flows of 7,000 m^3, 25,000 m^3 and 33,000 m^3. Designs for the nine treatment plants and details of their respective cost estimations are presented in Appendix F, Vol. IV.

The cost of each selected alternative method is presented at 1981 price level. It is assumed that all civil works can be done by Malaysian contractors, with unit cost presented in Chapter 4, Section 4.6. It is also assumed that most of the mechanical and electrical equipment will be imported. Regarding operation and maintenance cost, each component of the cost; namely, labor, electricity and repair, is estimated based on requirement.

The results of the estimation are tabulated in Tables 5.1 and 5.2. Table 5.1 shows total construction cost, operation and maintenance cost and land acquisition cost for all cases concerning capacity for the three alternative processes. On the other hand, Table 5.2 shows the annual cost calculation for each cost listed in Table 5.1. Allowances for depreciation for the calculations are assumed to be based on 30 years for civil and architectural works and 15 years for mechanical and electrical equipment, but depreciation allowance is excluded for calculation of land acquisition cost. Interest rate is assumed to be 10 percent.

As regards the construction cost, for daily average flow of 7,000 m^3/day, the stabilization pond process is the least costly. However, for

25,000 m^3/day and 33,000 m^3/day daily average flow, the aerated lagoon is the least expensive process. The oxidation ditch is the most expensive for each of the three daily average flow rates.

Concerning operation and maintenance cost at each daily average flow rate, the oxidation ditch process requires the highest cost, while the stabilization pond has the lowest cost requirement among the three processes. Annual operation and maintenance cost are approximately one to two percent for the stabilization pond, five to seven percent for the aerated lagoon and five to six percent for the oxidation ditch, against construction costs.

The unit price of land varies depending on the location from 10.3 to 30.1 M\$/m^2 in the Project Area, according to data obtained from Municipal and State Government departments concerned. While oxidation ditch requires the least cost for land acquisition, it is noted that the cost for land amounts to a considerable expenditure in the total cost of sewerage construction work. For the purpose of cost comparison, unit price of 20 M\$/m^2 is adopted as a representative figure.

As shown in Table 5.2, oxidation ditch is the most expensive process in each of the three daily average flow rates among the three alternative processes, followed by aerated lagoon process, while stabilization pond is the least expensive process. However, it should be noted that the difference in annual cost among the three processes becomes smaller with increase in daily flow rate and especially in the case of daily average flow rate of 33,000 m^3/day, the difference between stabilization pond and aerated lagoon is almost negligible. Therefore, it is expected that in the Project Area where land price is relatively high, the larger the treatment plant (e.g., more than 33,000 m^3/day) or the higher the price of land (e.g., more than 20 M\$/m^2), the more preferable the aerated lagoon process becomes.

Table 5.1. Cost Comparison of Selected Alternative Treatment Process

Alternative Process		Daily Average Flow (m^3/day)		
		a) 7,000	b) 25,000	c) 33,000
1) Construction Costs (M$1,000)				
Alt. I Stabilization Pond Process		5,400	11,400	15,720
	C + A	(4,080)	(9,900)	(13,720)
	M + E	(1,320)	(1,500)	(2,000)
Alt. II Aerated Lagoon Process		5,700	8,550	11,650
	C + A	(3,900)	(5,800)	(7,970)
	M + E	(1,800)	(2,750)	(3,680)
Alt. III Oxidation Ditch Process		6,580	11,100	16,760
	C + A	(3,700)	(6,860)	(10,760)
	M + E	(2,880)	(4,240)	(6,000)
2) Operation & Maintenance Costs (M$1,000/year)				
Alt. I Stabilization Pond Process		82	138	199
Alt. II Aerated Lagoon Process		302	625	771
Alt. III Oxidation Ditch Process		337	636	936
3) Land Acquisition Costs (M$1,000)				
Alt. I Stabilization Pond Process		2,000	4,400	6,400
Alt. II Aerated Lagoon Process		600	2,000	2,800
Alt. III Oxidation Ditch Process		400	600	1,000

Note: In construction cost, C + A represents civil and architectural works component and M + E that of mechanical and electrical works.

Unit cost of land is M$20/$m^2$ in all cases.

Table 5.2. Comparison of Annual Cost

(Unit: M$1,000/year)

Process	Daily Average Flow (m^3/day)	Depreciation		Interest	Operation and Maintenance Cost	Total
		Civil and Architectural	Mechanical and Electrical			
Stabilization Pond	7,000	24	42	538	82	686
	25,000	60	47	1,149	138	1,394
	33,000	83	63	1,609	199	1,954
Aerated Lagoon	7,000	24	57	458	302	841
	25,000	35	87	767	625	1,514
	33,000	48	116	1,051	771	1,986
Oxidation Ditch	7,000	22	91	507	337	957
	25,000	42	133	851	636	1,662
	33,000	65	189	1,291	936	2,481

5.2. Proposed Sewerage System

5.2.1. Selection of Treatment Plant Site and Treatment Process

Since large areas are required for treatment plant and location of the sites affects overall sewerage facilities planning, selection of the treatment site is of great importance. Also, as mentioned in Section 5.1., selection of the treatment process depends on the availability of the land as well as the price of land.

It is evident that location of the treatment plant should be as close as possible to the center of each zone for the sake of economy in wastewater collection and ease of operation. Since it requires sizable investment and procedure for requisition of required land space, early consideration is necessary.

Desirable sites from the engineering viewpoint were therefore studied and submitted for consideration to the Municipal authorities for ascertaining availability of the required land. The agreed locations after certain modification are shown in Fig. 5.2 and available land space and unit price of land for each treatment plant is shown in Table 5.3.

According to information obtained from Kelang Municipality, no land is available within or near Port Kelang, Zone-2. Therefore, wastewater generated in this zone should be conveyed to the neighboring Port Kelang, Zone-1 or Zone-3.

Table 5.3. Available Land Space for Treatment Plant

Treatment Plant No.	Sewerage District	Zone	Land Space (ha)	Unit Price of Land (M$/$m^3$)	Treatment Process *
1	Kelang North	Zone-1	13	26.9	A.L.
2		Zone-2	17	26.9	A.L.
3	Kelang South	Zone-1	11	30.1	A.L.
4		Zone-2	15	26.9	A.L.
5	Port Kelang	Zone-1	12	12.9	A.L.
6		Zone-2 and Zone-3	16	21.5	A.L.
7-a	North Port	Zone-1	3	12.9	S.P.
7-b		Zone-2	3	12.9	S.P.
8	Kapar		14	12.9	S.P.
9	Meru		11	10.8	S.P.

* A.L. = aerated lagoon
S.P. = stabilization pond

Taking into account the availability of land space and price of land at each possible site, aerated lagoon is considered to be the appropriate process by the year 2000 for those sewerage zones which have larger wastewater quantity and higher land price. On the other hand, for sewerage zones with small wastewater quantity and lower land price, stabilization pond is recommended. However, at an earlier stage of operation while sewage flow is considerably smaller than planned, construction of stabilization pond should be considered for those sewerage zones where aerated lagoon is recommended, because of low construction cost and ease of operation. The stabilization pond will be modified to aerated lagoon at a later stage, according to sewage flow increase.

5.2.2. Selection of Trunk Sewer Routes and Pumping Station Sites

Due to flat terrain of the Project Area and the limited availability of the land for treatment plant, installation of a number of pumping stations is unavoidable. When depth to invert reaches the neighborhood of 8 m, a pumping station should be provided to avoid the excessive extra cost of laying deep sewers.

Proposed trunk sewer routes and location of pumping stations are selected based on the following considerations:

1) Topographical condition
2) Required minimum number of pumping stations and availability of land for the purpose
3) Cost of investment required
4) Availability of land for trunk sewers
5) Road and traffic condition

As mentioned in the previous section, sewage in Port Kelang, Zone-2 should be conveyed to either Zone-1 or Zone-3. An alternative study was conducted to seek a better scheme. The estimated construction cost of two alternatives is based on preliminary engineering design, the layout plan for which is shown in Fig. 5.1, and estimates are shown in Table 5.4.

Since the construction cost of the two alternatives are almost the same, advantages and disadvantages concerning other aspects are taken into account. Alternative-2 is recommended because for the following reasons:

1) Results of the priority evaluation, described in Chapter 6, indicate higher priority for Zone-1 than for Zone-2 and Zone-3, both of which have the same priority rank. Thus, Zone-1 should be provided with sewerage independently from Zone-2 to avoid higher initial investment.

2) Number of pumping stations required is three for Alternative-2, which is one less than that for Alternative-1. Reduction of pumping stations is desirable from operation and maintenance viewpoint.

Proposed trunk sewer routes and pumping station locations are indicated in Fig. 5.2 through 5.9. Summary of the pumping station design is shown in Table 5.5. Calculation tables and longitudinal sections of the trunk sewers and details of the pumping stations are presented in Appendix I, Vol. IV. Preliminary Engineering Design.

Fig. 5.1. Two Alternatives in Port Kelang District

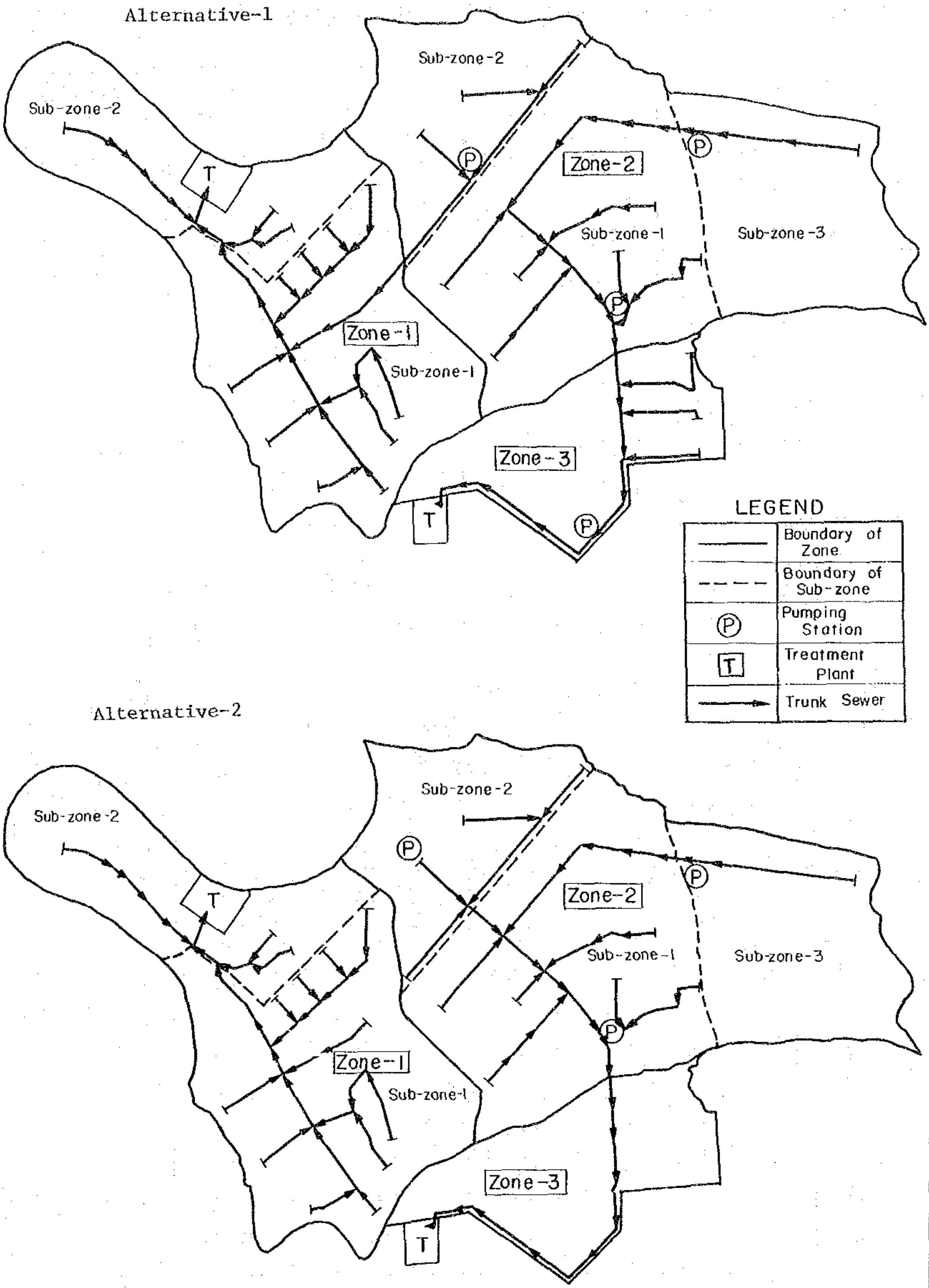


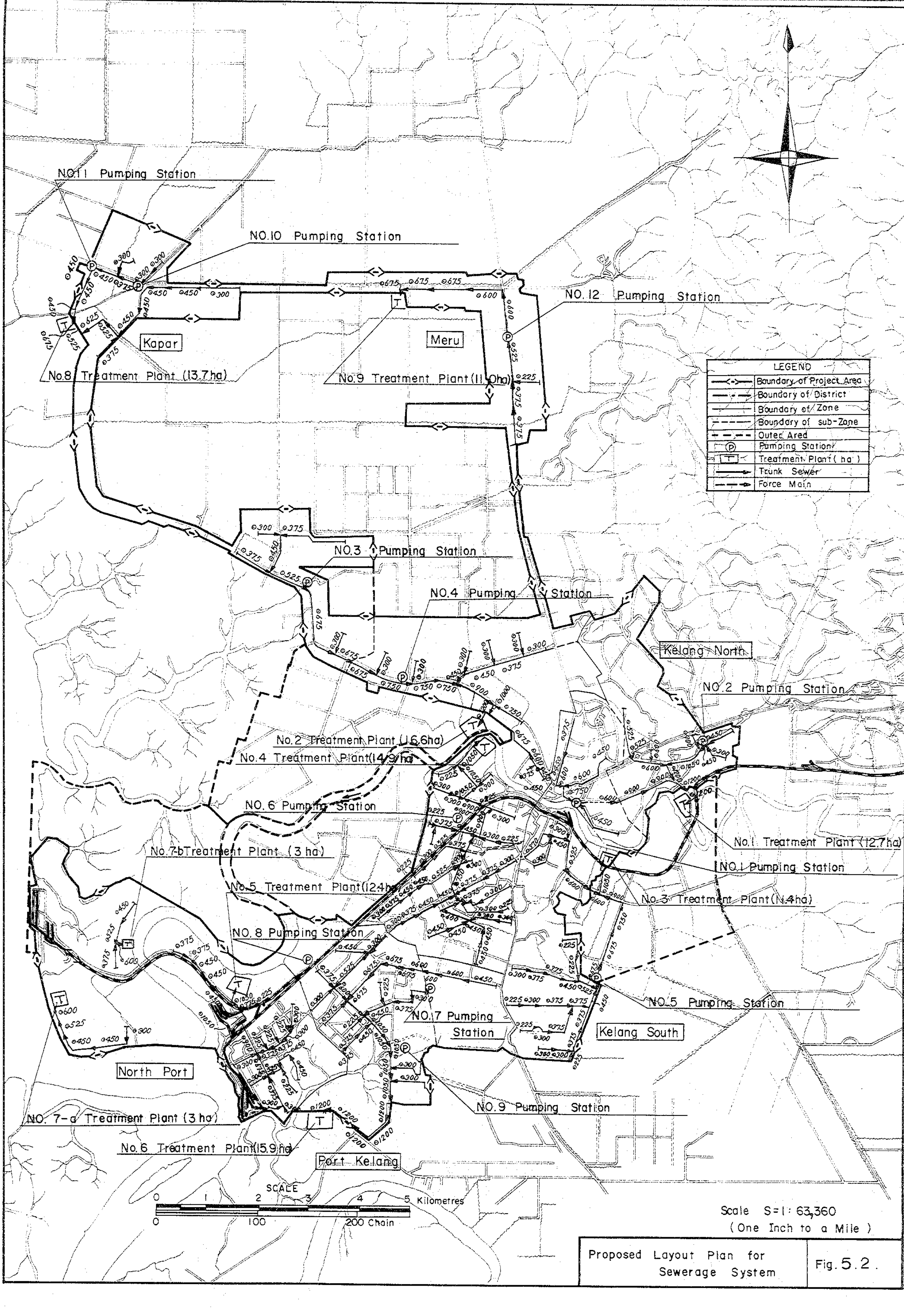
Table 5.4. Construction Cost of Two Alternatives in Port Kelang District

(Unit: M$1 million)

Item	Alternative-1			Alternative-2		
	Zone-1 (Zone-2)	(Zone-2) Zone-3	Total	Zone-1	Zone-2 Zone-3	Total
Trunk Sewer	18.0	21.5	39.5	12.2	28.1	40.3
Pumping Station	0.7	3.3	4.0	-	3.9	3.9
Treatment Plant	11.0	11.0	22.0	8.6	12.5	21.1
Total	29.7	35.8	65.5	20.8	44.5	65.3

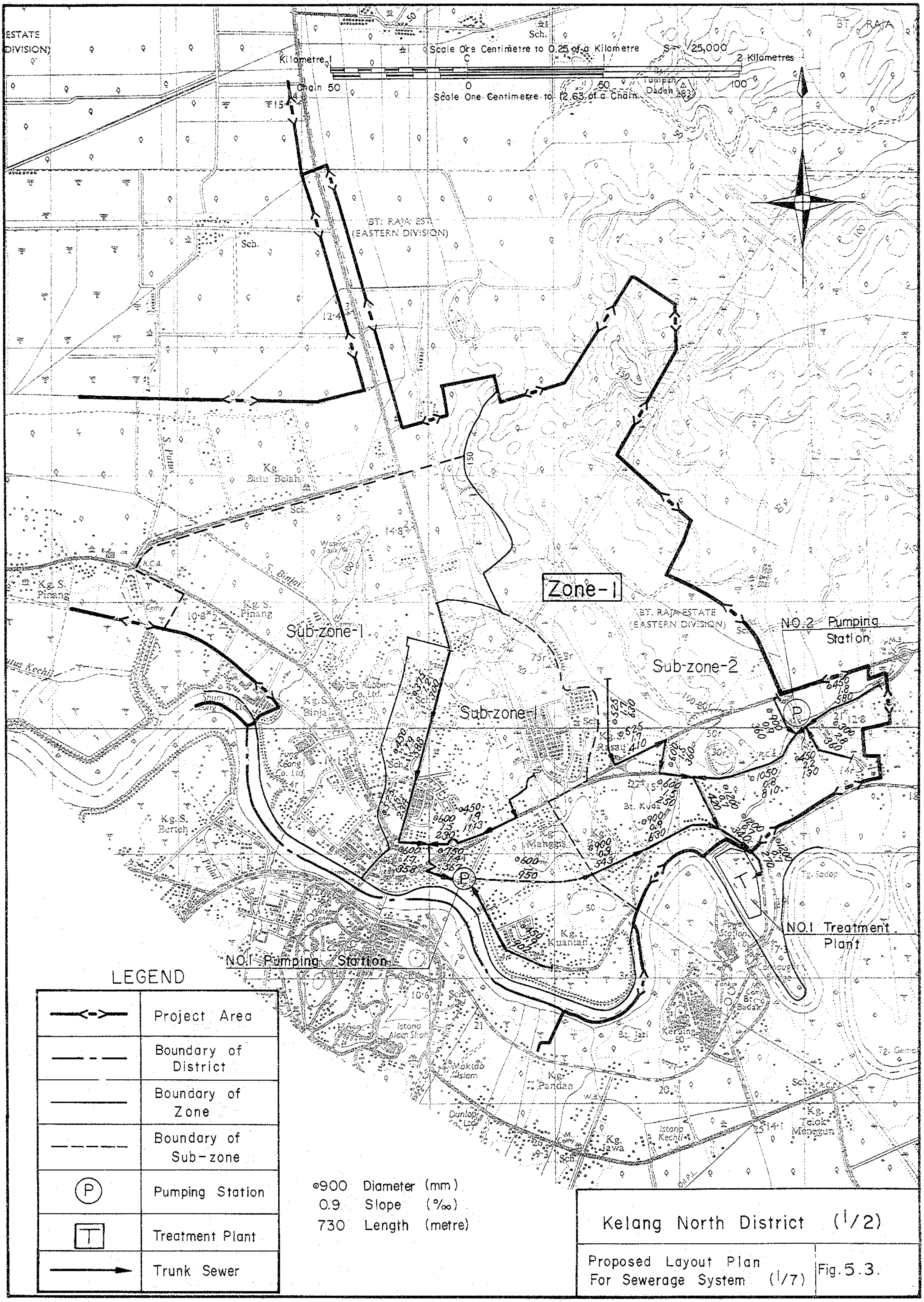
Table 5.5. List of Intermediate Pumping Stations

No.	Sewerage Division District, Zone	Peak Flow (m^3/day)	Required Land Space (m^2)	Pumps		Total Head (m)
				Diameter (mm)	No.	
1	Kelang North, Z-1	0.518	350	300	3	15
2	" " , Z-1	0.489	380	500	2	13
3	" " ; Z-2	0.126	210	250	2	12
4	" " , Z-2	0.255	270	300	2	11
5	Kelang South, Z-1	0.326	300	400	2	10
6	" " , Z-2	0.730	480	500	2	11
7	Port Kelang, Z-2	0.250	265	400	2	11
8	" " , Z-2	0.223	255	300	2	9
9	" " , Z-2	0.812	500	650	2	10
10	Kapar	0.072	185	200	2	14
11	"	0.096	195	200	2	12
12	Meru	0.091	195	200	2	11



Proposed Layout Plan for Sewerage System

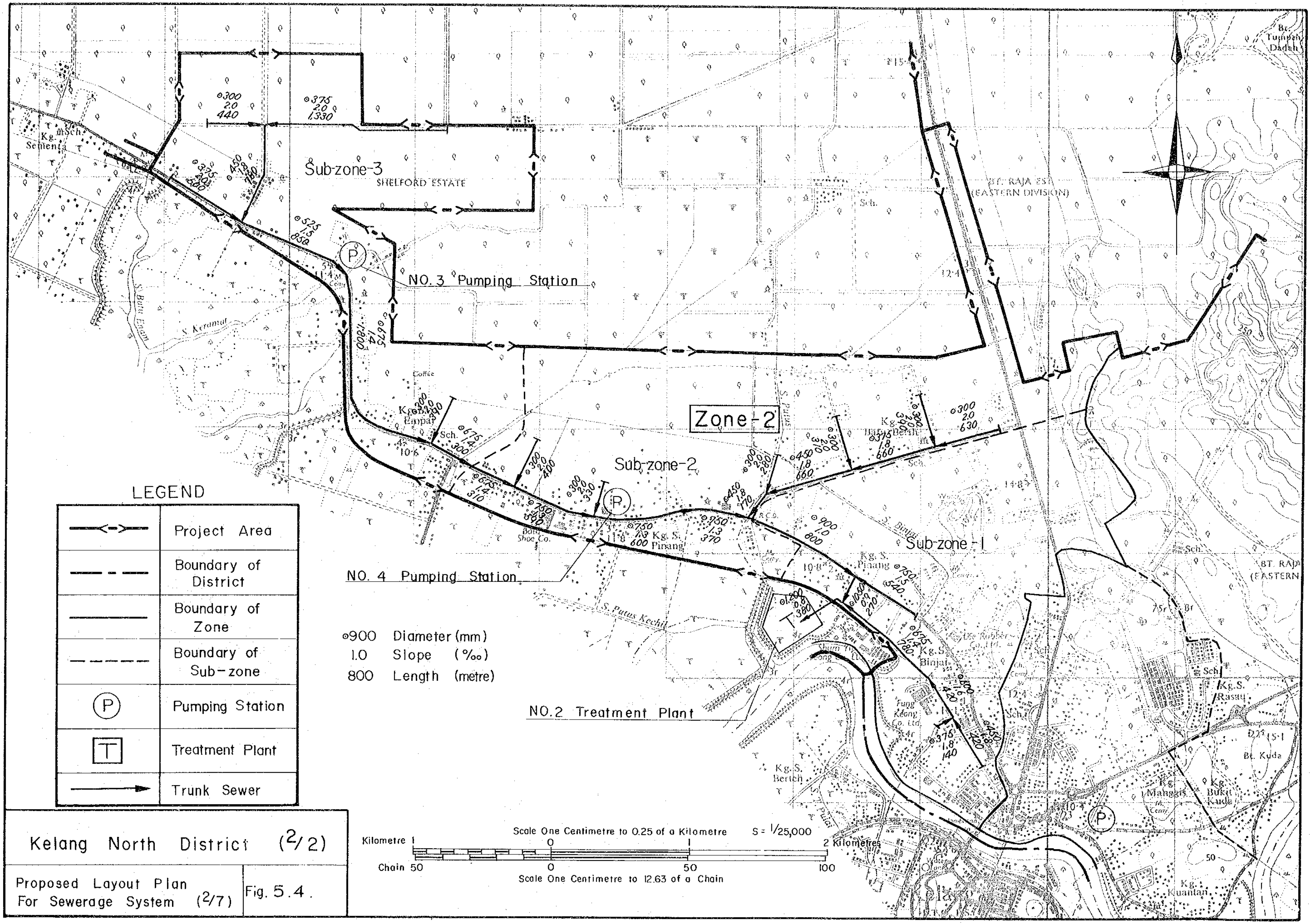
Fig. 5.2.



Kelang North District (1/2)

Proposed Layout Plan For Sewerage System (1/7)

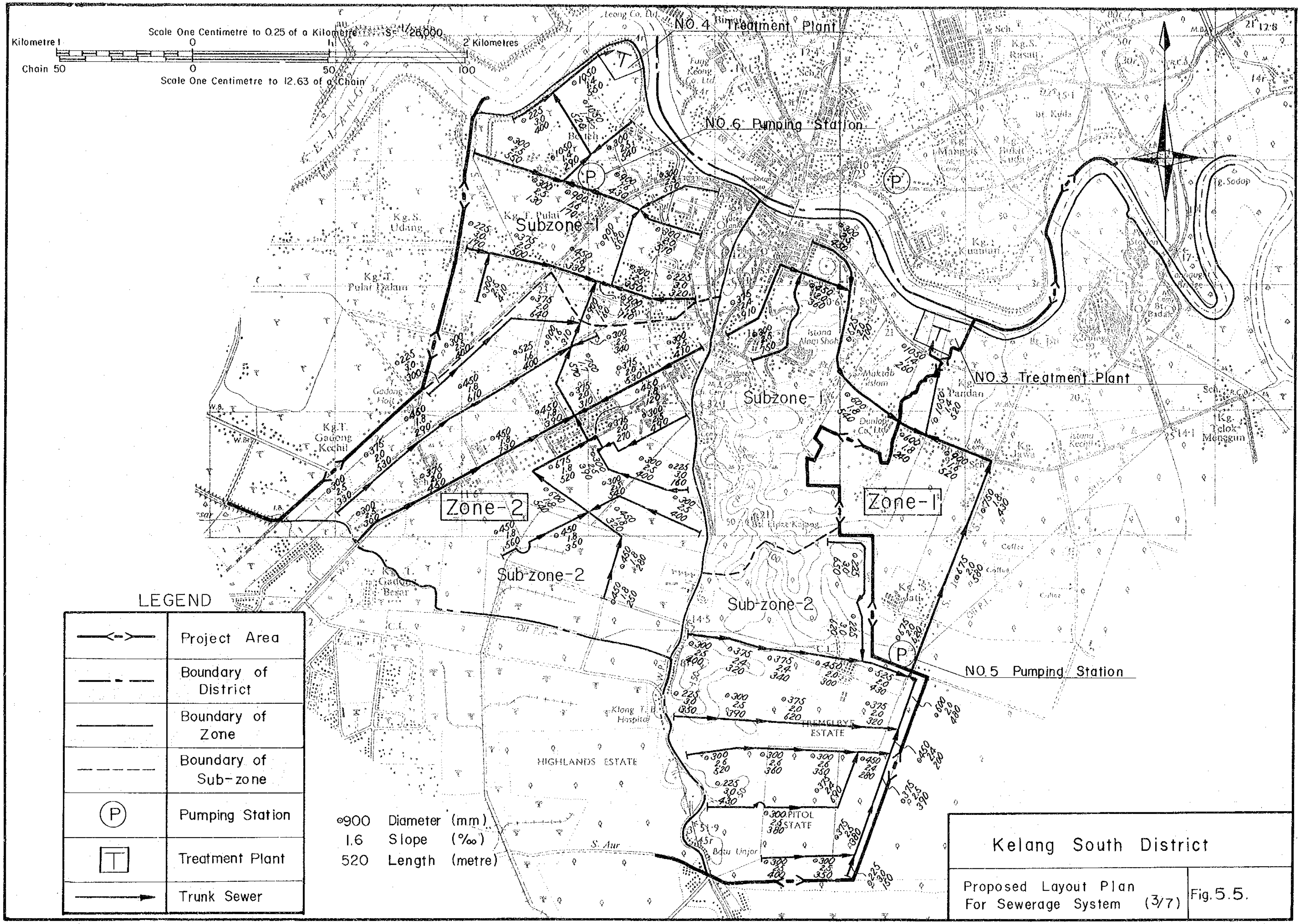
Fig. 5.3.

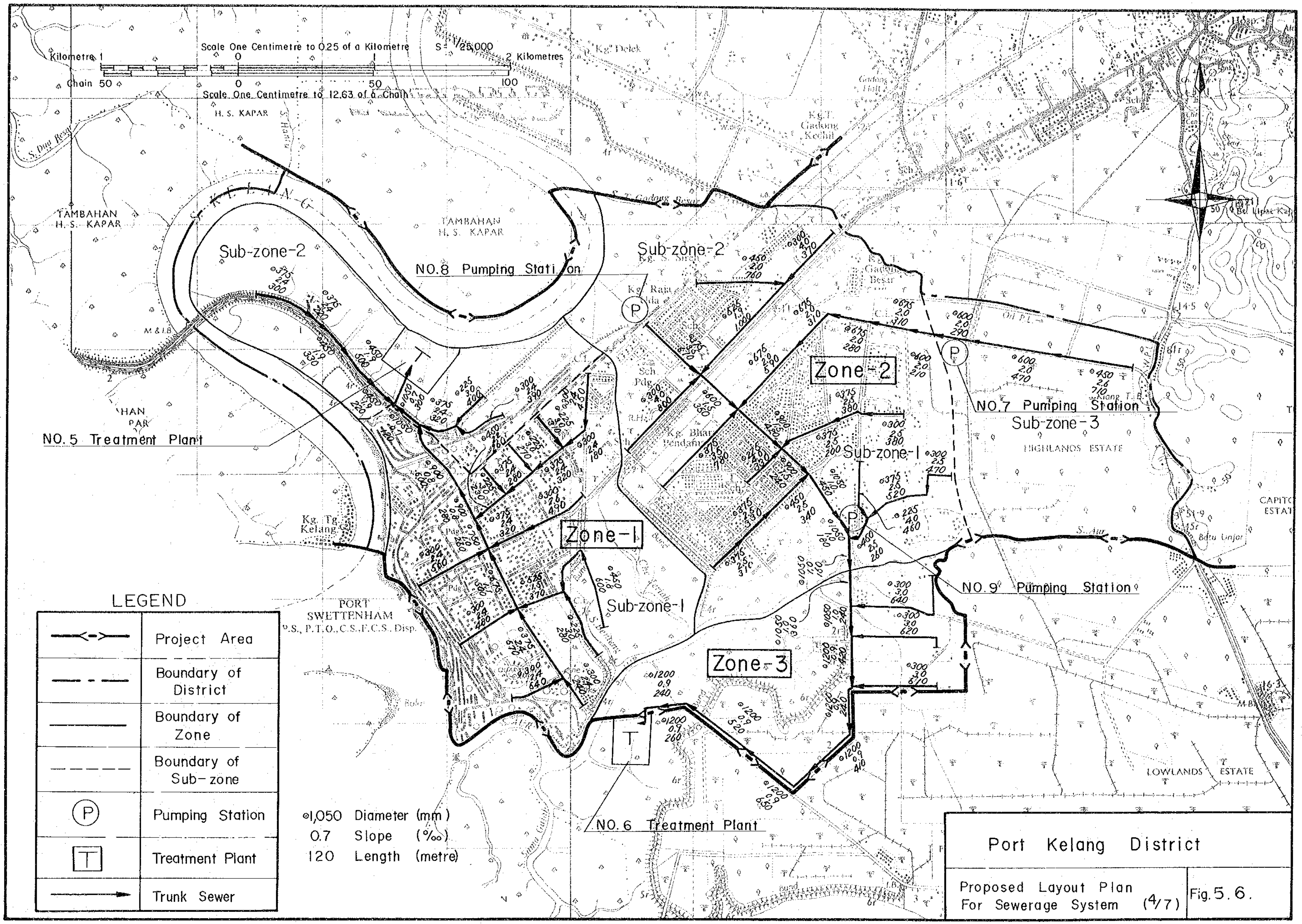


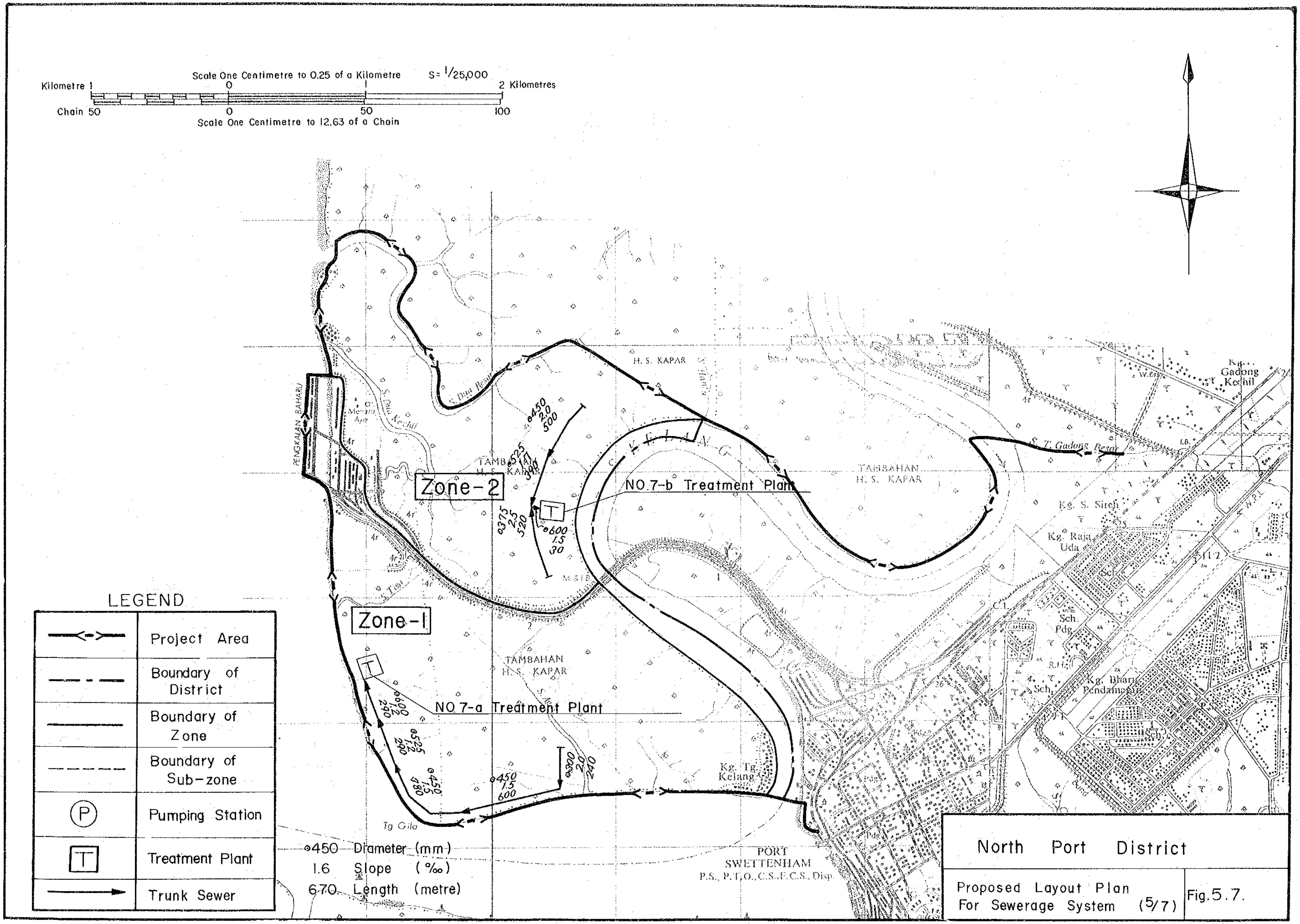
Kelang North District (2/2)

Proposed Layout Plan For Sewerage System (2/7)

Fig. 5.4.


Scale One Centimetre to 0.25 of a Kilometre
Kilometre 1 0 1 2 Kilometres
Chain 50 0 50 100
Scale One Centimetre to 12.63 of a Chain
NO.4 Treatment Plant
NO.6 Pumping Station
NO.3 Treatment Plant
NO.5 Pumping Station
Subzone-1
Subzone-1
Zone-2
Zone-1
Sub-zone-2
Sub-zone-2
LEGEND
Project Area
Boundary of District
Boundary of Zone
Boundary of Sub-zone
Pumping Station
Treatment Plant
Trunk Sewer
⌀900 Diameter (mm)
1.6 Slope (‰)
520 Length (metre)
Kelang South District
Proposed Layout Plan For Sewerage System (3/7)
Fig.5.5.

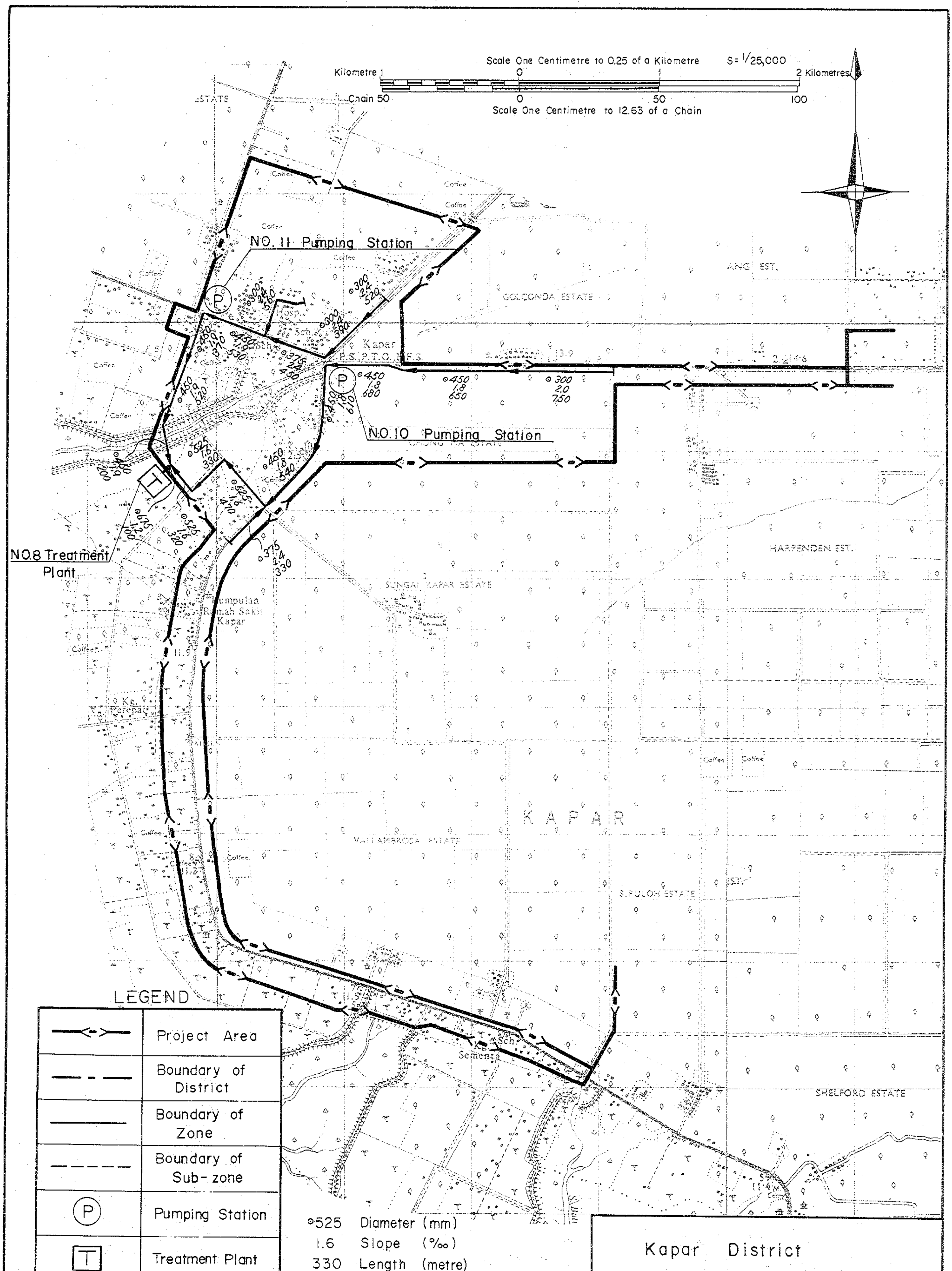

Scale One Centimetre to 0.25 of a Kilometre
S= 1/25,000
Kilometre 1
0
1
2 Kilometres
Chain 50
0
50
100
Scale One Centimetre to 12.63 of a Chain
H. S. KAPAR
TAMBAHAN
H. S. KAPAR
TAMBAHAN
H. S. KAPAR
Kg. Delek
Kg. T. Gadong Kechil
Sub-zone-2
Sub-zone-2
NO.8 Pumping Station
NO.5 Treatment Plant
Zone-2
NO.7 Pumping Station
Sub-zone-3
HIGHLANDS ESTATE
Sub-zone-1
Zone-1
Kg. Tg. Kelang
Sub-zone-1
NO.9 Pumping Station
PORT SWETTENHAM
Zone-3
NO.6 Treatment Plant
LOWLANDS ESTATE
CAPITOL ESTATE
LEGEND
Project Area
Boundary of District
Boundary of Zone
Boundary of Sub-zone
Pumping Station
Treatment Plant
Trunk Sewer
⌀1,050 Diameter (mm)
0.7 Slope (‰)
120 Length (metre)
Port Kelang District
Proposed Layout Plan
For Sewerage System (4/7)
Fig. 5.6.



North Port District

Proposed Layout Plan For Sewerage System (5/7)

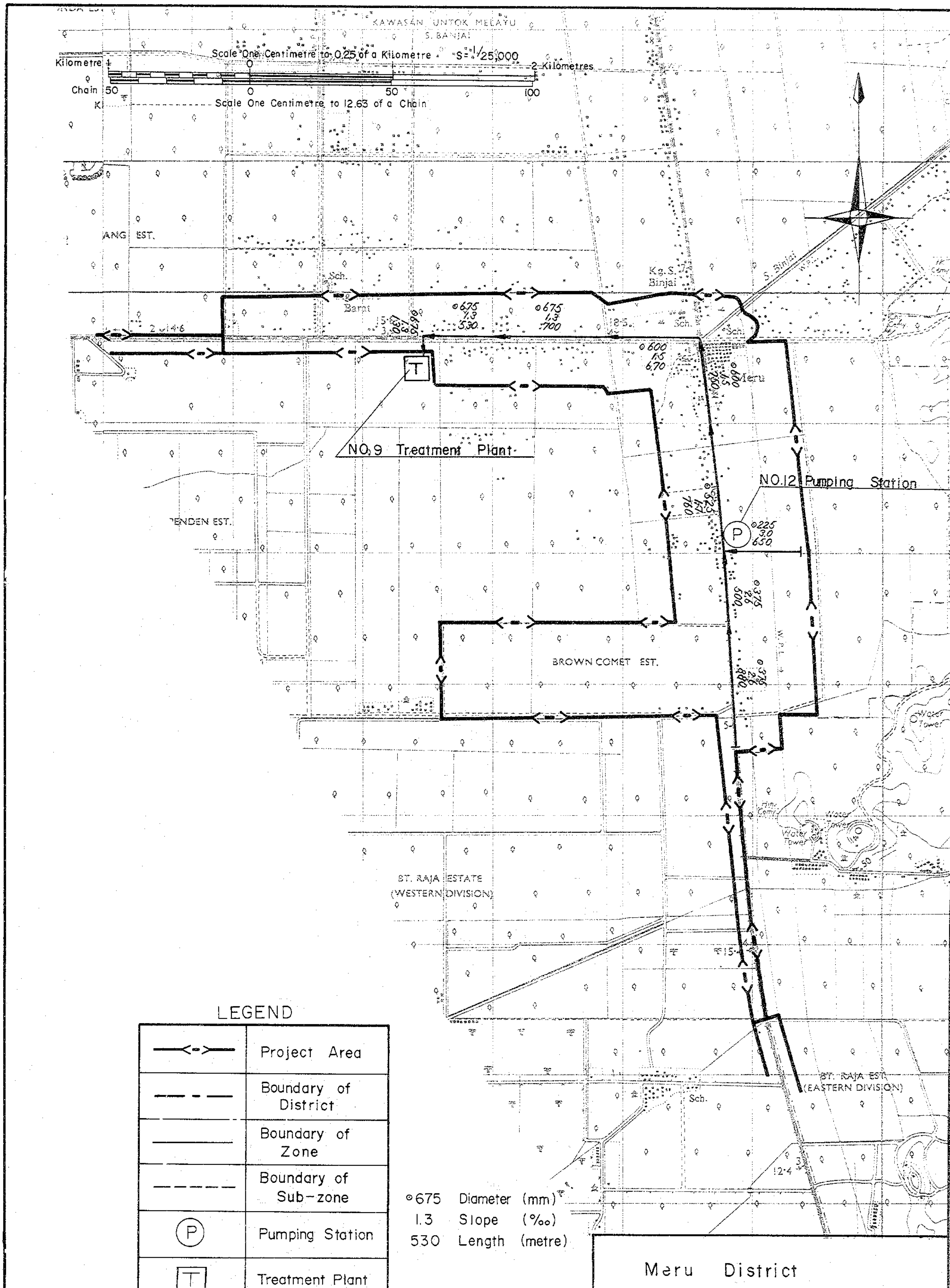
Fig.5.7.



Kapar District

Proposed Layout Plan For Sewerage System (6/7)

Fig. 5.8.



Meru District

Proposed Layout Plan For Sewerage System (7/7)

Fig. 5.9.

5.3. Estimated Construction Cost

5.3.1. Construction Cost

Construction cost for all sewerage facilities, such as trunk sewers, branch and lateral sewers, house connections, pumping stations and treatment plants are estimated based on the following procedure. All costs are presented at 1981 price level.

1) Sewers

a) Trunk Sewers

Profiles of all trunk sewers shown in Fig. 5.2 are designed (Ref.: Appendix I, Vol. IV) and cost function for sewer construction is developed. Cost for trunk sewers is estimated based on the design and cost function thus developed (Ref.: Appendix H, Vol. IV).

b) Branch and Lateral Sewers

For estimating construction cost of branch and lateral sewers which is not shown in Fig. 5.2, each total length of sewers by sizes obtained from preliminary engineering design is used. Two typical residential areas and one commercial area considered to represent an average future condition are selected to work out the average sewer length. Then, the construction cost for all the branch and lateral sewer sizes are estimated, multiplying the unit costs by the lengths. For the other land use areas; i.e., institutional, industrial and port areas, cost per area for the residential area is modified by average length of roads in each land use area (Ref.: Appendix H, Vol. IV).

c) House Connections

For cost estimation of house connections, cost of a typical house connection facility is estimated, and number of house connections in a unit of each land use area is worked out, using the detailed layout plan of each area (Ref.: Appendix H, Vol. IV).

2) Pumping Stations

Construction cost for all pumping stations are estimated based on the capacity and total head of pumps in each pumping station. Pump type is assumed to be submersible because of the relatively small capacities of proposed pumping stations. It is also assumed that most of the mechanical and electrical equipment will be imported, but material for building and civil works will be locally available in Malaysia. Details of cost estimation are presented in Appendix H, Vol. IV.

3) Treatment Plants

Construction cost for all treatment plants are estimated based on the daily average flow rate and type of process adopted. Four treatment plants for the North Port, Zone-1 and Zone-2, Kapar and Meru districts are planned to be based on the stabilization pond process. Cost of the remaining six treatment plants are estimated on the basis of the aerated lagoon process. Details of the cost estimation are presented in Appendix H, Vol. IV.

5.3.2. Government and Private Contributions

Cost of trunk sewers, pumping stations and treatment plants, together with branch and lateral sewers in the areas already developed, will be borne by the government except for those in North Port district. Branch and lateral sewers in the areas to be developed shall be constructed by the developers concerned as a part of development. After the construction, they are expected to be transferred to the government for maintenance. All cost of house connections shall be provided by the house owner.

Based on the above-mentioned considerations, all costs are divided accordingly into government and private contributions. Construction cost for the entire Project Area are presented in Tables 5.6.

Engineering fee, including detailed design with tender documentation and construction supervision, is included as a separate item at the rate of 15 percent. Contingency cost to cover unforeseen conditions is included in the cost estimates as a separate item at the rate of 20 percent.

Total cost for sewerage facilities covering the whole Project Area is estimated as approximately M$511 million at 1981 price level, of which M$414 million is considered to be government contribution and the rest of M$97 million for private contribution. Since the total served population in the year 2000 is projected to be about 380,000, construction cost per capita is calculated to be M$1,340/capita on the average.

Table 5.6. Construction Cost by Sewerage Zone

(Unit: M$1,000 at 1981 Price Level)

Sewerage District	Zone	Construction Cost				Engineering Fee	Contingency	Land Acquisition	Total	Contributions	
		Sewer	Pumping Station	Treatment Plant	Sub-total					Government	Private
Kelang North	Zone-1	30,084	2,605	14,930	47,619	7,143	10,952	3,444	69,158	60,602	8,556
" "	Zone-2	37,426	1,494	12,460	51,380	7,707	11,817	4,485	75,389	58,444	16,945
Kelang South	Zone-1	29,719	888	12,030	42,637	6,396	9,807	3,441	62,281	58,471	3,810
" "	Zone-2	41,908	1,768	12,030	55,706	8,356	12,812	4,030	80,904	68,841	12,063
Port Kelang	Zone-1	21,877	-	8,550	30,427	4,564	6,998	1,599	43,588	40,607	2,981
" "	Zone-2 Zone-3	49,440	3,870	12,460	65,770	9,866	15,127	3,457	94,220	79,635	14,585
North Port	Zone-1	5,299	-	3,553	8,852	1,328	2,036	800	13,016	-	13,016
" "	Zone-2	3,664	-	4,181	7,845	1,177	1,804	800	11,626	-	11,626
Kapar		15,396	1,124	5,400	21,920	3,288	5,042	1,773	32,023	25,087	6,936
Meru		13,233	582	6,000	19,815	2,972	4,557	1,191	28,535	22,270	6,265
Total		248,046	12,331	91,594	351,971	52,797	80,952	25,020	510,740	413,957	96,783

Note: Engineering Fee = 0.15 x Construction Cost

Contigency = 0.20 x (Construction cost + Engineering Fee)

CHAPTER 6

IMPLEMENTATION SCHEDULE

CHAPTER 6 IMPLEMENTATION SCHEDULE

6.1. Parameters for Determining Priorities

It is the normal procedure that the implementation schedule of the Project is established based on the priorities according to the degree of the needs of the zones and sub-zones. In order to assess such priorities, arbitrary rating procedure is considered appropriate for the Project by assigning reasonable relative weights to five major controlling parameters as follows:

	Parameter	Points assigned
1)	Population density	400
2)	Development condition	200
3)	Waste load generation	200
4)	Excreta disposal system	100
5)	Flood condition	100
	Total	1,000 points

Incidence of water-borne diseases may also be considered to be one of the parameters for evaluation of priority. However, in the Project Area, the cases of water-borne disease are considerably small (Ref.: Section 2.4. Public Health Condition), and this is therefore purposely excluded.

A detailed explanation for each of the above parameters are given below:

1) Population Density

One of the major importance of the sewerage system is the improvement of environment for the welfare of the maximum number of population. It is, therefore, necessary to plan for the provision of sewerage facilities according to the order of density of population. Hence, the highest rank is assigned to it.

2) Development Condition

The condition of development in the Project Area differs according to area and will continue to be different even in the future. Since the urgency of the needs for the sewerage system depends heavily on condition of development. Priority has to be determined with due consideration on the existing and future development plan.

3) Waste Load Generation

The second highest rank is also assigned to waste load generation, due to the fact that no sanitary sewerage system exists in the Project Area to handle the waste load generated. It is, therefore, necessary to assign this item a high priority in order to identify the areas as to the urgency of sewerage facilities.

4) Excreta Disposal System

The existence of facilities for excreta disposal contributes greatly to the sanitary condition of the area concerned. Therefore, due weight of 100 points is given in its rating.

5) Flood Condition

Due to the inadequacy of the existing drainage systems, floods occur frequently. Improvement of sanitary conditions in flood-prone area by provision of an adequate sewerage system, parallel to the improvement of drainage facilities, would undoubtedly be significantly achieved, hence inclusion in the rating system.

6.2. Priority Evaluation Results

The evaluation results concerning all of the sewerage sub-zones are given in Table 6.1 and Fig. 6.1 with assessment points for each of the five items. The highest total points of 705 is marked by Kelang North, Zone-1, Sub-zone-1, followed by Port Kelang, Zone-1, Sub-zone-1, with the second highest mark of 690. The third is Kelang South, Zone-2, Sub-zone-2 with 630 points.

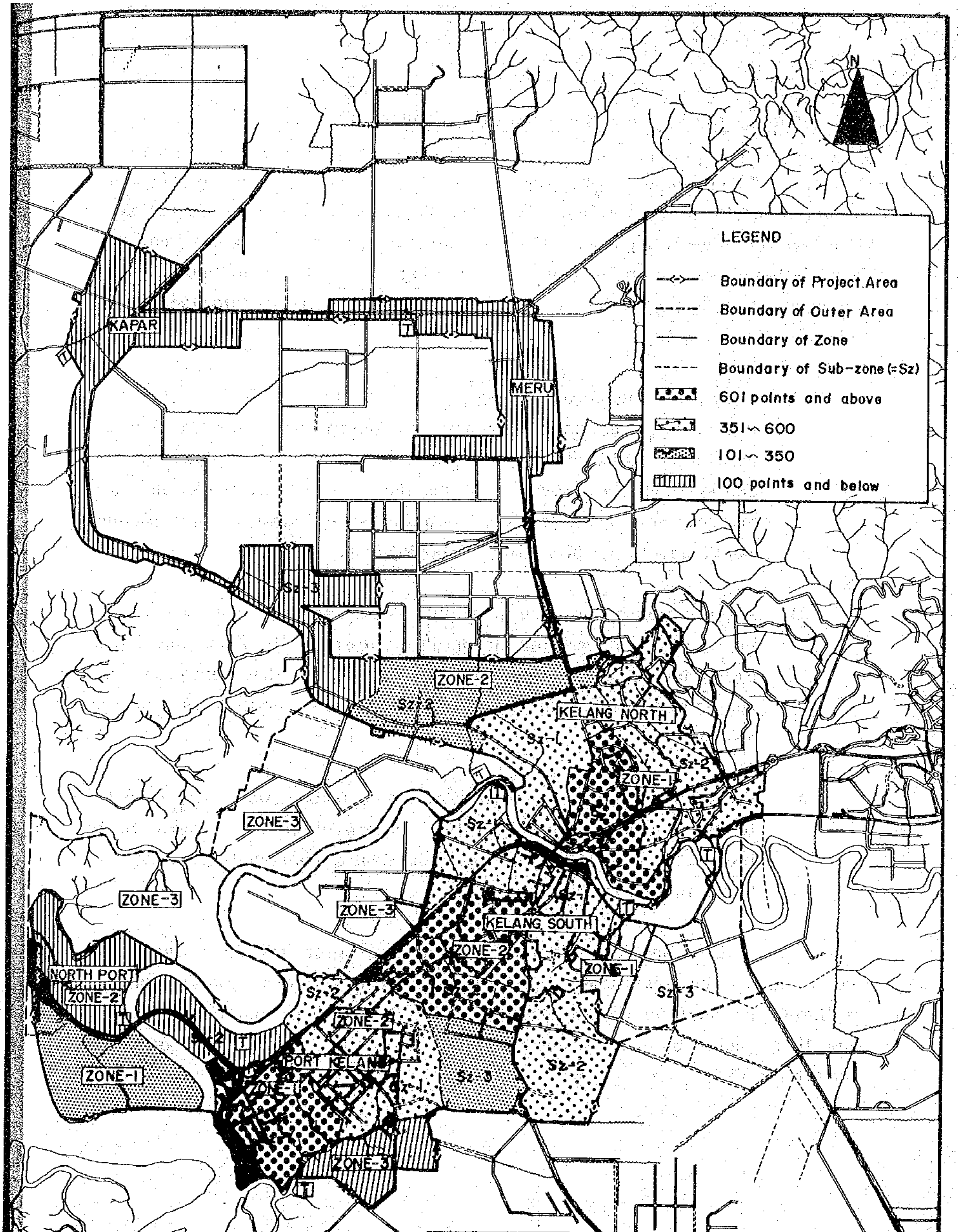
Five sub-zones are identified at the level of 600-400 points. These sub-zones, therefore, are considered to have a higher priority than the remaining sub-zones. Additionally, two sub-zones, i.e., Kelang South, Zone-1, Sub-zone-2 and also Kelang South, Zone-1, Sub-zone-1 are considered necessary for earlier implementation due to their strategic locations.

With implementation of works in these ten sub-zones above mentioned, it is considered that the Project Area will be covered fairly satisfactorily by modern sewerage system ensuring higher level of sanitary environment, based on which the phasing schedules will be considered. The total area of these ten sub-zones is 3,855 ha, approximately half of the whole Project Area. Most of the currently developed and developing areas are included in these sub-zones.

The remaining half of the Project Area is excluded from the implementation schedule up to the year 2000 for the following reasons: (1) All sewerage facilities in North Port district shall be provided by development authorities concerned, and (2) the remaining sub-zones will not be fully developed by the year 2000. In these areas, the sewerage plan should be reviewed and considered as required by development plans at a later stage.

Table 6.1. Implementation Priorities Evaluated by Parameters

Sewerage Division			Rating Points according to Parameters						Priority Order
District	Zone	Sub-zone	Population Density	Development Condition	Waste Load Generation	Excreta Disposal	Flooding Condition	Total	
Kelang North	1	1	280	200	175	25	25	705	1
" "	1	2	160	150	100	0	25	435	7
" "	2	1	200	100	200	50	50	600	4
" "	2	2	40	0	25	0	50	115	13
" "	2	3	0	0	25	0	0	25	18
Kelang South	1	1	80	100	100	50	25	355	10
" "	1	2	120	200	50	0	0	370	9
" "	2	1	200	100	75	50	100	525	6
" "	2	2	280	150	125	25	50	630	3
Port Kelang	1	1	240	200	175	25	50	690	2
" "	1	2	0	0	75	0	0	75	15
" "	2	1	200	150	100	100	50	600	4
" "	2	2	120	100	75	100	25	420	8
" "	2	3	200	50	75	0	25	350	11
" "	3		40	0	25	0	0	65	16
North Port	1		0	150	175	0	0	325	12
" "	2		0	50	50	0	0	100	14
Kapar			40	0	0	0	0	40	17
Meru			0	0	25	0	0	25	18



Implementation Priority | Fig. 6.1.

6.3. Implementation Schedule up to the Year 2000

Based on the priority evaluation results, as well as the construction costs of the sewerage facilities discussed in Section 5.3 (Estimated Construction Cost), implementation schedule by phases up to the year 2000 is established as shown in Table 6.2 and Fig. 6.2. The construction schedules are provisionally identified into three phases, taking into account the following considerations:

1) Financial consideration, as discussed in Chapter 7 (Financial Provisions), in particular will be taken into consideration for immediate undertaking of first phase program. However due caution shall be exercised to develop the plan with adequate size of areas and facilities since an under-sized scope of work planned would defeat the objective of the Project.

2) After completion of the feasibility study for priority area, a few years are required for preparatory work of its first phase program, inclusive of detailed design with tender documentation, land acquisition, procurement of equipment and civil work contract awards.

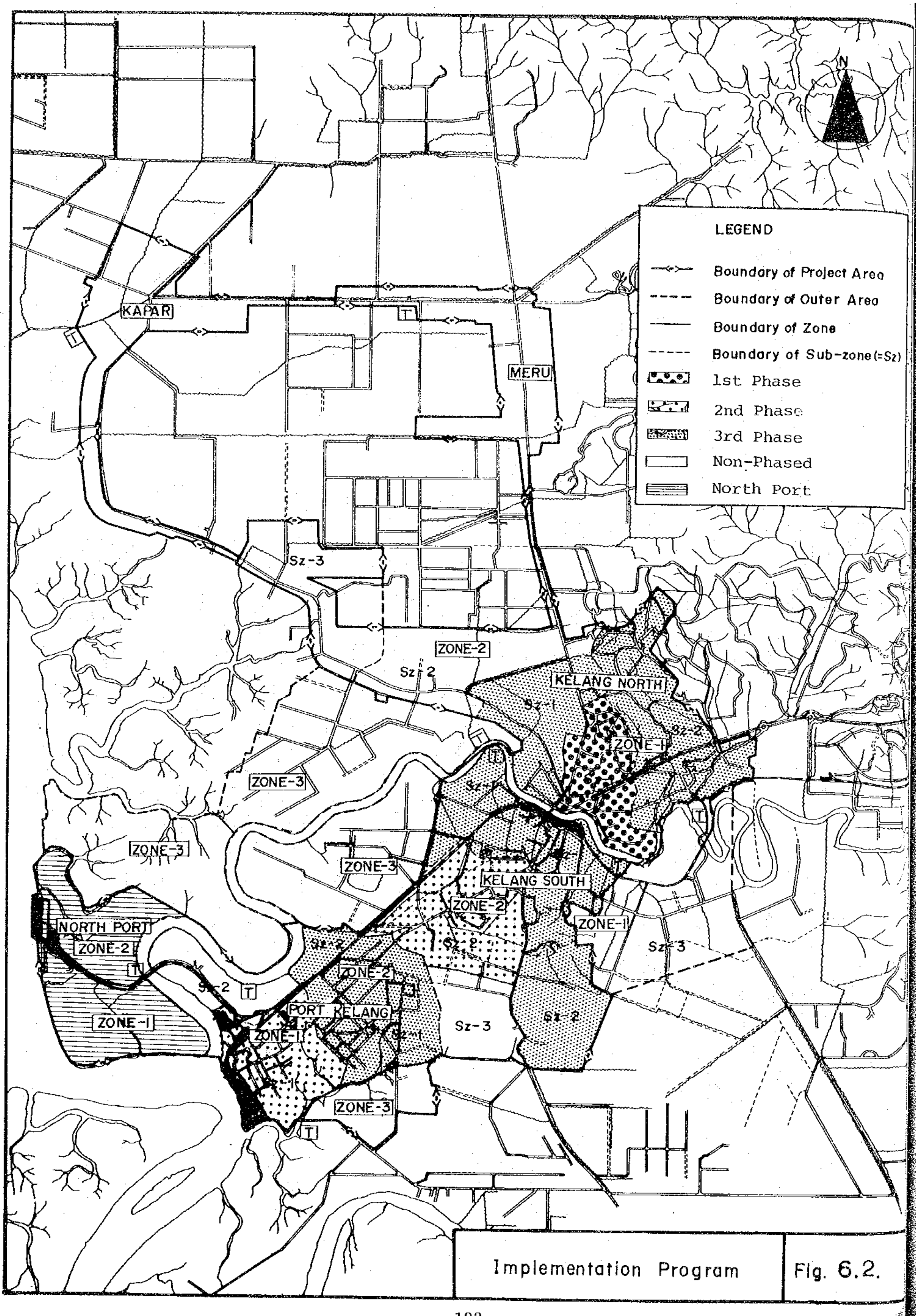
3) Considering that the above stated preparatory work may take two to three years including official approval of the Project to be included in the Fourth Malaysia Plan, construction work may begin in mid-1980s.

It is expected that the first phase program will take five to six years up to the year 1990. The second phase program however may be initiated, particularly its preparatory work, during the construction work of the first phase before its completion in order to expedite its completion by/around 1995.

As regards implementation of the third phase program, it is expected that further review needs be undertaken in due course as to the magnitude of work and extent of investment in the light of development progress and availability of financial resources.

Table 6.2. Implementation Schedule up to the Year 2000

Phase	Sewerage District, Zone and Sub-Zone	Area (ha)
First Phase (- 1990)	Kelang North, Z-1, S-1	338
Second Phase (- 1995)	Port Kelang, Z-1, S-1	410
	Kelang South, Z-2, S-2	512
Third Phase (- 2000)	Kelang North, Z-2, S-1	401
	Kelang North, Z-1, S-2	589
	Port Kelang, Z-2, S-1	445
	Port Kelang, Z-2, S-2	186
	Kelang South, Z-2, S-1	315
	Kelang South, Z-1, S-2	353
	Kelang South, Z-1, S-1	306
Total		3,855



Implementation Program Fig. 6.2.

6.4. Construction Cost by Phases

On the basis of the implementation schedule up to the year 2000, construction cost of each of the three phases is calculated at 1981 price level and summarized in Table 6.3. These figures include engineering cost and contingencies for implementation. Land acquisition cost for treatment plants are added in the First Phase construction cost, assuming that all required space up to 2000 will be purchased during the First Phase period. Areas served and population served by 2000 are also presented.

Construction cost for non-phased areas are summarized in Table 6.4. In North Port district, construction of sewerage facilities shall be carried out by the development authorities concerned instead of the Kelang Municipality. It should also be noted that several sub-zones in the Project Area are excluded from the implementation schedule up to the year 2000 due to the lack of development plans at this stage.

Breakdown of these construction cost of three phases up to 2000 for each item are presented in Tables 6.5 to 6.7.

Table 6.3. Construction Costs up to the Year 2000

(Unit: M$1,000 at 1981 Price Level)

Phase	Construction Cost		Sewerage District, Zone and Sub-zone	Area Served (ha)	Population (persons in 2000 A.D.)
	Government Contribution	Private Contribution			
First Phase (- 1990)	41,027	6,032	Kelang North, Z-1, S-1	338	36,000
Second Phase (1991 - 1995)	83,459	14,691	Kelang South, Z-2, S-2	512	57,800
			Port Kelang, Z-1, S-1	410	20,500
Third Phase (1996 - 2000)	202,123	46,094	Kelang North, Z-1, S-2	589	40,800
			Kelang North, Z-2, S-1	401	32,000
			Kelang South, Z-1, S-1	306	9,000
			Kelang South, Z-1, S-2	353	28,000
			Kelang South, Z-2, S-1	315	24,200
			Port Kelang, Z-2, S-1	445	39,700
			Port Kelang, Z-2, S-2	186	9,900
Total	326,609	66,641		3,855	297,900
	393,250				

Table 6.4. Construction Costs for Non-Phased Areas

(Unit: M$1,000 at 1981 Price Level)

	Government Contribution	Private Contribution	Sewerage District, Zone and Sub-zone	Area Served (ha)	Population (persons in 2000 A.D.)
	-	25,819	North Port, Z-1	461	4,700
			North Port, Z-2	349	5,400
	75,919	46,782	Kelang North, Z-2, S-2	458	14,200
			Kelang North, Z-2, S-3	418	1,400
			Port Kelang, Z-1, S-2	225	0
			Port Kelang, Z-2, S-3	248	23,200
			Port Kelang, Z-3	230	5,100
			Kapar	621	17,100
			Meru	573	10,400
Total	75,919	72,601		3,583	81,500
	148,520				

Table 6.5. Summary of Sewerage Construction Costs for First Phase Program (-1990)

(Unit: M$1,000 at 1981 Price Level)

Description	Government Contribution	Private Contribution	Total	Remarks
a. Trunk Sewer	6,646	-	6,646	
b. Branch and Lateral Sewer	7,210	1,692	8,902	
c. House Connection	-	2,680	2,680	
d. Pumping Station	1,319	-	1,319	
e. Treatment Plant	12,070	-	12,070	
f. Sub-total	27,245	4,372	31,617	
g. Enginnering Cost				
Design	2,724	437	3,161	(f) x 0.10
Supervision	1,362	218	1,580	(f) x 0.05
h. Contingency	6,266	1,005	7,271	(f+g) x 0.20
i. Land Acquisition	3,430	-	3,430	
Total	41,027	6,032	47,059	

Table 6.6. Summary of Sewerage Construction Costs for Second Phase Program (-1995)

(Unit: M$1,000 at 1981 Price Level)

Description	Government Contribution	Private Contribution	Total	Remarks
a. Trunk Sewer	21,965	-	21,965	
b. Branch and Lateral Sewer	16,201	5,341	21,542	
c. House Connection	-	5,306	5,306	
d. Pumping Station	1,768	-	1,768	
e. Treatment Plant	16,464	-	16,464	
f. Sub-Total	56,398	10,647	67,045	
g. Engineering Cost				
Design	5,640	1,064	6,704	(f) x 0.10
Supervision	2,820	532	3,352	(f) x 0.05
h. Contingency	12,972	2,448	15,420	(f+g) x 0.20
i. Land Acquisition	5,629	-	5,629	
Total	83,459	14,691	98,150	

Table 6.7. Summary of Sewerage Construction Costs for Third Phase Program (-2000)

(Unit: M$1,000 at 1981 Price Level)

Description	Government Contribution	Private Contribution	Total	Remarks
a. Trunk Sewer	62,763	-	62,763	
b. Branch and Lateral Sewer	31,530	19,624	51,154	
c. House Connection	-	13,651	13,651	
d. Pumping Station	6,820	-	6,820	
e. Treatment Plant	37,101	-	37,101	
f. Sub-Total	138,214	33,275	171,489	
g. Engineering Cost				
Design	13,821	3,327	17,148	(f) x 0.10
Supervision	6,911	1,663	8,574	(f) x 0.05
h. Contingency	31,789	7,653	39,442	(f+g) x 0.20
i. Land Acquisition	11,388	-	11,388	
Total	202,123	45,918	248,041	

6.5. Operation and Maintenance Cost by Phases

Operation and maintenance cost is assumed to be comprised of payroll, electricity supply, repair and administrative cost. These costs increase gradually along with the extension of the sewerage served areas and sewerage facilities. In order to analyze and develop financial plans, calculation of operation and maintenance cost by phases is conducted according to the implementation program proposed in the previous Section 6.3.

The amount of payroll is calculated according to the estimated staff requirements based on reasonable assumptions derived from data obtained in Malaysia and Japan. Staff requirements for proper performance of sewerage service are discussed and presented in Chapter 9, and labor requirements for each sewerage facility, such as sewers, pumping stations and wastewater treatment plants are presented in Appendix H, Vol. IV.

Electricity consumption is calculated based on capacities of electrical equipment and running time calculated by daily average flow anticipated after completion of each phased program. Cost for electricity is estimated based on the prevailing initial rate of M$12/month for each kilowatt of maximum demand and consumption rate of M$0.17/kWH.

Annual cost for repair of civil works and buildings is assumed to be 0.25 percent of the construction cost and that of mechanical and electrical equipment is assumed to be 2 percent.

Careful consideration is given to estimate the cost during the First Phase period because preparatory works before the operation of sewerage facilities also requires some amount of payroll and administrative cost. After completion of each phased program, annual operation and maintenance cost is assumed to remain the same throughout the phase as at the end of the completed phase.

The estimated annual operation and maintenance cost is presented in Table 6.8, which shows that when the sewerage system is completed by the year 2000, approximately M$5.7 million will be required annually.

Table 6.8. Estimated Annual Operation and Maintenance Cost

(Unit: M$1,000/year, at 1981 Price Level)

Year	Operation and Maintenance Costs			
	Payroll	Electricity Supply/Repair	Adminis-tration	Total
1983	137	-	14	151
1984	137	-	14	151
1985	165	-	17	182
1986	165	-	17	182
1987	180	-	18	198
1988	267	-	27	294
1989	348	-	35	383
1990	394	-	39	433
1991-1994	394	581	39	1,014
1995	449	581	45	1,075
1996-1999	449	1,812	45	2,306
2000	473	1,812	47	2,332
2001-	473	5,198	47	5,718

CHAPTER 7

FINANCIAL PROVISIONS

CHAPTER 7 FINANCIAL PROVISIONS

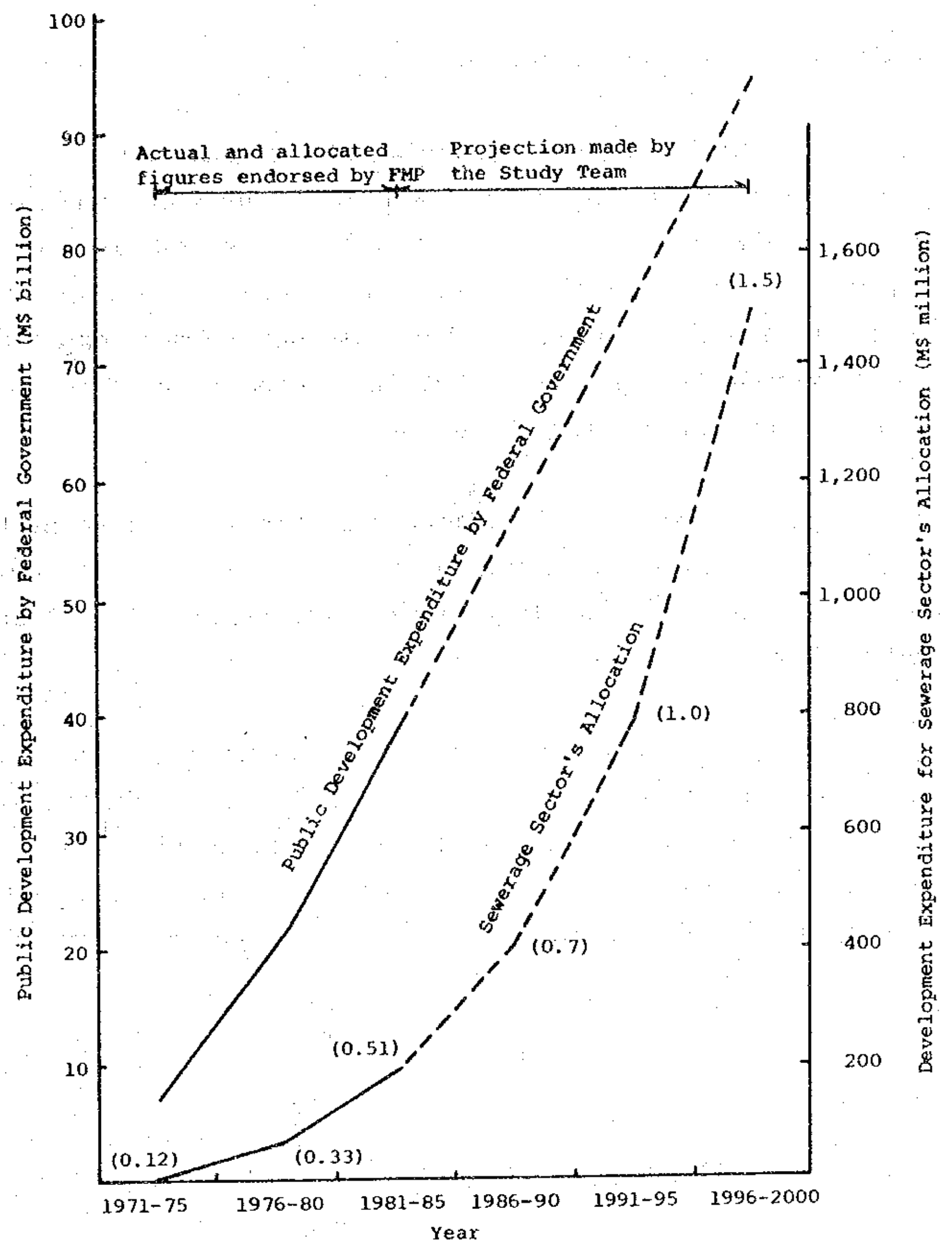
7.1. Probable Allocation within the Plan

For the Master Plan to arrive at a reasonable and realistic budgetary provision, an approach is taken to review and analyze the overall national plan for public development and its expenditures by the Federal Government, as embodied in the currently approved Fourth Malaysia Plan. Based on such undertakings, a sector-wise development expenditures in the field of sewerage is then forecasted for the purpose of planning adequate construction program for the Master Plan.

Fig. 7.1 shows public development expenditures in the sewerage sector from 1971 to 1985, including those endorsed in the Fourth Malaysia Plan, together with reasonably considered projections from 1986 to 2000 by the Study Team.

It is projected that the public development expenditure of the Federal Government will continue to grow, at least during the immediate future, as in the past. This projection by the Study Team will bring out the justifiable forecast for the increasing need for future public development programs, during immediate ten or twenty years.

Fig. 7.1. Public Development Expenditure and Probable Allocation for Sewerage Sector



Note: (1) ( ) shows the share (%) of sewerage sector's allocation in the F.G. development expenditure.

(2) Price escalation of 6.5 percent per year is assumed as predicted in the FMP.

Source: Tables 2-2 and 9-1 of the FMP plus the Study Team's estimations.

As shown in Fig. 7.1 the sewerage sector absorbed only 0.12 percent and 0.33 percent of total public development expenditures in the Second and Third Malaysia Plan periods. In the approved Fourth Malaysia Plan (1981-85), M$200 million is to be allocated to the sewerage sector, which is 0.51 percent of the total expenditure. In the considered opinion of the Study Team, the share of the sewerage sector's allocation will increase to 0.7 percent, 1.0 percent and 1.5 percent in the respective periods of 1986-90, 1991-95 and 1996-2000. Such projection is considered to be reasonable based on the following factors. (a) growth in income and the increasing requirements of urbanization, (b) increasing popular demand for a sound environment, and (c) experience in Japan in correlationship between sewerage development expenditure and urban/industrial development.

The following Table 7.1 and Fig. 7.2 show the relationship among industrialization, urbanization and per capita consumption, to shares of sewerage development expenditures in total public development expenditures for Malaysia and Japan. Industrialization is meant as the percentage of employees in secondary and tertiary industry sectors within the total labor force, while urbanization is meant as the percentage of urban inhabitants in the total population. Per capita consumption is obtained from the total consumption divided by the population.

As seen in the above-mentioned table and figure, it is reasonable to say, according to the above-mentioned three indicators, that conditions in Malaysia in 1980 show similarity to those of Japan in 1955. While the process of industrialization differs from country to country, depending on resources endowment and cultural and human resources, a trend in public expenditures, especially expenditures for social infrastructural development, presents meaningful similarity among different countries particularly in Asia. For this reason, the Japanese experience is considered worth including in consideration of future public expenditures in Malaysia, and the forecast concerning shares of sewerage development expenditures -- 0.7 percent during 1986-90, 1.0 percent during 1991-95, and 1.5 percent during 1996-2000 -- seems to be reasonable.

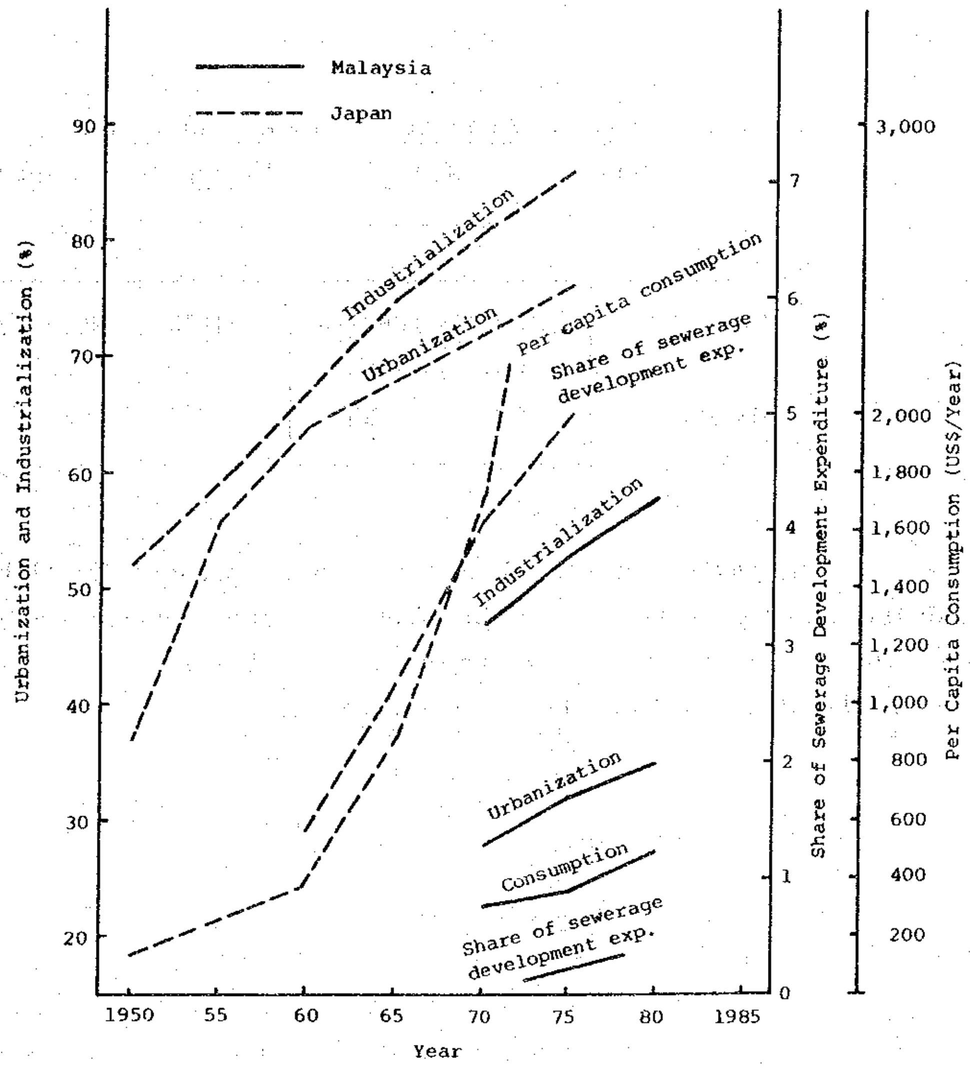
Table 7.1. Share of Sewerage Development Expenditure and Urbanization, Industrialization and per Capita Consumption

	1950	1955	1960	1965	1970	1975	1980	1985
Malaysia								
Urbanization (%)					28	32	35	
Industrialization (%)					47	53	58	
Share of Sewerage Dev. Expenditure (%)						0.12	0.33	0.51
Per Capita Consumption *1) (US$/Year)					307	350	486	
Japan								
Urbanization (%)	37	56	64	68	72	76		
Industrialization (%)	52	59	67	75	81	86		
Share of Sewerage Dev. Expenditure (%)			1.4	2.7	4.1	5.0		
Per Capita Consumption *2) (US$/Year)	132	259	373	882	1,732	3,540	4,695	

Source: Fourth Malaysia Plan
Japan Statistical Yearbook 1965-80

Note: *1) US$1 = M$2.2
*2) US$1 = ¥220

Fig. 7.2. Relationship between Share of Sewerage Development Expenditure in Total Public Development Expenditure and Other Indicators



Note: Sewerage development expenditure in Japan includes a part of drainage development

Within the forecast, the sewerage sector's allocation in the development expenditure is estimated to be M$410 million, M$800 million and M$1,500 million in the respective periods of 1985-90, 1991-1995 and 1996-2000. Thus, a probable budget allocation in the Master Plan for Kelang Municipality is reasonably estimated to be propotional to the population of the Municipality, compared to the urban population of the country. As a result, the following Table 7.2 is obtained.

Table 7.2. Probable Allocation of F.G. Budget for Sewerage Master Plan of Kelang Municipality

Period	1981-85	1986-90	1991-95	1996-2000
M$ Million	4	30	42	58

The amount of this allocation is not sufficient for MPK to undertake the sewerage system. Judging from the rapid development of its social and economic activities and proximity to Kuala Lumpur and Shah Alam, the budget allocation for MPK should be increased.

7.2. Financial Status of Kelang Municipality

Table 7.3 shows Kelang Municipality's revenues and expenditures for 1980 and estimates for 1981. Its budget and accounts are subject to approval by the State Government, but within broad legal limits it is free to impose certain taxes and provide services at its discretion.

Total revenue in 1980 was M$15 million, of which M$12 million (or 84 percent) came from household property assessment revenues. In 1981, the total revenue is estimated at M$18 million, of which the household property assessment revenue is estimated to be M$16 million (or 88 percent). These taxes are levied on the basis of property assessment value of individual households within the MPK's administrative area and such rates vary from 7 to 15 percent in the areas lying within the MPK boundary inclusive of the Malay Reservation. (Table 7.4 shows the percentage of property tax rate according to the different areas.)

Total expenditure on the other hand, was M$17 million in 1980 and is estimated at M$21 million for 1981, of which about 50 percent consists of costs of salaries and wages.

This resulted in a deficit of M$1.8 million in the financial balance of MPK in 1980, which is expected to remain in the red with a deficit of M$3.1 million in 1981. However, MPK's financial situation is expected to be strengthened, following the reassessment of present property values.

The present MPK property tax revenue is based on the 1974 assessment, although present practice is to reassess all properties at 5-year intervals. As property value is presently being reassessed, the budget from 1984 will be based on the reassessed value.

Table 7.3. Revenues and Expenditure (Kelang Municipality)

(Unit: M$)

Revenues	1980	1981 (Estimate)
Revenue from Municipal Office, Kelang	12,334,000	15,976,400
Revenue from Kapar Branch	124,200	159,200
Revenue from Meru Branch	27,600	43,900
Rental Payment of Low Cost House	165,000	165,000
Specific Contribution toward Main Drainage	750,000	900,000
Government Contribution toward its Liabilities	158,510	158,500
Monetary Aid for Maintenance of Roads	615,000	628,000
Specific Contributions - Government Aid	738,010	177,000
Total Revenues	14,912,320	18,208,000
Expenditures		
Expenditure on Salaries and Wages	8,505,400	11,564,400
Office Expenditures	3,465,200	3,961,700
Expenditure on Public Works	1,412,210	2,045,040
Special Expenditures	1,884,200	2,514,300
Development Expenditures	600,040	800,050
Main Drainage Expenditure	149,700	282,800
Special Works - Government Aid	738,010	177,000
Expenditures Government Liabilities	1,000	1,000
Total Expenditures	16,755,760	21,346,290
Deficit	1,843,440	3,138,290

Table 7.4. Property Tax Rate for Kelang Municipality According to Area

Area	Tax Rate (%)
Within Sectors 1-32 (Inside the town)	15
Zone 'A' (Telok Gadong Rd)	15
Zone 'B' (Eng Ann Estate)	15
Mukim (Outside the town area)	14
Extension Area	11
Village (Pendamaran) (Pendamaran Jaya)	10
Kapar Town	10
Meru Town	10
Malay Reservation in Meru Town	8
Existing Malay Reservation Area	7