CHAPTER 4. PRINCIPAL FEATURES OF PROPOSED PROJECTS FOR PRIORITY AREAS

4.1 Alternative Drainage Improvement Plans

The alternative drainage improvement plans are selected through combinations of "quick disposal of flood" and "source control of flood" as described in the formulation of the Drainage Structure Plan (see Part 1). The quick disposal of flood is made through channel improvement, construction of diversion channel and/or installation of drainage pumping station. On the other hand, the source control of flood is by various types of flood detention facilities such as the flood detention pond, the storage tank in a house lot, and the storage in a public open space. All alternative improvement plans are subject to the target design level of 5-year return period as proposed in the foregoing Drainage Structure Plan. Determination of definitive locations and structural features of improvement measures as the facility components is based on the detailed topographic and hydrological conditions.

4.1.1 Possible Measures

The following are applied as the possible measures for alternative drainage plans.

(1) Channel Improvement of Trunk Drains

The channel improvement is applied for all priority areas in common. Deepening of channel rather than widening is applied as the principal measure for channel improvement so as to minimize the land acquisition and number of house relocation. Utmost effort is further given to "natural river engineering" on the channel improvement whereby wildlife conservation and natural beauty are enhanced. The natural river engineering involves construction of earth channel with sod facing and/or stone pitching, preservation of wet land and construction of flood retarding basin. The concrete-lined channel is, however, applied to congested areas where acquisition of the right-of-way is difficult.

(2) Construction of New Trunk Drain and New Diversion Channel

When the existing trunk drains need to be widened to an extremely large extent leading to a significant number of house relocation, new trunk drain(s) and or new diversion channel(s) are proposed to disperse the design discharge and minimize the channel width as well as house relocation. The alignment of new trunk drain and/or diversion

channel is delineated in due consideration of topography and the existing land use conditions.

(3) Rehabilitation of Existing Flood Detention Pond

Rehabilitation is made for the existing two (2) flood detention ponds in the area of Line-G and one (1) in the area of Sg. Ayer Salak. All of these existing ponds are of the wet pond type, and the impounding water is seriously polluted due to inflow of wastewater. To remedy such an environmental deterioration, the ponds are dried up during non-flooding time by the following structures: (a) outfall to divert the non-flooding discharge from inflow to the pond, (b) ditch at the bottom of the pond, and (c) outlet structure which is placed lower than the inlet point.

(4) Construction of New Flood Detention Ponds

The new flood detention ponds are constructed in three (3) priority areas other than Prt. Pokok Mangga. The ponds are either designed as the dry pond, the wet pond or the wet land. The structural features of the dry pond are as described in the foregoing rehabilitation of the existing pond. As for the wet pond and the wet land, both of them continue to impound the water even during non-flooding time. However, they could be applied only when a substantial part of the catchment area is covered with the new land development where less non-treated water is expected to inflow into the pond. The difference between the wet pond and the wet land is that the wet pond is enhanced as an artificial pond through extensive excavation work. On the other hand, the wet land is applied to the existing natural swampy area on the premise of minimum earth work so as to preserve the present natural conditions. All of the wet ponds are provided with an amenity space around their impounding spaces, therefore, they could function as community ponds. Moreover, some of the dry ponds also could be used as community ponds, provided that they are placed in a rather extensive vacant space where large-scale amenity facilities could be provided.

4.1.2 Drainage Basin of Sg. Air Mendidih in Sungai Petani

The possible alternative plans as well as components included in each of the plans are presented hereinafter (refer to Fig. 4-1).

Component of Measure	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Channel Improvement	√	√	√	√
Construction of Detention Ponds in Newly Developed Areas		√	√	√
Construction of On-site Detention Ponds in Public Open Spaces			√	√
Installation of Storage Tank in Individual Houses				√

Note: (√) means selection of better alternative with/without diversion.

(1) Channel Improvement

The existing trunk drain network includes the four (4) channels of Sg. Air Mendidih, Line-N, Line-P and Line-N, as shown in Fig. 4-2. The channel flow capacity of all trunk drains other than Line-N is lower than the peak discharge equivalent to a 2-year return period, therefore, the channel improvement is proposed as one of the principal measures in the basin. The objective improvement length is as below:

Name of Trunk Drain or River	Improvement Length (m)
1. Sg. Air Salak	1,310
2. Line-N	1,090
3. Line-O	630
4. Line-P	1,410
Total	7,020

(2) Construction of Detention Ponds in Newly Developed Areas

The extensive vacant lands spread in the upper reaches of two (2) trunk drains, Line-O and Line-P. As projected the lands are to be converted into built-up areas, so that drastic increment of peak flood runoff discharge is expected. To cope with increment of peak discharge, the following three (3) detention ponds are proposed (refer to Fig. 4-1):

Name of Pond	Topography	Name of Downstream Trunk Drain	Pond Type	Active Storage Capacity (m^3)	Remarks
1. Police Hutan	Flat land	Line-P	Wet Pond	48,700	Community Pond
2. Upper Line-P	Valley-bottom	Line-p	Dry Pond	8,900	
3. Line-N	Valley-bottom	Line-N	Dry Pond	16,000	
Total				352,520	

(3) Construction of On-site Detention Pond in Public Open Space

There are two (2) suitable sites for construction of on-site detention ponds, namely "Sek. Men. Sains" and "IKM". The following are the location and potential storage capacity estimated on the basis of topographic map with a scale of 1:2,000.

Description	Features of On-site Detention Pond	
	Sek. Men. Sains	IKM
Catchment Area (ha)	15.0	7.4
Ponding Area (ha)	2.9 (pond) 2.5 (ground)	1.1 (ground)
Storage Depth (m)	0.4 (pond) 0.2 (ground)	0.3 (ground)
Storage Volume (m^3)	16,600	3,300
Specific Storage Volume (m^3/ha)	1,110	450

In addition, the trunk drain of Line-N has a quite large channel storage volume in its upper section along the residential estates of Taman Peruda and Taman Bandar Baru

Azham. This channel section could be utilized for flood control through installation of an appropriate outlet control structure. The potential channel storage volume of the section is as estimated below:

Description	Features of Flood Detention Section of Line-N
Sectional Area of Drain	20 m^2
Drain Length	800 m
Storage Volume	16,000 m^3
Catchment Area	59.4 ha
Specific Storage Volume	270 m^3/ha

(4) Installation of Storage Tank in Individual House Lot

Installation of a storage tank in the individual house lot is assumed as a possible measure to reduce the peak runoff discharge in the existing built-up area where other drainage improvement measures could be hardly introduced.

4.1.3 Drainage Basin of Line-G in Sungai Petani

The possible alternative plans as well as the components included each of these plans are presented hereinafter (refer to Fig.4-3).

Component of Measures	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Channel Improvement	√	√	√	√
Rehabilitation of Existing Detention Ponds		√	√	√
Construction of Diversion Channel			√	√
Construction of Detention Ponds in Newly Developed Areas				√

Note: (√) means selection of better alternative with/without diversion.

(1) Channel Improvement

The channel improvement is to be made for the existing trunk drain of Line-G and its upper channel section (refer to Fig. 4-4). The improvement length is 3,020m. The present channel flow capacity of Line-G could not meet even the probable peak runoff discharge of 2-year return period. Moreover, its downstream section of about 200m has a smaller cross-sectional size than the upstream section of about 400m as given below. Such reverse leads an excessive flood discharge to the downstream section, and channel overflow easily occurs.

Drainage Section	200-400m	400-800m
Drain Type	R.C Roadside Drain	R.C Drain
Approximate Drain Size	w: 1.0m, d: 1.6m	w: 3.1m, d: 1.4m
Channel Slope	0.20%	0.42%
Flow Capacity	2.7 m^3/s	14.9 m^3/s

(2) Construction of Diversion Channel

In order to retrieve the above lower section of Line-G which is extremely meandering, proposed is a diversion channel with straight alignment along the major road, as shown in Fig. 4-4. The length and catchment area of the diversion channel and the existing meandering portion are as below:

Description	Features of Diversion Channel of Line-G	
	Length (m)	Catchment Area (km^2)
New Diversion Channel	280	255
Existing Meandering Section	400	17
Total	680	272

(3) Rehabilitation of Existing Detention Ponds

Rehabilitation is proposed for two (2) existing functional detention ponds named "Taman Keladi" and "Taman Sri Wang". The salient features of these ponds and the possibility for rehabilitation are summarized in the following table.

Description	Taman Keladi		Taman Sri Wang	
	Existing	Proposed Rehabilitation	Existing	Proposed Rehabilitation
Catchment Area	69.6 ha		28.1 ha	
Area of Pond	18,850 m^2	25,680 m^2	6,230 m^2	6,870 m^2
Maximum Depth	3.0 m	3.6 m	2.1 m	3.5 m
Effective Depth	2.4 m	3.0 m	1.5 m	2.9 m
Gross Storage	47,610 m^3	79,380 m^3	10,780 m^3	20,890 m^3
Effective Storage	36,050 m^3	63,000 m^3	7,300 m^3	16,800 m^3
Specific Ef. Storage	520 m^3/ha	910 m^3/ha	260 m^3/ha	600 m^3/ha

(4) Construction of Detention Ponds in Newly Developed Areas

The following two (2) flood detention ponds are proposed at the existing rather extensive vacant lands in the middle and upper reaches of Line-G.

Name of Pond	Topography	Name of Downstream Trunk Drain	Pond Type	Active Storage Capacity (m^3)	Remarks
1. Upper Line-G	Valley	Line-G	Wet Pond	24,640	
2. Middle Line-G	Swampy Area	Line-G	Dry Pond	17,000	Community Pond

4.1.4 Drainage Basin of Pokok Mangga in Melaka

The possible alternative plans as well as the components included in each of the plans are presented hereinafter (refer to Fig. 4-5).

Component of Measures	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt.7
Channel Improvement	√	√	√	√	√	√	√
Construction of New Trunk Drain				√	√	√	
Construction of On-site Detention Ponds		√			√		
Installation of Individual House Storage			√			√	
Construction of Diversion Channel							√
Construction of Pumping Stations							√

Note: (√) means selection of better alternative with/without diversion/pumping stations.

(1) Channel Improvement

The channel improvement is made to the following three (3) trunk drains of Prt. Pokok Mangga, Prt. Besar Limbongan and Prt. Malim (refer to Fig. 4-6).

Name of Trunk Drain or River	Improvement Length (m)
1. Prt. Pokok Mangga	3,260
2. Prt. Besar Limbongan	920
3. Prt. Malim	2,230
4. Prt. Lorong Pandan	1,870
Total	8,280

(2) Construction of New Trunk Drain

There are three (3) existing trunk drains in the drainage area of Pokok Mangga, but their flow capacities are extremely small. Should the design runoff discharge be drained only by those existing trunk drains, the channels need to be widened in an extremely large extent leading to the significant number of house relocation. In order to avoid such unfavorable conditions, one new trunk drain is proposed in the drainage area of Pokok Mangga running almost along the centerline of the area where a non-built-up area still remains. The principal features of the new trunk drain are as given below (refer to Fig. 4-5(2/2):

Station No.	Catchment Area (ha)	Design Discharge (m^3/s)	Channel Length (m)	Average Channel Bed Slope	Average Channel Width (m)	Average Channel Depth (m)
0 – 1.1K	267	33	1,100	1/3,060 (0.0327%)	13.0	1.8
1.1 – 2.0K	180	21	900		8.5	1.8
2.0 – 2.55K	114	16	550		7.0	1.8
Total	561	70				

(3) Construction of Diversion Channel and Construction of Drainage Pumping Station

For the same reasons as the above Item (1), a new diversion channel is alternatively proposed to drain the stormwater in the northern part of the drainage area toward Sg. Malim. The storm water in the remaining southern part is drained to the Melaka Strait through the existing trunk drains of Prt. Pokok Mangga and Prt. Besar Limbongan. Thus the drainage basin is divided into the following three (3) sub-basins [refer to Fig. 4-5(3)]:

Sub-basin	Existing Network	Diversion Scheme
Pokok Mangga (Lower)	203.0 ha	107.5 ha
Upper Pokok Mangga	-	212.3 ha
Besar Limbongan	267.9 ha	151.1 ha

It is herein noted that a natural gravity outlet to Sg. Malim from the new diversion channel is hardly made due to the higher water head of Sg. Malim. Accordingly, the outlet is made with the pumping station placed at the downstream end of the new diversion channel.

(4) Construction of On-site Detention Pond in Public Open Space

The target basin is located in the coastal plain. The topography is low and flat, and the groundwater level is near the ground surface so that a large-scale detention pond is not appropriate. Thus, the on-site type of detention pond is suitable in the newly developed areas, even though a large volume of storage capacity is not expected. From this point of view, the on-site detention pond is proposed to take 5% of the whole existing and projected built-up area by 2020.

(5) Installation of Storage Tank in Individual House Lot

Installation of a storage tank in individual house lot is proposed as an alternative measure of the above construction of on-site detention pond in public open space to reduce the peak runoff discharge. The storage tank is assumed to be installed at each household in the whole existing and projected built-up area by 2020.

4.1.5 Drainage Basin of Sg. Ayer Salak in Melaka

The possible alternative plans as well as the components included in each of the plans are presented hereinafter (refer to Fig. 4-7).

Component of Measures	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Channel Improvement	√	√	√	√
Rehabilitation of Existing Detention Ponds			√	√
Construction of Detention Ponds in Newly Developed Areas		√	√	√
Land Elevation to Minimum Platform Levels				√
Provision of Drainage Reserves				√

Note: (√) means selection of better alternative with/without diversion/pumping stations.

(1) Channel Improvement

The channel improvement is made to one (1) river channel, Sg. Ayer Salak, and two (2) trunk drains, Prt. AB-1 and AB-11 (Fig. 4-8). The flow capacity of these river and trunk drains is lower than the peak discharge equivalent to 2-year return period in most of the stretches. The wide swamp areas, however, extend in the middle reaches of AB-1 and AB-11, and their natural flood retarding function works well to reduce flood peak discharges and prolong flood concentration times. If channel improvement is made without preservation of the function, the flood hydrographs will drastically swell in the lower reaches. From this point of view, the channel improvement is proposed on the premise of maintaining the flood retarding effects of the existing swamp areas. The improvement length of the proposed channels is as given below:

Name of Trunk Drain or River	Improvement Length (m)
1. Sg. Ayer Salak	4,780
2. Prt. AB-1	3,910
3. Prt. AB-11	2,950
4. Tributaries	4,100
Total	15,740

(2) Rehabilitation of Existing Detention Ponds

There is one existing functional detention pond named Bkt. Rambai in Prt. AB-11. The salient features of the pond and possibility for rehabilitation are summarized below:

Description	Features of Existing Pond	Features of Proposed Rehabilitation
Catchment Area	98.1 ha	
Area of Pond	19,550 m^2	21,100 m^2
Maximum Depth	1.6 m	4.1 m
Effective Depth	1.0 m	3.5 m
Gross Storage	24,780 m^3	69,900 m^3
Effective Storage	15,850 m^3	59,000 m^3

(3) Construction of Detention Ponds in Newly Developed Areas

The following four (4) flood detention ponds are proposed at the rather extensive vacant lands. Among them, designing work on two (2) ponds, Tg. Minyak-1 and Tg, Minyak-2, have already been completed by the land developers.

Name of Pond	Topography	Name of Downstream Trunk Drain	Pond Type	Active Storage Capacity (m^3)	Remarks
1. Tg. Minyak-1	Valley	Sg. Ayer Salak	Wet Pond	63,560	
2. Upper Ayer Salak	Valley	Sg. Ayer Salak	Dry Pond	19,920	
3. Tg. Minyak-2	Swampy Area	Prt. AB-1	Wet Pond	70,370	Community Pond
4. Middle AB-1	Swampy Area	Prt. AB-1	Wet Land	29,280	
5. Middle AB-11	Swampy Area	Prt. AB-11	Dry Pond	54,150	Community Pond
Total				352,520	

Among the objective flood detention ponds, "Middle AB-1" is to remain as wet land so as to preserve the existing natural environmental conditions. Moreover, both of the ponds ["Tg. Minyak (2)" and "Middle AB-11"] are proposed as community ponds to provide the amenity space.

4.2 Optimum Drainage Improvement Plan

Comparative study on the alternative plans was made taking the project cost, the number of house relocation, and other social and environmental impacts into account. As the result, the following components of the drainage improvement measures are selected as the optimum plan for each of the priority areas (refer to Table 4-1).

Drainage Area	Selected Alt. No.	Improvement Measures as Components of the Optimum Plan
Sg. Air Mendidih	Alt. 3	1. Channel improvement of four (4) existing trunk drains 2. Construction of on-site flood detention ponds 3. Construction of new flood detention ponds at three (3) possible sites.
Sg. Line-G	Alt. 4	1. Channel improvement of one (1) existing trunk drain 2. Construction of one (1) new diversion channel 3. Rehabilitation of the existing two (2) off-site flood detention ponds 4. Construction of new flood detention ponds at two (2) possible sites
Prt. Pokok Mangga	Alt. 4	1. Channel Improvement of three (3) existing trunk drains 2. Construction of one (1) new trunk drain which runs almost along center line of the basin
Sg. Ayer Salak	Alt. 3	1. Channel improvement of one (1) river channel and two (2) existing trunk drains 2. Rehabilitation of one (1) existing flood detention pond 3. Construction of five (5) new flood detention pond

The principal advantages of the optimum plans are as enumerated below:

(1) Least project cost is expected compared with the other alternative plans;

(2) Least house relocation is also expected compared with the other alternatives, thus minimizing the social impact of project implementation;

(3) Channel improvement is minimized by the flood detention facilities, which could minimize the drainage discharge flowing into the downstream river channel thus reducing the possibility of river channel overflow. The minimum channel improvement could also minimize the dredging volume of sludge accumulated in the channel, which could reduce the adverse environmental impact of project implementation.

The advantage in Item (3) above is, however, not expected from the optimum drainage improvement plan for Pokok Mangga. That is, the optimum drainage improvement for Pokok Mangga is solely for "quick disposal of flood" without any flood detention facility. This is attributed to the topographic conditions, i.e., Pokok Mangga is a typical coastal plain area where a possible site with a substantial flood detention capacity is hardly secured. This is because of the extremely flat, low-lying ground level and the high ground water level. Conceived is pumping drainage as one of the eligible drainage measures for Pokok Mangga due to the topographic condition. It was, however, verified through hydraulic simulation that gravity drainage could be possible for the area, hence, pumping drainage is not applied as one of components of the optimum plan.

It is further noted that the flood detention measure by storage tank in a house lot is not applied as a component of the optimum drainage improvement plan for the drainage area of Sg. Air Mendidih. This is attributed to its higher installation cost than other alternative measures and difficulties in obtaining the individual agreement of house owners. However, a certain flood detention effect by the measure was verified through the detailed hydrological study for the priority area. Moreover, the measure does not require any house relocation and the water stored in the storage tank could serve as secondary water resources. From this point of view, the measure should be applied to a densely populated area in particular, where no alternative drainage improvement measure other than the storage tank in a house lot is applicable. The subsidy system should also be established to encourage the house owners to install the facility.

4.3 Outline of the Proposed Project Facilities

4.3.1 Components of Facilities

The proposed drainage facilities consist of improved drainage channels and various types of flood detention facilities. Details of these facilities are as described hereinafter.

(1) Improvement Drainage Channels

The channel improvement is made for all priority areas in common (refer to Fig. 4-9). Deepening of channel rather than widening is applied as the principal measure for channel improvement so as to minimize the land acquisition and the number of house relocation. Utmost effort was further given to "natural river engineering" on the channel improvement whereby wildlife conservation and natural beauty are enhanced. The natural river engineering involve construction of earth channel with sod facing and/or stone pitching on the channel, preservation of wet land and construction of flood retarding basin. The concrete-lined channel is, however, applied to congested areas

where acquisition of right-of-way is difficult. The length of the proposed channel improvement is as given below:

Drainage Area	Name of Drainage Channels	Improvement Length (m)		
		Earth Channel	Concrete Channel	Total
Sg. Air Mendidih	1. Sg. Air Mendidih	1,310	-	1,310
	2. Line-N	430	660	1,090
	3. Line-O	-	630	630
	4. Line-P	-	1,410	1,410
	Sub-total	1,740	2,700	4,440
Line-G	Line-G	-	3,020	3,020
Pokok Mangga	1. Prt. Pokok Mangga	-	3,260	3,260
	2. Prt. Besar Limbongan	-	920	920
	3. Prt. Malim	-	3,230	3,230
	4. Prt. Lolong Pandan	-	1,870	1,870
	Sub-total	-	9,280	9,280
Sg. Ayer Salak	1. Sg. Ayer Salak	4,780	-	4,780
	2. Prt. AB-1	3,910	-	3,910
	3. Prt. AB-11	2,950	-	2,950
	4. Tributary	4,100	-	4,100
	Sub-total	15,740		15,740
Total		17,480	15,000	32,480

In addition to the above improvement of the existing drainage channels, constructions of a new diversion channel and a new trunk drain are proposed for the drainage areas of Line-G and Pokok Mangga respectively. Details of these new channels are as described in sub-section 4.1.3 (2) and sub-section 4-1.4 (2) [refer to Figs. 4-9 (2/6) and (3/6)].

(4) Rehabilitation of Existing Flood Detention Ponds

Rehabilitation is made for the existing two (2) flood detention ponds in the area of Line-G and one (1) in the area of Sg. Ayer Salak (refer to Figs. 4-10 to 4-12). All of these existing ponds are of the wet pond type, and impounding water is seriously polluted due to inflow of wastewater. To remedy such an environmental deterioration, the ponds are dried up during non-flooding time by the following structures: (a) outfall to divert the non-flooding discharge from inflow to the pond; (b) ditch at the bottom of the pond; and (c) outlet structure which is placed lower than the inlet point (refer to Fig. 4-13 to 4-14). The storage volumes of the existing ponds are also enlarged to increase the flood detention capacity, as given below:

Drainage Area	Name of Pond	Active Storage Capacity (m^3)	
		Existing	After Rehabilitation
Line-G	1. Taman Keladi	36,050	63,000
	2. Taman Sri Wang	7,300	16,800
Ayer Salak	3. Bukit Lambai	15,850	59,000
Total		59,200	138,800

(3) Construction of New Flood Detention Ponds

The new flood detention ponds are constructed in three (3) priority areas other than Pokok Mangga (refer to Figs. 4-15 to 4-17). The ponds are designed either as dry pond, wet pond or wet land. The structural features of the dry pond are as described in the foregoing rehabilitation of existing ponds. As for the wet pond and the wet land, both of them continue to impound water even during non-flooding time. However, they could be applied only when a substantial part of the catchment area is covered with new land development where less non-treated water is expected to inflow into the pond. The difference between the wet pond and the wet land is that the wet pond is enhanced as an artificial pond through extensive excavation work. On the other hand, the wet land is applied to the existing natural swampy area on the premise of minimum earth works so as to preserve the present natural conditions.

All wet ponds are provided with an amenity space around the impounding space, so that they could function as community pond. Some dry ponds are also used as community pond, provided that they are placed in a rather extensive vacant space where large scale amenity facilities could be provided. The following table gives the principal features of the proposed new flood detention ponds:

Drainage Area	Name of Pond	Name of Downstream Trunk Drain	Pond Type	Active Storage Capacity (m^3)	Remarks
Sg. Air Mendidih	1. Police Hutan	Line-P	Wet Pond	48,700	Community Pond
	2. Upper Line-P	Line-p	Dry Pond	8,900	
	3. Line-N	Line-N	Dry Pond	16,000	
	4. Sek. Men, Sains	Line-N	Wet Pond	16,600	On-site Pond
	5. IKM	Line-N	Wet Pond	3,300	On-site Pond
Line-G	1. Upper Line-G	Line-G	Wet Pond	24,640	
	2. Middle Line-G	Line-G	Dry Pond	17,000	Community Pond
Sg. Ayer Salak	1. Tg. Minyak (1)	Sg. Ayer Salak	Wet Pond	63,560	
	2. Upper Ayer Salak	Sg. Ayer Salak	Dry Pond	19,920	
	3. Tg. Minyak (2)	Prt. AB-1	Wet Pond	70,370	Community Pond
	4. Middle AB-1	Prt. AB-1	Wet Land	29,280	
	5. Middle AB-11	Prt. AB-11	Dry Pond	54,150	Community Pond
Total				352,520	

(4) Rise of Platform Level

There are low-lying areas along the drainage channels where land development for new residential, industrial and/or commercial areas is projected but its existing ground level is lower than the design high water level of the proposed drainage channel improvement and the storm rainfall is hardly drained into the channel. The land developers will need to elevate the such ground level (called "platform level") to the design high water by land reclamation. From this viewpoint, the necessary extent of land elevation as well as its corresponding reclamation volume is estimated. The land reclamation effects to facilitate the drainage of storm rainfall. At the same, the reclamation areas could be used as dumping sites for dredged and/or excavated materials from flood detention ponds and drains provided that the premises that any toxicity is not assessed in the materials.

The proposed reclamation areas in the low-lying areas are located as shown in Fig.4-18. Listed below are the estimated volumes for reclamation and the volumes for dredging/excavation for flood detention pons and drainage.

Name of Drainage Area	Reclamation Volume ($1,000m^3$)	Dredging/Excavation Volume ($1,000m^3$)
1. Sungai Petani		
1.1 Sg. Air Mendidih	42.2	
1.2 Line G	170.5	62.3
Sub-Total	212.7	248.4
2. Melaka		
2.1 Prt. Pokok Mangga	262.7	239.4
2.2 Sg. Ayer Salak	1,097.8	568.5
Sub-total	1,360.5	807.9
Ground Total	1,573.2	1,056.3

As estimated above, the dredging and/or excavation volume could cover the necessary reclamation volume for the proposed drainage improvement works in Sungai Petani. Thus, the land developers could expect the source of reclamation materials from the proposed drainage improvement works. Nevertheless, the dumping site is required for the excessive dredging and/or excavation volume of about 35.7 thousand m^3. The excessive volume should be dumped through the measures described in the sub-section 2.4.2 (3). In contrast to the case of Sungai Petani, the reclamation volume exceeds the dredging/excavation volume in Melaka, and therefore, the land developers are required to obtain the alternative sources for reclamation materials of about 483.1 thousand m^3.

4.3.2 Work Quantities of Facilities

The following table presents an outline of the proposed project facilities:

Work Item	Unit	Work Volume				
		Sg. Air Mendidih	Line-G	Prt. Pokok Mangga	Sg. Ayer Salak	Total
1. Channel Improvement						
Number of Channel		4	3	5	8	20
Channel Length	km	4.4	3.0	10.8	15.7	33.9
Earth Work	$1000m^3$	90.4	20.0	239.4	443.9	793.7
Concrete Work	$1000m^3$	5.9	5.3	51.0	-	62.2
Number of Box Culverts		11	5	6	14	36
Number of Bridges		8	0	10	8	26
2. Rehabilitation of Existing Detention Pond						
Number of Ponds		-	2	-	1	3
Area of Pond	ha	-	3.3	-	2.1	5.4
Catchment Area	ha	-	97.6	-	98.1	195.7
Earth Work	$1000m^3$	-	32.7	-	12.9	45.6
Slope Protection	$1000m^2$	-	37.1	-	18.8	55.9
Concrete Work	$1000m^3$	-	0.4	-	0.3	0.7
Metal Work	ton	-	2.5	-	1.7	4.2
Road Work	$1000m^2$	-	3.9	-	2.0	5.9
3. Construction of New Detention Pond						
Number of Ponds		2	2	-	5	9
Area of Pond	km^2	3.6	6.1	-	29.4	39.1
Catchment Area	km^2	139.3	394.6	-	1,176.5	1,710.4
Earth Work	$1000m^3$	70.2	59.8	-	121.2	251.2
Slope Protection	$1000m^2$	31.6	58.7	-	45.2	135.5
Concrete Work	$1000m^3$	-	0.4	-	0.4	0.8
R.C. Structure	$1000m^3$	0.3	0.5	-	1.1	1.9
Metal Work	ton	0.9	0.9	-	2.3	4.1
Road Work	$1000m^2$	4.1	3.1	-	5.7	12.9
4. Construction of On-site Detention Pond						
Number of Ponds		3	-	-	-	3
Area of Open Space	ha	7.1	-	-	-	7.1
Earth Work	$1000m^3$	28.1	-	-	-	28.1
Bottom Protection	$1000m^2$	36.0	-	-	-	36.0
Concrete Work	$1000m^3$	0.7	-	-	-	0.7
Metal Work	ton	0.6	-	-	-	0.6

4.4 Project Cost

The total project cost is estimated at RM 57.93 million (US$ 15.2 million) for construction cost and RM 0.84 million (US$ 0.22 million) for annual average operation and maintenance cost on the price level as of May 1999. The details of project cost are given below:

(Unit: RM million out of Parentheses and Million Yen in Parentheses)

Item	Sg. Air Mendidih		Line G		Prt. Pokok Mangga		Sg. Ayer Salak		Total	
1. Construction Cost										
Channel Improvement	7.20	(230)	3.22	(103)	14.64	(468)	25.75	(823)	50.81	(1,624)
Rehabilitation of Existing Detention Pond	-	(-)	0.54	(17)	-	(-)	0.29	(9)	0.83	(26)
Construction of New Detention Pond	1.05	(34)	1.47	(47)	-	(-)	3.23	(103)	5.75	(184)
Storage Facility in Public Open Space	0.54	(17)	-	(-)	-	(-)	-	(-)	0.54	(17)
Total	8.79	(281)	5.23	(167)	14.64	(468)	24.27	(775)	57.93	(1,850)
2. Annual Operation and Maintenance Cost										
Drainage Channel	0.04	(1.2)	0.01	(0.3)	0.05	(1.6)	0.20	(6.4)	0.30	(9.6)
Detention Pond	0.11	(3.5)	0.10	(3.2)	-	(-)	0.33	(10.5)	0.54	(17.2)
Total	0.15	(4.8)	0.11	(3.5)	0.05	(1.6)	0.53	(16.9)	0.84	(26.8)

4.5 Project Implementation and Disbursement Schedules

The project implementation and disbursement schedules for the priority areas are proposed to complete within five years in the Eighth Malaysia Plan (2001-2005), as shown in Fig. 4-19 and Table 4-1. The objective work items of implementation are broadly classified into detailed design, land acquisition and construction works. Among them, the detailed design for all priority areas would require about one (1) year starting in early 2001 and the land acquisition for about two-and-a-half (2.5) years starting from the beginning of 2002 will follow. The construction period is assumed to be three (3) years from the beginning of 2003 to the end of 2005.

The construction works are further divided into channel improvement and rehabilitation/construction of flood detention ponds. The channel improvement would be implemented in such a manner that the improvement is made from downstream upward. As for the flood detention ponds, the rehabilitation of existing ponds would be ahead of construction of new ponds. The required construction periods for each of construction items are set forth in due consideration of the necessary excavation volume as well as the embankment volume.