VOLUME 4 – SECTOR IV

URBAN DRAINAGE IMPROVEMENT PLAN

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

FINAL REPORT

VOLUME 4: SUPPORTING REPORT ON FEASIBILITY STUDY

SECTOR IV: URBAN DRAINAGE IMPROVEMENT PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTOR IV

URBAN DRAINAGE IMPROVEMENT PLAN

1. INTRODUCTION

1.1 Study Phase

The Study on Integrated Urban Drainage Improvement for Melaka and Sungai Petani in Malaysia (hereinafter referred to as "the Study") started in February 1999, covering two phases of study, Phase 1 and Phase 2. The Phase 1 study was completed in July 1999 and clarified a strategic plan for long-term drainage improvement up to the year 2020. It also selected four (4) priority drainage project areas as the objective areas for the feasibility study in Phase 2.

The feasibility study in Phase 2 started in September 1999 and was completed in March 2000. In the feasibility study, a comparative study was made among alternatives composed of the possible drainage improvement measures. Major components of these proposed measures are conventional channel improvement works, flood detention facilities and flood retarding facilities.

This Sector IV, Urban Drainage Improvement Plan, of the Supporting Report, Vol. 4, presents the results of urban drainage planning in the feasibility study.

1.2 Study Area

The study area covers the following four (4) drainage basins, as shown in Fig. IV-1. Two priority drainage areas are in Sungai. Petani and the other two are in Melaka. All of the selected drainage areas are suffering from habitual flooding which tends to be more serious due to the recent intensive land development.

Municipality	Drainage Basin	Drainage Area	Ratio of Urbanization		
			Year of 1999	Year of 2005	Year of 2020
Sg. Petani	Sg. Air Mendidih	3.62 km^2	65.8%	82.7%	99.7%
	Line G	2.73 km^2	35.4%	43.3%	87.3%
Melaka	Prt. Pokok Mangga*	4.71 km^2	51.3%	53.4%	99.6%
	Sg. Ayer Salak	17.20 km^2	22.2%	43.2%	99.9%

* Drainage area includes Prt. Besar Limbongan drainage basin.

2. PRINCIPAL PLANNING CONCEPT

2.1 Planning Principles

Historically, stormwater was considered as a resource to be quickly disposed. The notion was to remove it from the contributing area as rapidly as possible. More recently, however, stormwater has been looked upon as a resource to be captured and utilized for groundwater recharge, recreation, and other purposes and/or detained as a water quality control or peak-flow reduction measure. The principal mechanism employed is storage. This approach, so-called source control or control in-process, is also consistent with the regulatory policy in Malaysia that requires construction of detention pond for flood control to the land development activities with an area of 10 ha or more.

The stormwater source control strategy has the advantages compared with the conventional channel improvement, so-called quick disposal or end-of-pipe control. Design discharge flowing from drainage area into a river course should be always equal to or smaller than a certain value derived from the design discharge or present flow capacity of the river channel. The river improvement works, however, tends to delay compared with the progress of drainage improvement, due to differences in project scale, necessary budget and magnitude of social and environmental impacts.

Although there might be various methodologies to coordinate discharges between a river and drainage channels, drainage improvement can be proceeded through employing the source control strategy without any obstruction originating from the poor flow capacity of the river. Further increment of storage capacity in the basin simultaneously increases safety level of the river from flooding. Under the source control strategy, upgrading works of drainage system can be independent on the progress of river channel improvement. From the temporal planning viewpoints, the source control strategy has a great advantage compared with quick disposal or conventional channel improvement strategy.

Regarding the plan formulation, the drainage improvement plan should be formulated with the optimum combination of the various countermeasures. Selection of the optimum combination should be made through comprehensive consideration and evaluation on the following aspects:

(1) Technical Viability

The recent intensive land development in Malaysia tends to cause a drastic increment of the peak runoff discharge. If the drainage channel improvement were unrestrictedly made to cope with such incremental peak discharge, the downstream river would receive a serious overload beyond the flow capacity and cause frequent flooding. Moreover, it is virtually difficult to attain the unrestricted drainage channel improvement due to difficulties of land acquisition, unfavorable topographic conditions, and other natural and socio-economic conditions.

The source control facilities could reduce the incremental peak discharge by the land development, but their available construction sites will be limited due to topographic conditions, geological conditions, soil conditions and other natural and socio-economic conditions. Moreover, the facilities could not always perform the target design level without drainage channel improvement, due to their limited storage capacity.

In addition to the above drainage channel improvement and source control facilities, the particular drainage facilities such as gate and drainage pump may be required when the water level of the interior drainage channel is often lower than the exterior water level.

Thus, the drainage effect as well as the technical advantage in construction, operation and maintenance of the alternative drainage measures will be closely related to various site conditions such as topography, geology, soil (erosion and permeability), vegetation, and flow capacity/water level of the exterior river or sea. Accordingly, the technically viable combinations of the alternative drainage measures should be selected through careful clarification on these site conditions.

(2) Project Cost

Increment of the project cost for source control facilities could lead to less project cost for the drainage channel improvement and the river channel improvement, in particular in the densely congested urban areas. The variation of project cost for various combination of the drainage channel improvement and the control facilities should be examined, and the combination with the least project cost should be given as one of the important factors to select the optimum combination.

(3) Social and Natural Environmental Impacts

Alternative drainage measures will bring various social and natural environmental impacts. In this connection, one of the important factors to select the optimum combination of the alternative drainage measures should be addressed to the following issues:

(a) Less relocation by the project implementation;

(b) Less adverse effects to the natural environment (water quality, aquatic life and so on);

(c) Adding of value of the space for drainage facilities as amenity; and

(d) Improvement of urban scenery.

2.2 Principal Measures Applied to Drainage Improvement

The applicable measures to drainage improvement are summarized in this section. The following are basic principles to select the suitable countermeasures.

(a) An increment in flood discharge caused by human activities should be controlled at the source so as to avoid the external adverse effects.

(b) Configuration of countermeasures should be made in due consideration of suitability for the topographic features of a catchment.

(c) Configuration of countermeasures should also be made in due consideration of good effects for natural environmental cycle, such as hydrological cycle, water purification cycle, in order to avoid reduction of base flow and occurrence of water pollution.

(d) Countermeasures should be selected from the viewpoint of easy operation and maintenance, and low running costs.

Based on the above principles, the following are the proposed countermeasures for urban drainage improvement.

2.2.1 Channel Improvement

The basic concept of all drainage channel designs is to reduce flood area and duration by providing a smoother, steeper, or larger channel than the existing streams. Urban drainage channels are typically designed to eliminate flooding in the protected area for all floods smaller than and equal to design events. The channel improvement has been the core works of the conventional measures.

Sometimes the natural streams with poor flow capacities are noticed in the urbanizing areas. For this kind of streams the channel improvement might be an inevitable countermeasure, since a source control is not always resolvable. In this case, a preferable balance should be studied between the channel improvement and the source control measures.

Compared with the natural river streams, the urban drainage channels are quite small and artificial, and there could be few opportunities found out to be upgraded or enhanced as environmental resources/functions. In spite of these unfavorable situations, urban drainage channels and adjacent areas are often highly valued as aesthetic resources in the congested urban areas.

Use of vegetation and natural materials is one of the typical measures to protect and maintain visual quality. Vegetation and natural riverine substances, e.g., gravel and rock, can be used alone or in combination with structures to provide a more natural appearance. Minimizing the extent of bank and streamside clearing and using vegetation in the design preserve the natural appearance of the project setting. Restoration of excavated, eroded, and cleared areas can be performed as a part of construction activities.

Applicable species of vegetation to protect channel side slope areas depends on the frequency and duration of inundation, and velocity. In general the flood velocity on the side slope is expected not to exceed 1.8 to 2.4 m/s.

In the feasibility study, three types of drain channel are proposed in accordance with the situations of the locality where the channel is/will be placed. The following table gives the criteria for selection of channel type.

Channel Type	Shape (Side Slope)	Place to be Adopted
Earth Drain	Trapezoid (1:2)	Rural or urbanizing area where land acquisition is relatively easy
Concrete-Lined	Trapezoid (1:1)	Restoration of concrete lining in rural area at present
R.C Drain	Rectangular (-)	Congested urban area where land acquisition is difficult, restoration of existing R.C drain, low-lying area

2.2.2 Construction of Diversion Channel

Diversions alleviate flood damages by reducing discharge directly. Diversion channel bypasses stormwater around or away from a specific area. In general the diversion includes a bypass channel and a control structure that is a broad-crested side-overflow weir. For drainage improvement, the diversion measures also include the bypass channel that receives the whole stormwater. In this case, the previous channel will be abandoned or receives stormwater only from the remaining area.

2.2.3 Construction of Gate/Pumping Facilities

An interior area is defined as the area protected by the dike, floodwall or seawall, which are called the line-of-protection, from direct river, lake or tidal flooding. Interior areas may also include low depressions and natural sinks. The line-of-protection excludes floodwater originating from the exterior source but often aggravates the problems of interior flooding by blocking natural flow paths or outlets.

Protected interior areas, formerly flooded from the exterior source by slowly rising floodwaters, may now flood from rainfall events that are localized, occur suddenly and provide less warning. Interior floodwaters are normally passed through the line-of-protection by gravity outlets when the interior water levels are higher than water levels of the exterior. This is called a positive gravity condition. When exterior stages are higher than the interior, floodwaters are stored and/or diverted and pumped over or through the line-of-protection. This condition is known as a blocked gravity condition.

Against this kind of flooding, adopted are three types of the possible structural measures: (1) gate/pumping drainage; (2) separation of flood runoff from upper reaches; and (3) drainage channel improvement. The suitable drainage plan should be formulated through good combination of these measures taking each advantages and disadvantages into account.

The gate and/or pumping facilities are placed at the downstream end of the drainage channel. When the exterior water level is higher than the interior water level, the gate is closed and the stormwater is either stored in the interior basin or pumped out to the exterior area. The pumping facilities are one of the effective measures in the interior basin but they need higher operational cost. Prior to selection of pumping station, the possibility and viability of another type of drainage should be properly studied.

2.2.4 Rehabilitation of Existing Detention Ponds

Based on the field reconnaissance, it was clarified that environment in most of the existing detention ponds is seriously deteriorated due to receiving domestic and industrial wastewater. The sewer systems of the catchment basins of these deteriorated ponds are combined sewers, since the areas were developed in the 1980s. In dry weather, both of the domestic wastewater from the septic tanks and the industrial wastewater from in-house treatment plants flow into the detention ponds. During storms, both wastewater and stormwater flows into the ponds. As a result, the following environmental deterioration occurs in the ponds.

(a) In dry weather the impounded wastewater emits offensive odor to the neighborhoods of the ponds.

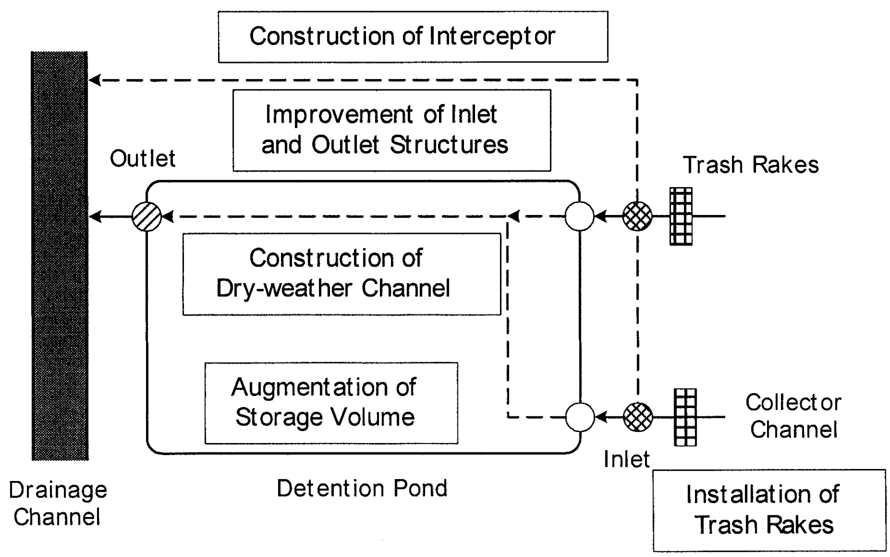
(b) During storms, storm runoff entrains the thrown rubbish and the deposited sediment in the combined sewer channel, and they accumulate in the ponds as sludge.

(c) During heavy downpour, the accumulated rubbish is discharged out to the downstream channel, and it clogs the some portion of the channel resulting in small-scale flooding.

The above-mentioned conditions were partly improved in the newly constructed ponds in accordance with the Indah Water's new guideline, "Guidelines for Developers", revised in 1998. Since then, the separate sewer and mechanical treatment systems have been adopted in the newly developed areas.

Environmental deterioration of the detention ponds is caused by inflow of wastewater and thrown rubbish from their catchment areas. Thus the rehabilitation works for existing detention ponds need to be made by a comprehensive approach integrating structural and non-structural measures, targeting the entire catchment areas of the ponds. The rehabilitation program should involve the following components:

(a) Structural rehabilitation of pond: augmentation of storage volume, installation of trash rakes, improvement of inlet and outlet structures, construction of dry-weather channel or interceptor (refer to the following figure);



<u>Conceptual Layout for Rehabilitation of Existing Detention Pond</u>

(b) Solid waste management: proper solid waste collection system;

(c) Domestic wastewater management: proper management of septic tank desludging and upgrading to the separate sewer system in future; and

(d) Educational campaign to residents: proper trash and wastewater treatment.

2.2.5 Construction of Detention Ponds in Newly Developed Areas

Detention ponds delay excess runoff and attenuate peak flows in surface drainage systems. During peak flows, the detention pond holds excess water until the inflow decreases and releases it during flood recession periods. Detention pond should consider sedimentation that occurs during detention. Detention facilities include on-site and off-site types. Furthermore, off-site detention ponds include embankment and excavation type, retarding basin with broad-crested side-overflow weir, and retarding basin of wetland. Their salient features are summarized in Table IV-1.

On-site detention is the detention of stormwater at the source before it reaches a drainage network or receiving water. On-site detention pond is installed in open space between houses or flats, parking lots or recreational facilities. On-site detention facilities usually hold stormwater either in series or in parallel, as a group of facilities, within the collection system, since each volume of the storage is limited due to site constraint.

Off-site detention holds stormwater collected by the upstream drainage network, and releases it to the downstream drain. Functionally, the on-site detention differs little from off-site detention other than the location where the storage occurs.

Since off-site detention needs a collecting channel network, construction of off-site detention facilities is suitable in the hilly areas with some gradient or the low-lying plain along the channel. On the other hand, since a drain network with only short distance can satisfactorily accomplish an on-site detention system, there are few topographic constraints for construction of on-site detention facilities. Thus on-site detention has particular effectiveness for solving flooding problems in the low-lying areas with wide flat topography.

So far the detention ponds are constructed in accordance with land development activities of which areas are 10 ha or more. As the number of detention ponds increases scattering over the basin, the maintenance works will need more manpower and cost for a responsible agency. In order to solve the problem, the large-scale off-site detention could play an important role to integrate the detention ponds to be constructed in parallel with land development activities. For attaining the above, the following procedures should be taken:

(a) The possible land development area in an intensively urbanizing basin for a certain period is to be predicted beforehand.

(b) Based on the prediction, the necessary volume to be controlled by the integrated off-site detention is to be computed, and the necessary structure is also to be designed at the suitable site.

(c) The detention pond is to be constructed as a preceding investment, and the cost is to be allocated to the succeeding development activities through establishment of proper collection system for the charge.

As a result, the developers have to pay the allocated cost instead of construction of the respective detention pond. For the developers, the cost to pay might be lower than the construction cost of respective detention pond because of economies of scale. Further, the minimum development area required for pond construction could be easily lowered, if this system properly works out.

2.2.6 Construction of On-site Detention Ponds in Public Open Space

In connection with storage potential of on-site detention utilizing open spaces, the following table presents the maximum storage depth adopted in Japan. These are determined considering the limitation without interference of the existing or original land use.

Storage Potential of On-site Detention

Land Use	Storage Site	Maximum Storage Depth	Potential Storage Area Ratio (Ponding Area / Catchment Area)	Potential Specific Storage Volume
Flat-type Housing	Open Spaces between Flats	0.3 m	40%	1,200 m^3/ha
Parking Lot	Parking Area	0.1 m	80%	800 m^3/ha
School	School Ground	0.3 m	40%	1,200 m^3/ha
Park	Open Spaces	0.2-0.3 m	40-60%	1,200 m^3/ha

Note: Specific Storage Volume = Storage Volume (m^3) Catchment Area (ha)

For instance, the maximum depth of 0.3 m for on-site detention using school ground is determined in due consideration of walkable depth of pupils, especially in an elementary school. The maximum depth of 0.1 m for parking lot is also determined considering the height of brake drum of vehicles. Further, the ratio of potential storage area to the catchment and the expected specific storage volume are also shown as reference, based on experiences in Japan.

Regarding storage duration in on-site detention for immediate use after storm detention, it is within two (2) hours after storm subsidence in Japan. Based on this criterion, the required storage capacity is computed applying the 5-year storm rainfall. The storage capacities that fulfill the requirement of fully discharging stored water in two (2) hours after storm subsidence are given in the table below. The required specific storage volume is equivalent to one second compared with potential values except for parking lot. Enough hydraulic head is necessary for smooth discharging in the parking lot due to shallow storage. In conclusion a storage volume of 600 m^3/ha should be an adequate target for on-site detention, if proper multiple usage between original use and storm detention is to be attained.

Required Storage for Short-time Detention

Land Use	Storage Site	Storage Depth	Potential Storage Area Ratio (Ponding Area / Catchment Area)	Required Specific Storage Volume
Flat-type Housing	Open Spaces between Flats	0.15 m	40%	600 m^3/ha
Parking Lot	Parking Area	0.09 m	80%	710 m^3/ha
School	School Ground	0.15 m	40%	600 m^3/ha
Park	Open Spaces	0.1-0.15 m	40-60%	600 m^3/ha

Note: Specific Storage Volume = Storage Volume (m^3) Catchment Area (ha)

A wide ponding area and shallow depth characterize on-site detention, while a small ponding area and deep depth characterize off-site detention. In general, this is a clear difference between on-site and off-site detention and it supports the advantage of on-site detention for low-lying areas.

2.2.7 Installation of Storage Tank in Individual House

A storage tank installed in an individual house is the ultimate type of the smallest on-site detention. Although there are several remaining issues for widely spreading this scheme, the individual house storage has the following advantages.

(a) Stored water can be utilized for supplemental water sources so that the facility would be effective during drought.

(b) For densely urbanized areas, individual house storage is one of the few possible source control measures.

(c) Also for the urbanizing low-lying areas, individual house storage is one of the few possible source control measures.

In this study, effectiveness and viability to install the individual house storage are examined in two typical basins, Sg. Air Mendidih as urbanized basin and Prt. Pokok Mangga as low-lying basin.

2.2.8 Land Elevation to Minimum Platform Levels

The developers or landowners have to elevate the land lots to be developed/rebuilt, which is located in the flood-prone areas along the river/drainage channels, up to the minimum platform levels. As a result, floods will not affect the land lots. On the other hand, the activities of land elevation will decrease natural flood retarding function along the stream. In order to avoid an excessive urbanization with land elevation, the well-balanced urban planning is essential.

The land elevation is considered one of the supplemental measures in planning stage. Thus this measure is not included in the alternative measures studied in Chapter 4.

2.2.9 Provision of Drainage Reserves

Based on the results of flooding simulation, DID can select the effective natural retarding areas and designate the areas as drainage reserves. DID also should discuss the preservation of natural retarding functions with the related agencies, Town and Country Department and the local government. If an area to be preserved is large and can be clearly delineated, the area should be designated as a natural preservation area or a river/drainage reserve area in an urban planning.

Any type of land development activities shall be prohibited in the area, except for a specific type of development that can preserve the retarding function, such as buildings with piling foundations. Further, drainage reserve would work out not only for conservation of natural flood retarding function but also for protecting residents from excessive floods.

The areas with natural retarding function are delineated in Chapter 3, and the suitable facilities in these areas are proposed for augmentation of the function in Chapter 4.