4.4 Drainage Basin of Prt. Pokok Mangga in Melaka

4.4.1 Possible Countermeasures

The Prt. Pokok Mangga drainage basin is located in the low-lying coastal plain. The altitude ranges only between 1.5 m and 4.0 m, as described in Subsection 3.1.3. Further the groundwater level exists normally less than 1 m underneath the ground. Thus the off-site flood detention facilities are not suitable in this basin due to the flat topography and high groundwater level.

The existing channel flow capacities are extremely lower than the 2-yr flood discharge in the entire stretch. In order to alleviate serious flooding, channel improvement works are crucial as a principal measure in the basin. In due consideration of the above-mentioned conditions and present land use, the following three alternative networks of trunk drain can be set up as depicted in Fig. IV-9.

(a) Following the original draining basin: Pokok Mangga and Besar Limbongan;

(b) Additional new draining basin in the central part of the whole basin: Pokok Mangga, new trunk drain and Besar Limbongan; and

(c) New diversion draining into Sg. Malim: Lower Pokok Mangga, Upper Pokok Mangga and Besar Limbongan.

Table IV-4 enumerates the salient features of the alternative drainage networks.

Based on the above drainage networks, the following are possible countermeasures in the Prt. Pokok Mangga drainage basin.

(1) Channel Improvement

Preliminary channel design is described below.

(a) Down-most Section

Prt. Pokok Mangga discharges collected stormwater directly into the sea (Melaka Strait). Thus, the tidal level shall be examined carefully for setting the invert level at the down-most section. Furthermore, the invert level is to be set up as low as possible, so as to increase the flow capacity of Prt. Pokok Mangga. Compared with tidal level and the mouth of Pokok Mangga, the design invert level of 0.00 m at the mouth is determined.

Sea/Drain	Tide/Mouth	Riverbed Elevation
Sea Level	Mean High Water Spring	0.64 m
(Kuala Melaka)	Mean High Water Neaps	0.05 m
Pokok Mangga	CH 0 m	0.35 m

Besides Prt. Pokok Mangga, there are no available cross-sectional data of the trunk drains, Prt. Besar Limbongan and others. As for the design invert level of the mouth of Besar Limbongan, the following present situations are recommended judging from the ocular site inspection.

(b) Design Invert Level and Slope

Starting from the mouth to directly connect to the upper-most section, the design invert level is determined. Design channel slope of 0.0333% is set up over the whole stretch.

As for Prt. Besar Limbongan, the design slope of 0.10% is set up following the present channel slope clarified by a simple site measurement.

(c) Design Bank, High-water Level and Depth

High-water level is set up, enveloping the existing bank and delineating the parallel line to design channel-bed. Freeboard of 0.3 m is added to determine design bank level. Backwater effect from the sea is not considered since the high-water level of 1.80 m at the mouth is higher than the mean high water spring of 0.64 m. As a result, design water depth is 1.8 m over the whole stretch.

As for Prt. Besar Limbongan, design water depth of 1.6 m is determined following the present channel depth clarified by a simple site measurement.

(d) Drain Type

As explained in the Chapter 3, the Pokok Mangga drainage basin is located in the low-lying area where the draining capacity is extremely poor due to flat topography. Further, stagnant water in the dry weather accelerates propagation of water hyacinth resulting in reduction of channel flow capacity. In due consideration of the above, R.C. drain is recommended in this basin.

Drain	Segment	Drain Type
Pokok Mangga	CH 0 m - CH 3,270 m	R.C drain
Others	-	R.C drain

(2) Construction of New Trunk Drain

Considering the poor flow capacity of the drainage channel as a particular characteristic in low-lying areas, the drainage area should be modified as follows:

(a) Making the drainage area smaller by dividing it into some parts; and

(b) Making the conveyance channel length shorter by finding a suitable receiving water nearby.

This countermeasure, construction of new trunk drain, is regarded as following the former solution, while the diversion measure proposed in the next section is another solution combining both solutions.

As described frequently, flow capacity of existing trunk drains is extremely low. Thus the new trunk drains have to extensively collect stormwater. As a result of this countermeasure, the catchment areas will be changed as follows:

	Original Network	New Trunk Drain Scheme
Pokok Mangga	202.95 ha	132.30 ha
New Trunk Drain	-	267.81 ha
Besar Limbongan	267.95 ha	70.79 ha

Preliminary channel design for new trunk drain is enumerated below.

(a) Channel Alignment

New trunk drain starts from Prt. Malim, runs southerly through the agricultural land between Prt. Pokok Mangga and Lorong Pandan, and finally empties into Melaka Strait, as depicted in Fig. IV-9(2/3). The channel route is determined to minimize the number of houses relocated by the project.

(b) Down-most Section

Design invert level of the outfall is set up at 0.00 m, same as that of Prt. Pokok Mangga.

(c) Design Channel Slope and Depth

Topographic map with a scale of 1:2,000 is the only available information for the new trunk drain. Design channel slope of 0.0327% is set up over the whole stretch, referring to the ground elevation on the topographic map. Design water depth can be assumed at 1.8 m according to the similarity of topography to Prt. Pokok Mangga. Backwater effect from the sea also is not considered for the same reason as Prt. Pokok Mangga.

(d) Drain Type

R.C. drain is recommended for the same reason as Prt. Pokok Mangga.

(3) Construction of Diversion Channel

In the Prt. Pokok Mangga basin including the adjacent western side of the Lorong Pandan area, there are two possible receiving waters, Melaka Strait and Sg. Malim. Thus the whole drainage area can be divided into the following three areas taking topographic conditions into account (refer to Fig. IV-9(3/3)).

(a) Stormwater from the northern part will be discharged into Sg. Malim through the existing channel of upper part of Prt. Pokok Mangga and Prt. Malim.

(b) Stormwater from the southeastern part will be discharged into Melaka Strait through the existing channel of Lorong Pandan roadside drain and Prt. Besar Limbongan.

(c) Stormwater from the southwestern part will be discharged into Melaka Strait through the existing channel of lower Prt. Pokok Mangga. This drainage area will include the middle part of the basin by draining through a new drain, for the purpose of reducing the discharge received by Prt. Besar Limbongan.

As a result of this countermeasure, the catchment areas will be changed as follows.

	Original Network	Diversion Scheme
Pokok Mangga (Lower)	202.95 ha	107.51 ha
Upper Pokok Mangga	-	212.29 ha
Besar Limbongan	267.95 ha	151.10 ha

Further, design invert level and channel slope of Pokok Mangga has to be changed in this alternative. CH 1200 m of Pokok Mangga could be a hinge point where the draining basin is to be divided into two parts, upper Pokok Mannga and lower Pokok Mannga, examining the longitudinal profile of Pokok Mangga as shown in Fig. IV-3(4/6). The principal features of the Pokok Mangga channel are summarized in the following table.

Item	Lower Pokok Mangga	Upper Pokok Mangga
Receiving water	Melaka Strait	Sg. Malim
Channel length	1,200 m	2,070 m
Invert level of down-most section	0.00 m	0.77 m
Channel slope	0.133 %	0.040 %
Water depth	1.6 m	1.6 m

Preliminary design of diversion channel is described below.

(a) Diversion Alignment

Diversion channel starts from the upstream end of Prt. Pokok Mangga, immediately joins Prt. Besar Bachang, runs through the corner of parking area in Taman Asean, and finally empties into Sg. Malim, as illustrated in Fig. IV-9(3/3). The length of diversion is about 250 m.

(b) Design Invert Level and Slope

The diversion channel is extended from the downstream end of upper Pokok Mangga with a slope of 0.04%. Design invert level at the outfall is estimated at 0.67 m.

(c) Necessary Structure of Outfall

Adding 1.6 m of water depth to the invert level, high-water level at the outfall is estimated at 2.27 m. On the other hand, the probable water level of Sg. Malim at the outfall (CH 4,267 m) is estimated as follows, using runoff analysis and non-uniform flow computation.

Recurrence Period	Water Level
2-year	2.83 m
5-year	3.29 m

Compared with high-water level at the outfall and probable water level of receiving water, the following structures are additionally necessary to reduce the interior flood damage.

- Gate structure to prevent exterior water of Sg. Malim from entering the interior area while the water level of Sg. Malim is higher than the interior one.

- Pump station to lift stormwater over the exterior dike to Sg. Malim.

(d) Drain Type

R.C. drain is recommended for the same reason as Prt. Pokok Mangga.

(4) Construction of Pump Stations

As examined before, pump station is necessary only for the diversion discharging stormwater into Sg. Malim. The following are the results of preliminary study for the necessary structures.

(a) Sluice Gate

The sluice gate for the gravity outlet is normally located on the riverside of the dike. Necessary gate dimensions are at least the diversion channel width and the difference in height between invert level of outfall and the exterior bank level. Gate width depends on width of the diversion channel. Thus gate width of 12 m is at least necessary since preliminary estimation of diversion channel is 12 m wide and 1.9 m deep with 0.3 m freeboard. Meanwhile, gate height of 3.0 m is at least necessary, considering the height difference of 2.6 m between the invert level and the water level in a 5-yr flood, and the freeboard of 0.3 m.

(b) Pump Station and Regulation Pond

The use of regulation pond can significantly reduce gravity outlet and pumping station size and costs. A regulation pond may also increase the reliability of the system by providing additional time for appropriate operation before damaging water levels occur. Pond area, however, is limited due to the location in the urban areas. The area is found out adjacent to the outfall. A maximum volume of 6,000 m^3 is estimated through excavation. This amount of storage can reduce the necessary pump size from 29 m^3/s to 20 m^3/s.

(5) Construction of Detention Pond in Newly Developed Area

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 the large-scale detention pond is not appropriate. Thus on-site type of detention pond is suitable in the newly developed areas, even though a large volume of storage capacity is not expected.

The following are areas and volumes on the suitable sites with some extent for on-site detention. Detailed information is presented in the Supporting report on Design, Construction Plan and Cost Estimate of Proposed Facilities, Sector VI of Volume 4.

Number of Sites	69
Total Area	23.6 ha
Storage Depth	0.3 m
Storage Volume	70,800 m^3

(6) Installation of Storage Tank in Individual House

A storage tank will be installed in an individual house in the existing built-up area. A typical prototype of storage tank is tabulated below based on the drainage structure plan study.

Average extent of house lot (m^2)	200
Storage volume of a tank (m^3)	2
Specific storage volume (m^3/ha)	100
Extent of existing built-up area (ha)	370

4.4.2 Alternative Drainage Schemes

Among the preceding countermeasures, the following alternative drainage schemes are studied.

Countermeasures	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Channel improvement	√	√	√	√	√	√	√
Construction of new trunk drain				√	√	√	
Construction of diversion channel including pump station							√
Construction of on-site detention ponds		√			√		
Installation of individual house storage			√			√	

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

The following are the notion of each alternative:

Alt. 1 : Conventional structural method of drainage improvement

Alt. 2 : Effects of on-site detention facilities in addition to Alt. 1

Alt. 3 : Effects of individual house storage in addition to Alt. 1

Alt. 4 : Effects of new trunk drain

Alt. 5 : Effects of on-site detention facilities in addition to Alt. 4

Alt. 6 : Effects of individual house storage in addition to Alt. 4

Alt. 7 : Effects of diversion and pump facilities

4.5 Drainage Basin of Sg. Ayer Salak in Melaka

4.5.1 Possible Countermeasures

The following are possible countermeasures in Sg. Ayer Salak drainage basin, and the locations of these structural measures are illustrated in Fig. IV-10.

(1) Channel Improvement

The existing trunk drain network is delineated in Fig. 4-8. The channel flow capacity is lower than the peak discharge equivalent to 2-year flood in most of the stretches of upper Sg. Ayer Salak, Prt. AB1 and Prt. AB11. The wide swampy areas, however, extend in the middle reaches of AB1 and AB11, 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. Thus particular attention should be paid to the channel improvement scheme for the basin.

The preliminary study on channel design is described below.

(a) Downstream Section of Sg. Ayer Salak

The river stretch downstream of CH 4,200 m has already been improved as shown in Fig. IV-3(5). Thus channel improvement should be focused mainly on the upper stretch, and the lower stretch should not be improved again if possible.

(b) Design Invert Level and Slope of Sg. Ayer Salak

Starting from the section of CH 4,200 m in parallel with the existing channel bed, design invert level is determined. Design channel slope changes mainly at the junctions of major tributaries and the points of topographic change.

(c) Design Bank, High-water Level and Depth of Sg. Ayer Salak

High-water level is set up, enveloping the existing bank and delineating the parallel line to design channel-bed. Freeboard of 0.3 m is added to determine the design bank level. Backwater effect from Sg. Malim is not considered, since the effect already subsides in the target stretch upstream of CH 4,200 m. As a result, design water depth is set at 1.8 m over the upper stretch.

(d) Design Bank and High-water Level in Prt. AB1 and AB11

First of all, backwater effects from the main streams are to be considered in both drains. Longitudinal profiles of high-water level is set up, enveloping the existing bank from the upstream end, extending the high-water level of main stream horizontally from the downstream end. Freeboard of 0.3 m is added to determine the design bank level.

As a result, design water depth is 2.0 m over the whole stretch.

(e) Down-most Section of Prt. AB1 and Prt. AB11

For reference, the following are riverbed elevations of main streams at the confluence points.

Prt. AB1

River	Confluence Point	Riverbed Elevation
Sg. Ayer Salak	CH 2,130 m	-1.41 m

Prt. AB11

Drain	Confluence Point	Channel Elevation
Prt. AB1 (Design)	CH 475 m	-0.77 m

Compared with the deepest riverbed elevation of main stream, as well as the invert level of target drain mouth and water depth, the design invert levels of -1.25 m and 0.06 m at the mouths of AB1 and AB11 are determined, respectively. As a result, water depth is set at 2.5 m in AB1 and 2.0 m in AB11.

(f) Drain Type

The earth drain is applied to the whole stretch of trunk drains in Sg. Ayer Salak in accordance with the criteria, as described in Subsection 2.2.1.

(2) Rehabilitation of Existing Detention Ponds

There is one existing functional detention pond in the Prt. AB11 basin. The salient features of the pond and possibility for rehabilitation are summarized in the following table.

Name	Bkt. Rambai	
	Existing	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
Specific E. Storage	160 m^3/ha	600 m^3/ha

The following are the principal measures to rehabilitate the two ponds.

(a) In order to increase the storage volume, the ponding area shall be extended as wide as possible within the extent of the site.

(b) For the same purpose, pond surface shall be excavated as deep as possible within an adjustable height to the downstream drain channel.

(c) In order to enhance the deteriorated environmental situations, installation of trash rakes, improvement of inlet and outlet structures, and construction of dry-weather channel or bypass sewer shall be considered.

(3) Construction of Detention Pond in Newly Developed Area

The vacant lands to be developed in future extend widely over the entire basin. The land developers already designed the following two detention ponds.

Name	Tg Minyak (1)	Tg Minyak (2)
Drainage System	Sg. Ayer Salak	Prt. AB1
Catchment Area	134.6 ha	129.0 ha
Area of Pond	24,850 m^2	31,920 m^2
Pond Depth	2.74 m	2.31 m
Storage Volume	63,600 m^3	70,400 m^3
Specific Storage	470 m^3/ha	550 m^3/ha

In addition, the following three detention ponds can be planned in accordance with the existing drainage system and locations of new development.

Location of proposed pond		Upper Ayer Salak	Middle AB1	Middle AB11
Topography		Valley-bottom plain	Swampy Area	Swampy Area
Type of pond		Retarding basin with broad-crested side-overflow weir	Wetland	Embankment and excavation
Catchment area (ha)		664.34	261.99	164.40
Approx. dimension	Ponding area (m^2)	49,800	73,200	114,000
	Maximum storage depth (m)	1.2	1.2	1.3
	Storage volume (m^3)	20,000	29,300	54,200
	Specific storage volume (m^3/ha)	30	110	330

These detention ponds should be designed integrating the new development activities in each sub-basin. Regarding the pond planned for AB1, a retarding basin and wet land type might be suitable since the ponding areas are located in the wide swampy area and its catchment will be developed in near future. Furthermore the pond could function as water quality control facility during floods as well as dry weather.

4.5.2 Alternative Drainage Schemes

Among the preceding countermeasures, the following alternative drainage schemes are studied.

Countermeasures	Alt. 1	Alt. 2	Alt. 4
Channel improvement	√	√	√
Rehabilitation of existing detention pond		√	√
Construction of detention pond in newly developed areas			√

The following are the notion of each alternative:

Alt. 1 : Conventional structural method of drainage improvement
Alt. 2 : Effects of pond rehabilitation
Alt. 3 : Modification of present regulatory policy

5. OPTIMUM DRAINAGE IMPROVEMENT PLAN

5.1 Comparative Study on Alternatives

A comparative study on the alternatives is made taking project cost, number of house relocations, and other social and environmental impacts into account.

5.1.1 Project Cost

The project cost of each alternative is given in the table below (refer to Volume 4, Sector VI, Design, Construction Plan and Cost Estimate of Proposed Facilities).

Drainage Basin	Alternative	Construction Cost (1000 RM)	Structural Measures						
			Channel improvement	Construction of new trunk drain	Construction of diversion channel	Rehabilitation of existing pond	Construction of new detention pond	Construction of on-site detention pond	Installation of storage tank in individual house
Sg. Air Mendidih	Alt. 1	9,066	√						
	Alt. 2	8,962	√				√		
	Alt. 3	8,778	√				√	√	
	Alt. 4	30,056	√				√	√	√
Line G	Alt. 1	6,241	√						
	Alt. 2	5,788	√			√			
	Alt. 3	5,310	√			√	√		
	Alt. 4	5,221	√		√	√	√		
Prt. Pokok Mangga	Alt. 1	18,173	√						
	Alt. 2	18,021	√					√	
	Alt. 3	64,494	√						√
	Alt. 4	14,644	√	√					
	Alt. 5	14,901	√	√				√	
	Alt. 6	61,374	√						√
	Alt. 7	44,616	√		√				
Sg. Ayer Salak	Alt. 1	37,177	√						
	Alt. 2	36,179	√			√			
	Alt. 3	29,261	√			√	√		

Note: (√) indicates measure(s) applied to the alternative

5.1.2 House Relocation

The implementation of the project will require house relocation mainly due to channel improvement. Since urban drainage improvement projects are considered as relatively small-scale projects compared with other infrastructures such as highways and municipal water supply, house relocation may be the most serious negative impact to the locality. The number of houses to be relocated is counted by overlaying the facility layouts on the topographic map with a scale of 1:2,000, as shown in the following table.

Drainage Basin	Alternative	Number of Relocation House/Building			
		R.C	Wooden	Others	Total
Sg. Air Mendidih	Alt. 1	6	31	1	38
	Alt. 2	6	27	0	33
	Alt. 3	4	26	0	30
	Alt. 4	4	18	0	22
Line G	Alt. 1	1	1	0	2
	Alt. 2	1	1	0	2
	Alt. 3	0	1	0	1
	Alt. 4	0	0	0	0
Prt. Pokok Mangga	Alt. 1	32	16	1	49
	Alt. 2	27	9	1	37
	Alt. 3	27	9	1	37
	Alt. 4	24	5	0	29
	Alt. 5	23	5	0	28
	Alt. 6	23	5	0	28
	Alt. 7	26	4	1	31
Sg. Ayer Salak	Alt. 1	16	46	0	62
	Alt. 2	15	43	0	58
	Alt. 3	9	29	0	38

5.1.3 Environmental Impacts

According to the environmental evaluation in Sector IX, Volume 4, the following factors related to project implementation affect the environment.

(a) Soil erosion and sedimentation;
(b) Construction debris;
(c) Dust and noise; and
(d) Channel dredging.

Among these factors, the disposal of dredged materials would be the most serious issue. To minimize the volume of dredged materials, flood detention facilities are considered among the possible countermeasures to reduce the peak flood discharge and thus also reduce the volume of dredged materials. As a result, the adverse environmental impacts of project implementation are also reduced.

As for the other factors, there are no significant differences among the alternatives. Moreover, the adverse environmental impacts may not be so serious because the project scale is not so big.

5.1.4 Comparative Evaluation and Selection of Optimum Plan

As shown in the preceding subsections, the alternative that indicates the least cost also requires the least relocation of houses. Thus the alternative with the least cost is selected as the optimum plan in each drainage basin. The structural components of the optimum plan selected are summarized below.

Drainage Basin	Alternative	Structural Measures
Sg. Air Mendidih	Alt. 3	1. channel improvement of four (4) trunk drains 2. construction of three (3) off-site detention ponds 3. construction of two (2) on-site detention ponds
Line G	Alt. 4	1. channel improvement of one (1) trunk drains 2. channeling of one (1) new diversion 3. rehabilitation of two (2) off-site detention ponds 4. construction of two (2) off-site detention ponds
Prt. Pokok Mangga	Alt. 4	1. channel improvement of two (2) major trunk drains and others 2. channeling of one (1) new trunk drain
Sg. Ayer Salak	Alt. 3	1. channel improvement of one (1) river, two (2) major trunk drains and others 2. rehabilitation of one (1) off-site detention ponds 3. construction of five (5) off-site detention ponds

Fig. IV-11 depicts the hydrological changes between present and future conditions, and presents how the proposed optimum plan allocates the flood discharge to the selected structural measures. The following are hydrological evaluations based on this figure.

(1) Sg. Air Mendidih Drainage System

Sg. Air Mendidih forms a shallow valley along the stream by its fluvial functions. Accordingly, some parts of flood runoff flow down the valley without stagnation. Under the future condition, most flood discharge increment by urbanization over the basin is stagnant due to the limited flood carrying capacity of the valley.

Regarding flood detention, the proposed facilities cover 30% of the entire basin as tabulated below. On the other hand, the detention facilities reduce flood peak discharge by 30%, from 112 m^3/s to 79 m^3/s. The coverage area and flood control effects of proposed detention facilities can be interpreted as well-functioning of the facilities. Further, the detention facilities can offset the increment of flood discharge by urbanization.

Area of entire drainage basin	362 ha
Total catchment area of detention facilities	167 ha
Total storage volume	99,300 m^3
Specific storage to total catchment	590 m^3/ha
Specific storage to entire basin	270 m^3/ha

(2) Line G Drainage System

In the lower reaches of Line G, a relatively flat topography is formed by the fluvial functions of Sg. Petani. Due to the flat topography, the ratio of stagnant inundation to flood runoff is slightly bigger than that of Sg. Air Mendidih.

The proposed facilities cover 86% of the entire basin with some overlapping as tabulated below. On the other hand, the detention facilities reduce flood peak discharge by 70%, from 98 m^3/s to 29 m^3/s. The coverage and flood control effects of proposed detention facilities can be interpreted as well-functioning of the facilities. Further, a drastic reduction of retarding function, which is presented as stagnant inundation in Fig. IV-11, can be supplemented by the storage capacity of detention facilities.

Area of entire drainage basin	272 ha
Total catchment area of detention facilities	233 ha
Total storage volume	152,800 m^3
Specific storage to total catchment	660 m^3/ha
Specific storage to entire basin	560 m^3/ha

(3) Prt. Pokok Mangga Drainage System

As described in the Chapter 3, the flat topography extends over the Pokok Mangga drainage basin. In spite of this situation, the ratio of stagnant inundation to flood runoff is slightly smaller compared with Sg. Air Mendidih and Line G, because flood runoff can flow down the wide road beside the channel.

The proposed new trunk drain will absorb the increasing runoff by urbanization. Since the lower stretches of Prt. Pokok Mangga and Prt. Besar Limbongan are located in the congested residential areas, land acquisition would likely be difficult. The new trunk drain can alleviate the discharge load on both trunk drains, and land acquisition in the lower stretches will be unnecessary. Thus, the new trunk drain will facilitate channel improvement in both of the existing trunk drains.

(4) Sg. Ayer Salak Drainage System

The hydrological structure of Sg. Ayer Salak drainage system is considerably different from the other drainage systems, because the improved channel in the lower reaches has a flow capacity equivalent to more than a 5-yr flood computed under the present condition of land use. Under both present and future conditions, the improved channel cannot fully receive the flood discharge equivalent to its flow capacity due to lack of proper drainage system in the middle and upper reaches.

The proposed facilities cover 63% of the entire basin with some overlapping as tabulated below. On the other hand, the detention facilities reduce flood peak discharge by 32%, from 213 m^3/s to 145 m^3/s. In spite of the wide coverage of detention facilities, the reduction ratio of flood peak discharge is small because the specific storage is not so large due to topographic constraints. However, the detention facilities alleviate the flood discharge up to the channel flow capacity.

Area of entire drainage basin	1,720 ha
Total catchment area of detention facilities	1,091 ha
Total storage volume	296,500 m^3
Specific storage to total catchment	270 m^3/ha
Specific storage to entire basin	170 m^3/ha

5.2 Proposed Urban Drainage Improvement Plan

5.2.1 Drainage Basin of Sg. Air Mendidih in Sg. Petani

The following are the structural components of the proposed urban drainage improvement plan in Sg. Air Mendidih drainage basin.

(1) Channel Improvement

The proposed channel improvement works are summarized below. The longitudinal profile of design channel and the plan of channel alignment are presented in Figs. IV-12 and IV-13, respectively.

Drain	Type	Width	Depth	Length
Sg. Air Mendidih	Earth	17.0-23.0 m	2.0 m	1,310 m
Line N	Earth	11.0 m	2.0 m	430 m
	R.C	1.5-4.5 m	2.0 m	660 m
Line O	R.C	3.5 m	2.0 m	630 m
Line P	R.C	1.0-3.0 m	2.0 m	1,410 m

(2) Construction of New Detention Pond

The following two detention ponds are to be constructed prior to land development activities.

Location of proposed pond		Polis Hutan	Upper Line P
Topography		Flat land	Valley-bottom plain
Type of pond		Embankment and excavation	Retarding basin with broad-crested side-overflow weir
Catchment area (ha)		54.49	84.82
Approx. dimension	Ponding area (m^2)	25,400	10,200
	Maximum storage depth (m)	2.6	1.5
	Storage volume (m^3)	48,700	8,900
	Specific storage volume (m^3/ha)	890	100

(3) Construction of On-site Detention Pond

The following two (2) on-site detention ponds are to be constructed.

Name	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)	0.6 (pond) 0.2 (ground)	0.3 (ground)
Storage volume (m^3)	22,400	3,300
Specific storage volume (m^3/ha)	1,490	450

In addition, the drains in the upper Line N can be utilized for flood control through installation of appropriate control structure of outlet.

Sectional area of drain (m^2)	20
Drain length (m)	800
Storage volume (m^3)	16,000
Catchment area (ha)	59.4
Specific storage volume (m^3/ha)	270

5.2.2 Drainage Basin of Line G in Sg. Petani

The following are the structural components of the proposed urban drainage improvement plan in Line G drainage basin.

(1) Channel Improvement

The roposed channel improvement works are summarized below. The longitudinal profile of design channel and the plan of channel alignment are presented in Figs. IV-14 and IV-15, respectively.

Drain	Type	Width	Depth	Length
Line G	R.C	1.5-4.0 m	2.0 m	2,160 m
Diversion	R.C	3.5 m	2.0 m	280 m
Others	R.C	3.5 m	1.0 m	180 m

(2) Rehabilitation of Existing Detention Ponds

The following two (2) existing detention ponds are to be rehabilitated to increase the flood control capacity and for environmental upgrade.

Name	Taman Keladi		Taman Sri Wang	
	Present	After rehabilitation	Present	After 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 effective storage	520 m^3/ha	910 m^3/ha	260 m^3/ha	600 m^3/ha

(3) Construction of New Detention Pond

The following two (2) new detention ponds are to be constructed prior to land development activities.

Location of proposed pond		Upper Line G	Middle Line G
Topography		Valley-bottom plain	Swampy area
Type of pond		Retarding basin with broad-crested side-overflow weir	Retarding basin with excavated dry-weather channel
Catchment area (ha)		179.53	232.70
Approx. dimension	Ponding area (m^2)	18,200	42,500
	Maximum storage depth (m)	2.0	1.8
	Storage volume (m^3)	24,700	48,300
	Specific storage volume (m^3/ha)	140	210

5.2.3 Drainage Basin of Prt. Pokok Mangga in Melaka

Channel improvement is the proposed urban drainage improvement plan in Prt. Pokok Mangga drainage basin. The proposed channel improvement works including new trunk drain are summarized below. The longitudinal profile of design channel and the plan of channel alignment are presented in Figs. IV-16 and IV-17, respectively.

Drain	Type	Width	Depth	Length
Prt. Pokok Mangga	R.C	3.0-8.0 m	1.8 m	3,270 m
Prt. Besar Limbongan	R.C	5.0 m	1.6 m	920 m
Others	R.C	2.0-3.5 m	1.6-1.8 m	4,100 m
New Trunk Drain	R.C	7.0-13.0 m	1.8 m	2,550 m

5.2.4 Drainage Basin of Sg. Ayer Salak in Melaka

The following are the structural components of the proposed urban drainage improvement plan in Line G drainage basin.

(1) Channel Improvement

The proposed channel improvement works are summarized below. The longitudinal profile of design channel and the plan of channel alignment are presented in Figs. IV-18 and IV-19, respectively.

Drain	Type	Width	Depth	Length
Sg. Ayer Salak	Earth	11.0-25.0 m	1.8 m	2,160 m
Diversion	R.C	3.5 m	2.0 m	280 m
Others	R.C	3.5 m	1.0 m	180 m

(2) Rehabilitation of Existing Detention Pond

The following one (1) existing detention pond is to be rehabilitated to increase the flood control capacity and for environmental upgrade.

Name	Bkt. Rambai	
	Existing	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
Specific E. Storage	160 m^3/ha	600 m^3/ha

(3) Construction of New Detention PondS

Five (5) detention ponds are to be constructed prior to land development activities.

The land developers already designed the following two (2) detention ponds out of the five.

Name	Tg Minyak (1)	Tg Minyak (2)
Drainage System	Sg. Ayer Salak	Prt. AB1
Catchment Area	134.6 ha	129.0 ha
Area of Pond	24,850 m^2	31,920 m^2
Pond Depth	2.74 m	2.31 m
Storage Volume	63,600 m^3	70,400 m^3
Specific Storage	470 m^3/ha	550 m^3/ha

The following three (3) detention ponds are to be planned prior to land development activities.

Location of proposed pond		Upper Ayer Salak	Middle AB1	Middle AB11
Topography		Valley-bottom plain	Swampy Area	Swampy Area
Type of pond		Retarding basin with broad-crested side-overflow weir	Wetland	Embankment and excavation
Catchment area (ha)		664.34	261.99	164.40
Approx. dimension	Ponding area (m^2)	49,800	73,200	114,000
	Maximum storage depth (m)	1.2	1.2	1.3
	Storage volume (m^3)	20,000	29,300	54,200
	Specific storage volume (m^3/ha)	30	110	330

5.2.5 Platform Level for Future Development

When the developers and landowners develop/rebuild the land lots in the flood-prone areas, they have to elevate the lots up to the proper platform level. As a result, floods no longer affect the land lots. The platform level is proposed, as follows.

(a) Platform level is to be set up in tiers by enveloping the design bank level;

(b) Minimum interval of the platform level is to be 0.1 m; and

(c) Height difference between the adjacent levels shall be minimized as much as possible by adjusting the stretch length of channel segment.

Table IV-5 presents the proposed platform level for future development. Based on the level, the areas to be elevated for each drainage basin are as illustrated in Fig. IV-20.