VOLUME 3 – SECTOR VI

DESIGN, CONSTRUCTION PLAN AND COST ESTIMATE OF PROPOSED FACILILITIES

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

FINAL REPORT

VOLUME 3: SUPPORTING REPORT ON DRAINAGE STRUCTURE PLAN

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

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1. PRELIMINARY DESIGN OF PROPOSED DRAINAGE FACILITIES

1.1 General

As discussed in SECTOR IV, URBAN DRAINAGE IMPROVEMENT PLAN, the following drainage facilities have been studied as applicable structural measures. They are herein preliminarily designed as the components of the Drainage Structure Plan, substantially referring to the current drainage design manual of DID, namely, the "URBAN DRAINAGE DESIGN STANDARDS AND PROCEDURES FOR PENINSULAR MALAYSIA".

1.2 Channel Improvement

The primary purpose of channel improvement is to augment the flow capacity of channels so that more volume of runoff discharge can flow down safely.

(1) Alignment and Longitudinal Profile

In principle, the existing channel alignment should be kept as much as possible to practically confine storm water except in the event that it is considered to be economically and technically acceptable to divert, shorten or detour the watercourse.

As for the longitudinal profile of drainage channel, a steep gradient of channel bed is desirable to ensure a sufficient flow capacity under the moderate flow velocity ranging from 1 m/s to 3 m/s. However, in order to maintain the stability of the watercourse its longitudinal profile should be set naturally based on the existing channel gradient, practically in parallel to the ground elevations along the watercourse.

(2) Cross-section

In a congested area, a reinforced concrete channel of a rectangular single cross-section should be employed to expect the utmost flow capacity and also to minimize the area of land acquisition, although it will be structurally costly due to the erection of reinforced concrete wall. Regarding the freeboard for channel walls, 0.3 m is considered to be added to the design high water level taking into consideration that wave height, hydraulic jump and floating debris would rise. (Refer to Fig. VI-1.)

(3) Underpass Structures

To pass a drainage channel under the existing public roads, a concrete box culvert or a bridge will be provided. In this study, from an economical point of view, a concrete box culvert is tentatively employed for the channel width of 4.0 m or less, while a reinforced concrete bridge is employed for the channel width of more than 4.0 m. (Refer to Fig. VI-1.)

Basic features of proposed drainage channels in Sungai Petani and Melaka are shown in Table VI-1 and their typical cross sections are presented in Fig. VI-2.

1.3 Retarding Basin

A retarding basin has the function of regulating the peak discharge through temporary diversion and storage of floodwaters by means of mostly natural basin located in the middle reaches of a river. This measure is very effective for the control of flood with a short flood concentration time and requires the construction of limited structures. However, its applicability definitely depends on a suitable site that technically and regionally allows temporary inundation. A typical drawing of retarding basin with side overflow weir is conceptually shown in Fig. VI-3.

1.4 Detention Pond

Detention ponds have the function of temporarily storing runoff discharge on the way to the rivers and thus flattening the peak runoff discharge. They are planned and constructed in urbanizing and/or future developing areas as one of the applicable measures among several drainage plans. This is because most of such areas have a difficulty in acquiring enough sites for ordinary drainage channel improvement or they are technically managed to detain runoff discharge before joining into the lower rivers that do not have sufficient flow capacities to pass the runoff discharge safely.

(1) Necessity of Adequate Structure Design to Improve Existing Pond Conditions

Although there are twenty-one detention ponds being operated in the study area, unfortunately, most of them are not always functioning well. Besides, the residents do not prefer the public facilities. This is because of their makeshift structure design on the least cost basis and the poor environmental circumstances. In order to improve such conditions, rehabilitation of existing facilities as well as new construction of appurtenant structures should be executed, adequately applying a functional and practicable structure design as mentioned below.

(a) Pollution Control at Pond

Since most of the existing ponds are wet ponds having two functions, storm water control and oxidation for domestic wastewater, the stored wastewater emit an offensive odor because of sludge accumulation and methane fermentation. To resolve this issue, the JICA study team basically recommends the adoption of a dry pond, except in areas fully served by a separate sewage system or if there is no possibility that domestic effluents will come, although the quality of stored water may be improved gradually by the decrease of oxidation with the extension of IWA (Indah Water Agency) services.

The following measures are also useful to control pollution at the pond:

- To provide a rubbish trap with a screen at the inlet structure, immediately before rubbish pour into the pond.
- To confine the usual wet area and/or watercourse with the installation of concrete drain at the bottom to minimize the source of smell.
- To protect the pond's slope and bottom with stone pitching and/or turfing against hydraulic fluctuation and raindrop erosion.

(b) Easy Maintenance to Fulfill Pond's Function

The findings of the JICA study team reveal that the existing detention ponds and appurtenant structures lack the proper maintenance resulting in malfunctions. Particularly, rubbish control is a significant issue to ensure the prescribed function, and the following structures should be designed and installed adequately so that regular maintenance works can be performed surely.

- To construct approach and maintenance roads towards the bottom of pond and around the pond, respectively.
- To build a screen and an inspection hatch for the outlet structure to prevent clogging with rubbish and provide ease of inside inspection of the outlet structure.

(c) Regional Community Space

Some detention ponds have the possibility for use as a preferable facility in the

region. In this connection the environmental conditions of pond area should be enhanced to a satisfactory level so that the residents will easily accept the area as an amenity space. Generally, provision of the following structure conditions is useful for the detention pond to be managed as a community space with multiple functions other than flood control.

- To provide a dry area (higher stage) for recreation or amenity space with the construction of a multistage pond.

- To store non-contaminated water in the bottom (lower stage of wet pond) as a community space for water sports.

(2) Outline of Proposed Detention Pond

Based on the hydraulic dimensions fixed in the previous sectors and the above-mentioned design concept, four (4) kinds of applicable detention ponds are embodied, as shown in Fig. VI-4. These are the non-community pond of earth type (dry condition), non-community pond of slope protection type (dry condition), community pond of slope protection (wet condition), and community type of slope protection type (dry condition), focusing on multiple use of pond, structure design and condition of pond. Their characteristics are summarized in Table VI-2. As for the planning of detention pond in this drainage structure plan, these four types of detention ponds will be arranged uniformly in the objective areas. Basic design features of detention pond, which are commonly applied for the said four kinds of ponds are extracted as follows:

Required Capacity (1 unit)

Storage Capacity	:	12,800 m^3
Max. Water Depth of Pond	:	3.2 m
Two Orifices at Outlet Structure	:	Lower, 0.32m(w) × 0.5m(d)
		Upper, 0.5m(w) × 0.5m(d)

Structural Features

Type of Pond	:	Excavation (partly embankment)
Freeboard for Non-overflow Section	:	0.6 m
R.C. Out/Inlets with Screen	:	1 unit each
Paved Approach/Maintenance	:	3 m in width

Roads

As a typical appurtenant structure of the detention pond, a general drawing of inlet/outlet structure, which reflects the above-mentioned design concepts, is presented in Fig. VI-5.

1.5 Storage Facility in Public Open Space (On-site Detention Pond)

School playgrounds, parks, parking lots and other wide public places may be utilized as temporary storage ponds. These places need to be excavated to a certain depth to ensure a sufficient regulation capacity for storm water without marring their original functions.

Storage water will be led to the outlet by the side drains placed at the circumference of excavated pond and released naturally through the orifice of the outlet structure.

Required dimensions of this system are hydraulically fixed in the previous sectors. A preliminary design of typical storage facility in public open space is prepared as shown in Fig. VI-6 and its features are summarized below:

Required Capacity (1 unit)

Required Open Space	:	4,000 m^2
Storage Capacity	:	1,200 m^3
Storage Water Depth	:	0.3 m
One Orifice at Outlet Structure	:	0.2m(w) × 0.05m(d)

Structural Features

Type of Storage Facility	:	Surface excavation
RC Wall with Side Drain	:	0.6m high, 260 m in total length
Bottom Surface Protection	:	4,000 m^2 of turfing
R.C. Outlet with Grating	:	1 unit

1.6 Storage Tank in House Lot

Water storage tanks are installed on the ground to store rainfall water from the roofs of houses and buildings. It is necessary to scatter the storage facilities in wide areas involving a number of private house lots, because a single unit of facility has a very small capacity.

Rainfall water will be collected with roofs and rainwater down-pipes and stored in FRP storage tank installed at a house lot. Then, naturally the storage water will be released out through the outlet orifice of the tank.

Required dimensions of this system are hydraulically set in Sector I, Hydrology. One unit of typical storage system in house lot is illustrated in Fig. VI-7 and its salient features are summarized below:

Required Capacity

Required Installation Space	:	2 m^2
Storage Capacity	:	2 m^3
Storage Water Depth	:	1 m
Outlet Orifice of Storage Tank	:	0.04m(w) × 0.03m(d)

Structural Features

Type of Storage Facility	:	FRP storage tank
PVC Pipe Plumbing	:	40 m in total length

2. CONSTRUCTION PLAN

2.1 General

The drainage structure plan is formulated to attain the maximum drainage improvement effects in Sungai Petani and Melaka areas at the target year 2020. For this purpose, an integrated approach of improvement of existing drainage channels, rehabilitation of existing detention ponds and construction of detention facilities is necessary.

2.2 Construction Works

As discussed in Sector IV, Urban Drainage Improvement Plan and in the previous Chapter, the required drainage facilities for the proposed drainage structure plan are technically identified and their work quantities are estimated as follows:

(1) Channel Improvement

Work Item	Unit	Quantities		
		Sg. Petani	Melaka	Total
Number of Channels		44	24	68
Channel Length	km	42.0	36.5	78.5
Earth Works	1000m^3	652	832	1484
Concrete Works	1000m^3	145	172	317
Number of Box Culverts		14	14	28
Number of Bridges		101	57	158

(2) Rehabilitation of Existing Detention Pond

Work Item	Unit	Quantities		
		Sg.Petani	Melaka	Total
Number of Ponds		124	1	13
Area of Pond	ha	18.2	2.6	20.8
Earth Works	$1000m^3$	803	61	864
Turfing & Stone Pitching	$1000m^2$	394	33	427
Concrete Works	$1000m^3$	6.7	0.2	6.9
Metal Works	ton	36.0	2.8	38.8
Road Works	$1000m^2$	39.2	5.7	44.9

(3) Construction of New Detention Pond

Work Item	Unit	Quantities		
		Sg.Petani	Melaka	Total
Area of Pond	km^2	1.8	2.5	4.3
Earth Works	$1000m^3$	7,141	9,869	17,011
Stone Pitching	$1000m^2$	411	568	979
Turfing	$1000m^2$	1,695	2,343	4,638
R.C. Structure	$1000m^3$	62.4	86.2	148.6
Metal Works	ton	207	286	493
Road Works	$1000m^2$	512	708	1,220

(4) Construction of Storage Facility In Public Open Space

Work Item	Unit	Quantities		
		Sg.Petani	Melaka	Total
Area of Open Space	km^2	0.3	1.4	1.7
Earth Works	$1000m^3$	1.3	7.0	8.4
Turfing	$1000m^2$	80	422	502
R.C. Structure	$1000m^3$	267	1,407	1,674
Metal Works	ton	3.3	17.6	20.9

2.3 Basic Construction Plan of Structural Measures

The improvement of existing drainage channels is planned to confine the design flood with a certain return period by means of widening of drainage channel. In this case a careful and prompt action should be made to land acquisition in the built-up areas under the restricted right-of-way so as to facilitate project implementation. On the other hand, the rehabilitation of existing detention ponds might be executed smoothly, since the extension of facility spaces will not be required so much. As for the construction of new detention facilities, more practical institutional setup and administrative enforcement should be discussed to implement the project securely.

The following four structural measures are conceptually conceived for the structure plan of the drainage improvement:

(1) Construction of RC drainage channel

(2) Construction of detention pond

(3) Construction of storage facility in public open space (on-site detention pond)

(4) Installation of storage tank in house lot

Among them, the installation of storage tank in one house lot is inapplicable for the structure plan in this stage due to less storage efficiency and high installation cost.

(1) RC Drainage Channel

RC drainage channel is one of the most preferable channel types to attain flood control with a high degree of effectiveness because of ensuring the most flow capacity with the least channel area. This work comprises trench excavation and reinforced concrete placing mostly along the existing course of drainage channel. In principle the improvement of drainage channel should be implemented stepwise from the downstream to the upstream in expectation of discharging floods into the connecting rivers quickly.

(2) Detention Pond

This work mainly consists of excavation work and installation of RC structures of inlet/outlets. In the low-lying area where unconsolidated soil and/or high groundwater table are distributed, the pond's slope and bottom might need to be protected with concrete lining or stone pitching to sustain slope stability. Therefore, it should be anticipated that the required construction cost of detention pond will vary drastically according to the geological condition at the site.

During construction the spoil banks for bulky excavations should be arranged properly. Careful attention should also be paid to sediment flow from the site, if the construction work is continued for a few years through rainy season.

(3) On-site Detention Pond

Since this construction work will be carried out in the facilities being used, the relation between present utilization condition and flood detention function should be clarified and informed to the public.

Shallow excavation and installation of RC wall with side drain are the main work items and a relatively short period of construction is generally expected.

3. OPERATION AND MAINTENANCE PLAN

3.1 General

The operation and maintenance of proposed drainage facilities are periodical and emergency activities consisting of patrol, checkup, cleanup, repair and so on. The works themselves are not so complicated and sophisticated, however, they should be executed periodically and certainly to ensure the prescribed functions and capacities of the drainage facilities.

3.2 Required Operation and Maintenance Work

In the proposed drainage improvement plan no particular activity for operation will be required for the moment, since there is no mechanical device provided except for a sluice gate which is furnished to be used during maintenance period for the outlet channel at the detention pond. Therefore, the major activities of the operation and maintenance might be limited to the ordinary works such as dredging, removal of drifting rubbish and weeding. However, immediately after a relatively big storm, the following special attentions should be paid to detention facilities so as to ensure their expected effects:

- To clean the orifices of outlets, which have the significant function of releasing the temporarily stored water naturally under the designed effects.
- To remove rubbish trapped on the steel screens/gratings at inlet/outlet structures.

3.3 Operation and Maintenance Plan

In this connection, the operation and maintenance plan for the proposed drainage facilities is tentatively elaborated as follows, on the quarterly performance basis consisting of manpower and equipment, although actual service agencies for the works have not yet been organized administratively. (Refer to Tables VI-12 and VI-13.)

For Drainage Channel

Frequency (quarterly)	:	one time for 10,000 m^2 (channel area)
Manpower (man-day)	:	9 man-days in total per time
Equipment (unit-day)	:	1 backhoe, 1 dump truck, 4 grass cutters per time

For Detention Pond

Frequency (quarterly)	:	one pond-time (5,500m^2 of pond site)
Manpower (man-day)	:	3.5 men-days in total per time

Equipment (unit-day) : 0.5 backhoe, 0.5 dump truck, 1.5 grass cutters per time

As for the operation and maintenance of storage systems in public open spaces and in individual houses, each owner of the land is currently expected to perform them as part of voluntary tasks.

4. COST ESTIMATE OF PROPOSED FACILITIES

4.1 General

For all components of the optimum drainage improvement plan selected in the previous Sector IV, Urban Drainage Improvement Plan, their construction costs are estimated based on the preliminary designs figured out in the previous Chapters and under the following conditions. These construction costs are summarized totally and represented as project cost, together with their annual operation and maintenance costs.

4.2 Basic Conditions

(1) Unit Cost

Most unit costs applied in the preparation of this Section are basically derived from the available data published by the Department of Statistics, Ministry of Finance and the DID district offices. Although some unit costs are quoted based on prevailing market prices in the study areas of Sungai Petani and Melaka, in principle, the same basic unit costs are applied for the cost estimate at this stage, since no significant discrepancy has been encountered on both market prices. Applied basic unit costs and prices are listed in Table VI-3.

(2) Materials and Equipment

All construction materials and equipment employed in this study are expected to be manufactured and/or available at the construction stage in Malaysia. Therefore, all the prices of materials and equipment are estimated in Malaysian Ringgit (RM).

(3) Construction Cost and Currency Conversion Rate

The construction cost is basically composed of direct cost, indirect cost and compensation. The indirect cost comprising engineering services cost and administration cost is practically estimated as 20% of the direct cost.

All of the following costs are estimated on the Malaysian Ringgit (RM) basis using the currency conversion rate of US$1.00 = 3.8 RM = 121.4 Yen prevailing in May 1999.

4.3 Required Construction Cost

(1) Construction Cost

The construction cost of the proposed facilities is categorized into the cost of rehabilitation, the cost of reconstruction, and the cost of new construction. Each cost is briefly explained below, focusing on the future treatment of the existing facilities and the necessity of land acquisition. Tables VI-4 to VI-9 and Fig. VI-8 represent typical unit construction costs estimated for the proposed structures. As for the unit construction cost of detention ponds (refer to Table VI-7), the average cost of the four kinds of detention ponds is regarded as the representative unit construction cost of detention ponds and applied uniformly in the objective areas.

(2) Rehabilitation Cost

Some of the existing detention ponds need to be rehabilitated locally so as to perform the prescribed functions and storage capacities. The JICA study team had investigated the condition of each structure, and roughly estimates their rehabilitation costs to improve the structural qualities of the existing detention ponds same as the proposed detention ponds. Thirteen (13) detention ponds, out of twenty-one (21) existing detention ponds identified in this study, are expected to be rehabilitated and stand as part of the components of the optimum drainage improvement plan. Their rehabilitation points and costs are summarized in Table VI-10.

(3) Reconstruction Cost

Since some of the existing drainage channels are assessed to have insufficient flow capacity to pass the prescribed flow, the existing cross-section area of the channel requires to be increased employing the utmost cross-section area of rectangular concrete channel to minimize land acquisition area. In this case, the required construction cost is categorized as the reconstruction cost. (Refer to Table VI-11.)

(4) New Construction Cost

"New construction cost" is literally applied for the cost of newly constructed facilities at new sites. As for detention facilities such as detention pond, storage facility in public open space and storage tank in house lot, their total construction costs by specified

drainage basin are estimated, uniformly setting each unit construction cost on the objective area identified before. (Refer to Table VI-11.)

4.4 Operation and Maintenance Cost

The operation and maintenance (O&M) cost is practically estimated following the O&M plan discussed in the previous section. It is specified by drainage channel and detention pond as shown in Tables VI-12 and VI-13.

The O&M costs for Sungai Petani and Melaka are generally counted on the annual basis, comprising 0.20 million RM/year and 0.22 million RM/year for drainage channels and 1.93 million RM/year and 2.67 million RM/year for detention facilities, respectively. (Refer to Table VI-14)

4.5 Project Cost for Drainage Structure Plan

The project cost for the drainage structure plan is composed of the cost of drainage channel improvement and the cost of the detention facilities such as the rehabilitation of the existing ponds, newly constructed ponds and storage system in public open space. It totally amounts to 416 million RM comprising 176 million RM for Sungai Petani and 240 million RM for Melaka.

The details of project cost by drainage basin and work component are presented in Table VI-14, referring to the annual O&M cost of 2.1 million RM/year for Sungai Petani and 2.9 million RM/year for Melaka, respectively.