PART 2

FEASIBILITY STUDY

THE STUDY ON INTEGRATED URBAN DRAINAGE IMPROVEMENT FOR MELAKA AND SUNGAI PETANI IN MALAYSIA

FINAL REPORT

VOL. 2 MAIN REPORT

PART 2: FEASIBILITY STUDY

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CHAPTER 1. INTRODUCTION

Four (4) priority drainage areas are selected for the Feasibility Study from among the objective drainage sub-basins for the Drainage Structure Plan presented in Part 1. Two (2) of these drainage areas belong to the Sungai Petani river system in the Kuala Muda District of Kedah State, while the other two (2) belong to the Malim river system or its adjacent coastal drainage systems in the Melaka Tengah District of Melaka State. The four drainage priority drainage areas as given below.

Priority Drainage Area	Catchment Area (km^2)	Urbanized Ratio (%)		
		in 1999	in 2005	in 2000
Sungai Petani				
1. Sg. Air Mendidih	3.62	65.8	82.7	99.7
2. Line-G	2.73	35.4	43.3	87.3
Melaka				
3. Prt. Pokok Mangga	4.71	51.3	53.4	99.6
4. Sg. Ayer Salak	17.20	22.2	43.2	99.9
Total	28.26			

All of these priority areas contain a high flood damage potential and early implementation of the project is highly expected by the government agencies concerned. These areas also require a wide variety of drainage improvement measures due to different topographies and land use; hence, the results of this Feasibility Study are expected to present a technical guideline for the future drainage improvement in Malaysia. Therefore, as a part of the entire study objectives, a guideline on urban drainage improvement is prepared and a substantial part of the results of this Feasibility Study are used.

CHAPTER 2. PRESENT CONDITION OF PRIORITY DRAINAGE AREAS

2.1 Drainage Condition

2.1.1 Drainage Basin of Sg. Air Mendidih in Sungai Petani

There are four (4) trunk drains in this drainage area; namely (1) Sg. Air Mendidih, (2) Line-N, (3) Line-O and (4) Line-P in the catchment area of 363 ha (refer to Fig. 2-1). Among these trunk drains, Line-N collects storm water from the upper reaches of about 70% of the entire drainage area and drains it southward into Sg. Air Mendidih. Sg. Air Mendidih finally collects all storm water from the entire catchment area and drains it into Sg. Petani. Both Line-O and Line-P are the branches of Line-N that collect the storm water from the northwestern part of about 40% of the entire drainage area.

Sg. Air Mendidih has U-shaped earth channel sections. The other three trunk drains also have U-shaped earth channels in general but change to concrete-lined channels of less widths along several congested riverine areas. The sizes of these trunk drains are extremely small to cope with even the probable peak runoff discharge of a 2-year return period (refer to Fig. 2-2). Besides, the bank level of the drains is almost the same as or slightly higher than the ground level of the hinterland, and flood tends to gradually overflow from the drains and inundate the hinterland.

The hinterland forms a flat alluvial plain belt with a width of 50 to 500m that lies along almost the entire stretch of the trunk drains. There are hillside slopes running along the perimeter of the alluvial plain belt, and the ground level at the top of slopes is 3 to 5m higher than that of the alluvial plain. Due to such topographic conditions, flood overflow tends to inundate the alluvial plain.

There are several roads across the alluvial plain, and culverts are used to pass the roads over the drains (refer to Table 2-1). The size of culverts is extremely smaller than the size of upstream drains so that they greatly hinder flood flow on the drains. Moreover, the roads are about 1 to 1.5m higher than the ground level of the alluvial plain and once storm waters inundate the alluvial plain, the roads dam up the inundation water further increasing the inundation depth and duration.

2.1.2 Drainage Basin of Line-G in Sungai Petani

There is one trunk drain called "Line-G" in this drainage area. The trunk drain originates in a hilly area in the eastern end of the drainage area, and flows down westward but changes its

course northward after passing under the North-South Superhighway and, finally, pours into Sg. Petani (refer to Fig. 2-3). The total catchment area of the trunk drain is about 272.8 ha, and principally characterized by the following sub-drainage areas:

(1) A hilly area of 75.9ha: The area is located in the upstream end or the eastern part of the drainage area. This area still preserves its natural vegetation without any land activity, but land development is projected by the year 2020. Due to the land development, a drastic increment of basin runoff discharge is expected.

(2) Two residential areas of 97.7ha in total: A residential area of 69.7ha is located upstream from North-South Superhighway, while another of 28.1ha is downstream from the highway. Two (2) flood detention ponds, "Taman Keladi" and "Taman Sri Wang", are situated at the downstream end of each of these residential areas, respectively.

Name of Pond	Catchment Area (ha)	Effective Storage Capacity	
		Volume (m3)	Equivalent Rainfall Depth for Storage (mm)*
Taman Keladi	69.7	36,050	52
Taman Sri Wang	28.1	7,300	26

* Equivalent rainfall depth for storage = Storage volume ÷ Catchment area

(3) The storm water from the residential areas is stored in the flood detention ponds and then discharged into the trunk drain. The outlet channels from the flood detention ponds join the trunk drain at about 1.8km and 1.5km upstream from the confluence with Sg. Petani.

(4) A low-lying area of about 20.5ha in the middle reaches: All of the storm water from the above three (3) areas flow into this flat low-lying area. Most of this area has remained as a natural wet land without any development, and storm water habitually retards in the area. Thus, this area is expected to function as a retarding basin, particularly, for the runoff discharge from the aforesaid projected land development area mentioned in Item (1) above.

The trunk drain has a concrete-lined channel of about 800m downstream from the natural retarding basin mentioned in Item (4) above. The concrete-lined channel is changed to an earth channel in and upstream from the natural retarding basin. The concrete-lined channel has been recently constructed, but the downstream channel size is smaller than the upstream size, which could cause an unfavorable condition, i.e., when an excessive flood discharge is loaded into the downstream channel, overflow would easily occur. According to the

non-uniform calculation, the present channel flow capacity could not meet the probable flood runoff discharge of even a 2-year return period (refer to Fig. 2-4).

2.1.3 Drainage Basin of Pokok Mangga in Melaka

This drainage area covers 471ha, which is broadly divided into two (2) sub-drainage basins: Pokok Mangga (203ha) and Prt. Besar Limbongan (268ha). The storm water in the drainage area is currently drained into the Strait of Melaka through two (2) central trunk drains called "Prt. Pokok Mangga" and "Prt. Besar Limbongan" running from north to south (refer to Fig. 2-5). There is also another trunk drain called "Prt. Malim" and several secondary drains that run in parallel westward or eastward and drain into the above central trunk drains.

The entire drainage area has an extremely flat ground level ranging 1.5 to 4m above LSD. Due to such flat low-lying ground, the trunk drains as well as the secondary drains have gentle channel bed slopes of about 1 to 6000, according to the results of channel survey undertaken by DID. The trunk drains also have small cross-sections with the average width of 5.5m and depth of 1.3m. Moreover, the drains are of the earth channel type where a great volume of weeds overgrow, a great hindrance to channel flow.

The Melaka Strait has a Mean High Water Spring of 0.64m above LSD at Kuala Melaka. On the other hand, the channel bed of the trunk drains is 0.22m above LSD at the downstream end (i.e., the river mouth) and 0.7m above LSD even at the upstream end (3,270m upstream from the river mouth). Thus, the channel bed levels are relatively low as compared with the tidal level, and the storm water is hardly drained during high tide.

Due to the gentle channel bed slopes, the small channel cross-sections, and the higher tidal levels compared with the channel bed levels, the channel flow capacities of the trunk drains are far smaller than the probable peak runoff discharge of a 2-year return period, as shown in Fig. 2-6. Thus, habitual flood inundation areas are widely scattered and many swampy areas could be seen in this drainage area.

2.1.4 Drainage Basin of Sg. Ayer Salak in Melaka

The drainage network in this drainage area is represented by Sg. Ayer Salak, a tributary of Sg. Malim, and two (2) trunk drains called "Prt. AB-1" and "Prt. AB-11" (refer to Fig. 2-7). The catchment area of Sg. Ayer Salak is 1,750.3ha, including those of Prt. AB-1 and Prt. AB-11 that share 365.3ha (21%) and 220.4ha (13%), respectively.

Sg. Ayer Salak originate in a hilly land in the northwest end, collecting the stormwater in the southern part of the drainage area and flowing into Sg. Malim. In the upstream end of the hilly land, land development is presently in progress, and a flood detention pond with a catchment area of 134.4ha has almost been completed. In the lower reaches, a flat alluvial plain spreads out to where a rather extensive residential area has been completed. The channel improvement for Sg. Ayer Salak is presently in progress and, upon completion, the channel flow capacity would be able to cope with the probable design discharge of 25-year return period.

In contrast with Sg. Ayer Salak, the flow capacities of Prt. AB-1 and Prt.-AB 11 are far smaller and could not cope with the probable flood discharge of even a 2-year return period. The catchment area of Prt. AB-1 is located in the northern part of the drainage area. The lower reach is a rather flat land used as a residential area, while the upper reach is a hilly land. Land development of about 129.0ha is projected in the upper hilly land and a flood detention pond is going to be constructed to store the flood runoff discharge from the land development area.

The catchment area of Prt. AB-11 is on the south of the catchment area of Prt. AB-1. An industrial estate called Bukit Rambai is located in the upper reach, and there exists a flood detention pond with a catchment area of about 98.1ha to store the flood runoff discharge from the estate. There is also a natural wet pond in the middle reaches which has a potential as a retarding basin (refer to Fig. 2-7).

2.2 Topography and Permeability of Surface Soil

2.2.1 Drainage Basin of Sg. Air Mendidih in Sungai Petani

The drainage area tends to gently slope westward and southwestward as a whole except the northeastern part and the alluvial plain along the watercourse. Most of the gently sloping area used to be covered with lateritic soil, which generally shows high permeability. However, most of the lateritic soil has been removed and/or compacted due to the recent extensive land development and road construction. As a result, the variegated and/or pallid layers are exposed on the ground surface, extremely lowering the previous permeable capacity.

As for the northeastern part of the area, its topography is rather undulating with ground elevation of less than 10m. This part is more than 55ha or 15% of the entire drainage area and it still remains as natural land, preserving the lateritic soil on the surface with thickness of more than 3m. Accordingly, high permeability is expected in this part. Land development for this area is projected by the year of 2020, and the infiltration measures for storm water

could be applied, should the land development be made maintaining the lateritic soil as the infiltration layer.

In addition to the above gently sloping area and the undulating area, there is the alluvial plain along Sg. Air Mendidih and its tributaries. This alluvial plain has a soft ground condition with high water content and shows an extremely low permeability.

2.2.2 Drainage Basin of Line-G in Sungai Petani

The topography in the drainage area is hilly and/or gently sloping. The hills as represented by Bukit Tok Acheh (EL.73 m) are located in the northeastern part of the drainage area where the original topography is still maintained without any intensive land development. On the contrary, the intensive land development has brought about a dynamic topographic change in the present gently sloping area that spreads out in the southwestern part.

The hilly area is covered with lateritic soil, but the thickness is rather limited ranging from about 1 to 2m. A substantial part is subject to land development in the future, and the existing thin lateritic soil has to be removed due to the slope gradient of hills and the subsurface weathered rock will be exposed. The weathered rock has a low permeability and therefore, infiltration measures for storm water could hardly be applied to the land development in this hilly area.

As for the gently sloping area, the surface lateritic soil has been removed and/or compacted due to the recent extensive land development and road construction as in the drainage area of Sg. Air Mendidih. The previous topographic map reveals that low land areas have been widely distributed and utilized as paddy field in the lower reaches of this gently sloping area. However, most of them had been filled up and only a few has remained as swamp area at present.

2.2.3 Drainage Basin of Pokok Mangga in Melaka

The topography of the entire drainage area shows a typical coastal plain feature that contains an extremely flat ground level and a high groundwater level (less than 1 m below the ground level). A paddy field extensively spreads out in this drainage area, however, its greater part has been reclaimed for the sake of land development. Due to the high groundwater level, the entire drainage area has a low ground permeability. The superficial soil of the area except for the reclamation area is classified as alluvial soils, gley soil and acid sulphate soil, which generally show clayey and silty facies. As for the reclamation area, the lateritic soils are generally used as filling materials.

2.2.4 Drainage Basin of Sg. Ayer Salak in Melaka

The topography of this drainage area is classified into moderately sloping hill in the northern part, and coastal plain in the southern part. The superficial soil of the hilly area is mostly covered with lateritic soils of reworked type, which are known as "Malacca Series" on the soil classification. The thickness of lateritic soil is about 2 m as a whole and hardly exceeds 3 m. A part of the hilly area is, however, now being transformed into a flat terrain due to intensive land development. As a result, the layer of lateritic soil has been removed and/or compacted due to the land leveling works, leading to the low permeability of the ground.

Extensive land reclamation was also made recently through a large scale land development in the coastal plain which was formerly utilized as paddy field. A part of the former paddy field is now abandoned as swamp area (marsh area).

2.3 Present and Projected Land Use

The existing land use in the four (4) drainage study areas was confirmed and updated in detail through the supplementary field reconnaissance and the aerial photographs newly taken with a scale of 1 is to 6000. The projected land use for the year 2005 was also delineated through the information on committed developments in these areas prepared by the Local governments. As a result, the existing and projected land use for the priority drainage areas are delineated, as shown in Tables 2-2 to 2-4 and Figs. 2-8 to 2-19. The particular characteristics of their land use states are as described bellow.

2.3.1 Drainage Basin of Sg. Air Mendidih in Sungai Petani

The total area of this basin is 362 ha. out of which about 66% has been developed as the built-up area.

(1) Existing Land Use

The existing land use in the area is classified into residential use (31%), institutional use (11.7%), commercial use (5.1%), roads and railway (16.3%), and vacant land including cemetery land (32.8 %). As listed, the largest share is taken by the vacant land, which is found on either side of the road that leads to the Swiss Garden Inn, and along the river corridor.

(2) Projected Land Use

The land use in the river basin is expected to change over the next 20 years. In the near term (2005) significant increases are expected for residential and commercial use. By 2020, the major land use increase in the area will be for commercial use, which is expected to increase by 5.7% per annum from 18.5ha at present to 59ha in 2020. On the other hand, residential use is expected to grow by only 1.2% in the river basin, while institutional and recreational use will increase by 1.7% and 2.4%, respectively.

2.3.2 Drainage Basin of Line-G in Sungai Petani

The area was previously a rubber plantation on the higher ground while paddy was planted in the lower grounds. Most of the paddy lands have been reclaimed for housing development while some are left as idle land. In contrast to the Sg. Air Mendidih Basin, the Line-G Drainage Basin is relatively underdeveloped. About 60% of the area (180ha) is not built up and is either under agriculture or vacant/idle land.

(1) Existing Land Use

The residential area takes 19% (or 57ha) of the entire drainage basin, while commercial uses and industrial uses account for only 1.5% (or 4.38ha) and 1.7% (5.03ha), respectively. In view of the low residential population base, commercial uses are limited to local shops within the housing schemes, and most of the commercial premises are double storey shop houses. There is not much industrial use in the area, and the existing industrial use is limited to only wood works, storage yards and light industrial activities. Institutional uses only account for 1.5ha or 0.5% of the area since most of the school sites identified have not been built. Recreational uses are mainly in the form of local open spaces and account for 5.3% or 15.9 ha. There is still a substantial area under agriculture use especially rubber cultivation on the hilly areas. Agriculture use covered 96ha or 32.2% of the area. Total area under roads is 35ha or 11.8% of the area including the North-South Superhighway and the arterial roads linking the area to other parts of the town. Again, there are substantial areas of vacant land accounting for 27% or 81ha.

(2) Projected Land Use

In the near term by 2005, the main increase in land use is expected to be in residential use, which is expected to increase to 71ha by 2005 from the present 57ha. On the

other hand, there will be a marginal increase in commercial use to 5.35ha and institutional uses to 4.93ha. The corresponding increase in residential use will also result in an increase in roads and local open spaces. Industrial uses are not expected to increase in the near term. In the long term by 2020, most of the area is zoned for development in the Local Plan except for a major new recreational use in the higher ground to the east. This recreational use has been proposed for a Golf Course in the Local Plan. Most of the undulating grounds currently utilised for tree crops will be allowed for housing development with a net density of 21-100 units/ha. The major increase will be in residential use that is expected to increase to 168ha by 2020. There will be a significant increase in institutional and recreational land use. On the other hand, there will not be any significant increase in commercial and industrial uses in the area..

2.3.3 Drainage Basin of Pokok Mangga in Melaka

A dynamic increment of the residential area is expected in this basin due to easy accessibility to the Melaka town centre.

(1) Existing Land Use

Most of the lands abutting the main roads are developed while agricultural use is found in the interior lots. The flat topography makes it suitable for paddy cultivation. Urban development has mainly taken place along the main roads in a strip development pattern. Built-up land uses constitute 50.8% of the total area. Residential use accounts for 165ha and includes several new housing schemes. Institutional uses of 4.22ha comprise mainly schools and health centres. Existing commercial uses of 8.62 ha are mainly for shop houses facing the main road. Industries include informal uses such as sawmills and storage yards which will eventually be phased out.

(2) Projected Land Use

The land use in the drainage basin is expected to change significantly over the next 20 years. In the near term by 2005, committed projects include small housing schemes. There are also several commercial premises under construction. In the long term, most of the land is projected as residential use under the Local Plan. New institutional land uses are not identified in the land zoning plan under the Local Plan; however, additional community facilities such as schools and health facilities will be provided in tandem with housing development. Commercial uses are mainly

projected at the Malim Business Park and at the junction of the M3 and the FR19. It is also likely that local shops will be built in the housing schemes.

2.3.4 Drainage Basin of Sg. Ayer Salak in Melaka

Built-up land use currently accounts for 22% of the total land use in the area. Thus, the area has been predominantly under agricultural use but it is going to be converted to a major industrial area.

(1) Existing Land Use

The higher lands to the north were previously rubber plantation lands. Large tracts of land in this area had been levelled for the Bt. Rambai Industrial Estate. The lower lying areas along the banks of Sg. Ayer Salak were previously paddy areas but have now been converted to residential land use of 211ha or 10.1% of the total area. There are also a number of villages in the area including Kampong Ayer Salak and Kampong Paya Mengkuang.

There is also an existing animal farm (poultry) near the Bt. Rambai industrial area. Industrial uses currently account for 124ha or 6.0%. There are however several tracts of land that have been levelled for industrial development. Agricultural land constitutes 1,283ha (61.6%), while vacant land amounted to 335ha (16.1%).

(2) Projected Land Use

Major committed land uses in the near term by 2005 will be the expansion of residential land use and industrial land use at Bt. Rambai. Residential land use (net) is expected to increase to 362ha while industrial uses will increase to 294ha by 2005. In the long term by 2020, most of the area will be converted to built-up area. Industrial use will account for 803ha or 38.5% of the total area while residential use will account for 567ha or 27.2% of the total area. There will be a new commercial centre in the area of about 6.7ha. Again, new institutional uses have not been identified in the land zoning plan; however, these facilities will be provided according to planning standards as new residential development takes place. Both roads and recreational uses will increase in parallel with land development for residential land use and industrial land use. The big reduction will be in the area under agriculture and vacant land that will be converted to urban uses.

2.4 Environmental Conditions

The following items are confirmed as the typical features of present water quality and ecology in the priority drainage areas:

(1) Water Quality

Water quality monitoring was carried out at 20 points in total for the four (4) priority drainage areas. As a result, it was confirmed that suspended solids and organic wastes are the common significant pollutant sources of the existing drainage channels and flood detention ponds. Eutrophication of water by inorganic forms of phosphorous and nitrogen was also detected as another problem associated with water quality leading to massive algae blooms. The results of the water quality monitoring are summarized as below.

Parameter	Sg. Petani		Melaka	
	Sg. Air Mendidih	Line-G	Prt. Pokok Mangga	Sg. Ayer Salak
ph	4.5 – 6.7	5.8 – 6.8	6.5 – 7.6	3.9 – 6.8
BOD	3 – 35	2 – 26	2 – 42	4 – 17
COD	13 – 139	13 – 104	10 – 141	13 – 96
SS	10 – 90	12 – 52	8 – 932	10 – 602

Note: No significant content of toxic compound of heavy metals was detected.

(2) Ecology

The ecology of all priority areas is relatively sterile in general due to the built-up nature of the sites. It is, however, noted that there is a mangrove forest along the downstream of Sg. Petani that creates the richer ecology. The mangrove is located downstream from the confluence points of Sg. Air Mendidih and Line-G; therefore, the drainage improvement plan for the two priority areas in Sungai Petani could influence the ecological system of the mangrove.