VOLUME 4 – SECTOR VI

DESIGN, CONSTRUCTION PLAN AND COST ESTIMATE OF PROPOSED FACILITIES

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

FINAL REPORT

VOLUME 4: SUPPORTING REPORT ON FEASIBILITY STUDY

SECTOR VI: DESIGN, CONSTRUCTION PLAN AND COST ESTIMATE OF PROPOSED FACILITIES

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DESIGN, CONSTRUCTION PLAN AND COST ESTIMATE OF PROPOSED FACILITIES

1. DESIGN OF ALTERNATIVE DRAINAGE FACILITIES

1.1 General

The drainage facilities should fulfill their functions for flood control mitigation and also preserve and/or improve their adjacent natural environment. As discussed in Sector IV, Urban Drainage Improvement Plan, the following drainage facilities are conceived as applicable structural measures for the drainage improvement plan in the priority study areas.

1.2 Drainage Channel

The drainage channel should have a sectional and plane shape to allow the passage of design flood discharge. However, since the flow velocity of the drainage channel change variously and the passage of channel water involves earth, sand and other matters, it should be designed to secure the function permanently and stably.

(1) Route and Alignment

The best route of channel improvement should be selected through examination on the route along the existing waterway and in comparison with alternative routes of new drainage channel, if necessary. The alignment should be as smooth as possible and determined in due consideration of the drainage channel, and project cost which includes the construction cost as well as maintenance cost.

(2) Longitudinal Profile

The design gradient of channel bed is usually set at the average of the existing bed gradient and should gradually change from steep to gentle one in the descending course in order to minimize the channel bed fluctuation. The channel construction and maintenance cost should be also taken into consideration in determining the channel bed gradients.

(3) Cross Section

The cross-sectional design should be made considering the prescribed flow capacity, topographic and soil conditions, environmental condition and construction cost. A single cross-section should be normally adopted as the cross-section shape of a drainage channel so as to secure maximum cross-section area under the restricted right-of-way. A concrete flume type with a rectangular single cross-section area will be employed to expect the utmost flow capacity as well as a self-standing structure, particularly, in the congested area or low lying area. Enumerated below are the cross-sectional design standards to be practicably applied for the drainage channel improvement in this stage.

Type	Structural Characteristics	Applicability for Urban Drainage
Earth channel (Naked channel)	A trapezoidal cross-section shape is formed and the gentler side slope than 45° is required to keep stable against sliding failure. (Recommended side slope, 1:1.5 to 2.0)	Low cost construction can be expected, but periodical weeding is necessary. Relatively wide area for the right-of-way is necessary.
Lined channel	A trapezoidal cross-section shape is formed and the steeper side slope than 45° lined with stone pitching, concrete and turfing can be applied.	Relatively easy maintenance can be expected. Comparing to earth channel much narrower area for the right-of-way is required.
R.C. channel (Flume type)	A rectangular reinforced concrete cross-section is formed. The type can be constructed under any topographic and geological conditions.	Although the construction is costly, easy maintenance can be expected. The right-of-way can be minimized.

(4) Freeboard

The open drainage channel should take a freeboard in order to cope with rise of design high water level by wave height, hydraulic jump and drifting materials. The following should be given as the height of freeboard:

- If 20% of the channel depth is more than 0.3m : 0.3m
- If 20% of the channel depth is less than 0.3m : 20% of the channel depth

(5) Underpass Structure

A box culvert or a pipe culvert will be adopted as the proposed drainage channel, when the channel needs to pass under the existing roads or other structures. Once culvert structure is constructed, it is virtually difficult to further increase the flow capacity of the culvert unlike open channels, and debris and other drifting materials

could possibly close the structure. In order to cope with such unfavorable conditions, the culvert should take 130% of the design flow discharge for open channel if the culvert is submerged, or take 0.3m of freeboard height if the culvert is not submerged. As for structure design, R.C. structure should be adopted in order to secure sufficient strength to sustain dead and live loads.

1.3 Rehabilitation of Existing Flood Detention Pond

The existing flood detention pond has been designed to delay and reduce the peak flood discharge by means of temporarily storing runoff discharge on the way to the rivers. It has been planned and constructed in being urbanized area and/or future developing area as a practicable measure among several drainage plans.

(1) Necessity of Rehabilitation of Existing Flood Detention Pond

As mentioned in the previous reports, it is questionable that the existing ponds could fulfill their prescribed functions during flooding time and their environments are not always preferable to residents due to offensive odor, sludge accumulation and methane fermentation. In this regard the existing ponds and appurtenant structures need to be rehabilitated adequately so as to improve the existing conditions.

The existing conditions of ponds and applicable structural measures for betterment of the condition are summarized as follows:

Existing Conditions	Applicable Structural Measures
Offensive odor and contaminated water quality	• To adopt a dry type pond. • To confine wet area and/or watercourse to minimize source of smell. • To discontinue domestic effluents pouring into a pond or reroute them out of the pond.
Eroding and weeding	• To protect the surface of pond slope and bottom with lining.
Rubbish, debris and sludge accumulation	• To provide a rubbish and sand trap basin with a screen at the inlet structure. • To construct an open channel type of outlet structure with a screen to prevent from clogging.
Maintenance	• To construct approach and maintenance roads towards the bottom of the pond and around the pond, respectively in the expectation of easy and certain removal/transportation of raked rubbish and sludge. • To install an inspection hatch for the outlet structures so as to conduct easy inspection and maintenance. • To install a conduit pipe to release the dead water in the case of a wet pond.

In the priority study areas there are three ponds being operated such as Taman Sri Wang and Taman Keladi in Sungai Petani and Kawasan Industri Bukit Rambai in Melaka. These ponds will be rehabilitated to better the existing environmental conditions to a satisfactory level for residents as well as to meet the requirements of the drainage improvement plan as formulated before. The basic contents of rehabilitation for each pond are briefly described below.

(2) Pond of Taman Sri Wang (Sungai Petani)

The pond of Taman Sri Wang is located in the Line G basin of Sungai Petani area. A relatively deep excavation and a low embankment will be required to secure some twice the storage capacity of the existing one, since it is probably difficult to extend the pond area widely due to the limited land space. As for appurtenant structures of the existing pond the above structural measures for rehabilitation will be applied practicably, which will also be figured out in the following sub-section as part of design concepts of new detention pond. To prevent influx of domestic effluents, which have mainly caused offensive odor and water contamination, a storm-outfall structure with rerouted pipe out of the pond should be provided immediately before pouring into the pond (refer to Fig. VI-1). The distinct structural features in the existing and improvement conditions are enumerated in the following table and a general layout is presented in Fig. VI-2.

Description	Existing	To be improved
Type of Pond	Earth Pond/Dry Condition	Earth Pond/Dry Condition
Area of Pond (m2)	6,230	6,870
Max. Depth (m)	2.1	3.5
Effective Depth (m)	1.5(*)	2.9
Storage Capacity (m3)	7,300(*)	16,800
Inlet (unit)	1	1
Outlet (unit)	1	1
Embankment(Height, m)	N/F	1.0
Concrete Drain(Length, m)	N/F	145
Approach Road (Length, m)	N/F	30
Storm-Outfall (unit)	N/F	1

Note : (*) presents the estimated feature in this study. N/F presents "not furnished".

(3) Pond of Taman Keladi (Sungai Petani)

The pond of Taman Keladi is located in the upper reaches of Line G basin, Sungai Petani. A pond area will be extended to increase the storage capacity of the existing

one to 175%. As for appurtenant structures of the existing pond and storm-outfall structures to reroute domestic effluents out of the pond, the same design concept of the above case of Taman Sri Wang will be applied substantially. The salient structural features in the existing and improvement conditions are enumerated in the following table. A general layout is also presented in Fig. VI-3.

Description	Existing	To be improved
Type of Pond	Earth Pond/Dry Condition	Earth Pond/Dry Condition
Area of Pond (m2)	18,850	25,680
Max. Depth (m)	3.0	3.6
Effective Depth (m)	2.4(*)	3.0
Storage Capacity (m3)	36,050(*)	63,000
Inlet (unit)	5	5
Outlet (unit)	1	1
Embankment (Height, m)	1.5	1.5
Concrete Drain (Length, m)	N/F	350
Approach Road (Length, m)	N/F	80
Storm-Outfall (unit)	N/F	5

Note : (*) presents the estimated feature in this study. N/F presents "not furnished".

(4) Pond of Kawasan Industri Bukit Rambai (Melaka)

The pond of Bukit Rambai is located in the middle reaches of Sg. Ayer Salak basin in Melaka. To secure about four times the storage capacity of the existing one, the pond will be excavated down to 2.5 m below instead of the extension of pond area under the restricted pond site. As for appurtenant structures of the existing pond and storm-outfall structures to reroute domestic effluents out of the pond, the same design concepts as the above-mentioned ponds will be applied. The salient structural features in the existing and improvement conditions are enumerated in the following table. A general layout is also presented in Fig. VI-4.

Description	Existing	To be improved
Type of Pond	Earth Pond/Dry Condition	Earth Pond/Dry Condition
Area of Pond (m2)	19,550	21,100
Max. Depth (m)	1.6	4.1
Effective Depth (m)	1.0(*)	3.5
Storage Capacity (m3)	15,850(*)	59,000
Inlet (unit)	4	4
Outlet (unit)	1	1
Embankment (Height, m)	N/F	1.5
Concrete Drain (Length, m)	N/F	220
Approach Road (Length, m)	N/F	40
Storm-Outfall (unit)	N/F	4

Note : (*) presents the estimated feature in this study. N/F presents "not furnished".

1.4 New Flood Detention Pond

The flood detention ponds should be designed hydraulically to have the flood control function as prescribed in the previous section. In addition to the flood control function, those facilities contain a potential to provide the public amenity space and improve the scenery in the urban area. Accordingly, the design works will be made with a particular attention to such potential use of the facilities.

(1) Type of Pond

The flood detention pond basically contains the following three major types by pond structure condition and purpose.

Type/Function of Pond	Characteristics	Applicability
Earth Pond	Most of the existing ponds in Malaysia belong to this type. A low cost construction of pond is realized without lining of pond surface.	Rehabilitation of existing pond as it is. In the area where a low effect of the cost-benefit is expected.
Slope-Protection Pond	An acceptable environment in and around the pond as well as easy maintenance of the pond can be expected.	In the congested area under the restricted right-of-way, where a high effect of the cost-benefit is expected.
Community Pond	This type is preferable as a community or an ecological pond in the case of a large-scale of land development.	As an integrated pond in the relatively undulated land with a large-scale development.

In this study the above three types of ponds will be tentatively applied for priority projects mainly from technical viewpoints at the site considering the possibilities of

community use, normal condition of pond, dry or wet, and influx of domestic effluents, although designing of pond should be also discussed from the social requirements in the region including financial affordability for construction and maintenance.

(2) Inlet Structure with Pollution Trap

A channel type inlet structure with steel screen should be designed at the inlet of the pond in order to trap influxes of rubbish and sedimentation and easily remove the trapped matters. Moreover, some protection works such as gabion matters and revetment should be provided at the immediately downstream of inlet structures to protect the pond from scoring and erosion. A typical feature of inlet structure is presented as shown in Fig. VI-5.

(3) Outlet Structure

The outlet structure with of two orifices should be designed as a channel type of R.C. structure located at the relatively lower end of the pond structure taking topographic/geological conditions and a connection with the downstream channel into account. A steel screen should be also built at slightly far from orifices in order to prevent the orifices from clogging by drifting rubbish. An inspection hatch and a slide gate for orifices also should be installed to facilitate easy and sustainable maintenance work. A typical feature of outlet structure is presented as shown in Fig. VI-5.

(4) Spillway

When a pond is placed at a valley, its surrounding bank crest level is more than 1.5m high above the ground level, a spillway should be to safely spill out the flood discharge. The design discharge for the spillway should be equivalent to 120% of 100year return period for a concrete structure pond and 144% of 100-year return period for an embankment pond.

(5) Maintenance Road

There will be a great volume of rubbish and sediment being floated and deposited in the existing ponds. In order to remove these materials smoothly and surely through the regular maintenance, an approach road towards the bottom of the pond and a maintenance road around the pond are very useful and practicable. Therefore, these

maintenance roads should be designed for a new detention pond and further for the existing ponds through their rehabilitation works as far as possible.

1.5 Flood Retarding Basin

A retarding basin has the same function as detention pond to temporarily divert and store the channel flood flow. This facility is effective for flood control with short flood concentration time and requires less scale of structures located beside a drainage channel. However, its applicability depends on a suitable site where technically and regionally allows temporary inundation.

(1) Side Overflow Weir

A side overflow weir with a lower overflow crest than the adjacent banks will be provided as an inlet to divert flood discharge into the retarding basin. Such weir will be of a concrete structure to protect against scoring and erosion and to ensure the prescribed overflow function based on the hydraulic calculation.

(2) Sluice/Outlet

After the flood ends and the water level of the drainage channel drops below the storage water level of the retarding basin, storage water will be released gravitationally through sluice and/or outlet will be set at the lowest position of the site for retarding basin and releasing channel. The basic design concept on the sluice/outlet structure could be same as that for the aforesaid flood detention pond. However, the proposed site for each of the retarding basins will have quite variable topography, and therefore, the detailed structural dimensions of sluice/outlet needs to be determined through a hydraulic calculation taking the topographic conditions of the site into account.

1.6 Storage Facility in Public Open Space

A storage facility in public open space should be designed to effectively control the run-off rate in due consideration of the topographic and geological conditions, land use, security and maintenance.

(1) Location for Construction

The following locations are recommended as usable space for storage facility installation.

- School playground
- Park/Green District
- Parking lot
- Open space in housing complex
- Recreation area/sports park/public management area

(2) Inlet and Outlet

Inlet structure should be designed as orifice with interceptor for influx of sedimentation, rubbish, debris, and etc. to prevent orifice from clogging. The facility is subject to natural drainage, and should not be equipped with outlet control devices such as gate and valve, which require artificial operation.

Outlet structure should be designed as orifice or open channel. Side drain or drainage ditch should be designed at perimeter of the public open space in order to drain out the stored water smoothly and decrease the frequency and time of inundation in the space.

(3) Storage Area

Storage area should be a surface excavation pond surrounded by R.C. wall. The bottom of the pond should have a gentle slope and also be protected with turfing in expectation of smooth drainage after raining. The allowable maximum storage depth should be determined so as not to cause any significant effect to the original purpose of the ponding spaces as the play ground, parking lot, etc. A parking lot as the ponding space will have a maximum storage depth of about 0.1m in order to secure safety for car driving. Other space such as school playgrounds and parks will have the allowable storage depth of 0.3m for the sake of safety of children. (Refer to Fig. VI-6)

(4) Infiltration Facilities

When the following conditions are confirmed at the site of the storage facility, infiltration system might be designed as an additional outlet for the facility.

- Large infiltration capacity

- No deterioration of infiltration capacity in the future
- Easy construction
- Economical construction cost
- High durability

1.7 Storage Tank in House Lot

The storage tank in an individual house lot should be designed to store rainwater temporarily so as to delay and reduce the peak flood run-off discharge, and at the same time to use a part of the stored rainwater as water resources.

Rainwater storage tanks are installed on the ground or in the building to store rainwater, which is generally collected from roofs. However, it is necessary to scatter many storage tanks in wide areas involving a number of private house lots and office buildings, because the storage capacity of one unit is considerably small compared to other flood detention system.

Rainwater from roofs will be transmitted to a storage tank through roof gutters, down pipes and connecting pipes. Rainwater pipes should be of chemically inert material of PVC to avoid adverse effects on water quality. A typical collection system of rainwater in a private house lot is introduced as shown in Fig. VI-7.

1.8 Drainage Pump

Drainage pump should be designed at the downstream end if the drainage channel when the gravity drain is hardly made in a low-lying area due to backwater effect of high tide or water level of the downstream river channel.

(1) Pumping Capacity

The design discharge for drainage pump will be analyzed at the downstream end of the sub-basin applying a 2 to 10 year return period of rainfall. To lighten the burden on pumping station and minimize the scale of connecting channels, inundation damage to some extent should be allowed, and also the capacity allocation between a pump station and a corresponding regular pond should be studied.

(2) Type of Pump

Selection of a type of pump is an essential issue on designing a pumping station, although this issue governs most structures of civil and building works for the station

and the operation and maintenance works after completion. The following three types of pump are usually studied for the selection of a type of pump. Their distinct characteristics are summarized in Table VI-1, and the general layouts of these pumping systems are introduced as shown in Figs.VI-8 to VI-10.

- Stationary (conventional) type with axial flow vertical-shaft pump
- Movable type with truck-mounted submersible pump
- Unit type with submersible pump

1.9 Gate

The gate should be designed at the outlet point of drainage area in order to prevent the reverse flow from the external river or sea into the internal drainage channel, when the external water level is higher than the internal water level. The gate should be safely operated against flood flow at a water level equal to or lower than the design water level (or the design high tide level in case of a high tide section). The gate will be installed as part of sluice or sluice way to form the outlet of continuous levee. As an appurtenant structure for pumping station the gate will be usually provided to release the inner water gravitationally.

2. ALTERNATIVE PLANS AND REQUIRED FACILITIES

2.1 Alternative Plans

As discussed in the previous Sector VI of Urban Drainage Improvement Plan the selected components by the alternative plans are enumerated for each project as follows:

(1) Air Mendidih Basin (Sungai Petani)

Components by Alternative	Alt. 1	Alt. 2	Alt. 3	Alt. 4
1.Improvement of Existing Drainage Channel	√	√	√	√
2.Construction of Detention Facilities				
Polis Hutan D.P.		√	√	√
Upper Line P D.P.		√	√	√
Sek. Men Sains On-site D.P.			√	√
IKM On-site D.P.			√	√
Line N Channel Storage			√	√
3.Installation of Storage Tank in House Lot				√

Note : √ = available

(2) Line G Basin (Sungai Petani)

Components by Alternative	Alt. 1	Alt. 2	Alt. 3	Alt. 4
1.Improvement of Existing Drainage Channel	√	√	√	√
2.Construction of Diversion Channel (D-1)				√
3.Construction of Connecting Channel (TK-1)	√	√	√	√
4. Construction of Detention Facilities				
Taman Keladi D.P.(Rehabilitation)		√	√	√
Taman Seri Wang D.P.(Rehabilitation)		√	√	√
Upper Line G D.P.			√	√
Middle Line G D.P.			√	√

Note : √ = available

(3) Pokok Mangga Basin (Melaka)

Components by Alternative	Alt.1	Alt.2	Alt.3	Alt.4	Alt.5	Alt.6	Alt.7
1.Impvt.of Existing Drainage Channel	√	√	√	√	√	√	√
2.Construction of New trunk drains				√	√	√	
3.Const. of T. Asean Pumping Station							√
4. Construction of Detention Facilities							
On-site Detention Ponds		√			√		
5.Installation of S. Tank in House Lot			√			√	

Note : √ = available

(4) Aer Salak Basin (Melaka)

Components of Alternative	Alt.1	Alt.2	Alt.3
1.Improvement of Existing Drainage Channel	√	√	√
2.Construction of Detention Facilities			
Bukit Rambai D.P.(Rehabilitation)		√	√
Tg. Minyak (1) D.P.			√
Tg. Minyak (2) D.P.			√
Upper Ayer Salak D.P.			√
Middle AB1 D.P.			√
Middle AB11 D.P.			√

Note : √ = available

2.2 Basic Design and Cost Estimation

The basic structure designs of the above components are prepared in this section. Then, their construction costs are estimated applying the basic unit costs/prices quoted from prevailing market prices in the priority project areas (refer to Table VI-2). All of the following costs are

estimated on the Malaysian Ringgit (RM) basis using currency conversion rate of US$1.00 = 3.8 RM = 104.8 Yen as of November 1999.

(1) Drainage Channel Improvement

For the drainage channel improvement an earth type channel and a RC type channel are employed from an economical viewpoint under the restricted right-of-way. The former is adopted for the downstream sections of the Sg. Air Mendidih basin project and the whole sections of the Ayer Salak basin project. For the other sections, the later type is selected so as to minimize widening channel area. Typical cross sections of both earth and RC drainage channels are presented in Fig. VI-11. More detailed information on the drainage channel improvement is compiled in Sector IV of Urban Drainage Improvement Plan. In order to estimate costs for the drainage channel improvement the relations between the unit construction costs of drainage channels and the channel flow areas are studied as indicated in Fig. VI-12, referring to the unit construction costs of each drainage channel compiled in Tables VI-3 and VI-4.

(2) Proposed Detention Facilities

Based on the field investigations and the aerial-topographic map on a scale of 1 to 2000 prepared for this study, the promising sites for detention facilities are selected and their availabilities are analyzed from a hydraulic viewpoint. Table VI-5 shows salient features of the detention facilities proposed in this stage. Their basic designs are also made in this section as drawn in Figs.VI-13 to VI-15.

A cost estimation on the proposed facilities is conducted, referring to the basic designs, and summarized in the forms of Tables VI-6 to VI-10.

In the following technical descriptions on the proposed detention facilities are made by the projects.

(3) Detention Facilities for Sg. Air Mendidih Project

(a) Polis Hutan Detention Pond

This site is located at the huge open space in the upper reaches of Sg. Air Mendidih. Although supposedly, some development plan of this area has been presented in the past years, unfortunately any detailed information on this matter has not been obtained so far.

In view of the existing circumstances of this area, there is a high potential to realize the construction of a typical community pond with water spot, since a relatively wide area could be secured for this facility under the sustainable condition including swampy area. In designing, an effective storage water depth will be restricted within around 2.0 m at the maximum due to the flat land condition and the hydraulic condition to connect with the downstream channel of Line P. In due consideration of the above, however, a community pond with two stages is proposed at this stage to use the lower stage for water spot and the higher stage for a recreation purpose. The main features of this pond are extracted below (refer to Fig.VI-13(1/2) and Table VI-7(1/5)):

Type of Pond	:	Community type/Excavation/Wet
Surface Area of Pond	:	25,400 m^2
Effective Storage Capacity	:	48,700 m^3
Effective Water Depth	:	2.0 m
Appurtenant Structures	:	In/Outlets, Revetment for slope protection

(b) Upper Line P Detention Pond

This pond is located just at the entrance of residential area and on the left bank of the channel of Line P. The site is slightly ungulate and higher than the channel bed of Line P, so that relatively deep excavation will be required to secure the prescribed storage capacity. A side overflow weir is proposed as an inlet facility of this pond to cope with the topographic condition. To avoid storing domestic effluents, which will come from the existing residential area this pond should be a dry type with the installation of concrete drain at the pond bottom. The main features of this pond are extracted below (refer to Fig.VI-13(1/2) and Table VI-7(2/5)):

Type of Pond	:	Non-Community type/Excavation/Dry
Surface Area of Pond	:	10,200 m^2
Effective Storage Capacity	:	8,900 m^3
Effective Water Depth	:	2.0 m
Appurtenant Structures	:	Side overflow weir, Concrete drain

(c) Sek. Men Sains On-site Detention Pond

As a typical storage facility in public open place, this site is proposed as on-site detention pond. The site is being used for playground with water area in the central district of Sg.Petani. The ground will be excavated down by 0.2 m and, then RC walls of 0.5 m high, 0.6 m high and 1.0 m high will be arranged along the periphery of the site to store on-site rainfall. The main features of this pond are extracted below (refer to Fig.VI-13(2/2) and Table VI-7(3/5)):

Type of Pond	:	On-site Detention Pond/Excavation/Wet
Surface Area of Pond	:	5.4 ha (2.9 ha for pond, 2.5 ha for ground)
Effective Storage Capacity	:	22,400 m3
Effective Water Depth	:	0.2 ~ 0.6 m
Appurtenant Structures	:	RC wall (0.5~1.0m) with Side drain (0.3 m)

(d) IKM On-site Detention Pond

As same as the above facility this site also is proposed as on-site detention pond in the built-up area of Sg. Petani. Existing playground at the schoolyard of IKM will be excavated by 0.3 m below the ground surface. RC wall with side drain will be arranged along the surroundings of playground so as to store rainfall temporarily.

The main features of this pond are extracted below (refer to Fig.VI-13(2/2) and Table VI-7(4/5):

Type of Pond	:	On-site Detention Pond/Excavation/Dry
Surface Area of Pond	:	11,000 m2
Effective Storage Capacity	:	3,300 m3
Effective Water Depth	:	0.3 m
Appurtenant Structures	:	RC wall(0.6m) with Side drain(0.3 m)

(e) Line N Channel Storage

The upper portions of channel area of Line N is proposed for channel storage by means of installation of a fixed weir with orifice to cross the channel. A fixed weir of 6.0m high and 20 m long will be set to dam up floodwaters.

The main features of this pond are extracted below(refer to Fig.VI-13(2/2) and Table VI-7(5/5):

Type of Pond	:	Channel Storage/Natural/Wet
Surface Area of Pond	:	6,400 m^2
Effective Storage Capacity	:	16,000 m^3
Effective Water Depth	:	5.0 m (at fixed weir)
Appurtenant Structure	:	Concrete fixed weir (H:6 m, L:20m)

(4) Detention Facilities for Line G Project

(a) Upper Line G Detention Pond

This site is located in the immediately downstream of the existing detention pond at Taman Keladi. The proposed site for this pond is vacant at present and situated on the right side bank of the Line G channel beside the high way. To secure a storage capacity of 24,700 m3 the original ground will be excavated down by around 3.0 m at the maximum. A side overflow weir will be set at a boundary between the drainage channel of Line G and the pond area to divert floodwater into the pond. Since the existing residential area is expanded in the left bank and the upstream of the drainage channel and it is easily expected that domestic effluents will come into this pond, a normal condition of pond should be kept dry with the installation of concrete drain at the bottom to discharge stagnant waters.

The main features of this pond are extracted below [refer to Fig.VI-14 and Table VI-8(1/2)]:

Type of Pond	:	Non-community/Excavation/Dry
Surface Area of Pond	:	18,200 m2
Effective Storage Capacity	:	24,700 m3
Effective Water Depth	:	1.4 m
Appurtenant Structures	:	Side overflow weir, Concrete drain

(b) Middle Line G Detention Pond

This site is located in the immediately downstream of the existing detention pond at Taman Sri Wang. The site is relatively swampy and low lying. The course of Line G is meandering and passing in the prospective pond area. To increase storage capacity the surface excavation of around 1.0 m in depth will be required. At the downstream end of this pond a concrete fixed weir with orifice will be installed to dam up the water accompanying the construction of embankment (1.0 m high) along the periphery of the pond. As same as the case of the Upper Line G D.P. mentioned above, a concrete drain will be installed at the bottom of the pond to keep the pond dry other than flood season. Considering the pond location in this region and the structural characteristics of shallow pond this facility should be planned as a community pond for multipurpose use.

The main features of this pond are extracted below [refer to Fig.VI-14 and Table VI 8(2/2)]:

Type of Pond	:	Community/Excavation/Dry
Surface Area of Pond	:	42,500 m2
Effective Storage Capacity	:	48,300 m3
Effective Water Depth	:	1.2 m
Appurtenant Structures	:	Concrete fixed weir, Concrete drain, Embankment

(c) Rehabilitation of Existing Detention Ponds

In the project area of Line G basin two existing detention ponds at Taman Sri Wang and Taman Keladi are being operated. According to the proposed drainage improvement plan these facilities should be rehabilitated so as to increase the existing storage capacities and improve the existing appurtenant

structures. Main contents of the rehabilitation works are previously discussed in Chapter 1 and refer to Tables VI-6(1/3) and VI-6(2/3).

(5) Detention Facilities for Ayer Salak Project

(a) Tg. Minyak (1) Detention Pond

This site has been developed by private sectors and so far probably abandoned due to a shortage of budget. Therefore, basic design of this facility is substantially figured out and the first step excavation work also has been carried out at the site. The pond is located at the downstream end of one of tributaries (T5-1) in the upper reaches of Sg. Ayer Salak. Relatively deep excavation will be required to secure storage capacity of 63,600 m3 with 2.74 m of effective storage water depth.

In view of the topographic condition and the location in the region this pond should be used exclusively for flood control purpose and kept dry under the usual condition.

The main features of this pond are extracted below(refer to Fig.VI-15(1/5) and Table VI-9(1/5)):

Type of Pond	:	Non-community/Excavation/Dry
Surface Area of Pond	:	24,850 m2
Effective Storage Capacity	:	63,600 m3
Effective Water Depth	:	2.74 m
Appurtenant Structures	:	Outlet with orifice, Concrete Drain

(b) Upper Ayer Salak Detention Pond

This site is located in the upper reaches of Sg. Ayer Salak and also at the upper edge of the existing residential area. The pond is on the right bank of the channel of Sg. Ayer Salak and designed with side overflow weir to divert floodwater. Considering the topographic condition and the flood control effect, the construction of low height embankment with 1.0 m at the maximum is necessary to confine retarding water within this area. Accordingly, it is not economical to develop this site with large-scale, so that existing site condition should be kept as it is, substantially. However, a pond condition should be dry by means of the installation of concrete drain at the pond bottom due to the

hydraulic condition of side overflow weir and the possibility of influx of domestic effluents from the surroundings.

The main features of this pond are extracted below (refer to Fig.VI-15(2/5) and Table VI-9(2/5)):

Type of Pond	:	Non-community/Natural/Dry
Surface Area of Pond	:	49,800 m^2
Effective Storage Capacity	:	20,000 m^3
Effective Water Depth	:	0.6 m
Appurtenant Structures	:	Side overflow weir, Concretedrain, Embankment

(c) Tg. Minyak (2) Detention Pond

Development of this site has been planned by private sectors and probably suspended due to a shortage of budget. Basic design of this facility is already prepared.

The site is located in the relatively undulated area with height difference of around 5.0 m at the maximum. Therefore, at the lower side of the site the construction of embankment and concrete fixed weir with spillway function will be required to store floodwater safely. From the location of this facility in the region and topographic condition at the site a community type of pond can be realized to provide two stages making use of ground height difference. In the lower stage a water part can also be provided for an amenity water spot.

The main features of this pond are extracted below (refer to Fig.VI-15(3/5) and Table VI-9(3/5)):

Type of Pond	:	Community/Excavation/Wet
Surface Area of Pond	:	31,920 m^2
Effective Storage Capacity	:	70,400 m^3
Effective Water Depth	:	2.31 m
Appurtenant Structures	:	Fixed weir with spillway, Embankment Revetment

(d) Middle AB1 Detention Pond

This site is located in the middle reaches of a tributary (Prt. AB1) of Sg. Ayer Salak and in the downstream of the above Tg. Minyak D.P. This area is very flat and a course of natural drainage channel is passing in the middle of the area. In order to store floodwaters a concrete fixed weir (1.5m high) accompanying side embankments (1.2m high) will be constructed to cross the channel plain. Due to the location of this pond in the region and the condition of site this pond should be designed in the form of community type with wetland function.

The main features of this pond are extracted below (refer to Fig.VI-15(4/5) and Table VI-9(4/5)):

Type of Pond	:	Community/Wetland/Wet
Surface Area of Pond	:	73,200 m^2
Effective Storage Capacity	:	29,300 m^3
Effective Water Depth	:	0.6 m
Appurtenant Structures	:	Fixed weir, Embankment

(e) Middle AB11 Detention Pond

This site is located in the middle reaches of a tributary (Prt. AB11) of Sg. Ayer Salak. This area is relatively narrow spot and it is naturally to confine and sore floodwaters without large-scale excavation. Since a course of drainage channel is passing in the middle of this area, it is also easy to dam up drainage waters by means of concrete fixed weir at the end of pond area. To prevent overflow of stored water a concrete wall with 1.2 m high and 220 m long will be constructed along the existing road on the right bank.

This pond has a potential to be used as a community space due to the location in the region and the topographic condition. However, the pond condition should be dry with the installation of concrete drain and, so that stagnant water of domestic effluents from the existing residential and industrial areas on the right bank is discharged gravitationally.

The main features of this pond are extracted below refer to Fig.VI-15(5/5) and Table VI-9(5/5)):

Type of Pond	:	Community/Natural/Dry
Surface Area of Pond	:	114,000 m^2
Effective Storage Capacity	:	54,200 m^3
Effective Water Depth	:	0.7 m
Appurtenant Structures	:	Fixed weir, Concrete drain & wall

(f) Rehabilitation of Existing Detention Pond

As discussed in Chapter 1 a existing detention pond at Taman Industri Bukit Rambai is being operated in the immediately upstream of the above mentioned Middle AB11 D.P. This facility requires to be rehabilitated with increment of storage capacity. Detailed features of this work are already described in the said Chapter 1 and refer to Fig. VI-4 and Table VI-9(5/5).

(6) Storage Facilities in Public Open Space for Pokok Mangga Project

In the alternative study for the Pokok Manga project, a plan of storage facilities in public open space is studied in the part of Alts. 2 and 4. The locations of such storage facilities, namely on-site detention ponds, are indicated as shown in Fig. VI-16. The main features of this plan is summarized as follows:

Objective Area	:	470.9 ha
On-site Detention Pond Area	:	23.5 ha
Number of Detention Pond	:	99 sites
Average Depth of Pond	:	0.3 m
Total Storage Capacity	:	70,500 m^3

The unit construction cost of this system as shown in Table VI-10 is applied uniformly to estimate the whole cost of storage facilities planned in this area.

(7) Storage Tank in House Lot

The system of storage tank in house lot is studied in the Alt. 4 of the Air Mendidih project and in the Alts. 3 and 6 of the Pokok Mangga project. The objective areas for this system are summed up as follows:

Objective Area for Alt. 4 of Air Mendidih	:	167.7 ha
Objective Area for Alts.3&6 of Pkok Mangga	:	370.5 ha

The basic idea of this system is previously explained in Chapter 1(refer to Fig. VI-7) and the whole construction costs of the alternatives are estimated applying the unit construction cost of this system as shown in Table VI-11 uniformly for the objective areas.

(8) Pumping Station for Pokok Mangga Project

As one of the components in the Alt. 7 of the Pokok Mangga project, a pumping drainage system at Taman Asean is studied, which is located in the north part of the Pokok Mangga study area. A hydraulic analyses of pumping drainage is previously discussed in Sector IV of Urban Drainage Improvement Plan. In this stage an unit type of submersible pump (total installed capacity: 20m3/s) is selected as pumping drainage system, considering the availability of pumping equipment and the recent project tendencies in view of the high economical efficiency.(Refer to Table VI-1 and Figs. VI-8 to VI-10 in Chapter 1) The main features of this plan are summarized as follows:

Location	:	Taman Asean on the left side bank of Sg. Malim
Design Discharge	:	20 m3/s
Type of Pump	:	Unit type of submergible pump
Units of Pump	:	3 m3/s x 7 units(1.2m diameter)
Capacity of Regulation Pond	:	6,000 m3
Sluice Gate	:	Roller gate : 6.0 m(w) x 3.0m(h) x 2 units
Diversion Channel	:	12.0 m(w) x 1.6m(h) x 290 m long
Site for Slide Gate	:	3 sites at existing channels

The general layout of the Taman Asean pumping station system including a regulation pond of 6,000m3 storage capacity and appurtenant structures are prepared as shown in Fig. VI-17. The construction cost of the whole work of this system is also estimated as shown in Table VI-12.

2.3 Required Facilities and Construction Costs

All of the required facilities and the construction costs by the alternatives are summed up and tabulated in Table VI-13.

Consequently, the following alternatives, as indicated with shades in the table are selected as the proposed priority projects. A process to this conclusion is explained in the said Sector IV of Urban Drainage Improvement.

(1) Sg. Air Mendidih Basin (Sungai Petani)

Alternative 3 (Drainage Channel Improvement + 5 sites of Detention Facilities)

(2) Line G Basin (Sungai Petani)

Alternative 4 (Drainage Channel Improvement + 4 sites of Detention Facilities)

(3) Prt. Pokok Mangga Basin (Melaka)

Alternative 4 (Drainage Channel Improvement + New Trunk Drain Construction)

(4) Sg. Ayer Salak Basin (Melaka)

Alternative 3 (Drainage Channel Improvement + 6 sites of Detention Facilities)