New plant and animal communities should reappear and develop in time, the diversity of which will depend on biotope availability.

Proper flow regulation and channel management and health control will bring beneficial impacts.

(c) Socio-Economic Impacts

It is observed that some residential, commercial and institutional buildings or structures are located within the river reserve zone of Sg. Pinang. All the structures within the river reserve would have to be cleared.

Our study of landuse along the river banks of Sungai Pinang is shown in the Map (Figure 4.5). The structures identified from the river mouth to the Perak Road Bridge are as follows: 58 wooden structures, 15 semi-permanent buildings, 1 concrete building, 16 factories, 4 Government Quarters (1 quarter = 7 units), 6 flats, 3 schools, 3 office buildings, a shop, an eating shop, a mosque, 2 Chinese spirit house, 3 Indian temples and finally the slaughter house and the veterinary buildings. Indicated on the Map are 10 open spaces scattered at various parts of the river bank.

The squatter settlement along the river will be affected by construction of the coastal retention pond. The people affected would have to look for alternatives

housing and business sites. The squatters would have to seek cheap alternative housing away from the city centre. The actual number of squatters household affected is not known. However the location of this squatter areas are indicated on the Map (Figure 4.5). The number of people affected could be higher given the high population density of the area. It is expected that there will be social and physological impact on those who are to be displaced by the proposed widening of the river.

The landuse affected upstream from the Perak Road Bridge to the confluence of the Sungai Air Itam and Sungai Air Terjun is as shown in Map (Figure 4.6). There are 111 wooden houses and semi-permanent type, 6 units of double storey terrace houses, 3 shops, 2 mosques, 3 muslim burial grounds, 1 Sikh burial ground, 1 Japanese burial ground, 1 Hindu temple, a large open space along the City Stadium and finally a petrol station.

The commercial areas such as the shops is expected to suffer loss of income and employment through loss of business site and clients (consumers). The cost of moving to a new site is expensive.

In addition, the widening of Sungai Pinang and the enhancement proposals requires additional land area. Land acquisition is necessary along some stretches of

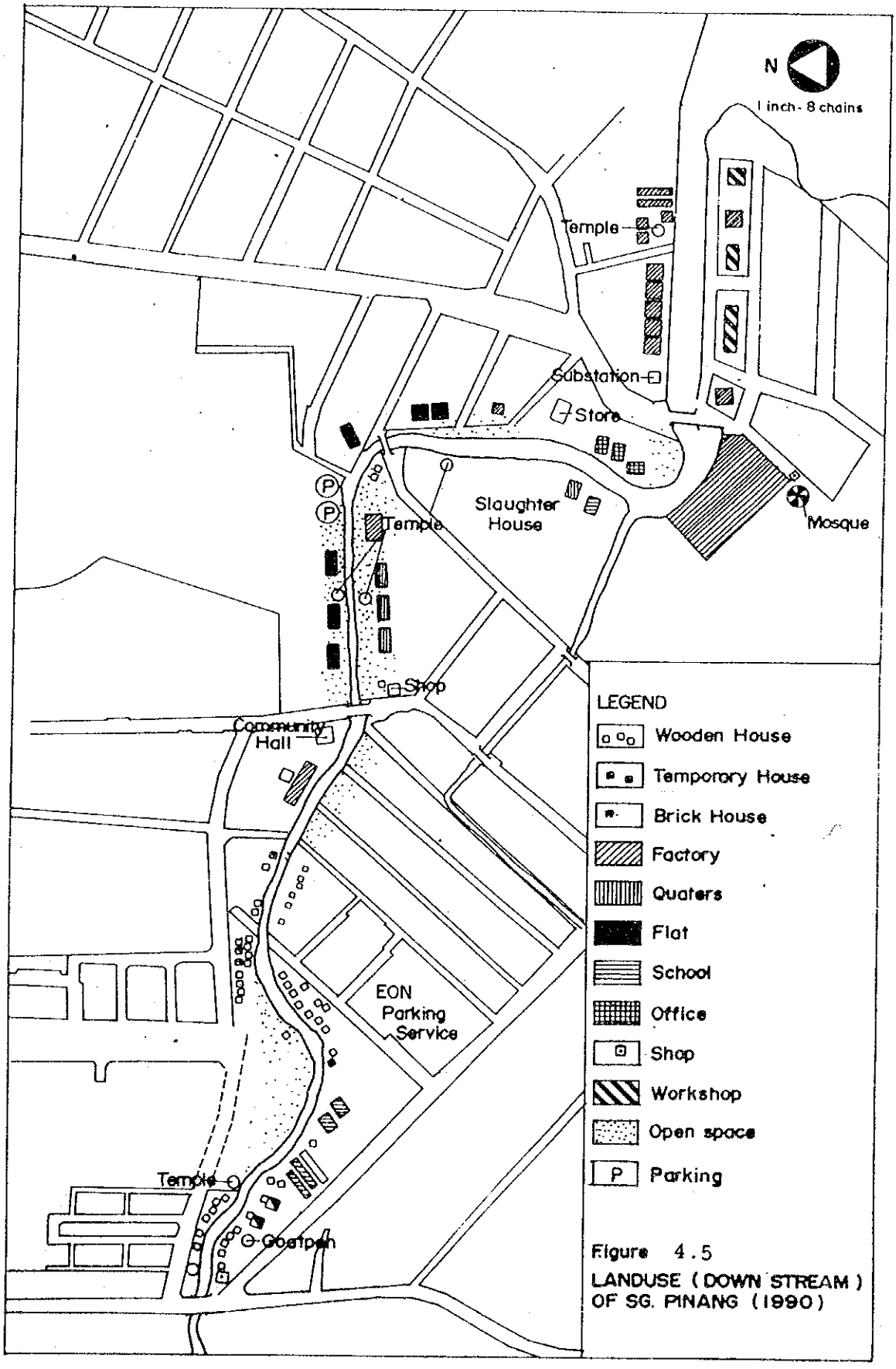

Figure 4.5
LANDUSE (DOWN STREAM)
OF SG. PINANG (1990)

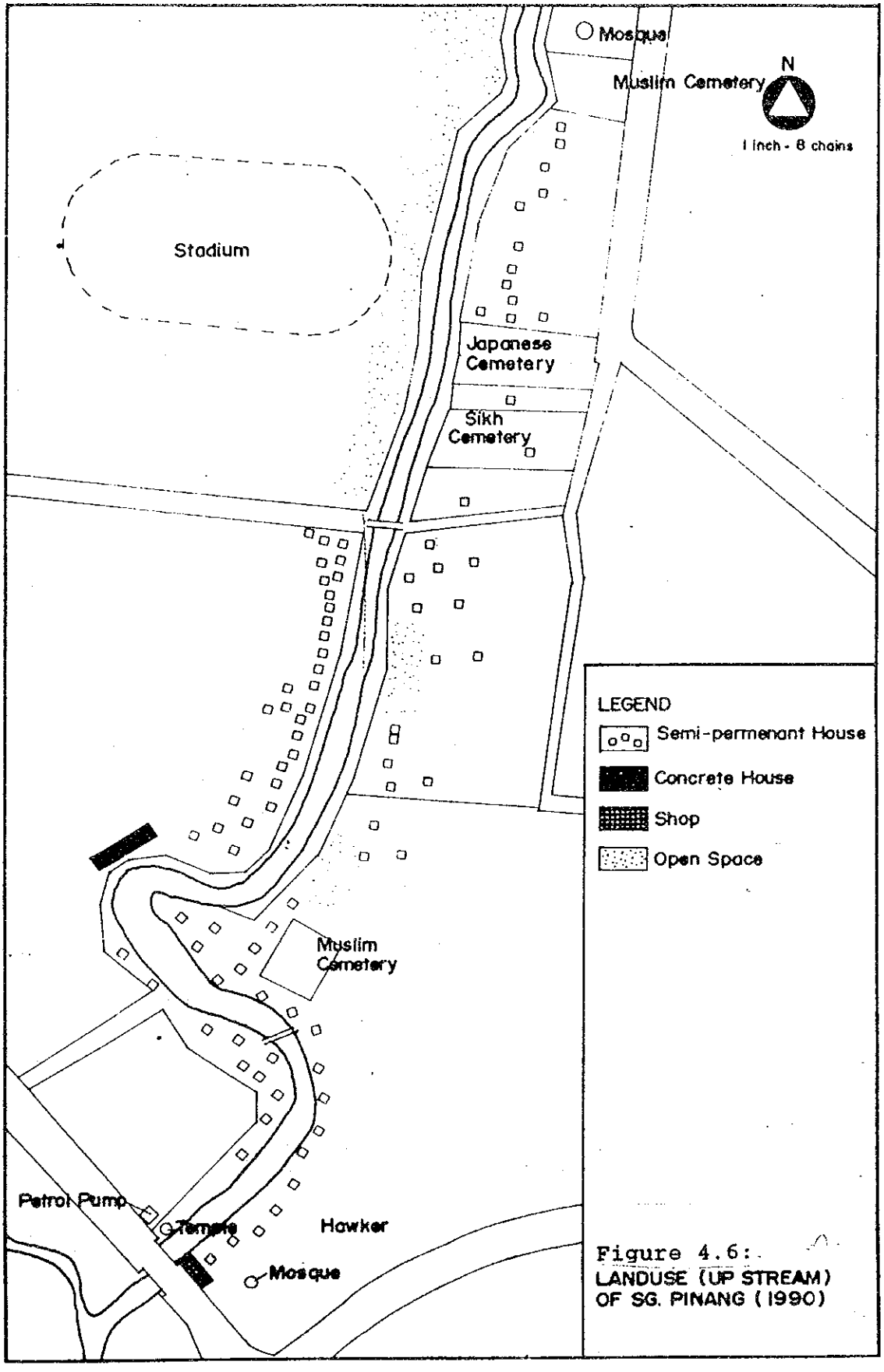

Figure 4.6:
LANDUSE (UP STREAM)
OF SG. PINANG (1990)

the river banks. The JICA study estimates the cost of land acquisition to be about 33,741,266 Malaysian Ringgit.

The religious institution is an important part of the cultural life of the people in the kampong along the river. The loss of these buildings, hence the social organisation that is part of this institution will be altered. Part of the religious institutions are the burial grounds which are to be relocated if the river is to be widened and improved. The religious authorities for the various communities have to be consulted prior to actual work on the proposals, to take into account local religious norms.

There are 16 small scale and large factories which are an important source of employment and income. The river improvement would affect their establishments and hence their production activities. Some might lose part of their buildings because of the widening of the river.

The river improvement schemes would affect the traditional Malay villages at Jalan Rawang and Jalan Trengganu. This is one of the important pockets of Malay community in the urban areas and is an important part of Penang history. Resettlements of the communities would disrupt their life styles and would lead to the community's demise. Ways should be

found to involve them in the river improvement schemes so that they become part of the programme of community development.

Other institutions affected are the schools and the government buildings. The playing area for the school children would be affected whilst in the case of the two other schools the back portion of the land area would be affected. The Government buildings - parts of the vetinary buildings and the slaughter house would be affected. Since the slaughter house is a source of pollution the whole complex should be relocated.

As shown on the map (see Figure 4.7) the river improvement activity would affect the landuse activity within the stipulated river reserve. The Sungai Air Terjun area passes through residential areas, shophouses and through the dobi area which is an important historical site. There are six wooden houses and 10 brick and concrete structures, and three shops. There are two Indian temples and a mosque which serve the local community. Hence any improvement would have to take into account the established community around York Road and the institutions that serve the people there.

The Sungai Air Itam passes through institutional areas such as schools, government quarters and the Suffolk House. Widening activity would affect

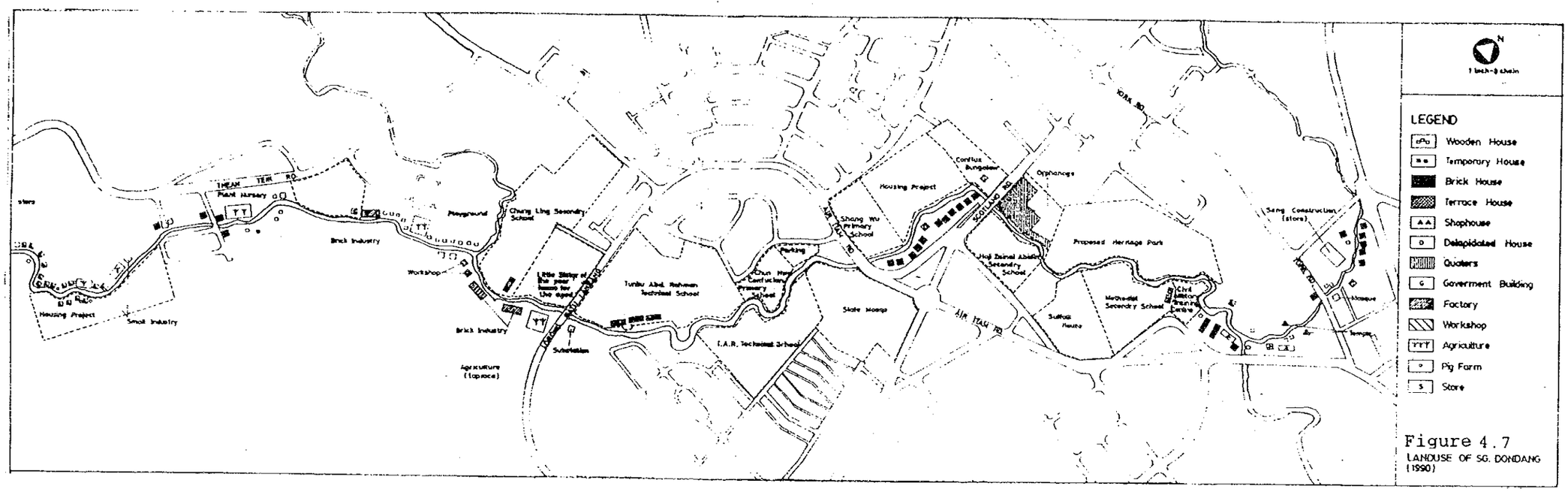

Figure 4.7
LANDUSE OF SG. DONDANG (1990)

buildings and playing fields of the schools and the institutional buildings close to the river. The proposed Heritage Park opposite Suffolk House and the Methodist Boys School should be closely intergrated with the proposed river improvement programme.

Further upstream up to the confluence of Sg. Air Itam and Sg. Dondang, Sg. Air Itam passes through more institutional areas such as schools and the state mosque. Here again the river improvement programme would affect structures that abbuts into the river reserve. For certain areas, land acquisition is necessary. The brick making factory and the vehicles repair workshop will be affected.

Along Sg. Dondang, the strutures affected are 20 wooden houses, 17 semi-permanent houses (brick and timber structures), 5 brick houses, 1 shop, a Chinese temple, 4 hog farm, 3 small scale factories and four areas which are still under agriculture. However, the area is to be developed into a residential areas and to be linked to the Air Itam new town. Hence the river improvement programme could be part of the future change in landuse within Thean Teik Estate.

5.0 MITIGATION AND ABATEMENT MEASURES FOR ENVIRONEMNTAL IMPACTS

Mitigation and abatement means for the environmental impacts identified in Chapter 4 can be taken to minimise the adverse impacts.

5.1 Retention Ponds

5.1.1 Retention Ponds

As the proposed sites for the retention ponds in the Sungai Dondang area are already designated by the MPPP structure plan as public recreation areas, there would not be serious land use conflicts as the retention pond sites would be designated as multi-use sites. The major impacts will be at the construction phase, where earth works and construction activities will generate noise and dust problems. The moving of the excavated earth to the coastal area for reclamation would also exerbate the existing traffic congestion at the Air Itam Area. The mitigation measures for these are mainly management problems whereby guidelines could be laid down for the construction works and transportation of the excavated earth. The transportation of earth should be done during non-peak hours.

At the operational phase, the main impacts identified are the quality of water going into the

ponds and the safety hazards. The organic load of the water at Sungai Dondang is high, but there would be sufficient dilution at flood periods. The more serious problem would be that of sediments in the flood waters which will settle and leave a layer of sediment in the recreational area when it is flood situation at 30 year return period. The mitigation measure should involve the control of soil erosion at the upper reaches of the river. To prevent other solid wastes and objects, such as plastic bags, branches of trees and other debris getting into the pond, there should be screens at the water intake points. There should also be provisions for the cleaning up after every flood event.

For safety reasons, there should be sufficient warning signboards and public education programs to inform the public and the users of the pond sites for recreation to avoid using these areas during floods.

5.1.2 Retention Ponds for Urban Drainage

The coastal retention ponds differ from the inland retention ponds both in its function and operational procedure. These ponds receive the drainage waters which would mean that it would be permanently covered with water with a high organic load. The pond may also be anaerobic which would generate smell problems. The discharge of these anaerobic waters at periodic intervals would result in the depletion of oxygen in

the coastal waters surrounding the water outlets. The pumping of the waters outside to the coastal area would also result in oxygen depletion if the organic matter in the retention pond water is high. It is also anticipated that there would be a considerable amount of rubbish in the drains that lead to the retention ponds.

The mitigation measures to improve the quality of the water in the retention ponds is a complex problem and more related to public health and hygiene rather than flood mitigation. Until such time when the sullage waters can be treated, it would be difficult to resolve this problem. Some management measures can be taken as to when would be the best times for the regular discharge of the pond waters, and there should be monitoring to work out the optimum times. There would be stricter controls in the dumping of solid wastes into the drains, but again, this is outside the purview of flood mitigation. There should be a series of screens to trap all the rubbish that gets into the drains so that such solids would not affect the workings of the pumps.

At the construction phase, there would be some impacts as a result of the excavation and construction of the ponds. The amount of excavation should be coordinated with the proposed land reclamation scheme of the CDD-21 project to minimise the amount of

excavation required. The noise, dust and traffic impacts can be minimised by management guidelines to the contractors.

5.2 River Diversion

There are some impacts on the physical and biological environments, but by far the more serious problems are socio-economic.

The physical and chemical environmental impacts are related to the construction of the box culvert, such as noise and dust. These are usually unavoidable, but they are temporary, lasting the duration of construction and can be minimised by management practises. The biological impacts are related to the impact of excavation on the root systems of the roadside trees. The Royal Palms, Roystonea regia have a fibrous root system and is shallow and not likely to be affected by the construction. However, the old Angsana trees, Pterocarpus indicus would have some roots that would reach the roads. However, since they have a tap-root system, the main roots are unlikely to be affected. Some monitoring should be made and it may require some trimming of branches to maintain the balance of branches to roots. The mahogany trees, Swietenia macrophyllum are generally younger and are not likely to cause much problems in terms of root loss.

The more serious socio-economic problems are to the traffic flow, hawkers and commercial establishments. The Gottlieb Road and Bagan Jermal Roads have 3 schools, namely, the Penang Chinese Girls School, the Por Tay School and the Saint Nicholas School for the visually handicapped.

The two Chinese schools with morning and afternoon sessions contribute much of the existing traffic problems when the students go to the school and leave the school. There would be a need to phase the construction of the river diversion in such a way that it would be possible to allow some traffic flow. The mitigation measures suggested are that only one traffic lane should be closed at any one time, and that the traffic should be diverted to other roads whenever possible. The traffic plan should be worked out with the traffic section of the local authority (MPPP). The Saint Nicholas School poses a different type of problem as the School uses the sidewalks and roads to teach the blind and visually handicap students to move independently with their walking sticks. This depends on the predictability of the features and structures of the road. The construction phase will result in many new structures in the road and sidewalks. The excavation would also result in holes dugged. There would be a need to take special precautions, such as the placing of fences or ropes to keep the students

from danger to themselves. There should be some consultation with the authorities of the school before any work is allowed to begin.

The 30 odd hawkers in front of the Penang Chinese Girls School operate from 6 p.m. to about midnight. Though this means that they would not be around at the actual construction, their activities would be affected as they depend on their clientele which would not be able to park their vehicles. There are a number of possible mitigation measures that could be taken. The first is relocation of these hawkers permanently in hawkers complexes where problems of hygiene and waste disposal can be more easily managed. Another alternative would be a temporary relocation to the stretches of roads which are not under construction. They could be moved to the Bagan Jermal section of the road while construction is taking place at Jalan Gottlieb. Another alternative is that the hawkers' stalls may be dispersed and the hawkers be given preferential treatment and licences in existing and new hawkers centres and shops. This problem should be discussed and resolved with the various departments of the local authority, the MPPP.

The impact of the commercial establishment is difficult to resolve completely and there would be some dissatisfaction no matter what measures are taken. However, the problem may be mitigated by working out a

traffic plan for the area. This problem is partly reduced because of the presence of service roads in the commercial areas. Some regulations should be worked out for the control and regulation of traffic flow during the period of construction.

5.3 River Improvement

The impacts of the river improvement are mainly in the construction phase, and like the river diversion scheme, the impacts are mainly socio-economic. There would be some physico-chemical and biological impacts, but they are relatively minor. The most serious of the physico-chemical impacts would be the disposal of the earth and mud of the river widening and deepening. With such a high volume of material excavated, the disposal to the land reclamation projects would appear to be a mutually beneficial solution. The amount of sea sand for the land reclamation of the eastern coast of the island is limited and there would be a need to find a source of fill material.

However, not all the dredged materials are acceptable for coastal reclamation. The EPA criteria for acceptability of dredged spoil disposal (1970 version) (Boyd et al., 1972) listed, among others, the limits of Hg, Pb and Zn expressed below. The dredged material will be considered polluted and therefore unacceptable for open water disposal if one or more of

the limits are exceeded.

Sediments in Fresh and Marine Waters	Concentration ppm (dry wt.)
Mercury (Hg)	10
Lead (Pb)	50
Zinc (Zn)	50

Comparison of the mean concentrations of Hg, Pb and Zn in the surficial sediments of Sg. Pinang, Sg. Air Itam, Sg. Dondang and Sg.Air Terjun (Table 3.7) with the EPA criteria indicates that the dredged materials from Sg. Pinang would not be acceptable as a fill material in coastal reclamation. Alternatives such as disposal on some secured landfill sites would have to be found.

6.0 CONCLUSIONS

The preliminary EIA has identified the major environmental impacts of the flood mitigation and drainage proposals for the Sungai Pinang basin. The relevant mitigation measures have been suggested.

The major adverse impacts are caused at construction phase while the enhancement to the environment occur at the stage of operation.

When the project is completed, it is anticipated that the flood problem of Sungai Pinang would be greatly improved if not solved.

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APPENDIX A

Concentrations of Heavy Metals in Surficial Sediments (ug/g dry wt.) of Sg. Pinang and Tributaries

Sampling Station	Sampling Date	Pb	Cu	Zn	Ni	Cd	Hg
SP1	5/ 9/90	15	8	100	3	0.3	0.97
	17/ 9/90	9	5	51	N.D.	0.1	0.73
	24/ 9/90	3	2	48	3	0.2	0.42
	7/10/90	2	2	40	1	0.1	0.30
	7/11/90	6	3	37	N.D.	-	-
	12/11/90	15	2	42	1	-	-
SP2	5/ 9/90	11	7	91	4	0.3	1.27
	17/ 9/90	56	19	48	5	N.D.	0.80
	24/ 9/90	38	15	105	5	0.3	1.19
	7/10/90	11	14	73	N.D.	0.4	0.78
	7/11/90	11	4	48	1	-	-
	12/11/90	16	3	47	1	-	-
SP3	5/ 9/90	100	41	75	10	1.1	0.96
	17/ 9/90	77	37	193	15	1.7	0.50
	7/11/90	31	19	116	4	-	-
	12/11/90	44	31	129	4	-	-
SAI3	5/ 9/90	29	3	59	3	0.3	1.19
	17/ 9/90	12	8	81	1	0.1	1.07
	24/ 9/90	3	1	33	1	0.1	0.82
	7/10/90	11	8	61	N.D.	0.2	3.12
	15/10/90	3	N.D.	17	N.D.	0.1	0.20
	7/11/90	9	2	36	1	-	-
	12/11/90	12	3	33	1	-	-
SD1	17/ 9/90	17	4	48	1	0.1	0.68
	24/ 9/90	6	3	46	1	0.1	1.31
	7/10/90	11	3	46	N.D.	0.2	3.03
	15/10/90	10	1	26	N.D.	N.D.	0.56

Cont'd

Sampling Station	Sampling Date	Pb	Cu	Zn	Ni	Cd	Hg
SD2	5/ 9/90	31	15	57	6	0.6	1.45
	17/ 9/90	19	5	54	3	0.1	2.64
	24/ 9/90	11	4	41	2	0.3	0.87
	7/10/90	6	4	34	N.D.	0.3	0.66
	15/10/90	6	1	34	N.D.	0.1	0.47
	7/11/90	4	2	26	N.D.	-	-
	12/11/90	14	2	20	N.D.	-	-
SAT1	24/ 9/90	9	1	8	1	0.1	1.43
	7/10/90	5	3	45	N.D.	0.3	4.13
	15/10/90	7	N.D.	21	N.D.	0.1	1.45
	12/11/90	4	1	8	N.D.	-	-
SAT2	5/ 9/90	1	2	13	3	0.3	1.31
	17/ 9/90	5	1	25	1	N.D.	0.75
	24/ 9/90	3	1	16	2	0.2	1.39
	7/10/90	9	1	32	N.D.	0.3	0.65
	7/11/90	7	1	8	N.D.	-	-
	12/11/90	6	1	8	N.D.	-	-

APPENDIX B

Microbiological Estimates of Total Coliforms (TC), Faecal Coliforms (FC), Faecal Streptococcus (FS) and the FC/FS ratios by the Three-Tubes Most Probable Numbers Method (MPN).

STATION	NO.	TC	FC	FS	FC/FS
SD1	**1.	2.4×10^6	2.4×10^6	4.3×10^5	5.58
	2.	2.4×10^6	2.4×10^6	2.4×10^6	1.00 *(M)
	3.	2.4×10^6	4.6×10^6	4.3×10^5	10.70
	4.	2.3×10^5	2.3×10^5	4.3×10^4	5.35
	5.	2.4×10^6	2.4×10^6	3.9×10^5	6.15
	6.	2.3×10^5	2.3×10^5	2.3×10^4	10.00
	$\log \bar{x}$	1.10×10^6	1.22×10^6	2.36×10^5	5.17
SD2	1.	2.3×10^5	9.3×10^5	4.3×10^4	21.63
	2.	9.3×10^5	9.3×10^5	2.4×10^5	3.88(M)
	3.	1.5×10^6	2.4×10^6	9.3×10^4	25.81
	4.	9×10^4	2.3×10^5	9×10^3	25.56
	5.	1.1×10^7	4.6×10^6	2.4×10^5	19.17
	6.	4.6×10^6	4.6×10^6	1.1×10^6	4.18
	$\log \bar{x}$	1.07×10^6	1.47×10^6	1.15×10^5	12.78
SAP-1	1.	2.3×10^5	2.3×10^5	9.3×10^3	24.73
	2.	3.9×10^5	3.9×10^5	9.3×10^3	41.94
	3.	2.1×10^5	2.1×10^5	1.5×10^4	14.00
	4.	4.3×10^5	4.3×10^5	4.3×10^3	100.00
	5.	9.3×10^5	9.3×10^5	4.6×10^4	20.22
	6.	9.3×10^5	4.3×10^5	4.6×10^4	9.35
	$\log \bar{x}$	4.37×10^5	3.85×10^5	1.51×10^4	25.50

STATION	NO.	TC	FC	FS	FC/FS
SAT-1	1.	2.3×10^4	2.3×10^4	1.4×10^2	164.29
	2.	2.4×10^5	9.3×10^4	9.3×10^2	100.00
	3.	4.3×10^4	2.3×10^4	1.5×10^3	15.33
	4.	3.9×10^4	3.9×10^4	7.5×10^3	5.20
	5.	4.3×10^4	4.3×10^4	9.3×10^2	46.24
	6.	4.3×10^4	2.3×10^4	7.5×10^2	30.67
	$\log \bar{x}$	5.08×10^4	3.52×10^4	1.00×10^3	35.20
SAT-2	1.	2.4×10^5	2.4×10^5	2.4×10^4	10.00
	2.	9×10^3	1.5×10^4	9.3×10^3	1.61 (M)
	3.	9×10^3	9×10^3	2.3×10^3	3.91 (M)
	4.	4.3×10^4	4.3×10^4	2.3×10^3	18.70
	5.	9.3×10^4	4.3×10^4	2.3×10^3	18.70
	6.	9.3×10^4	4.3×10^4	1.5×10^4	2.87 (M)
	$\log \bar{x}$	4.40×10^4	3.70×10^4	5.87×10^3	6.30
SAI-1	1.	2.4×10^5	2.4×10^5	2.3×10^3	104.35
	2.	1.1×10^6	1.1×10^6	9.3×10^3	118.28
	3.	9.3×10^4	2.3×10^4	2.4×10^4	0.96 (M)
	4.	9.3×10^4	9.3×10^4	9.3×10^3	10.00
	5.	2.4×10^5	2.4×10^5	1.1×10^5	2.18 (M)
	6.	2.4×10^5	9.3×10^4	4.6×10^4	2.02 (M)
	$\log \bar{x}$	2.26×10^5	1.53×10^5	1.70×10^4	9.00

STATION	NO.	TC	FC	FS	FC/FS
SAI-2	1.	-	-	-	-
	2.	2.1×10^5	4×10^4	1.5×10^4	2.67 (M)
	3.	4.3×10^5	2.3×10^5	4.3×10^4	5.35
	4.	9.3×10^5	4.3×10^5	4.3×10^4	10.00
	5.	2.4×10^7	1.1×10^7	4.6×10^5	23.91
	6.	1.5×10^6	2.3×10^5	1.5×10^5	1.53 (M)
log $\bar{x}$		1.25×10^6	3.94×10^5	7.18×10^4	5.49
SAI-3	1.	4.3×10^5	9.3×10^5	2.4×10^5	3.88 (M)
	2.	4.6×10^6	1.5×10^6	2.4×10^5	6.25
	3.	4.3×10^5	4.3×10^5	2.3×10^4	18.70
	4.	1.5×10^6	7.5×10^5	4.3×10^4	17.44
	5.	2.4×10^6	2.4×10^6	2.4×10^5	10.00
	6.	9.3×10^5	4.3×10^5	4.3×10^4	10.00
log $\bar{x}$		1.19×10^6	8.80×10^5	9.15×10^4	9.62
SAI-4	1.	-	-	-	-
	2.	1.1×10^6	1.5×10^6	2.4×10^5	6.25
	3.	4.3×10^5	4.3×10^5	7.5×10^4	5.73
	4.	9.3×10^5	9.3×10^5	4.3×10^4	21.63
	5.	4.6×10^6	2.4×10^6	4.3×10^4	55.81
	6.	2.4×10^6	9.3×10^5	2.3×10^4	40.43
log $\bar{x}$		2.17×10^6	1.06×10^6	5.98×10^4	17.73

STATION	NO.	TC	FC	FS	FC/FS
SP-1	1.	9.3×10^5	9.3×10^5	9.3×10^4	10.00
	2.	2.4×10^6	9.3×10^5	2.4×10^5	3.88 (M)
	3.	9.3×10^5	9.3×10^5	2.3×10^4	40.43
	4.	4.3×10^5	4.3×10^5	1.5×10^4	28.67
	5.	1.5×10^6	3.9×10^5	9.3×10^4	4.19
	6.	2.4×10^6	4.3×10^5	2.4×10^5	1.79 (M)
	$\log \bar{x}$	1.22×10^5	6.22×10^5	7.46×10^4	8.34
SP-2	1.	2.3×10^5	2.3×10^5	9×10^3	25.56
	2.	4.6×10^6	7.5×10^5	4.3×10^4	17.44
	3.	1.1×10^7	1.1×10^7	2.4×10^5	45.83
	4.	4.6×10^6	4.6×10^6	4.3×10^4	106.98
	5.	2.4×10^6	2.4×10^6	9.3×10^4	25.81
	6.	2.4×10^6	4.3×10^5	9.3×10^4	4.63
	$\log \bar{x}$	2.60×10^6	1.44×10^6	5.71×10^4	25.22
SP-3	1.	9×10^5	9.3×10^5	2.3×10^4	40.43
	2.	2.4×10^7	2.4×10^6	2.3×10^4	104.35
	3.	2.3×10^6	2.4×10^6	2.8×10^4	85.71
	4.	9×10^5	2.4×10^6	1.5×10^4	160.00
	5.	2.3×10^6	9.3×10^5	9×10^3	103.33
	6.	3.9×10^6	4.6×10^6	9.3×10^4	49.46
	$\log \bar{x}$	2.72×10^6	1.95×10^6	2.39×10^4	81.59

STATION	NO.	TC	FC	FS	FC/FS
SJ-1	1.	2.3×10^6	2.3×10^6	7.5×10^3	306.67
	2.	4.6×10^7	4.3×10^6	9.3×10^4	46.24
	3.	2.4×10^7	2.4×10^7	2.4×10^5	100.00
	4.	2.3×10^6	2.3×10^6	9.3×10^4	24.73
	5.	2.4×10^7	2.4×10^7	4.3×10^4	558.14
	6.	2.4×10^7	9.3×10^6	2.9×10^5	32.07
log $\bar{x}$		1.22×10^7	7.04×10^6	7.61×10^4	92.51

NOTE: *(M) - Indicates mixture of animal and human wastes.

** - Indicates dates of sampling where 1 to 6 are represented by 5/9, 11/9, 17/9, 24/9, 2/10 and 9/10/90 respectively.

APPENDIX C

Check List of Birds in the Study Area

Family: Accipitridae

Brahminy Kite *Haliastur indus*
Japanese Sparrowhawk *Accipiter gularis*
White-bellied Sea-eagle *Haliaeetus leucogaster*

Family: Apodidae

Asian Palm-Swift *Cypsiurus batasiensis*

Family: Ardeidae

Little Heron *Butorides stratus*

Family: Alcedinidae

Black-capped Kingfisher *Hylcyon pileata*
Common Kingfisher *Alcedo athis*
Collared Kingfisher *Hylcyon chloris*
White-throated Kingfisher *Hylcyon amyrnensis*

Family: Coraciidae

Dollarbird *Eurystomus orientalis*

Family: Corvidae

House Crow *Corvus solendens*
Large-billed Crow *Corvus macrorhynchos*

Family: Chlororpseidae

Common Iora *Ageot,joma tiphis*

Family: Columbidae

Pink-necked Pigeon *Treron vernans*
Spotted Dove *Stredopeioa chinensis*

Family: Diacaeidae

Scarlet-backed Flowerpecker *Dicaeum cruentatum*

Family: Hirundinidae

Barn Swallow *Hirundo rustica*
Pacific Swallow *Hirundo tahitica*

Family: Laniidae

Brown Shrike *Lanius cristatus*

Family: Laridae

Little Tern *Sterna albifrons*

Family: Meropidae

Blue-tailed Bee-eater *Merops philippinus*

Family: Muscicapidae

Pied Fantail *Rhipidure javanica*

Family: Nectariniidae

Brown-throated Sunbird *Aethreptes malacensis*
Olive-backed Sunbird *Nectarinia calcostetha*

Family: Ploceidae

Baya Weaver *Ploceus philippinus*
Scaly-breasted Munia *Lonchura punctulata*
White-headed Munia *Lonchura maja*
Eurasian treesparrow *Passer montanus*

Family: Oriolidae

Black-naped Oriole *Oriolus chinensis*

Family: Pycnonotidae

Yellow-vented Bulbul *Pycnonotus goiavier*

Family: Rallidae

Watercock *Gallicrex cinerea*
White-breasted Waterhen *Amaurornis phoenicurus*

Family: Sturnidae

Common Myna *Acridotheres tristis*
Crested Myna *Acridotheres cristatellus*
Jungle Myna *Acridotheres tuscus*
Philippine Glossy Starling *Aplonis panayensis*

Family: Sylviidae

Artic Warbler *Phyllocopus boralis*
Common Tailorbird *Orthotomus sutorius*
Great Reed Warbler *Acrocephalus arundinaceus*
Yellow-bellied Printa *Prinia flaviventris*

Family: Scolopacidae

Common Greenshank *Tringa nebularis*
Common Sandpiper *Actitis hypoleucos*
Lesser Golden Plover *Pluvialis dominica*
Mongolian Plove *Charadrisu mongolus*
Rofous-Necked Stint *Calidris ruficollis*

Family: Turdidae

Magpie Robin *Copysychus saularis*

APPENDIX D PHOTOGRAPHS OF STUDY SITES

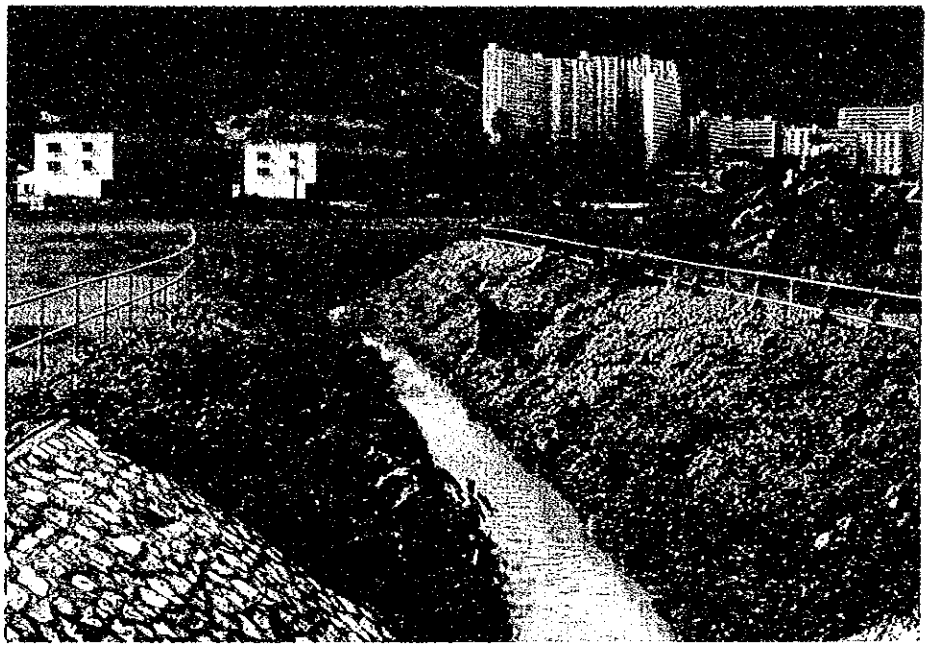

Plate 1: Sungai Dondang Near Proposed Retention Pond A Site.

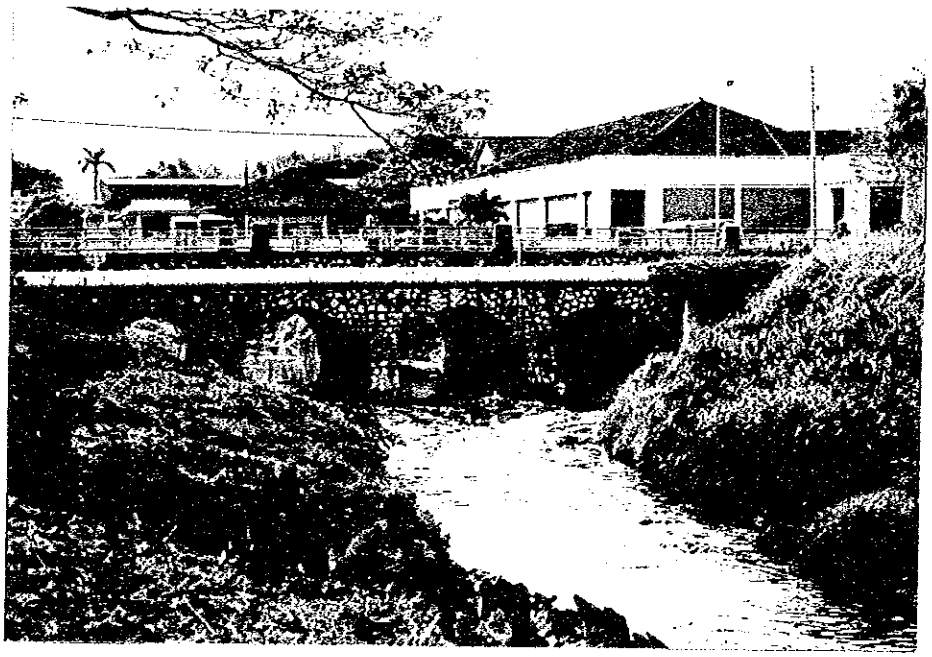

Plate 2: Sungai Dondang At Jalan Batu Lanchang.

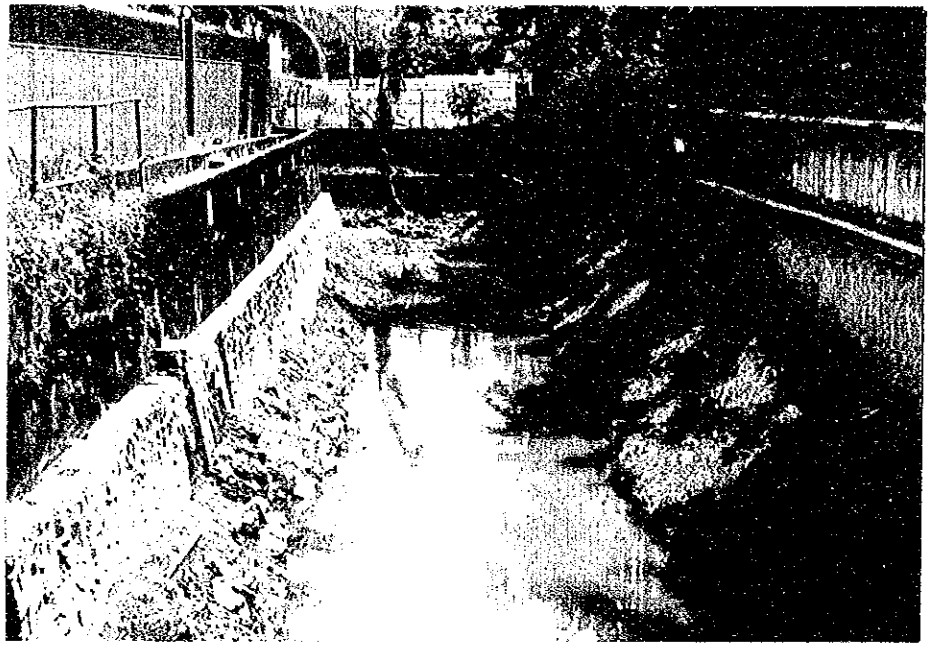

Plate 3: Sungai Air Terjun Near Jalan Kebun Bunga.

Plate 4: Sungai Air Itam And Sungai Air Terjun Confluence Along Jalan Air Itam.

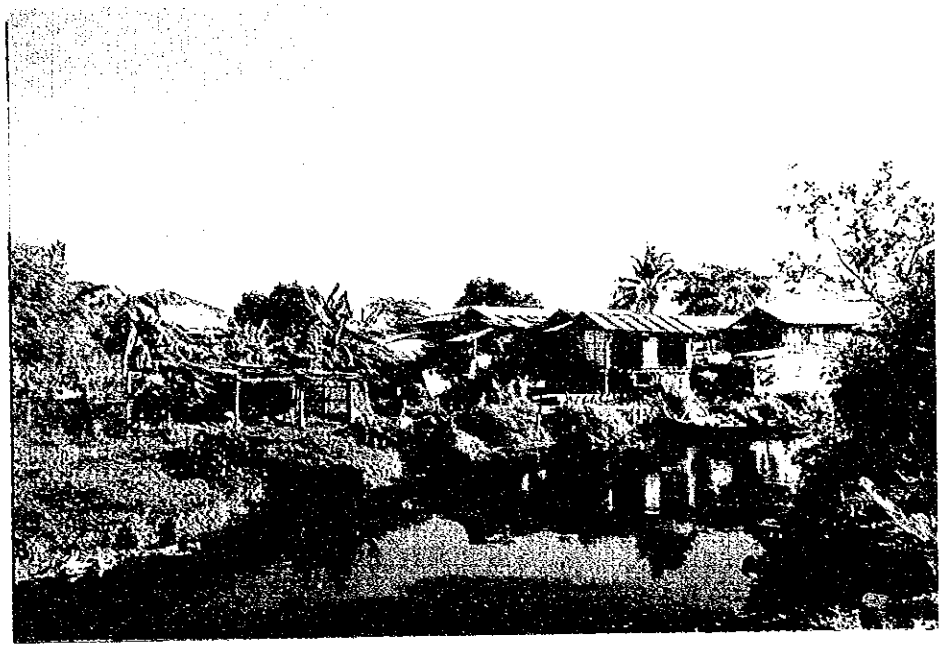

Plate 5: Sungai Pinang With Squatter Houses.

Plate 6: Sungai Pinang Near River Mouth.

Plate 7: Estuary Of Sungai Pinang At Low Tide.

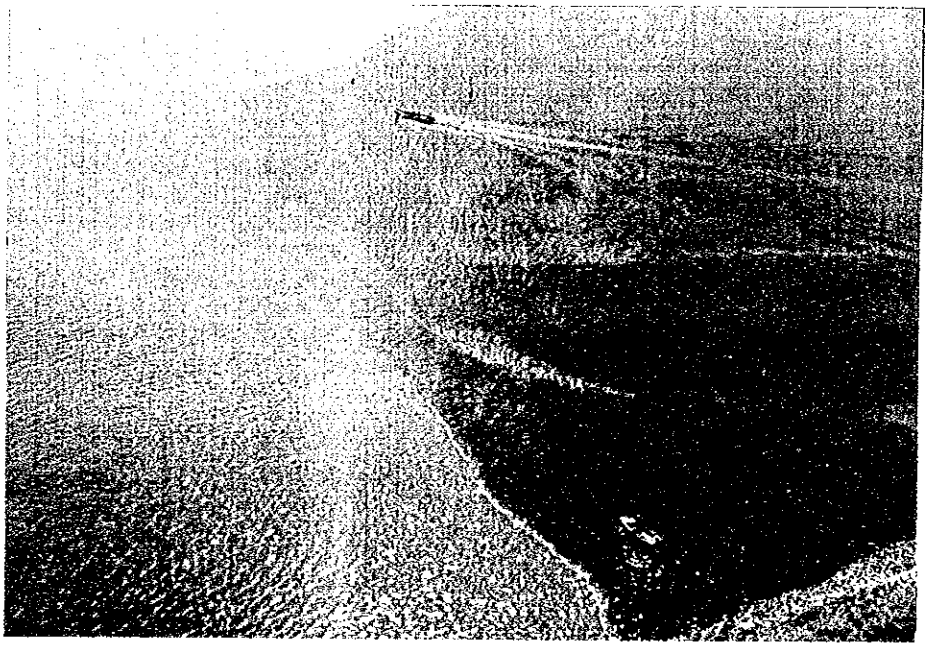

Plate 8: Estuary Of Sungai Pinang At High Tide Showing River Water And Sea.

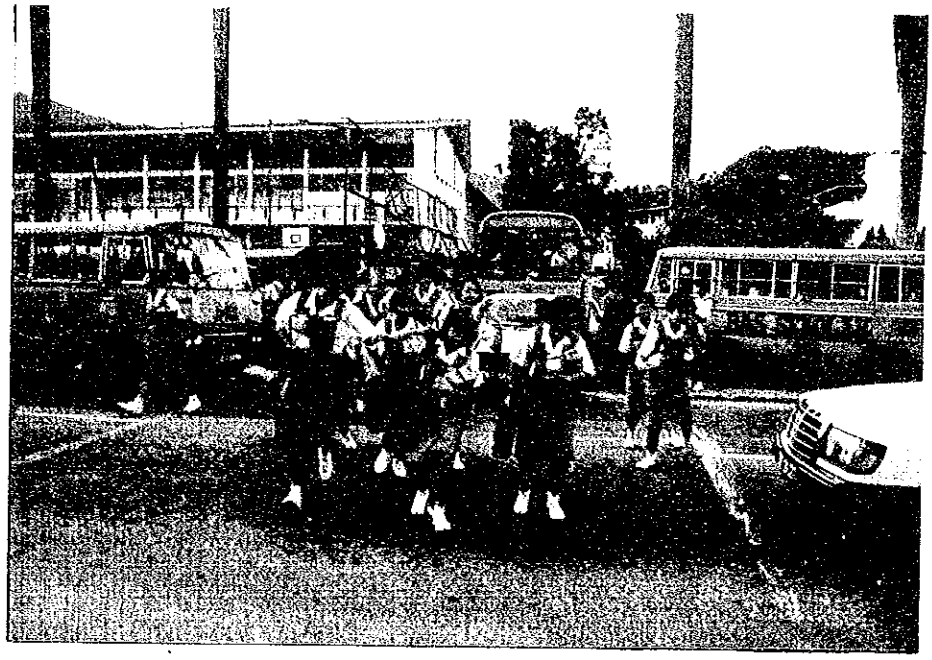

Plate 9: Penang Chinese Girls Secondary School Along Jalan Gottlieb.

Plate 10: Hawkers Stalls At Jalan Gottlieb.

APPENDIX E

STUDY TEAM OF THE ENVIRONMENTAL RESEARCH GROUP, UNIVERSITI SAINS MALAYSIA

Project Coordinator	:	Dr. Leong Yueh Kwong
Socio-Economic Planner	:	Dr. Alip Rahim
Economist	:	Mr. Chang Yii Tan
Chemist	:	Dr. Lim Poh Eng
Microbiologist	:	Dr. Wong See Yong
Limnologist	:	Dr. Ho Sinn Chye
Project Officers	:	Mr. Salehuddin
		Mr. Sunil S. Jayasuriya

FACTUAL REPORT

ON

SOIL INVESTIGATION AND WATER QUALITY INVESTIGATION

FOR

THE STUDY ON FLOOD MITIGATION AND DRAINAGE

IN

PENANG ISLAND, MALAYSIA

SUBMITTED TO

JAPANESE STUDY TEAM

ORGANIZED BY JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

6 SEPTEMBER, 1990

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Our Ref: K02-12R1

6 September, 1990

Japan International Cooperation
Agency Study Team
c/o Pacific Consultants International
7-5 Sekido 1-chome, Tama-shi
Tokyo 206
Japan

Attention: Mr. Y. Kaneko

Dear Sirs,

SOIL INVESTIGATION, RIVER AND COMMUNAL
WATER QUALITY INVESTIGATION
THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

We are pleased to submit 6 copies of the factual report on the above investigation.

Yours faithfully,
KISO-JIBAN CONSULTANTS (M) SDN BHD

for H. Todo
Director

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INTRODUCTION

A study on flood mitigation and drainage in Penang Island of Malaysia is at present undertaken by a Japanese Study Team organized by Japan International Cooperation Agency (JICA). Kiso-Jiban Consultants (M) Sdn Bhd was engaged by JICA to carry out soil investigation and water quality investigation.

The purpose of the present investigation are as follows:

1. To reveal ground conditions at the proposed locations of river channel improvement works and flood control facility.
2. To obtain basic formation for planning and selection of water treatment facilities, and evaluation of treatment efficiency.
3. To understand the treatment capacities of the existing communal plants.

This report presents the factual results of the soil investigation and water quality investigation. In this factual report, Chapters I and II describe the field investigation and laboratory tests performed, respectively. Chapter III illustrates the methods and equipment used for the investigation and Chapter IV presents the investigation results. Drilling logs, the detailed laboratory test results and the photoghraphic records of field works are attached in Appendices.

CHAPTER I

FIELD INVESTIGATION

The field investigation work consists of:

1. Exploratory boreholes with standard penetration tests at 13 locations.
2. River water quality investigation at 4 proposed flood control reservoir locations.
3. Water quality investigation at 4 communal treatment plant locations.

Soil Investigation

The soil investigation work was carried out at the following locations and to the following depths:

Location	Number of Boreholes	Depth below Ground Surface (m)
Proposed Pump Station	3	30
Discharge Channel	3	30
River Channel Improvement Section	7	11 ~ 13

The soil investigation field work was carried out during the period of 4 to 20 July, 1990. The water sampling work was performed during the period of 26 July to 23 August, 1990.

Water Sampling

Water samples were collected at 4 selected sampling points for Dondang retention ponds and 4 selected locations for 3 types of communal plants, namely, the activated sludge, septic tank with rectangular filter and septic tank with trickling filter. The detailed operation was performed as follows:

At Dondang Retention Ponds Area

Location of Pond	Type of Water Sampled	Location of Sampling
D1	River Water	Inlet of Retention Pond-A
D2	River Water	Discharge from Existing Water Treatment Plant
D3	River Water	Inlet of Retention Pond-B
D4	River Water	Inlet of Retention Pond-C

At Communal Plants

Location of Plant	Type of Water Sampled	Location of Sampling
Halaman Zoo Dua	Activated Sludge	- Inlet - Outlet of Primary Sedimentary Tank - Outlet of Aeration Tank - Outlet of Final Sedimentation Tank
Kampong Melayu	Septic Tank with Trickling Filter	- Inlet - Outlet of Septic Tank - Outlet of Trickling Filter

Location of Plant	Type of Water Sampled	Location of Sampling
Jalan Air Putih	Septic Tank with Rectangular Filter	- Inlet - Outlet of Septic Tank - Outlet of Rectangular Filter
Batu Maung	Activated Sludge	- Inlet - Outlet of Primary Sedimentation Tank - Outlet of Aeration Tank - Outlet of Final Sedimentation Tank

The layout and the locations of the soil investigation are shown in Figure 1. The location of sampling points for Dondang retention ponds are shown in Figure 2. The communal plant tank areas at Aver Itam and Batu Maung are indicated in Figure 3. In summary, Table 1 presents the details and locations of investigation points. Table 2 tabulates the total quantities of soil investigation and Table 3 shows the water sampling works performed.

Table 1 Details and Locations of Investigation Points

Borehole Location	Figure
For pumping stations P1 and P2	1, 1a
For Discharge Channel D1 to D3	1, 1b
For River Improvement R1 to R6	1, 1b, 1c, 1d

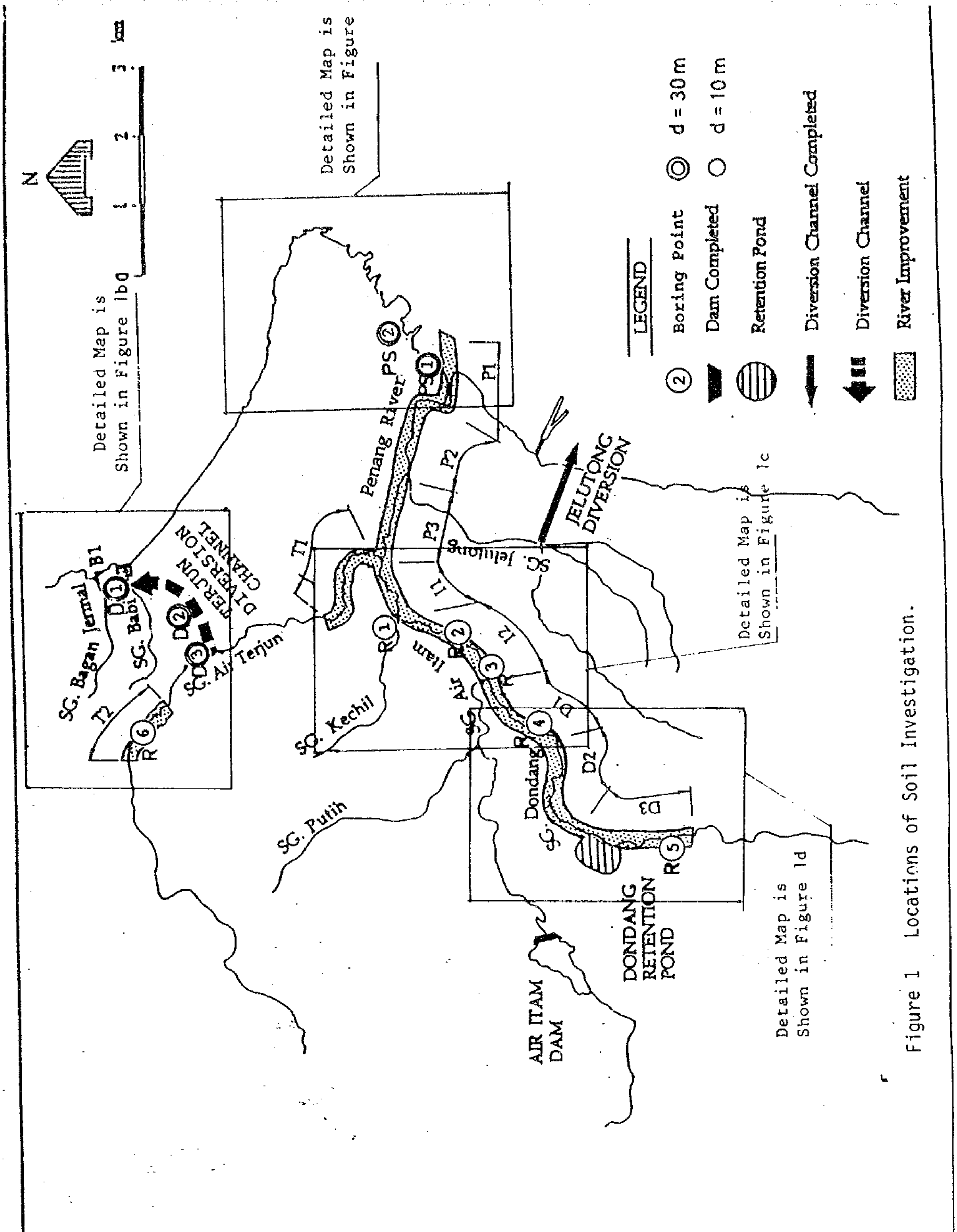


FIG. IV	PROPOSED FLOOD MITIGATION FACILITIES FOR MASTER PLAN OF PENANG RIVER

THE STUDY ON FLOOD MITIGATION AND DRAINAGE IN PENANG ISLAND

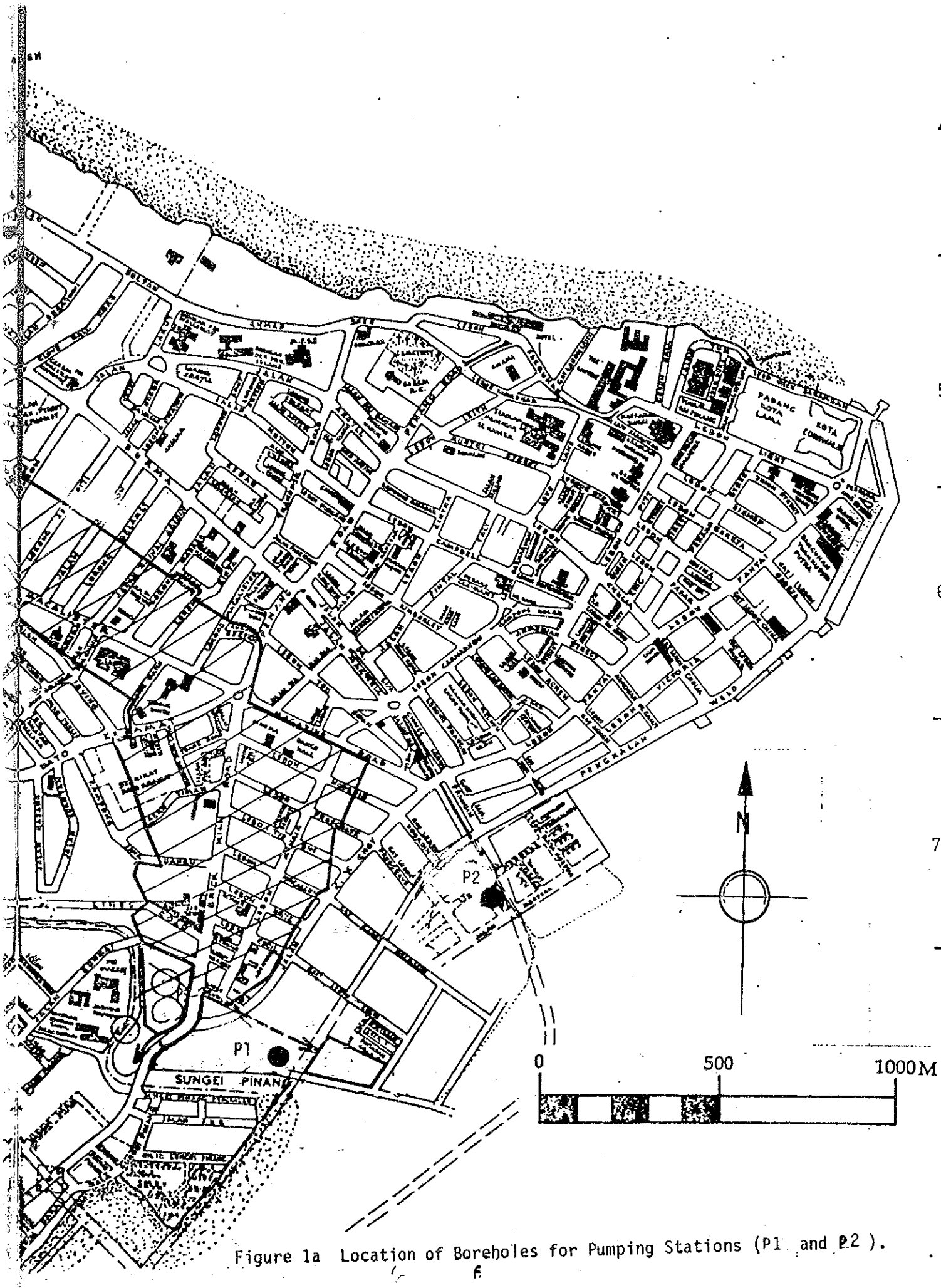


Figure 1a Location of Boreholes for Pumping Stations (P1 and P2).

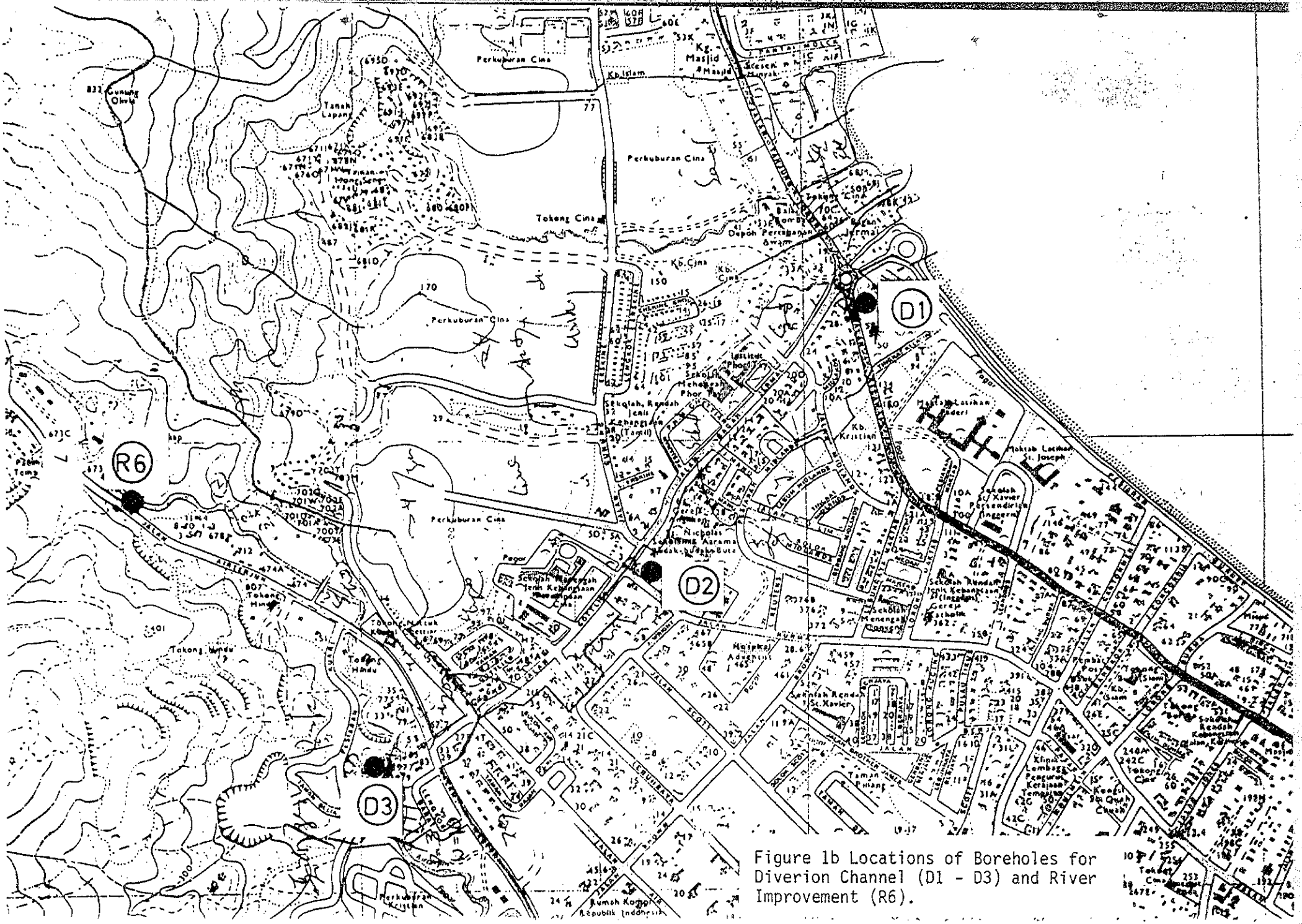


Figure 1b Locations of Boreholes for Diverion Channel (D1 - D3) and River Improvement (R6).

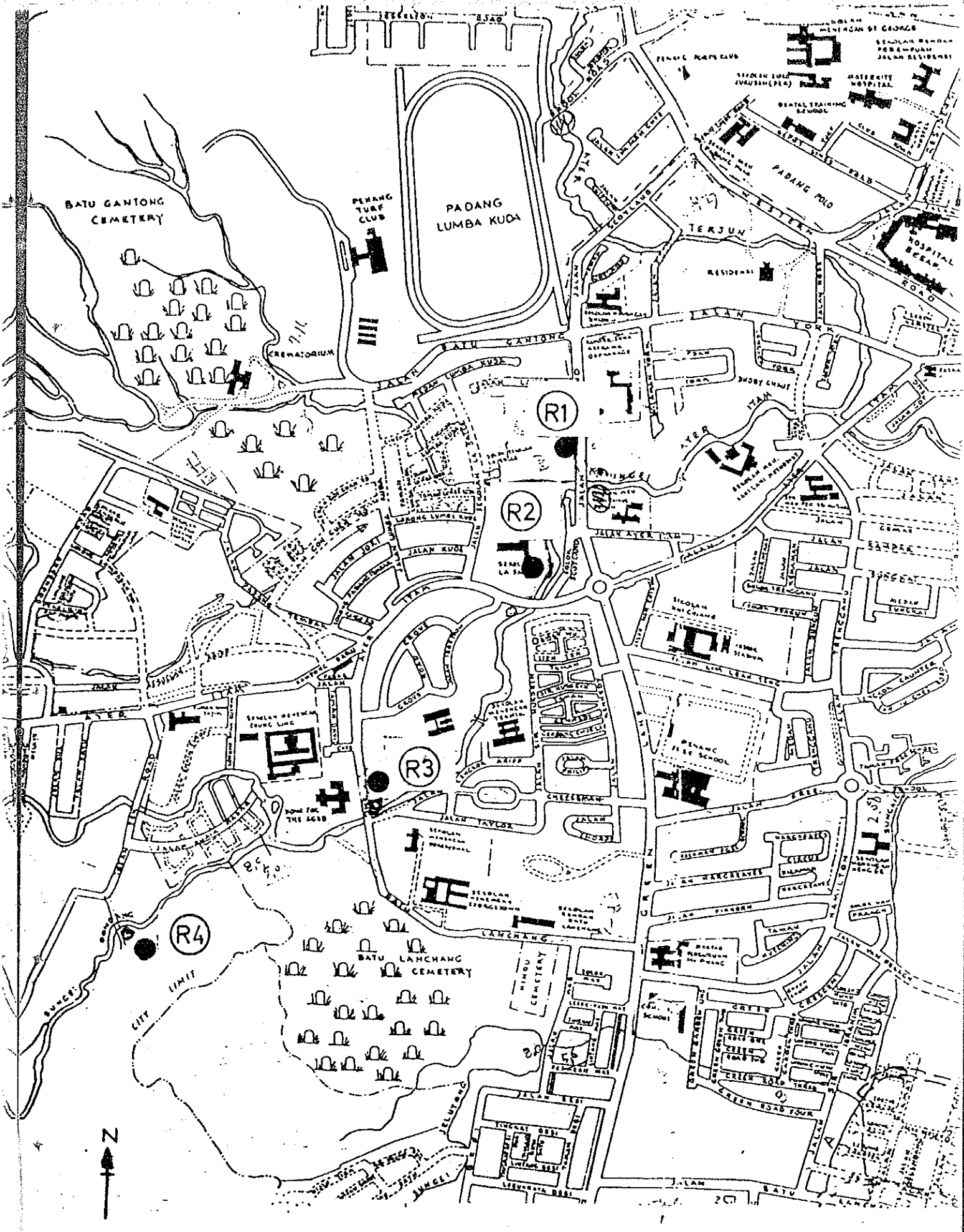


Figure 1c Locations of Boreholes for River Improvement.

Figure 1d Locations of Boreholes for River Improvement.

Water Sampling	Figure
For River Water Quality D1 to D4	2, 2a, 2b
For Commercial Plant Tanks 1 to 4	3. 3a, 3b, 3c to 3f

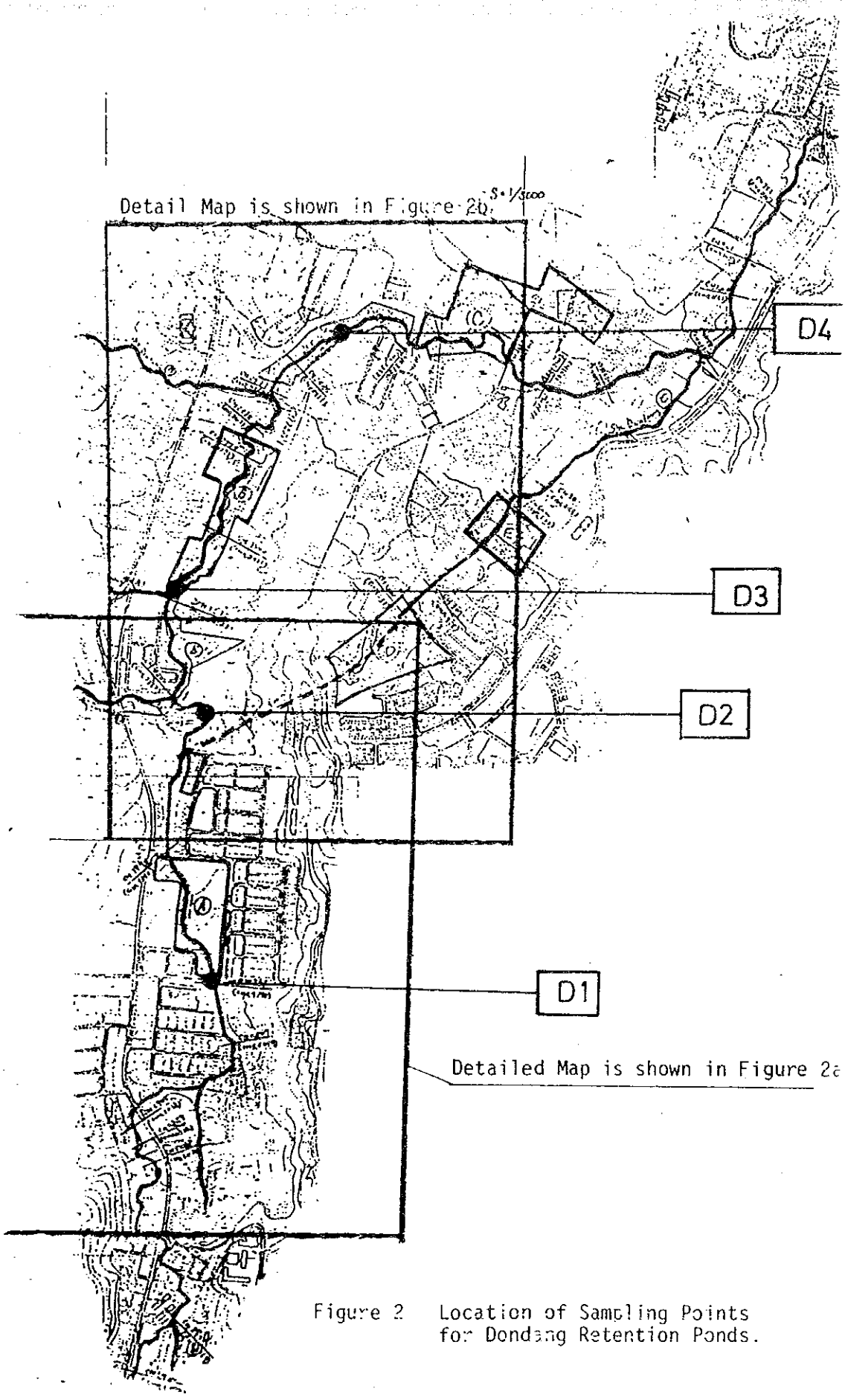


Figure 2 Location of Sampling Points for Dondang Retention Ponds.

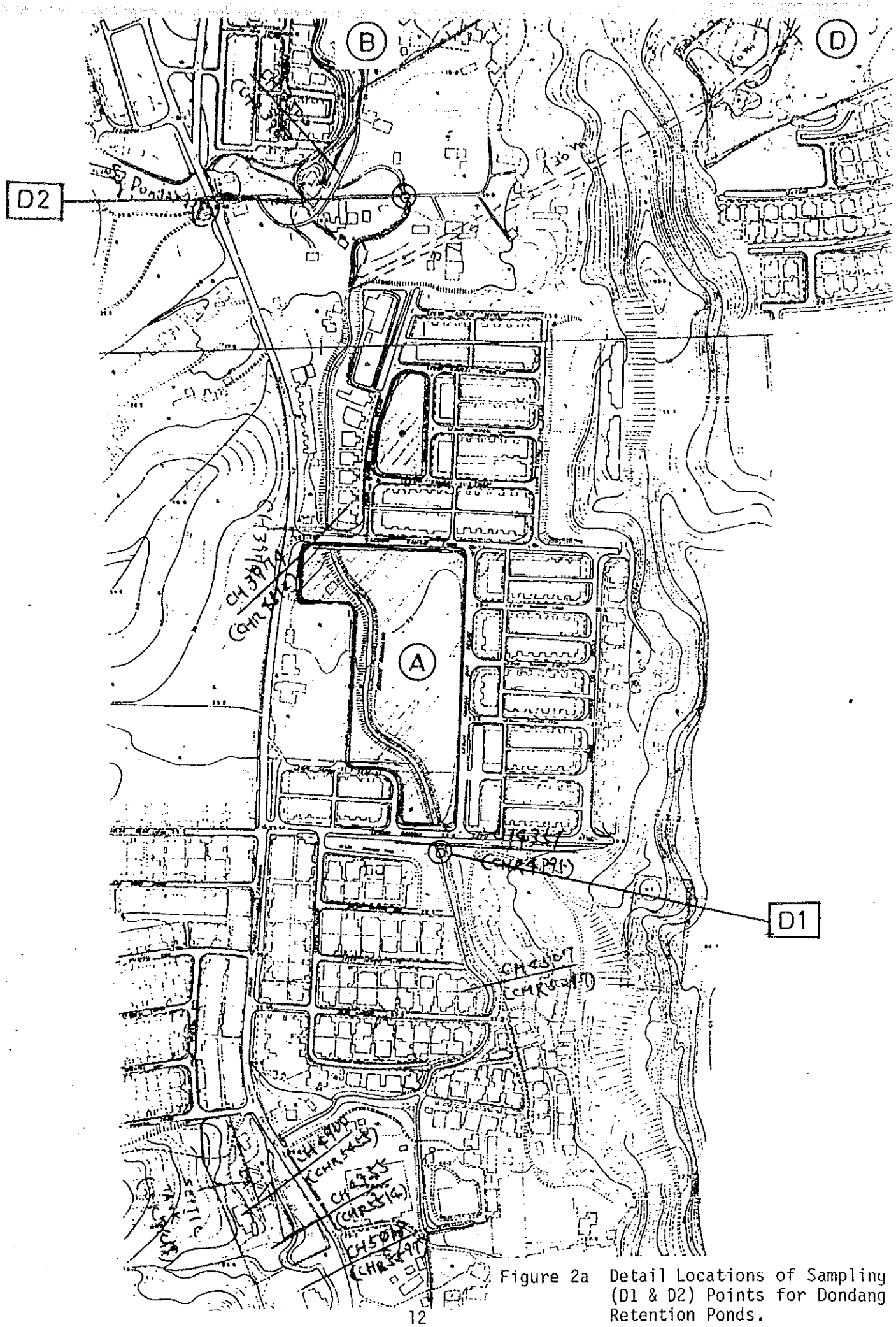


Figure 2a Detail Locations of Sampling (D1 & D2) Points for Dondang Retention Ponds.

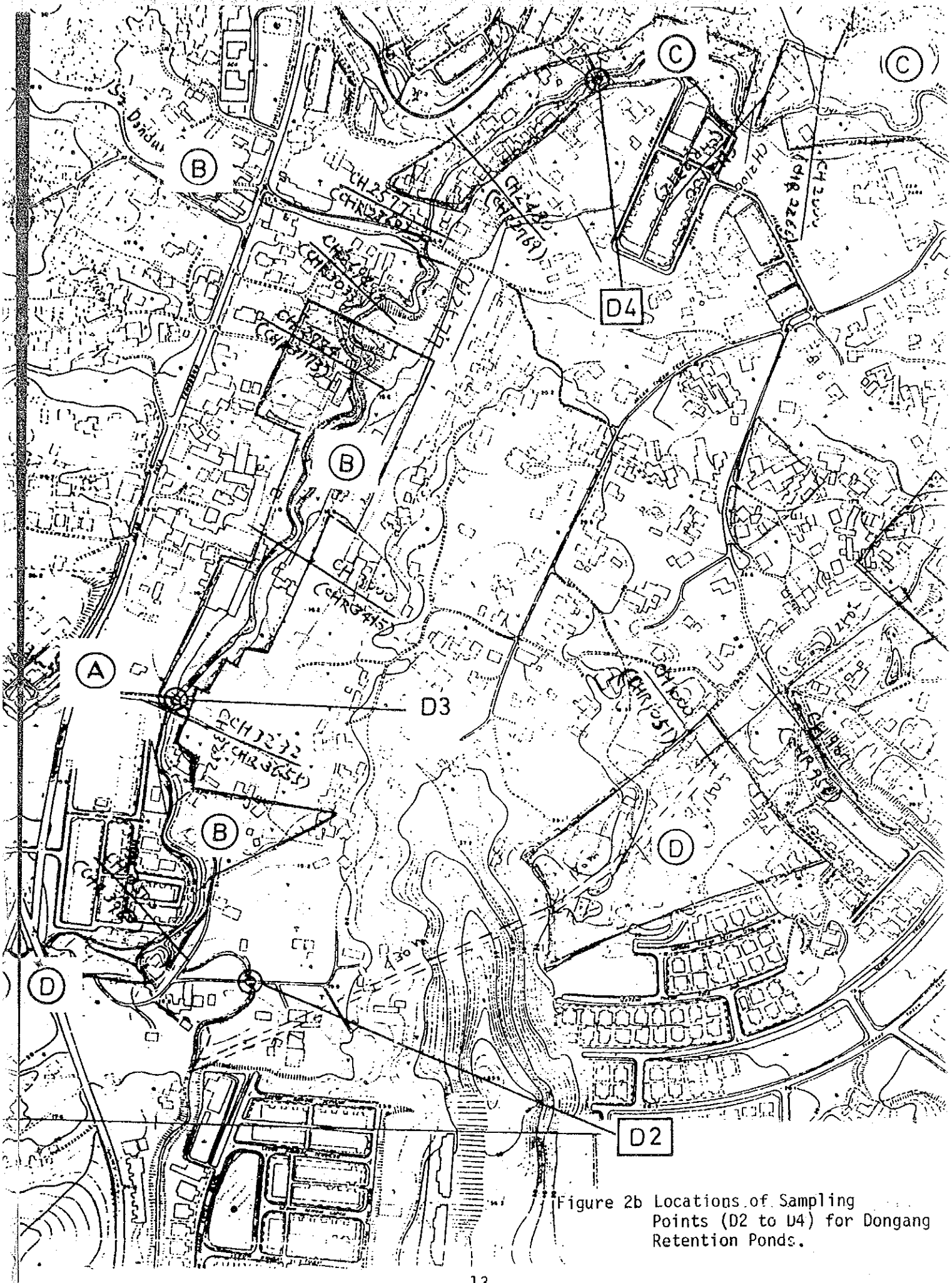


Figure 2b Locations of Sampling Points (D2 to D4) for Dongang Retention Ponds.

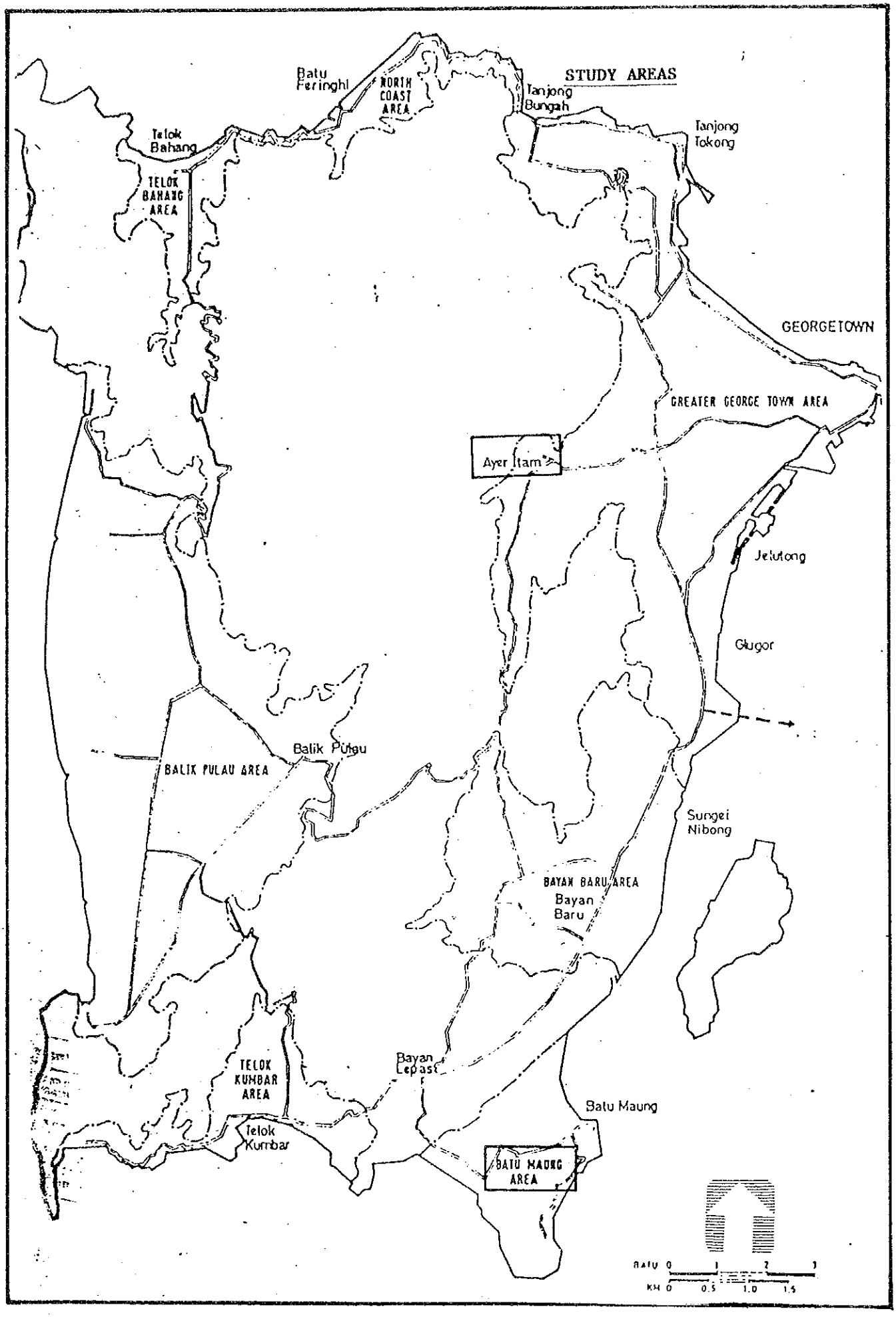


Figure 3 Areas of Communal Plant Tanks at Ayer Itam and Batu Maung

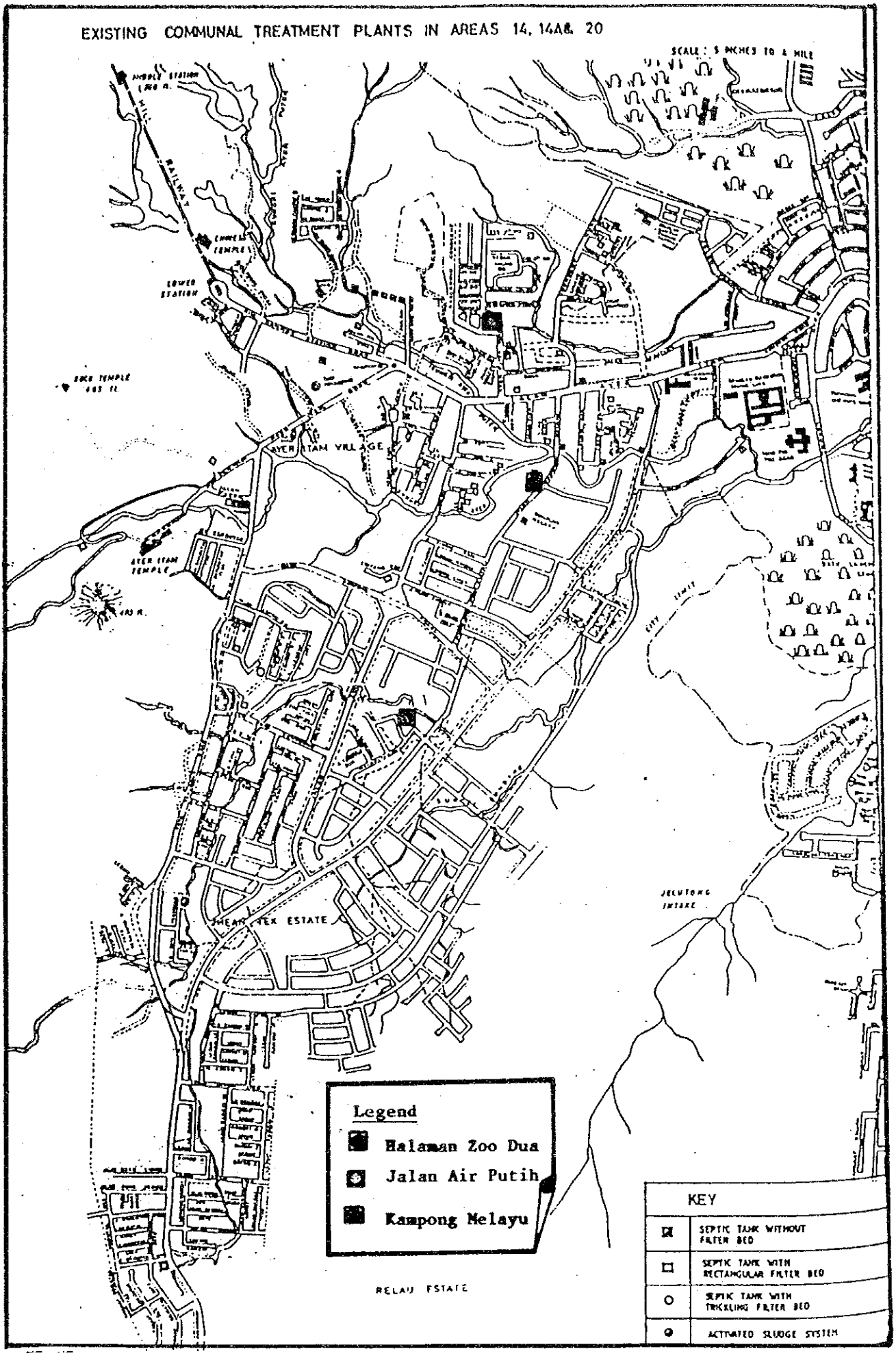


Figure 3a Locations of Communal Plants at Halaman Zoo Dua Kampong Melayu and Jalan Air Putih

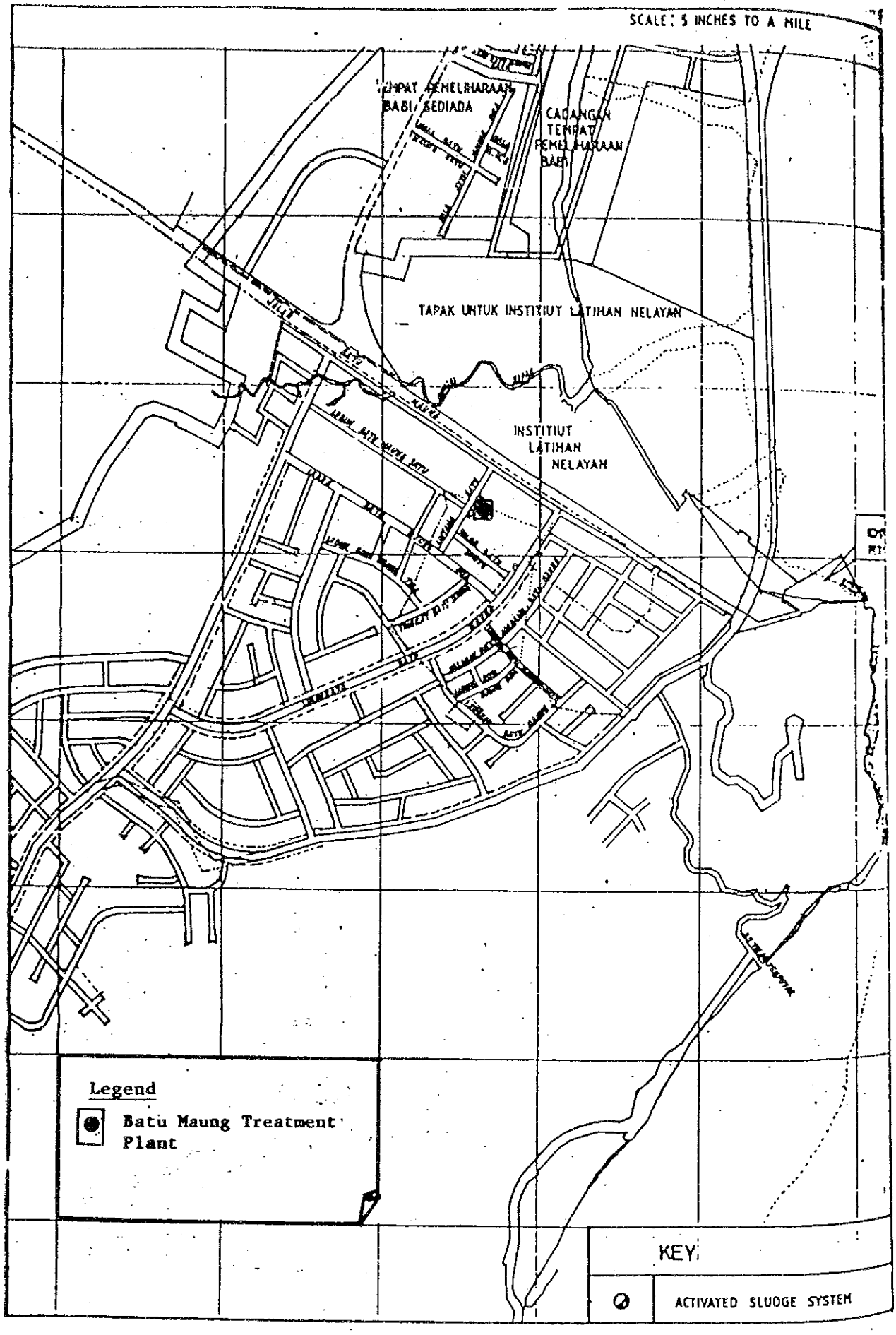


Figure 3b Location of Communal Plant at Batu Maung

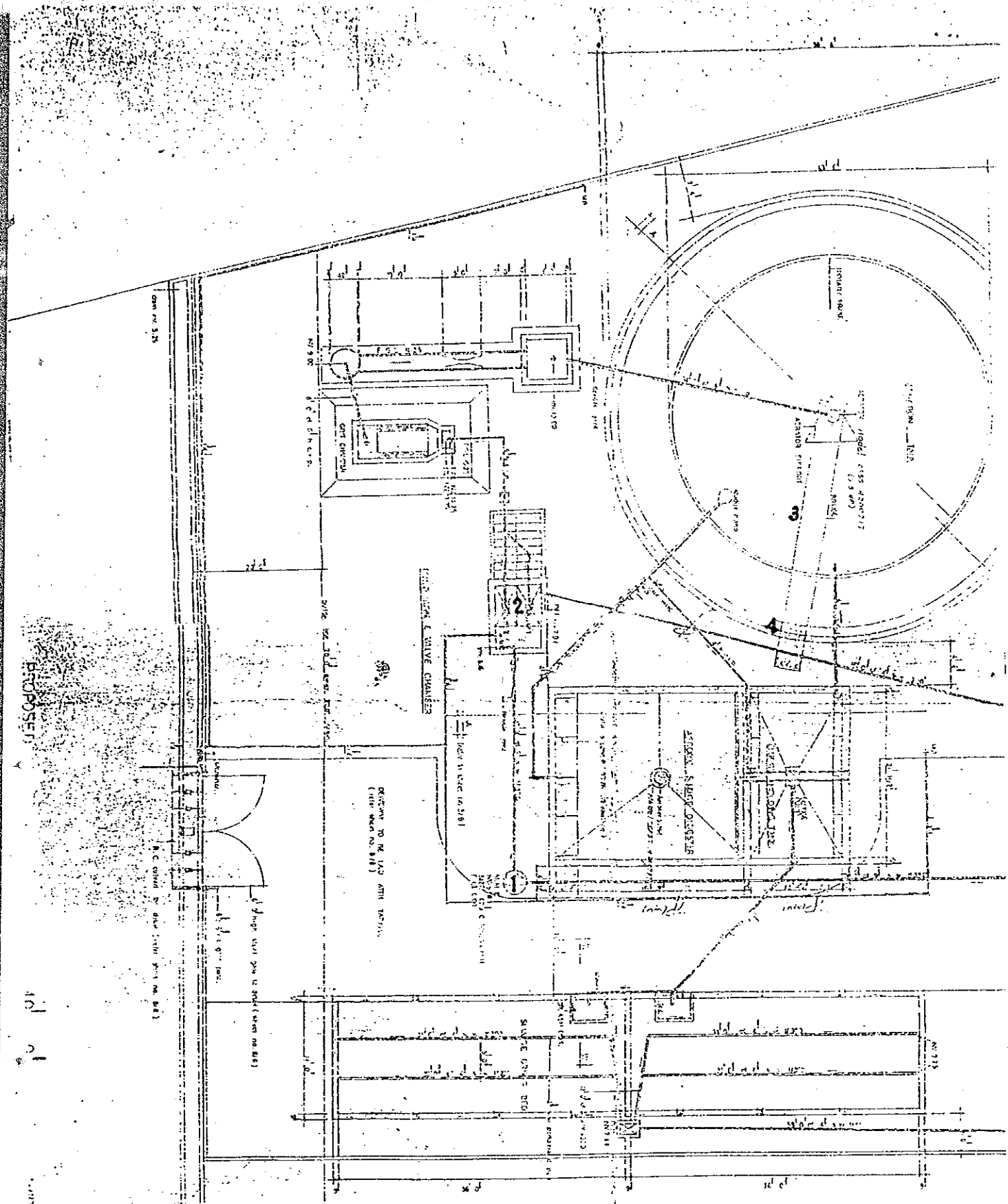


Figure 3c Sampling Points of Communal Plant at Halaman Zoo Dua

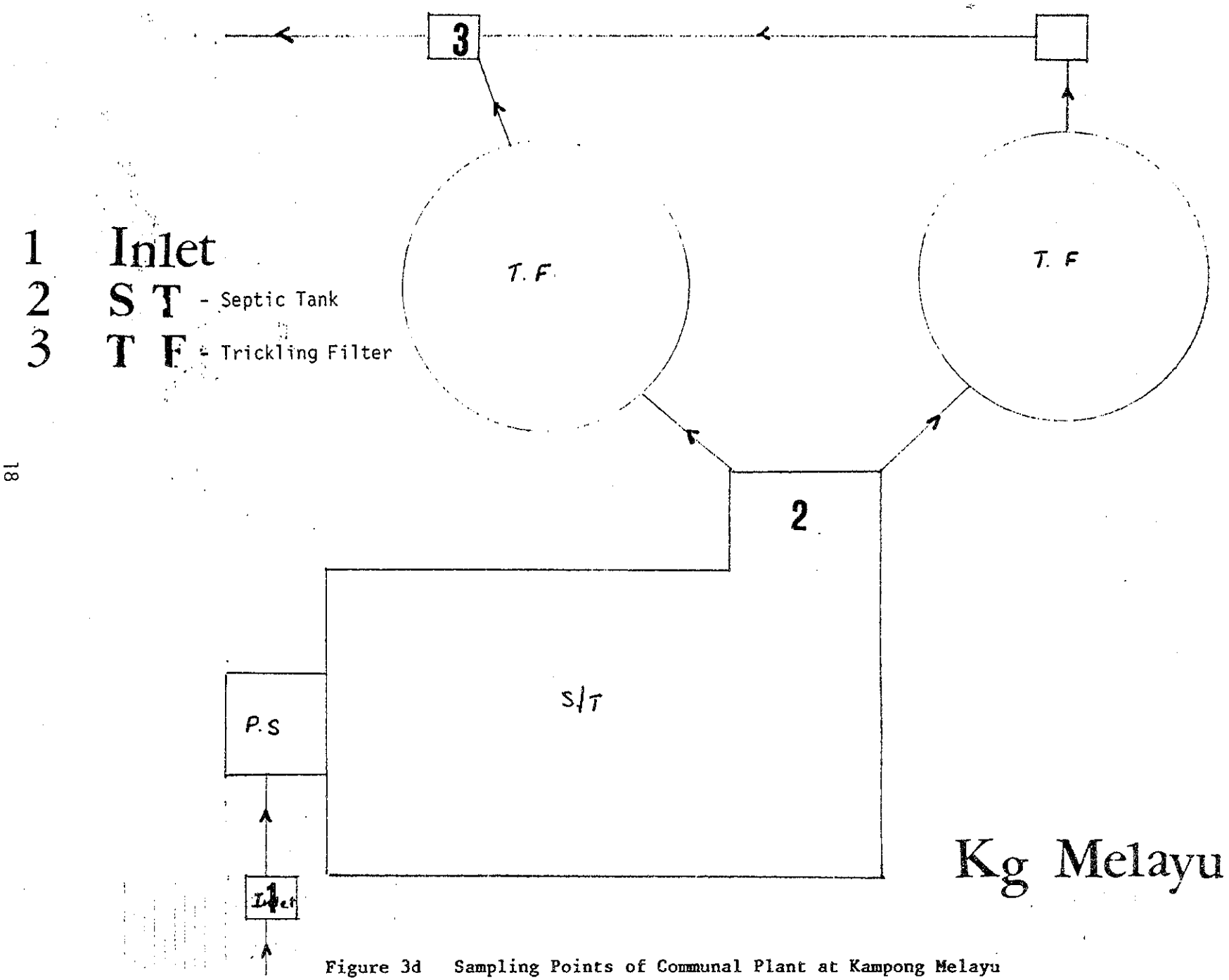
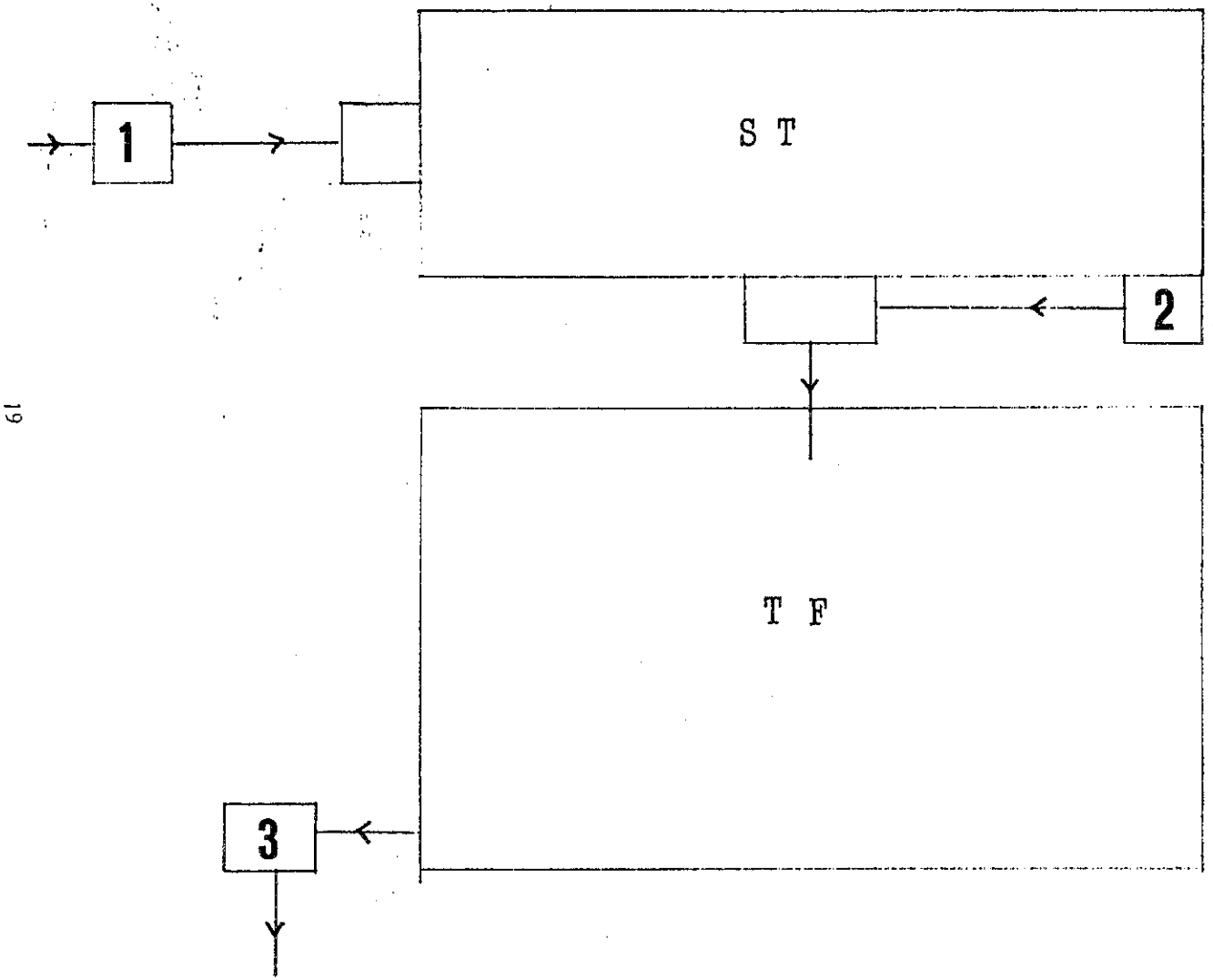


Figure 3d Sampling Points of Communal Plant at Kampong Melayu

Jln Air Putih



1 Inlet
2 ST -Septic Tank
3 TF -Trickling Filter

Figure 3e Sampling Points of Communal Plant at Jalan Air Putih

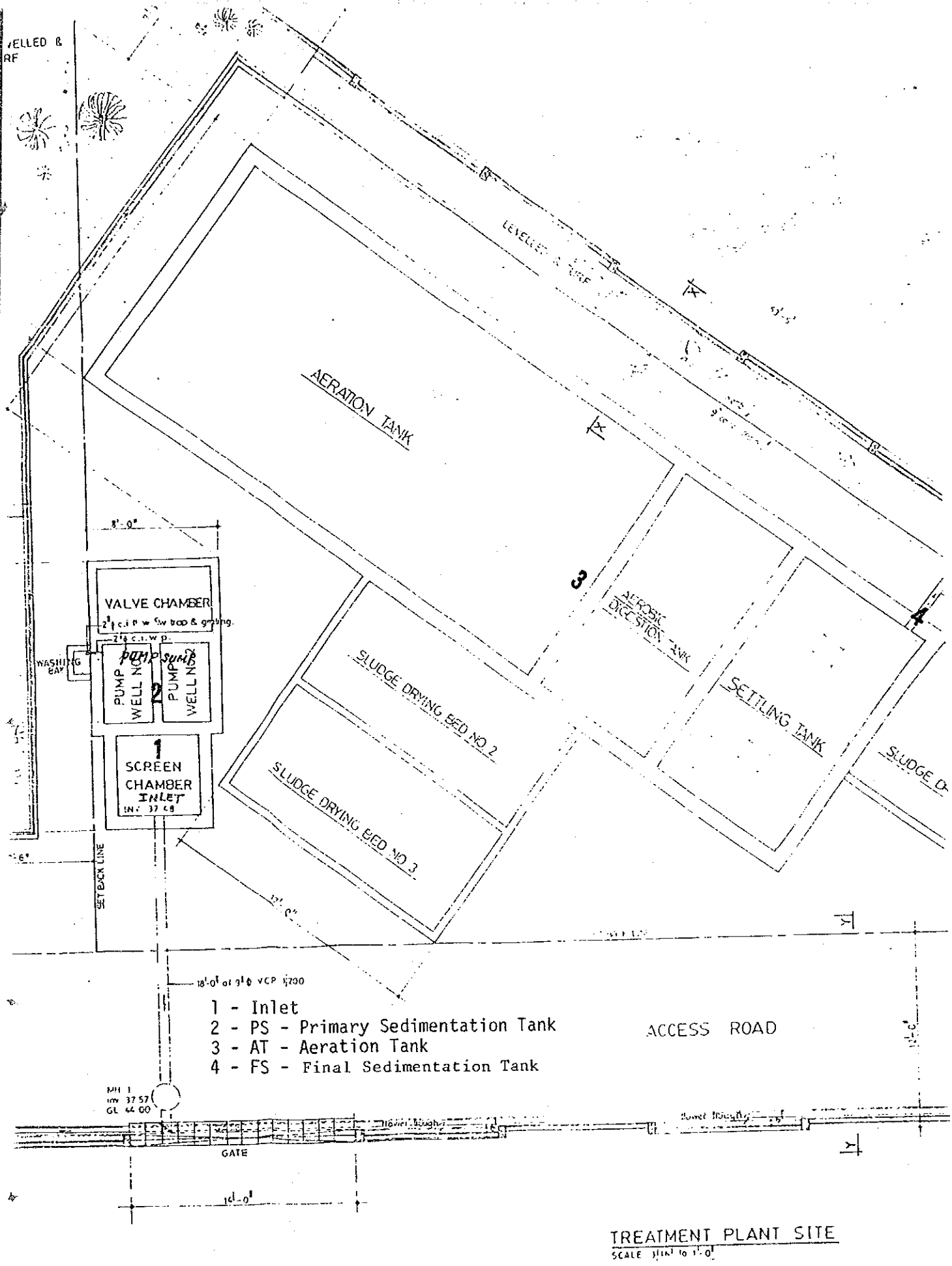


Figure 3f Sampling Points of Communal Plant at Batu Maung

Table 2 Total Quantities of Soil Investigation Works Performed

Borehole No.	Drilling (m)				Coring (m)	SPT No.
	0-10	10-20	20-30	30-40		
P1	10	10	9.95	-	-	29
P1A	10	5	-	-	-	12
P2	10	10	10	0.45	-	30
R1	10	2.45	-	-	-	12
R2	10	0.45	-	-	-	10
R3	10	2.45	-	-	-	12
R4	10	2.45	-	-	-	12
R5	10	0.45	-	-	-	10
R5A	3.5	-	-	-	-	3
R6	6	-	-	-	1.5	6
D1	10	10	10	0.45	-	30
D2	10	10	10	0.45	-	30
D3	10	10	10	0.45	-	30
Total	119.5	63.25	49.95	1.8	1.5	226

Table 3 Total Quantities of Water Sampling Works Performed

Type	Location	Sampling Time	
River Water	Dondang		26 July, 1990
	D1 to D4		6 August, 1990
			13 August, 1990
Activated Sludge	Halaman	7.00 am	6 August, 1990 to
	Zoo Dua	4.00 am	7 August, 1990
		7.00 am	22 August, 1990 to
		4.00 am	23 August, 1990
Septic Tank with Trickling Filter	Kampong Melayu	7.30 am	6 August, 1990 to
		4.30 am	7 August, 1990
Septic Tank with Rectangular Filter	Jalan Air Putih	8.00 am	6 August, 1990 to
		5.00 am	7 August, 1990
Activated Sludge	Batu Maung	9.00 am	6 August, 1990 to
		6.00 am	7 August, 1990
		9.00 am	22 August, 1990 to
		6.00 am	23 August, 1990

CHAPTER II

LABORATORY SOIL TESTS AND WATER QUALITY TESTS

Laboratory soil tests were performed in Sealand Drillers (M) Sdn Bhd's soil mechanics laboratory in Petaling Jaya in accordance with the British Standard. B.S. 1377 : 1975. The tests were performed to determine the moisture contents, particle size distribution and specific gravities of the soil samples.

Water quality tests were conducted at Edtech Associates and Biochem Laboratories in Penang. The tests were performed in accordance with "Standard Methods for the Examination of Water and Wastewater", ATWA - WPCF. The test iteems are as follows:

<u>At Dondang River Water Retention Ponds</u>

- pH
- Dissolved Oxygen (DO)
- Ammoniacal Nitrogen
- Chemical Oxygen Demand (COD)
- Biochemical Oxygen Demand (BOD)
- Coliform Count
- Escherichia Coli
- Suspended Solids
- Temperature

At 4 Communal Plants

- pH
- Dissolved Oxygen (DO)
- Temperature
- Chemical Oxygen Demand (COD)
- Biochemical Oxygen Demand (BOD)
- Suspended Solids
- Ammoniacal Nitrogen
- Total Phosphate (TP)
- Total Nitrogen (TN)
- Coliform Count
- Escherichia Coli

Table 4 tabulates the total quantities of laboratory tests performed on soil samples and Table 5 shows the total quantities of tests performed on water samples.

Table 4 Total Quantities of Laboratory Tests Performed on Soil Samples

Water Content	Specific Gravity	Particle Size Distribution
8	8	8
2	2	2
9	9	9
2	2	2
2	2	2
3	3	3
2	2	2
2	2	2
-	-	-
1	1	1
7	7	7
6	6	6
6	6	6
50	50	50

TABLE 5 TOTAL QUANTITIES OF TESTS PERFORMED ON WATER SAMPLES

Area	Location	pH	DO	AN	COD	BOD	CC	EC	SS	To_C	TP	TN	MLSS
Dondang Retention Ponds	D1	3	3	3	3	3	3	3	3	3	-	-	-
	D2	3	3	3	3	3	3	3	3	3	-	-	-
	D3	3	3	3	3	3	3	3	3	3	-	-	-
	D4	3	3	3	3	3	3	3	3	3	-	-	-
Communal Points	Tank 1	64	64	64	64	64	64	64	64	64	64	64	2
	Tank 2	14	14	14	14	14	14	14	14	14	14	14	-
	Tank 3	14	14	14	14	14	14	14	14	14	14	14	-
	Tank 4	62	62	62	62	62	62	62	62	62	62	62	2
Total		166	166	166	166	166	166	166	166	166	154	154	4

Legend :

DO - Dissolved Oxygen

AN - Ammoniacal Nitrogen

COD - Chemical Oxygen Demand

BOD - Biochemical Oxygen Demand

CC - Coliform Count

EC - Escherichia Coli

SS - Suspended Solids

To_C - Temperature in Degree celcius

TP - Total Phosphate

TN - Total Nitrogen

MLSS - Mixed Liquor Suspended Solid

CHAPTER III

METHODS AND EQUIPMENT USED

Soil Investigation

The methods of investigation are generally in accordance with the Japanese Industrial Standard (JIS) and the British Standard (BS).

All boring work was carried out using rotary boring machines with water as a drilling and flushing media. Boreholes wree 100mm in diameter. Standard penetration tests (SPT) were performed at 1m depth intervals in the boreholes. Disturbed soil samples were recovered in the SPT sampling tube. The SPT driving assembly was a self-tripping hammer, weighing 63.5 kg and dropping freely for a distance of 76cm.

Boring was terminated in the boreholes at the designated depths as reported in Chapter I Field Investigation.

Water Quality Investigation

At Dondang Retention Ponds Area

Sampling Points

Four points were selected along Sungai Dondang to establish the design water quality of inlet water to the purification facilities for the proposed retention ponds:

D1 Inlet of Retention Pond-A

D2 Water Quality after receiving discharge from existing water treatment plant.

D3 Inlet of Retention Pond-B

D4 Inlet of Retention Pond-C

Sampling Timing

Samples were collected three times during survey at intervals of several days to catch the fluctuation due to runoff and sewage water.

Sampling Methods

The water samples were collected from the surface water at the center of the stream and stored in narrow mouthed plastic bottle with a volume of 1 litre and kept in chilled place before analysis. The following measurement was performed during sampling process.

- Measuring and recording water temperature
- Measuring pH of fresh sample
- Observing and recording water colour and smell

At Communal Plants

In each plant, water samples were collected at certain intervals at the inlet and at treatment units of the outlet as follows:

- Activated sludge
  - Inlet
  - Outlet of primary sedimentation
  - Outlet of aeration tank
  - Outlet of final sedimentation

- Septic tank with rectangular filter

  Inlet

  Outlet of septic tank

  Outlet of filter

- Septic tank with trickling filter

  Inlet

  Outlet of septic tank

  Outlet of filter

Sampling Timing

Fixed sampling intervals are tabulated in the following:

- Activated sludge

Inlet	3 hours
Outlet of primary sedimentation tank	3 hours
Outlet of aeration tank	3 hours
Outlet of final sedimentation tank	3 hours

- Septic tank with trickling filter

Inlet	3 hours
Outlet of septic tank	6 hours
Outlet of filter	6 hours

- Septic tank with rectangular filter

Inlet	3 hours
Outlet of septic tank	9 and 12 hours
Outlet of filter	9 and 12 hours

Operation Condition Investigation

This condition investigation was carried out for the following major items:

- Inlet flow rate
- Aeration rate
- Sludge return rate
- MLSS
- Sludge withdrawal

Field observation was performed to record the following information:

- Temperature of air and water
- Smell
- Flow rate
- Color of water

CHAPTER IV

PRESENTATION OF INVESTIGATION RESULTS

The investigation results are presented in the following format:

4.1 Borehole logs are attached in Appendix A.

4.2 Summary and details of the laboratory soil test results are attached in Appendix B.

4.3 Summary and details of the water quality test results are attached in Appendix C.

4.4 Photographic records of soil investigation works are attached in Appendix D.

4.5 Photographic records of water sampling works are attached in Appendix E.

APPENDIX A

DRILLING LOGS

FIG DRILLING LOG

Project No. K02-12 Project The Study On Flood Mitigation And Drainage On Penang Island

Type of Drilling Rotary

Hole Number BH-P1 Elevation 1 m above road level m.

Date 6th to 10th July, 1990

Water Table GL -2.5 m m.

Driller Seaload (Muru)

Remarks
P : Standard Penetration Test
0

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling Depth in m.	Sampling Sample No.	Standard Penetration Test N-Value Blows/30cm	Blows Per Each 10cm 10 cm	10 cm	10 cm
	0.00	0.00												
1					Silty Sand	Brown	Loose	With roots gravels and rubbish (Fill)	1.15 1.45	P-1	7	2	2	3
2									2.15 2.45	P-2	6	1	3	2
3	-3.00	3.00	3.00						3.15 3.45	P-3	5	2	2	1
4					Clayey sand	Greenish grey	Loose to very loose	Sand is fine to medium grained. With seashell fragments.	4.15 4.45	P-4	6	2	2	2
5									5.15 5.45	P-5	5	1	2	2
6									6.15 6.45	P-6	4	1	1	2
7	-7.50	7.50	4.50						7.15 7.45	P-7	3	1	1	1
8					Marine clay	Greenish grey	Soft to very soft	Homogeneous	8.15 8.45	P-8	3	1	1	1
9									9.15 9.45	P-9	2	0	1	1
10	-10.00	10.00	2.50						10.15 10.45	P-10	4	1	1	2
11					Clayey sand	Light grey to light grey and yellowish brown	Loose	Sand is medium to coarse grained. With quartz gravels.	11.15 11.45	P-11	10	2	4	4
12	-12.00	12.00	2.00						12.15 12.45	P-12	8	2	2	4
13					Sandy clay	Light grey and yellowish brown	Loose	Sand is medium to coarse grained. With quartz gravels.	13.15 13.45	P-13	9	2	3	4
14	-14.00	14.00	2.00						14.15 14.45	P-14	12	3	5	4
15	-15.00	15.00	1.00		Silty clay	Whitish grey	Stiff	With trace of fine sand	15.15 15.45	P-15	13	4	4	5
16					Clayey sand	Whitish grey	Medium dense to very loose to medium dense	Sand is fine to medium grained. Sand is medium to coarse grained below 18m. With quartz gravels.	16.15 16.45	P-16	15	5	5	5
17									17.15 17.45	P-17	12	2	4	6
18									18.15 18.45	P-18	17	5	5	7
19									19.15 19.45	P-19	19	5	6	8
20									20.15 20.45	P-20	23	10	7	6
21									21.15 21.45	P-21	22	6	8	8
22														
23									23.15 23.45	P-22	1	1	0	0
24									24.15 24.45	P-23	5	2	2	1
25									25.15 25.45	P-24	13	6	3	4
26									26.15 26.45	P-25	16	5	5	6
27									27.15 27.45	P-26	50	10	17	23
28									28.15 28.45	P-27	28	7	9	12
29									29.15 29.45	P-28	16	4	6	6
30	-29.95	29.95	14.95			-END OF	DRILLING-		29.65 29.95	P-29	16	6	5	5
31														

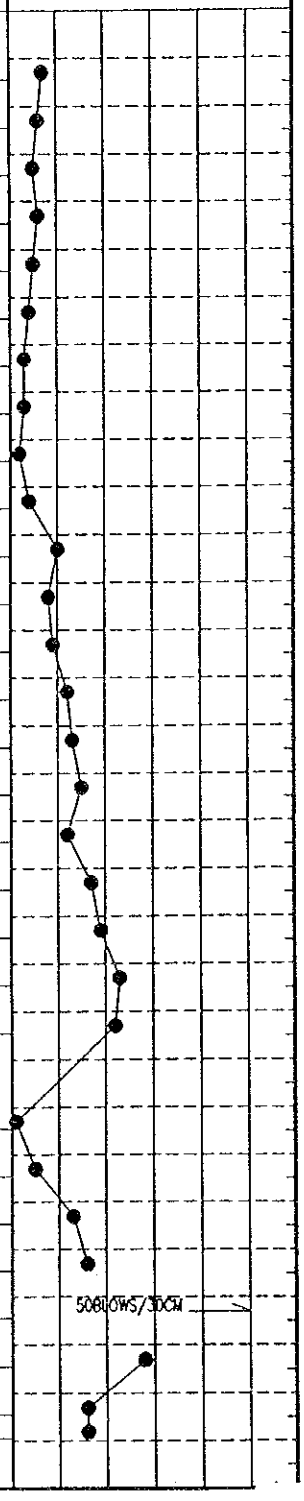


FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation and Drainage in Penang Island. Type of Drilling Rotary

Hole Number BH-P1A Elevation 1 m above road level m. Date 11th to 14th July, 1990

Water Table GL -2.5 m m. Driller Seaload (Mulu)

Remarks
P : Standard Penetration Test

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling: Depth in m.	Sampling: Sample No.	Standard Penetration Test: N-Value Blows/30cm	Blows Per Each 10cm: 0-10 cm	10-20 cm	20-30 cm	N - Value
	0.00	0.00													
1					Wash boring										
2															
3	-3.00	3.00	3.00												
4					Clayey sand	Grey	Very loose to loose	Sand is fine to medium grained. With seashells frogments.	3.15 3.45	P-1	3	1	1	1	
									4.15 4.45	P-2	4	2	1	1	
5	-5.40	5.40	2.40						5.15 5.45	P-3	5	2	2	1	
6					Marine clay	Greenish grey	Soft to very soft to soft	With trace of fine sand	6.15 6.45	P-4	3	1	1	1	
7									7.15 7.45	P-5	0	0	0	0	SELF PENETRATION BY HAMMER
8									8.15 8.45	P-6	0	0	0	0	SELF PENETRATION BY HAMMER
9									9.15 9.45	P-7	3	1	1	1	
10	-10.30	10.30	4.90						10.15 10.45	P-8	4	1	1	2	
11					Silty clay	Light grey and pinkish red	Medium stiff	Homogeneous	11.15 11.45	P-9	8	1	3	4	
12	-11.50	11.50	1.20		Clayey sand	Yellowish brown and light grey	Medium dense to loose	Sand is medium to coarse grained. With quartz gravels.	12.15 12.45	P-10	6	1	2	3	
13									13.15 13.45	P-11	15	6	5	4	
14									14.15 14.45	P-12	7	2	3	2	
15	-15.00	15.00	3.50					-END OF DRILLING-							
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															

FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation and Drainage in Penang Island

Type of Drilling Rotary

Hole Number BH-P2 Elevation 0.5 m above road level m.

Date 6th to 10th July, 1990

Water Table GL -1.5 m m.

Driller Seaload (Lee)

Remarks
P : Standard Penetration Test
0

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling: Depth in m.	Sampling: Sample No.	Standard Penetration Test: N-Value Blows/30cm	Blows Per Each 10cm: 0 to 10 cm	10 to 20 cm	20 to 30 cm	N - Value (10 20 30 40 50)
	5.00	0.00													
	4.90	0.10	0.10												
	4.60	0.40	0.50		Sandy silt	Dark brown	Soft	Sand is fine to medium grained. With roots (Top soil)	1.15 / 1.45	P=1	0	0	0	0	SELF PENETRATION BY HAMMER
1									2.15 / 2.45	P=2	0	0	0	0	SELF PENETRATION BY HAMMER
2	3.10	1.90	1.50		Clayey sand	Grey	Very loose	Sand is fine to medium grained. With quartz gravels.	3.15 / 3.45	P=3	0	0	0	0	SELF PENETRATION BY HAMMER
3									4.15 / 4.45	P=4	5	1	2	2	
4	1.50	3.50	1.60		Sandy clay	Grey	Very soft	Sand is fine to medium grained.	5.15 / 5.45	P=5	6	1	2	3	
5	0.00	5.00	1.50		Marine clay	Greenish grey	Very soft	Homogeneous. With fine to medium sand below 3.0m.	6.15 / 6.45	P=6	4	1	1	2	
6					Clayey sand	Light grey	Loose	Sand is medium to coarse grained. With quartz gravels.	7.15 / 7.45	P=7	3	1	1	1	
7	-2.00	7.00	2.00		Silty clay	Light grey and reddish	Medium stiff to	Homogeneous	8.15 / 8.45	P=8	1	0	0	1	
8					Marine clay	Greenish grey	Soft to very soft to medium stiff	With pockets of fine sand.	9.15 / 9.45	P=9	5	1	2	2	
9									10.15 / 10.45	P=10	7	2	2	3	
10									11.15 / 11.45	P=11	7	2	2	3	
11									12.15 / 12.45	P=12	11	2	3	6	
12	-7.00	12.00	5.00						13.15 / 13.45	P=13	4	1	1	2	
13					Clayey sand	Whitish grey	Medium dense to loose to medium dense	Sand is fine to medium grained. With quartz gravels.	14.15 / 14.45	P=14	16	4	6	6	
14									15.15 / 15.45	P=15	10	2	4	4	
15									16.15 / 16.15	P-16	10	3	3	4	
16	-10.50	15.50	3.50						17.15 / 17.45	P=17	7	2	2	3	
17					Sandy clay	Whitish grey	Stiff to medium stiff to stiff	Sand is medium to coarse grained. With quartz gravels.	18.15 / 18.45	P=18	5	1	2	2	
18									19.15 / 19.45	P=19	10	2	4	4	
19									20.15 / 20.45	P=20	15	5	5	5	
20									21.15 / 21.45	P=21	10	2	3	5	
21	-16.50	21.50	6.00						22.15 / 22.45	P=22	32	6	11	15	
22					Sandy clay	Light brown and whitish grey	Dense	Medium to coarse grained. With quartz gravels.	23.15 / 23.45	P=23	11	3	4	4	
23	-18.00	23.00	1.50						24.15 / 24.45	P=24	12	3	4	5	
24					Sandy clay	Whitish grey	Stiff	Sand is medium to coarse grained. With quartz gravels.	25.15 / 25.45	P=25	19	6	6	7	
25	-20.00	25.00	2.00						26.15 / 26.45	P=26	22	4	8	10	
26					Clayey sand	Whitish grey with yellowish brown	Medium dense	Sand is medium to coarse grained. With quartz gravels.	27.15 / 27.45	P=27	19	5	7	7	
27									28.15 / 28.45	P=28	17	5	6	8	
28									29.15 / 29.45	P=29	10	2	4	4	
29									30.15 / 30.45	P=30	21	4	7	10	
30	-25.45	30.45	5.45												
31						-END OF DRILLING-									

FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation and Drainage in Penang Island Type of Drilling Rotary

Hole Number BH-R1 Elevation 1.7 m above river bed m. Date 6th to 8th July, 1990

Water Table GL -1.7 m m. Driller Sealand (Ong)

Remarks
P : Standard Penetration Test
Q

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling Depth in m.	Sampling Sample No.	Standard Penetration Test N-Value Blows/30cm	Blows Per Each 10cm 0 to 10 cm	10 to 20 cm	20 to 30 cm	N - Value 10 20 30 40 50
	7.00	0.00													
1	6.50	0.50	0.50		Sandy silt	Brown	Loose	Sand is fine grained							
	5.50	1.50	1.00		Sandy silt	Grey	Soft	Sand is find grained	1.15 1.45	P-1	3	1	1	1	
2					Clayey sand	Light grey some yellow	Loose to medium dense	Sand is fine to coarse grained with fine gravels.	2.15 2.45	P-2	12	4	4	4	
3									3.15 3.45	P-3	6	2	2	2	
4									4.15 4.45	P-4	19	5	7	7	
5									5.15 5.45	P-5	16	5	5	6	
6									6.15 6.45	P-6	18	5	6	7	
7									7.15 7.45	P-7	11	2	4	5	
8									8.15 8.45	P-8	9	2	3	4	
9									9.15 9.45	P-9	10	3	3	4	
10									10.15 10.45	P-10	18	5	6	7	
11									11.15 11.45	P-11	20	7	6	7	
12	-5.45	12.45	10.95						12.15 12.45	P-12	16	4	5	7	
13						-END OF	DRILLING-								
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															

FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation and Drainage in Penang Island Type of Drilling Rotary

Hole Number BH-R2 Elevation 1.6 m above river bed m. Date 9th to 11th July,1990

Water Table GL. -1.9 m m. Driller Seaload (Ong)

Remarks
P : Standard Penetration Test
0

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling Depth in m.	Sample No.	Standard Penetration Test N-Value Blows/30cm	Blows Per Each 10cm 0-10 cm	10-20 cm	20-30 cm	N - Value 10 20 30 40 50
	6.00	0.00													
1					Silty sand	Brown grey	Loose	Topsoil-sand is fine to medium coarse some roots	1.15 1.45	P-1	2	0	1	1	
2	4.50	1.50	1.50												
					Sand	Grey	Very soft	Sand is fine to coarse. Some fine gravels.	2.15 2.45	P-2	1	0	0	1	
3									3.15 3.45	P-3	0	0	0	0	SELF PENETRATION BY HAMMER
4									4.15 4.45	P-4	1	0	0	1	
5	1.30	4.70	3.20												
					Clayey sand	Grey	Loose	Sand is fine to coarse with fine gravels.	5.15 5.45	P-5	7	2	2	3	
6	0.30	5.70	1.00												
					Silty clay	Grey light yellow	Soft	Medium to high plasticity	6.15 6.45	P-6	3	1	1	1	
7	-0.90	6.90	1.20												
					Clayey sand	Light grey	Loose	Sand is fine to coarse. Some fine gravels.	7.15 7.45	P-7	5	2	2	1	
8									8.15 8.45	P-8	5	1	2	2	
9	-2.80	8.80	1.90												
					Silty clay	Light grey	Soft	Medium to high plasticity. Some sand.	9.15 9.45	P-9	3	1	1	1	
10	-3.70	9.70	0.90												
	-4.45	10.45	0.75		Sand	Grey	Loose	Some fine gravels fine to coarse grained.	10.15 10.45	P-10	4	1	1	2	
11						-END-OF	DRILLING-								
12															
13															
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															

FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation and Drainage in Penang Island

Type of Drilling Rotary

Hole Number BH-R3 Elevation 1.9 m above sea bed m.

Date 12th to 14th July, 1990

Water Table GL. -0.7 m m.

Driller Sealand (Cheng)

Remarks
P : Standard Penetration Test
0

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling: Depth in m.	Sampling: Sample No.	Standard Penetration Test: N-Value Blows/30cm	Blows Per Each 10cm: 0-10 cm	10-20 cm	20-30 cm	N - Value
	9.00	0.00													
	8.50	0.50	0.50		Silty sand	Brown	Loose	Sand is fine grained							
1					Clayey sand	Grey	Very loose	Sand is fine grained with decayed wood.	1.15 1.45	P-1	2	1	0	1	
2	7.20	1.80	1.30												
					Gravelly sand	Light grey	Loose	Some bricks stone gravels and clay maximum size 2".	2.15 2.45	P-2	5	2	1	2	
3	6.10	2.90	1.10						3.15 3.45	P-3	0	0	0	0	SELF PENETRATION BY HAMMER
4					Organic clay	Light to dark grey	Very soft	High plasticity with organic matters.	4.15 4.45	P-4	0	0	0	0	SELF PENETRATION BY HAMMER
5									5.15 5.45	P-5	0	0	0	0	SELF PENETRATION BY HAMMER
6	3.20	5.80	2.90												
					Silty clay	Light grey	Very soft	Medium to high plasticity with occ. sand pockets.	6.15 6.45	P-6	0	0	0	0	SELF PENETRATION BY HAMMER
7									7.15 7.45	P-7	1	1	0	0	
8	1.20	7.80	2.00												
					Clayey sand	Light grey	Loose	Sand is fine to coarse grained.	8.15 8.45	P-8	6	1	1	4	
9	0.20	8.80	1.00												
					Sand	Light grey	Loose	Sand is coarse with fine gravels (quartz).	9.15 9.45	P-9	5	1	2	2	
10									10.15 10.45	P-10	6	1	2	3	
11	-1.80	10.80	2.00												
	-2.70	11.70	0.90		Sandy clay	Light grey	Soft	Sand is medium to coarse grained.	11.15 11.45	P-11	3	1	1	1	
12	-3.45	12.45	0.75		Silty clay	Light grey	Soft	Medium to high plasticity. Traces of sand.	12.15 12.45	P-12	3	1	1	1	
13						-END OF DRILLING-									
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															

FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation and Drainage in Penang Island Type of Drilling Rotary

Hole Number BH-R4 Elevation 1.3 m above river bed m. Date 14th to 16th July, 1990

Water Table GL -0.8 m m. Driller Seolands (Cheng)

Remarks
P : Standard Penetration Test
0

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling Depth in m	Sampling Sample No.	Standard Penetration Test N-Value Blows/30cm	Blows Per Each 10cm 0-10 cm	10-20 cm	20-30 cm	N - Value 10 20 30 40 50
	3.00	0.00													
1	2.00	1.00	1.00		Silty sand	Brown	Loose	Sand is fine grained with gross roots.	1.15 1.45	P-1	1	0	1	0	
2					Sandy clay	Grey	Very Loose	Sand is fine to medium coarse	2.15 2.45	P-2	1	1	0	0	
3									3.15 3.45	P-3	1	1	0	0	
4	-0.60	3.60	2.60		Organic clay	Dark grey	Very soft	High plasticity	4.15 4.45	P-4	0	0	0	0	SELF PENETRATION BY HAMMER
5	-1.30	4.30	0.70		Silty clay	Grey	Very soft	Medium to high plasticity some sand.	5.15 5.45	P-5	0	0	0	0	SELF PENETRATION BY HAMMER
6	-2.80	5.80	1.50		Sandy clay	Grey	Soft	Sand is medium to coarse grained.	6.15 6.45	P-6	3	1	1	1	
7									7.15 7.45	P-7	2	1	0	1	
8	-5.20	8.20	2.40						8.15 8.45	P-8	4	1	1	2	
9					Clayey sand	Grey	Loose	Sand is coarse grained.	9.15 9.45	P-9	5	1	2	2	
10									10.15 10.45	P-10	7	2	2	3	
11									11.15 11.45	P-11	7	2	2	3	
12	-9.45	12.45	4.25						12.15 12.45	P-12	11	3	3	5	
13						-END OF	DRILLING-								
14															
15															
16															
17															
18															
19															
20															
21															
22															
23															
24															
25															
26															
27															
28															
29															
30															
31															

FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation and Drainage in Penang Island

Type of Drilling Rotary

Hole Number BH-R5 Elevation 1.5 m above river bed m.

Date 16th to 18th July, 1990

Water Table GL -0.5 m m.

Driller Seolands (Cheng)

Remarks
P : Standard Penetration Test
0

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling: Depth in m.	Sampling: Sample No.	Standard Penetration Test: N-Value Blows/30cm	Blows Per Each 10cm: 0-10 cm	10-20 cm	20-30 cm
	5.00	0.00												
	4.50	0.50	0.50		Silty clay	Light grey yellow	Soft	Medium plasticity						
1	4.00	1.00	0.50		Silty clay	Brown	Soft	Some sand	1.15 1.45	P=1	0	0	0	0
2	3.50	1.50	0.50		Sand	Brown	Very Loose	Fine coarse						
	3.00	2.00	0.50		Clayey Sand	Grey	Very Loose	Fine to coarse grained.	2.15 2.45	P=2	4	1	1	2
3					Sand	Grey	Very loose	Fine to coarse with fine gravels	3.15 3.45	P=3	4	2	1	1
4	1.10	3.90	1.90						4.15 4.45	P=4	3	1	1	1
					Sandy clay	Grey	Soft	Sand is fine grained.						
5	0.10	4.90	1.00						5.15 5.45	P=5	1	0	0	1
					Silty clay	Grey	Very soft	Some fine sand.						
6									6.15 6.45	P=6	1	1	0	0
7	-1.70	6.70	1.80											
					Sand	Grey	Medium dense	Fine to coarse with fine gravels.	7.15 7.45	P=7	19	7	7	5
8									8.15 8.45	P=8	21	9	6	6
9	-3.80	8.80	2.10											
					Sandy clay	Light grey	Stiff	Sand is coarse grained.	9.15 9.45	P=9	10	3	3	4
10														
	-5.45	10.45	1.65						10.15 10.45	P=10	14	4	4	6
11						-END OF	DRILLING-							
12														
13														
14														
15														
16														
17														
18														
19														
20														
21														
22														
23														
24														
25														
26														
27														
28														
29														
30														
31														

N - Value: 10 20 30 40 50

SELF PENETRATION BY HAMMER

FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation and Drainage in Penang Island

Type of Drilling Rotary

Hole Number BH-R5A

Elevation 4.1 m above river bed m.

Date 16th July, 1990

Water Table - m.

Driller Seoland (Cheng)

Remarks
P : Standard Penetration Test
0

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling: Depth in m	Sampling: Sample No.	Standard Penetration Test: N-Value Blows/30cm	Blows Per Each 10cm: 0-10 cm	10-20 cm	20-30 cm
	1.00	0.00												
1	0.00	1.00	1.00		Sandy silt	Brown	Soft	Top soil						
2					Sandy clay	Brown	Medium stiff	Earth fill. Some gravels maximum size 1".	1.15 1.45	P-1	3	1	1	1
3									2.15 2.45	P-2	7	3	3	1
	-2.50	3.50	2.50						3.15 3.45	P-3	6	1	2	3
4						-END OF	DRILLING-							
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														
21														
22														
23														
24														
25														
26														
27														
28														
29														
30														
31														

FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation and Drainage in Penang Island. Type of Drilling Rotary

Hole Number BH-R6 Elevation 1.3 m above river bed m. Date 18th to 20th July,1990

Water Table GL -1.4 m m. Driller Seelond (Cheng)

Remarks
P : Standard Penetration Test
C : Coring
0

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks	Sampling Depth in m.	Sampling Sample No.	N-Value Blows/30cm	Blows Per Each 10cm 0-10 cm	10-20 cm	20-30 cm
	3.00	0.00												
1	2.00	1.00	1.00		Sandy silt	Brown	Soft	Sand is fine grained						
2					Sand	Grey	Very loose	Sand is fine to coarse grained.	1.15 1.45	P-1	0	0	0	0
									2.15 2.45	P-2	1	1	0	0
3									3.15 3.45	P-3	2	1	0	1
4									4.15 4.45	P-4	4	1	1	2
5	-1.60 -1.80	4.60 4.80	3.60 0.20		Gravel	Grey	Dense	Granite max. 1.5"	5.15 5.45	P-5	28	9	9	10
6	-3.00	6.00	1.20		Sand	Light grey	Medium dense	Sand is fine to coarse occasional gravels.	6.00 6.00	P-6	0	0	0	0
7					Granite	Grey white Light grey	Strong	Fine grained fresh	6.00	C-1				
	-4.50	7.50	1.50						7.00 7.50	C-2				
8						-END OF	DRILLING-							

Standard Penetration Test & Core Recovery (CR)

N - Value: 10 20 30 40 50 — RQD — CR — 20 40 60 80 100%

SELF PENETRATION BY HAMMER

SELF PENETRATION BY HAMMER

71 90

71 90

FIG DRILLING LOG

Project No. KL02-12 Project The Study on Flood Mitigation and Drainage in Penang Island Type of Drilling Rotary

Hole Number BH-D1 Elevation 0.5 m above road level m. Date 11th to 15th July, 1990

Water Table GL -3.9 m m. Driller Seaload (Lee)

Remarks
P : Standard Penetration Test
-

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks
	5.00	0.00						
1	4.00	1.00	1.00		Silty sand	Grey	Loose	Sand is fine to medium grained. With gravels. (Fill)
2	2.50	2.50	1.50		Clayey sand	Grey	Loose	Sand is fine to medium grained. With gravels. (Fill)
3	1.40	3.60	1.10		Sand	Grey	Loose	Medium to coarse grained. With quartz gravel.
4	1.00	4.00	0.40					
5					Clayey sand	Light grey	Loose	Sand is medium to coarse grained. With quartz gravel.
6	-1.00	6.00	2.00		Silty clay	Light grey to light blueish grey	Very soft	With trace of decayed woods. Homogeneous
7					Marine clay	Greenish grey	Very soft	Homogeneous
8	-3.00	8.00	2.00					
9					Sandy clay	Light grey	Soft to very soft to stiff	Sand is medium to course grained. With quartz gravel.
10								
11								
12	-7.50	12.50	4.50					
13					Clayey sand	Light grey to yellowish brown to reddish brown to light grey and yellowish black to reddish brown and light grey	Loose to dense	Sand is medium to coarse grained. With quartz gravel.
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30	-25.45	30.45	17.95			-END OF DRILLING-		

Sampling Depth in m	Sample No.	Standard Penetration Test N-Value Blows/30cm	Blows Per Each 10cm 0-10 cm	10-20 cm	20-30 cm	N - Value 10 20 30 40 50
1.15 1.45	P=1	6	2	1	3	
2.15 2.45	P=2	6	2	3	1	
3.15 3.45	P=3	9	4	3	2	
4.15 4.45	P=4	1	0	0	1	
5.15 5.45	P=5	0	0	0	0	SELF PENETRATION BY HAMMER
6.15 6.45	P=6	0	0	0	0	SELF PENETRATION BY HAMMER
7.15 7.45	P=7	0	0	0	0	SELF PENETRATION BY HAMMER
8.15 8.45	P=8	4	1	1	2	
9.15 9.45	P=9	0	0	0	0	SELF PENETRATION BY HAMMER
10.15 10.45	P=10	3	1	1	1	
11.15 11.45	P=11	9	3	3	3	
12.15 12.45	P=12	8	2	3	3	
13.15 13.45	P=13	11	3	3	5	
14.15 14.45	P=14	8	2	2	4	
15.15 15.45	P=15	18	4	7	7	
16.15 16.45	P=16	19	5	6	8	
17.15 17.45	P=17	13	3	4	6	
18.15 18.45	P=18	28	7	10	11	
19.15 19.45	P=19	25	8	8	9	
20.15 20.45	P=20	26	7	9	10	
21.15 21.45	P=21	10	3	3	4	
22.15 22.45	P=22	22	7	7	8	
23.15 23.45	P=23	17	6	5	6	
24.15 24.45	P=24	17	7	5	5	
25.15 25.45	P=25	34	9	11	14	
26.15 26.45	P=26	22	6	8	8	
27.15 27.45	P=27	24	7	8	9	
28.15 28.45	P=28	24	6	7	11	
29.15 29.45	P=29	38	9	14	15	
30.15 30.45	P=30	40	11	15	14	

FIG DRILLING LOG

Project No. KL02-12 Project The Study on Flood Mitigation and Drainage in Penang Island Type of Drilling Rotary

Hole Number BH-02 Elevation 0.2 m above sea level m. Date 15th to 20th July, 1990

Water Table GL -4.4 m m. Driller Sealand (Cheng)

Remarks
P : Standard Penetration Test
-

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks
	2.00	0.00						
1	1.00	1.00	1.00		Sandy silt	Dark brown	Soft	Sand is fine.
2	0.00	2.00	1.00		Sandy clay	Brown	Medium stiff	Sand is medium coarse.
3					Sandy clay	Reddish brown light grey yellow	Stiff to very stiff	Sand is fine to coarse grained. Sand is coarsed with depth. Some fine gravel. (quartz)
31	-28.45	30.45	28.45			-END OF DRILLING-		

Sampling		Standard Penetration Test				
Depth in m.	Sample No.	N-Value Blows/30cm	Blows Per Each 10cm 10 cm	10 cm	10 cm	N - Value 10 20 30 40 50
1.15 1.45	P-1	4	1	1	2	
2.15 2.45	P-2	4	1	1	2	
3.15 3.45	P-3	15	4	5	6	
4.15 4.45	P-4	11	3	3	5	
5.15 5.45	P-5	10	3	3	4	
6.15 6.45	P-6	13	4	4	5	
7.15 7.45	P-7	18	6	6	6	
8.15 8.45	P-8	16	4	5	7	
9.15 9.45	P-9	18	5	6	7	
10.15 10.45	P-10	18	4	7	7	
11.15 11.45	P-11	25	6	7	12	
12.15 12.45	P-12	15	4	5	6	
13.15 13.45	P-13	16	4	6	6	
14.15 14.45	P-14	15	3	5	7	
15.15 15.45	P-15	39	10	14	15	
16.15 16.45	P-16	40	12	13	15	
17.15 17.45	P-17	31	8	9	14	
18.15 18.45	P-18	26	8	9	9	
19.15 19.45	P-19	14	4	4	6	
20.15 20.45	P-20	20	6	6	8	
21.15 21.45	P-21	14	4	5	5	
22.15 22.45	P-22	11	3	3	5	
23.15 23.45	P-23	20	6	7	7	
24.15 24.45	P-24	28	8	10	10	
25.15 25.45	P-25	18	4	7	7	
26.15 26.45	P-26	17	4	6	7	
27.15 27.45	P-27	24	6	8	10	
28.15 28.45	P-28	19	6	6	7	
29.15 29.45	P-29	27	6	9	12	
30.15 30.45	P-30	32	9	10	13	

FIG DRILLING LOG

Project No. K02-12 Project The Study on Flood Mitigation And Drainage in Penang Island

Hole Number BH-03 Elevation 0.41m above road level m.

Water Table GL -4.8 m m.

Type of Drilling Rotary

Date 15th to 18th July, 1990

Driller Seaboard (Cheng)

Remarks
P : Standard Penetration Test
0

Scale in m	Elevation in m	Depth in m	Thickness in m	Legend	Type of Soil	Colour	Relative Density or Consistency	General Remarks
	41.00	0.00						
1	40.00	1.00	1.00		Silty clay	Yellow grey brown	Soft	With decayed wood
2					Sandy clay	White yellow brown	Medium stiff	Sand is fine to coarse grained.
3								
4	37.30	3.70	2.70		Silty clay	Light grey	Medium stiff	Traces of fine sand
5	36.20	4.80	1.10		Sandy clay	Light grey	Stiff	Sand is fine to coarse grained. Some fine gravels.
6								
7								
8								
9	32.00	9.00	4.20		Silty clay	Light grey	Stiff	Traces of fine sand.
10								
11								
12								
13								
14	27.20	13.80	4.80		Sandy clay	Light grey	Stiff	Sand is medium to coarse grained.
15								
16	24.80	16.20	2.40		Sandy clay	Yellowish brown white orange	Stiff to hard	Sand is medium to coarse.
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31	10.55	30.45	14.25			-END OF DRILLING-		

Sampling		Standard Penetration Test				
Depth in m.	Sample No.	N-Value Blows/30cm	Blows Per Each 10cm 10 cm	10 cm	10 cm	N - Value 10 20 30 40 50
1.15 1.45	P-1	10	2	4	4	
2.15 2.45	P-2	10	4	3	3	
3.15 3.45	P-3	10	3	4	3	
4.15 4.45	P-4	5	1	2	2	
5.15 5.45	P-5	9	3	3	3	
6.15 6.45	P-6	12	3	4	5	
7.15 7.45	P-7	14	4	5	5	
8.15 8.45	P-8	13	4	4	5	
9.15 9.45	P-9	10	3	3	4	
10.15 10.45	P-10	11	3	4	4	
11.15 11.45	P-11	10	3	3	4	
12.15 12.45	P-12	7	2	2	3	
13.15 13.45	P-13	12	5	4	3	
14.15 14.45	P-14	6	1	2	3	
15.15 15.45	P-15	12	3	4	5	
16.15 16.45	P-16	7	2	2	3	
17.15 17.45	P-17	9	2	3	4	
18.15 18.45	P-18	11	2	4	5	
19.15 19.45	P-19	27	8	9	10	
20.15 20.45	P-20	31	9	10	12	
21.15 21.45	P-21	15	3	6	6	
22.15 22.45	P-22	24	6	8	10	
23.15 23.45	P-23	16	4	6	6	
24.15 24.45	P-24	16	4	6	6	
25.15 25.45	P-25	38	11	13	14	
26.15 26.45	P-26	12	3	4	5	
27.15 27.45	P-27	40	12	13	15	
28.15 28.45	P-28	58	17	18	23	58BLOWS/30CM
29.15 29.45	P-29	41	9	14	18	
30.15 30.45	P-30	53	13	20	20	53BLOWS/30CM

APPENDIX B

LABORATORY SOIL TEST RESULTS

PROJECT: S.I. For Flood Kitigation Scheme At Sg Pinang

LOCATION: Penang

SEALAND DRILLERS (M) SDN. BHD.

Job Ref: SJ/918/90

SUMMARY OF LABORATORY TEST RESULTS

Borehole No.	Sample No.	Depth (m)	LABORATORY TESTS																
			M/C	B.D.	D.D.	Triaxial Compression U.U.		Atterberg Limits			Particle Size Distribution				Specific Gravity	Consolidation Test		Compaction Test	
						c	ϕ	L.L.	P.L.	P.I.	Clay	Silt	Sand	Gravels		Po	Cc	O.M.C.	Max. γ_d
			%	Mg/m^3	Mg/m^3	kN/m^2	deg.	%	%	%	%	%	%	%		kN/m^2		%	Mg/m3
BH P1	P1	1.15 - 1.45	60								49	36	15	0	1.797				
	P4	4.15 - 4.45	24								50	40	10	0	2.591				
	P6	5.15 - 5.45	33								45	25	30	0	2.425				
	P9	9.15 - 9.45	94								64	35	1	0	2.501				
	P11	11.15 - 11.45	19								29	11	59	1	2.629				
	P13	13.15 - 13.45	15								26	19	54	1	2.645				
	P16	16.15 - 16.45	14								64	31	5	0	2.632				
	P22	23.15 - 23.45	17								15	8	77	0	2.421				
BH P1A	P2	4.15 - 4.45	34								73	24	3	0	2.643				
	P5	7.15 - 7.45	89								65	30	5	0	2.397				

B-1

PROJECT: S.I. For Flood Mitigation Scheme At Sg Pinang

LOCATION: Penang

SEALAND DRILLERS (M) SDN. BHD.

Job Ref: SJ/918/90

SUMMARY OF LABORATORY TEST RESULTS

Borehole No.	Sample No.	Depth (m)	LABORATORY TESTS																
			M/C	B.D.	D.D.	Triaxial Compression U.U.		Atterberg Limits			Particle Size Distribution				Specific Gravity	Consolidation Test		Compaction Test	
						c	ϕ	L.L.	P.L.	P.I.	Clay	Silt	Sand	Gravels		Po	Cc	O.M.C.	Max. γ d
			%	Mg/m³	Mg/m³	kN/m²	deg.	%	%	%	%	%	%	%		kN/m²		%	Mg/m3
BH P2	P1	1.15 - 1.45	39								55	40	5	0	2.553				
	P2	2.15 - 2.45	86								46	37	17	0	2.797				
	P4	4.15 - 4.45	14								(	25)	75	0	2.648				
	P7	7.15 - 7.45	57								60	35	5	0	2.583				
	P9	9.15 - 9.45	79								49	28	23	0	2.408				
	P13	13.15 - 13.45	22								(	15)	85	0	2.449				
	P18	18.15 - 18.45	18								(	15)	85	0	2.627				
	P24	24.50 - 24.45	22								45	12	43	0	2.609				
	P28	28.15 - 28.45	22								(	27)	73	0	2.553				
BH D1	P2	2.15 - 2.45	24								(	6)	83	11	2.620				
	P5	5.15 - 5.45	57								48	38	14	0	2.150				
	P7	7.15 - 7.45	35								(	17)	70	13	2.613				
	P9	9.15 - 9.45	23								27	7	36	30	2.584				
	P11	11.15 - 11.45	25								38	7	42	13	2.482				
	P14	14.15 - 14.45	20								26	2	47	25	2.350				
	P19	19.15 - 19.45	23								25	10	59	6	2.402				