CHAPTER 5 DESIGNING

5.1 General

The drainage facilities should fulfil their functions for flood mitigation and also preserve and/or improve their adjacent natural environment. In accordance with the concepts, this Chapter prescribes the standard designing procedures for the following major drainage facilities:

(a) Drainage channel
(b) Flood detention pond and flood retarding basin
(c) Storage facility in public open space
(d) Storage tank in an individual house lot
(e) Drainage pump
(f) Gate

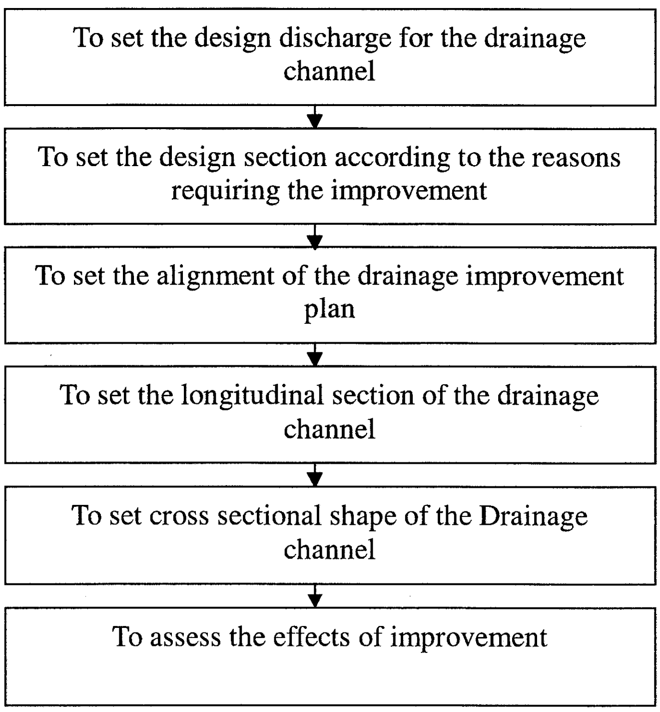
5.2 Drainage Channel

The drainage channel should be designed to allow the safe passage of the design flood discharge.

Explanation

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 changes variously and the passage of channel water involves earth, sand and other matters, it should be designed to secure the function permanently and stably. The designing of drainage channel should be made through the following procedures.

Fig. 5.1 Procedure for Formulating Channel Plan



The channel design should meet the purposes specified in the drainage improvement plan. As the procedure, the reasons and the section for the improvement should be first investigated and analyzed paying a particular attention to the following items:

(a) Whether or not the existing channel flow capacity is insufficient;

(b) Whether or not any irrigation weirs, bridges and other structures across the river form bottlenecks;

(c) Whether or not the channel alignment is correct; and

(d) What were the causes of the major disasters in the past.

The plane, longitudinal section and cross sectional shape of the drainage channel should not be assumed independently, but in the actual procedure, they should be provisionally set first independently and the best channel design should be finally decided after checking the respective portions. In order to examine the effects of improvement, assessed are not only the relationship between the project cost invested and economical effect after the improvement but also various factors such as the importance of the disaster prevention zone and effects in the respective stages during improvement works.

(1) Channel Flow Capacity

The channel flow capacity should be estimated on the basis of uniform flow or non-uniform flow calculation method according to the conditions of the drainage channel*[5-1]. The natural flow of the drainage itself is not steady because of temporal variations in the velocity, but could be substantially regarded as a steady flow in the ordinary channel plan. A proposed drainage channel is often set irrespective of the existing drainage channel. The channel cross-sections for such proposed drainage channel could have little change in its sectional shape, and the longitudinal change of velocity could be often disregard. In this case, the flow capacity should be calculated in principle by the uniform flow. However, when the drainage channel is affected by the backwater due to the tidal level at river mouth, or the water level of the downstream channel, discussion should be made by non-uniform flow calculation.

(2) Route and Alignment of Drainage Channel

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 existing and/or projected land use, the flood flow regime, the present alignment of the drainage channel, and project cost which include the construction cost as well as maintenance cost..

(3) Short Cut and Diversion Channel

When a new drainage channel such as short cut and diversion channel is required., the safe flow should be considered, and the peripheral groundwater level and the drainage for interior stormwater should be fully taken into consideration. The drainage channel should be set as an excavated drainage channel as practicably as possible.

(4) Design Water Level

The design water level is decided on the basis of the design discharge and the channel cross sectional shape/longitudinal profile, and should be arranged as low as possible below the ground level along the channel.

(5) 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.

(6) 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 as 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.

Table 5.1 Cross-sectional Design Standards

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.
Sheet pile channel	A rectangular sheet pile wall cross-section is formed without channel bottom slab. This type is suitable for deep channel. (Recommended channel depth, more than 3m)	In the case of a deep channel and the restricted right-of-way, this type will be applied, although the construction is costly.
Vegetated channel	A trapezoidal cross-sectional shape with very gentle side slope is formed with vegetation in view of environmental and ecological circumstances. Infiltration efficiency might be conditional on the soil and geological conditions.	Although the construction is not so costly, periodical maintenance is required. A wide space for securing gentle side slope is also necessary.

(7) 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 followings should be given as the height of freeboard:

(a) If 20% of the channel depth is more than 0.3m : 0.3m

(b) If 20% of the channel depth is less than 0.3m : 20% of the channel depth

(8) Revetment

The earth drainage channel will require the revetment at water hammer sections of the objective channel to protect the channel from erosion. The location, extension and construction method for revetment should be decided in consideration of flow regime, longitudinal profile, cross-sectional shape, slope gradient of channel wall and soil condition. The revetments will extend over an entire stretch of a steep channel and/or a small channel confined due to the restricted right-of-way. When the objective drainage channel could take a relatively wide right-of way, turfing or vegetated channel with gentle cross-sectional slopes will be applicable in order to facilitate infiltration effects and improve ecological circumstances.

(9) Underpass Structures

A concrete 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 the 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 in height, if the culvert is not submerged. As for structural design, a R.C. structure or a corrugated metal pipe should be adopted in order to secure sufficient strength to sustain dead and live loads. (Detailed hydraulic calculation refers to "Urban Drainage Design Standards and Procedures for Peninsular Malaysia"[*5-1] by Department of Irrigation and Drainage, Ministry of Agriculture, in 1975)

5.3 Flood Detention Ponds and Flood Retarding Basin

The flood detention pond and the flood retarding basin should be designed to delay and reduce the peak flood discharge. In addition to the flood control function, the facilities contain a potential to provide the public amenity space and improve the scenery in the urban area. Accordingly, the design works should be made with a particular attention to such potential use of the facilities..

Explanation:

The flood detention pond and the flood retarding basin are the typical off-site storage facilities based on the concept of "source control of flood" to store flood run-off in the objective drainage area. Their functions are essentially identical with that of a dam reservoir. Although the available depth is shouldower than that of a dam reservoir, their water area is relatively wide. When the design works of these facilities are oriented to multipurpose functions other than their flood control purpose, the applicability of other purpose such as recreation, environmental improvement should be discussed.

As for the existing conditions of detention ponds, it is questionable that the ponds could fulfil 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 in addition to the frequent execution of regular maintenance work.

The followings are the technical guidelines for rehabilitation of the exiting flood detention ponds as well as the new flood detention ponds and flood retarding basins:

(1) Rehabilitation of Existing Flood Detention Pond

As discussed in Chapter 1 the existing flood detention ponds are not well maintained nor operated. To improve this condition adequate structure measures should be considered, accompanying the execution of periodical maintenance works. Applicable structural designs are described in the followings, together with main causes of mal-function.

Table 5.2 Applicable Design for Rehabilitation of Existing Flood Detention Pond

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 with a screen and a basin 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.

(2) Design for New Flood Detention Pond

The flood detention pond has a function to temporarily store runoff discharge on the way to the rivers thus reducing the peak runoff discharge. The facility will be placed in the urban areas and/or future developing areas as an applicable measure among several drainage plans. Because, most of those areas are facing to difficulty in acquiring enough site for ordinary drainage channel improvement or they are technically managed to detain runoff discharge before joining into the lower rivers, which have not sufficient flow capacities to pass it safely.

(a) Type of Pond

The flood detention pond contains the following three major types. The detailed features and characteristics of these types are summarized in Table 5.3 and the general layouts are illustrated as shown in Figs. 5.2 to 5.4.

Type of Pond		Characteristics
Natural 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.
Surface-Lining Pond	:	A preferable environment in and around the pond as well as easy maintenance of the pond can be expected.
Multistage-Lining Pond	:	This type is preferable as a community or an ecological pond in case of a large scale of land development.

(b) 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 mattress and revetment should be provided at the immediately downstream of inlet structures in order to protect the pond from scoring and erosion. A typical feature of inlet structure is presented as shown in Fig.5.5.

(c) Outlet Structure

As prescribed in sub-section 3.4.4 the outlet facility consists of two orifices. These 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 sluice gate for orifices also should be installed to facilitate easy and sustainable maintenance work. A typical feature is presented as shown in Fig. 5.5.

(d) Spillway

When a pond is placed at a valley, its surrounding bank crest level is more than 1.5 m 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 100 year return period for a concrete structure pond and 144% of 100 year return period for an embankment pond.

(e) 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 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. A typical arrangement of the roads is shown in the general layout of Fig. 5.2.

Table 5.3 Summary of Characteristics by Type of Detention Pond

Description/Type of Pond	Natural Pond	Surface-Lining Pond	Multistage-Lining Pond
1. Design Concept			
Condition of Pond	Wet or Dry pond	Dry pond	Wet condition at lower stage, Dry condition at higher stage
Enviroment/Resident's Concern	Natural condition can be sustained. Ecological type pond is preferable for the residents.	Keeping a detention function of pond precedes natural environment.	Higher stage can be dried and used for other purpose as occasion demands. In this case the resident's concerns on environment of a detention pond can be enhanced. (ecological/community pond)
Maintenance	Diligent maintenance should be carreid out properly, otherwise a pond will not function shortly as detention facility.	Easy maintenance is expected.	Diligent maintenace should be carried out properly to use the both stages rightly. Higher maintenance cost will be required.
2. Structural Features			
Structural Design	Natural excavation bond	Excavation pond with lining bottom incl. concrete drain	Excavation pond with multistage consisting of lining dry condition of higher stage & naturral wet of lower stage
Bottom Protection	Natural/turfing wuth concrete drain	Concrete lining with concrete drain	Natural wet condition
Slope Protection (Revetment)	Natural/turfing	Stone-pitching/turfing	Stone-pitching/turfing
In/Outlets Structure	With rubbish trap and screen	With rubbish trap and screen	With rubbish trap and screen
3. Dimension			
Pond depth under the condition of gravitational release of outflow	Relatively shallow due to stability of pond slope	Relatively deep	Relatively deep
Freeboard above high water level	0.6m	0.6m	0.6m
Required Area of Pond Site	Relatively wide area is required to keep stability of pond slope	A required area can be minimized due to the adoption of steep pond slope with revetment .	Wide area is required.
4. Others			
Practicality	Low construction cost, but high maintenance cost	Relatively costly and exclusive use	Costly, but sophisticated and multipurpose use
Preferable Development Scale	Various development scale can be considered, but stable soil condition is required to sustain natural condition	Suitable for relatively small scale development under the condition of the restricted right-of-way	Rather large scale development is expected to make the most of development scale.
Reference Figures	Fig. 5.2	Fig. 5.3	Fig. 5.4

Fig. 5.2 General Layout of Natural Pond

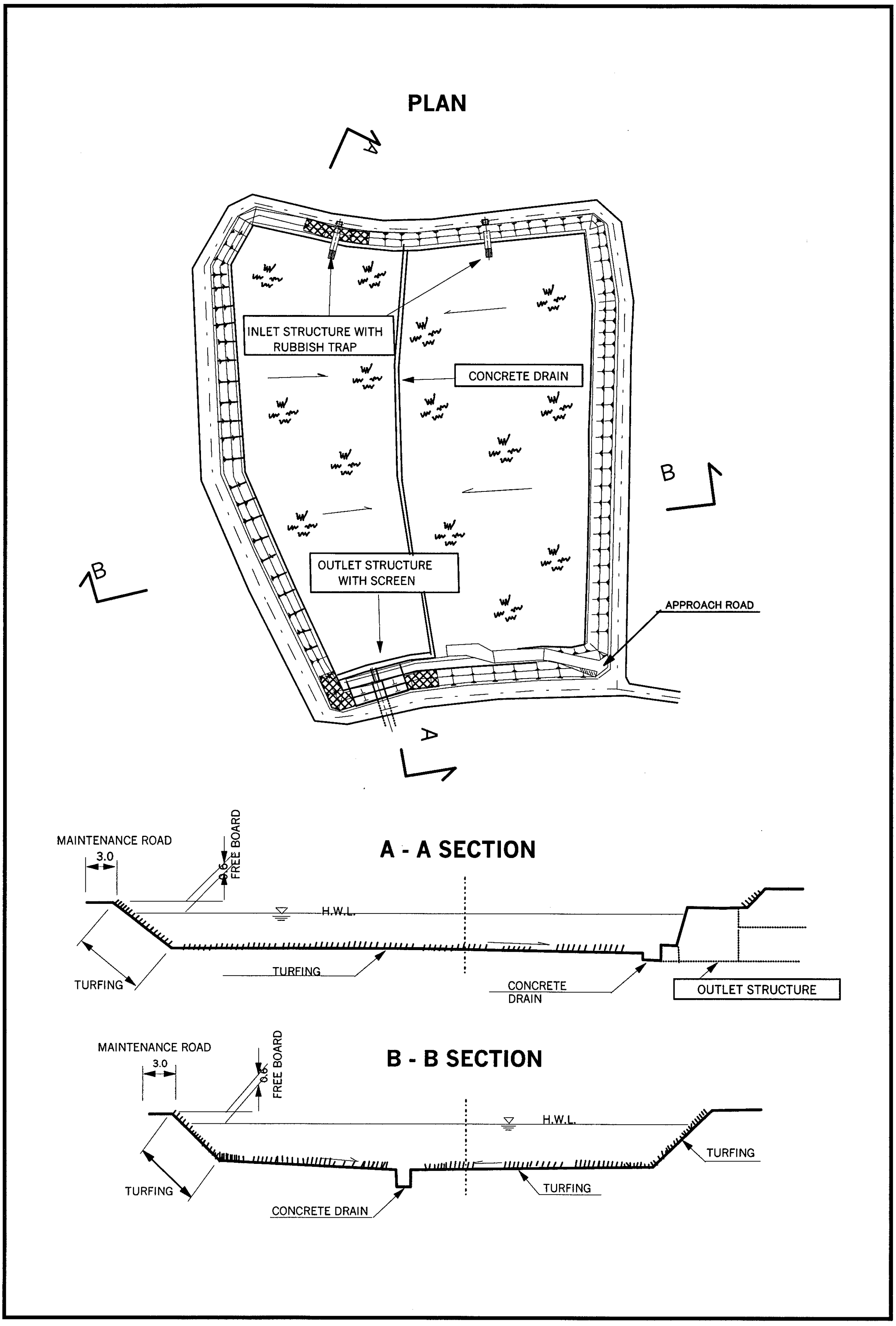


Fig. 5.3 General Layout of Surface Lining Pond

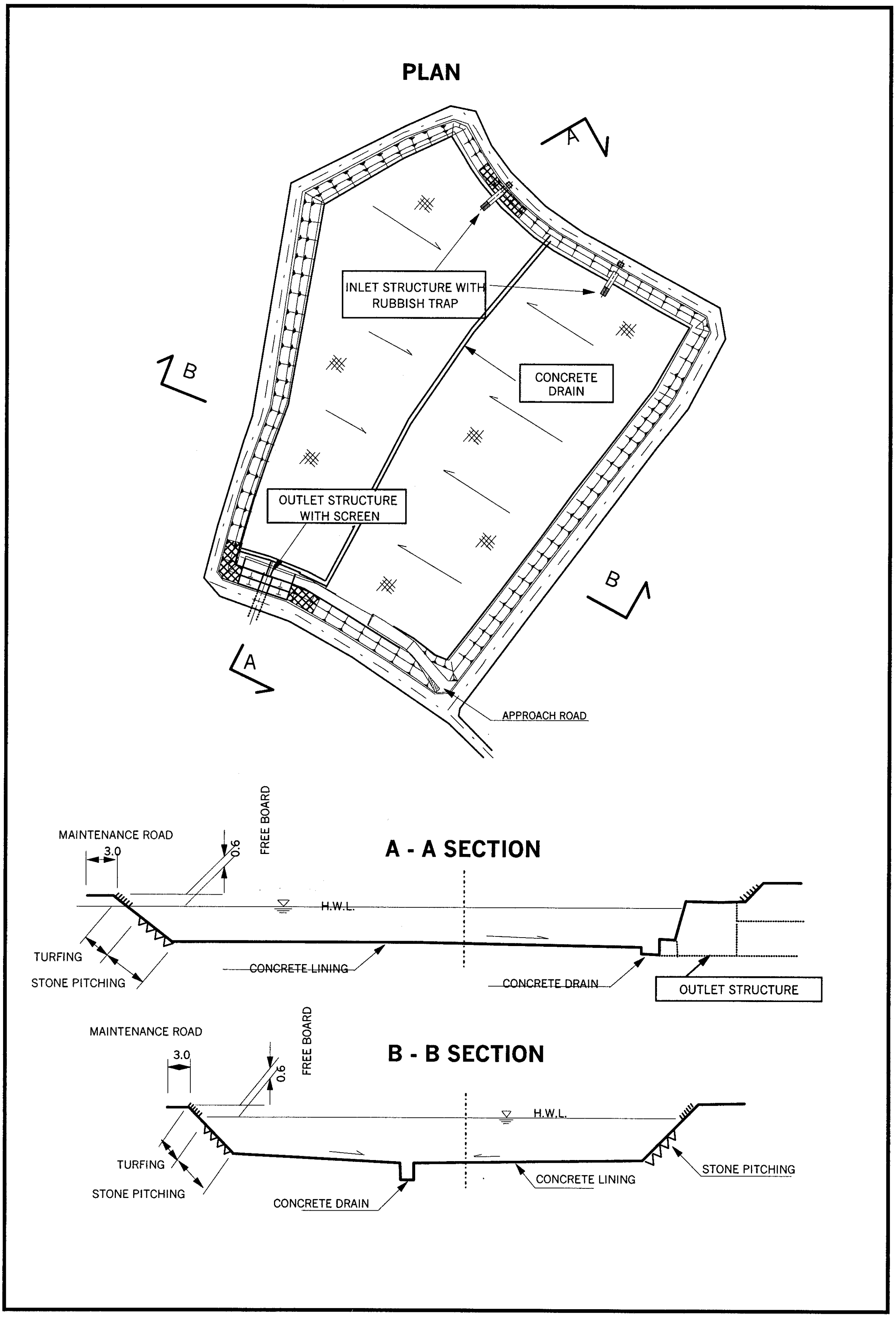


Fig. 5.4 General Layout of Multistage Lining Pond

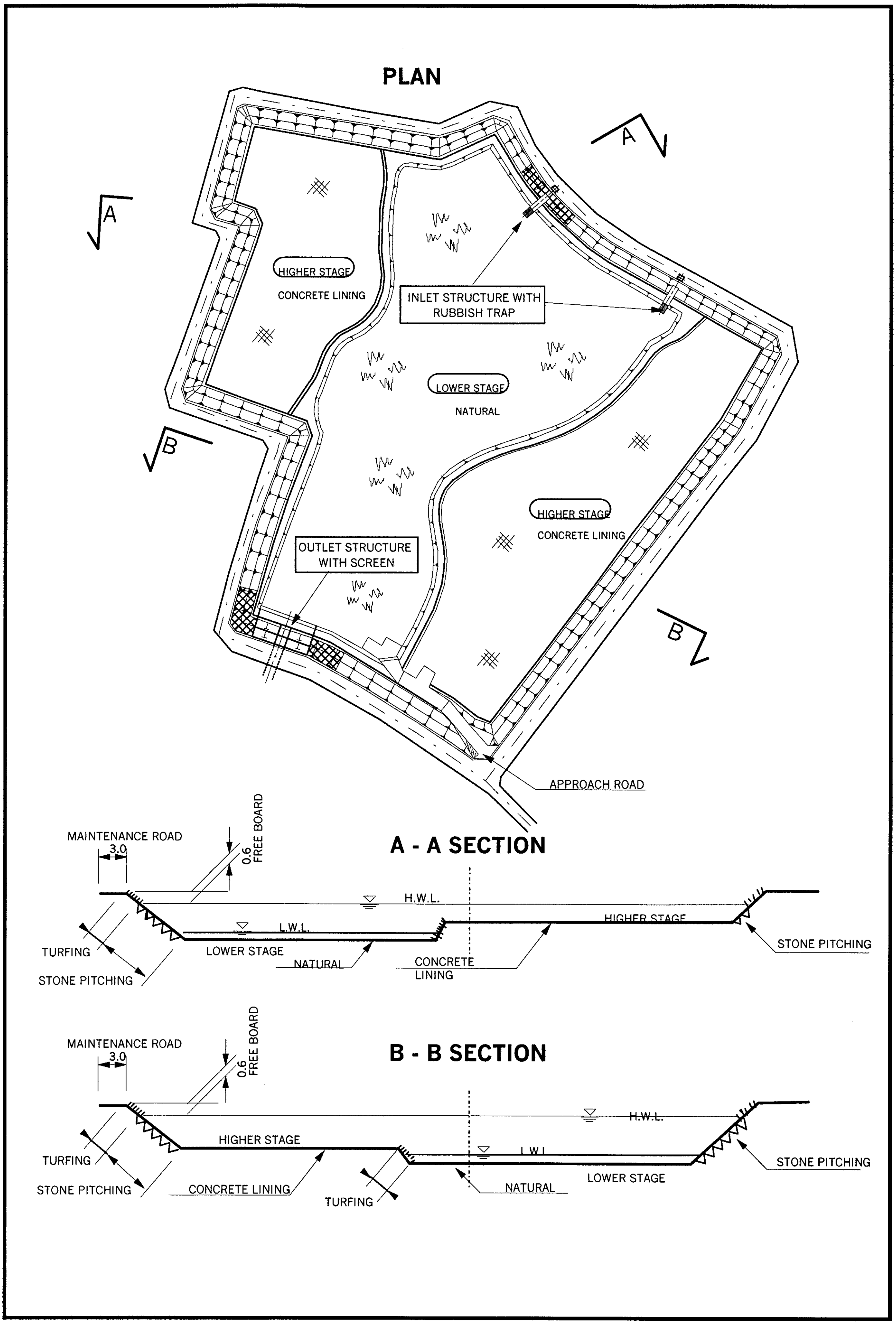
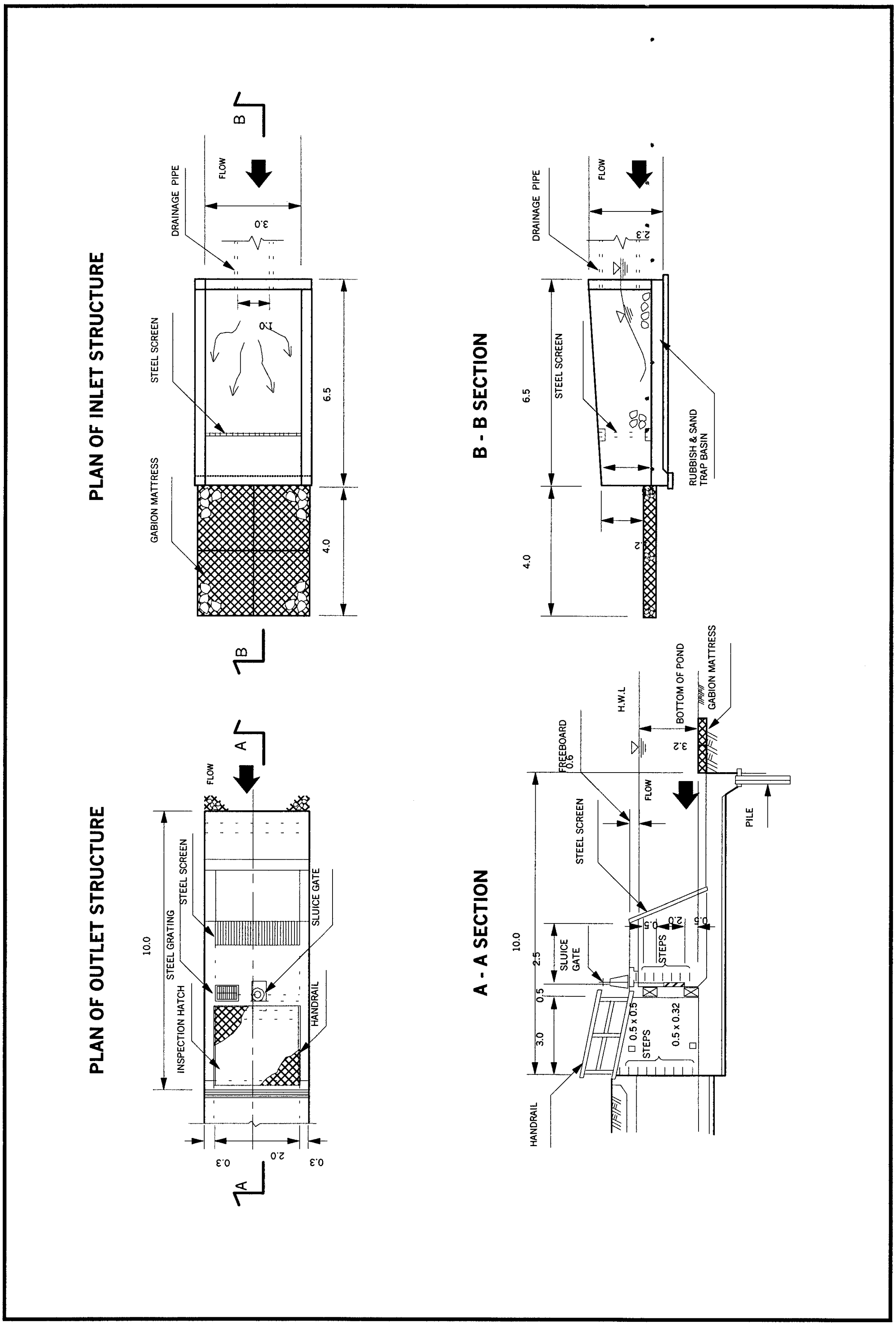


Fig. 5.5 Typical In/Outlet Structure of Detention Pond



(f) Multipurpose Use

When the flood detention pond is oriented to multipurpose, the designing works should be made in due consideration of regional conditions, social conditions, relevant projects and local needs of utilization and subject to a particular attention to the following points:

- The multipurpose use should not affect the flood detention function;
- Since there are various potentials of multipurpose use of the pond, it is necessary to analyze the target for utilization from regional and entire viewpoints.
- The flood detention pond should improve water environment and the adjacent landscape, and preserve aquatic life.

(3) Design for New Flood Retarding Basin

A retarding basin has a function 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. However, its applicability depends on a suitable site where technically and regionally allows temporary inundation.

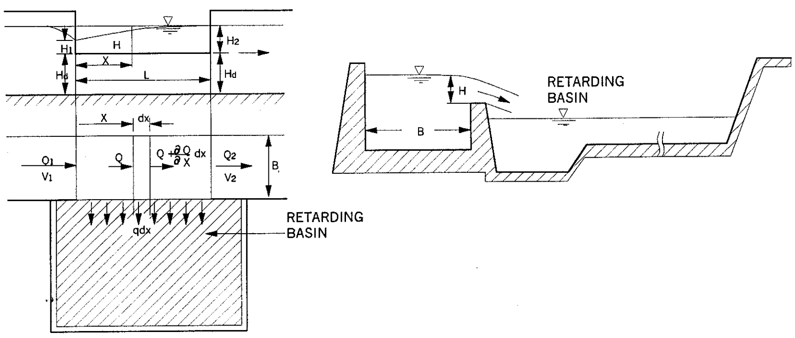
(a) Side Overflow Weir

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 over flow function based on the hydraulic calculation. A design flow capacity of side overflow weir will be calculated in principle applying the following equation of continuity.

$dQ/dx = \pm q$ and $Q_2 = Q_1 \pm \int_0^L q.dx$ ....(Eq.5.1)

Where; Q : Rate of flow
Q_1, Q_2 : Rate of flow before and after weir, respectively
l : Length of overflow section
q : Unit rate of overflow

Fig. 5.6 Side Overflow Weir



(b) 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 gate into the river channels and/or drainage channel. The sluice/outlet will be set at the lowest position of the site for retarding basin and near to the 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.

5.4 Storage Facility in Public Open Space

The storage facility in public open space should be designed to store rainwater temporarily so as to delay and reduce the peak runoff flows. School playgrounds, parks, parking lots and other wide public open spaces are used as on-site temporary storage space for this facility.

Explanation:

A storage facility in public open space should be designed to effectively control the flood run-off rate in due consideration of the topographic and geological conditions, land use, security and maintenance. This guideline prescribes designing standards for a surface excavation pond with side drain and orifice type of outlet as a typical storage facility. (Refer to Fig. 5.7)

(1) Location for Construction

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

(a) School playground

(b) Park/Green district

(c) Parking lots

(d) Open space in housing complex

(e) Recreation area/sports park/public management area

(2) Inlet and Outlet

Inlet and outlet should meet the following conditions.

(a) Inlet structure should be designed as orifice with interceptor for an influx of sedimentation, rubbish, debris, and etc. to prevent orifice from clogging.

(b) The facility is subject to natural drainage, and should not equipped with outlet control devices such as gate, and valve, which require artificial operation.

(c) Outlet structure should be designed as orifice or the open channel .

(d) 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 and.

(f) The allowable maximum ponding time duration should be beforehand determined so as to not cause any significant adverse effect to the original purposes of the ponding spaces as the play ground parking lot, etc. The detailed structural dimensions for the inlet and outlet should be subject to the allowable maximum ponding time.

(3) Storage Area

Storage area should be a surface excavation pond surrounded by RC wall. The bottom of the pond should have a gentle slope and also be protected with turfing in the expectation of smooth drainage after raining. The allowable maximum storage depth should be determined so as to not cause any significant effect to the original purposes of the ponding spaces as the play ground parking lot, etc. 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 play grounds and parks will have the allowable storage depth of 0.3m for the sake of safety of children.

(4) Infiltration Facilities

Infiltration system should be designed as an additional outlet in due consideration of the following site conditions:

(a) Topography

The applicable and inapplicable topographies for installation of infiltration facility are as described in the foregoing sub-section 2.5.2,

(b) Soil

The following conditions could be applied as the standards of applicable soil conditions for infiltration:

(i) The soil should have its coefficient of permeability of more than 10^{-5}cm/sec.

(ii) The air porosity of soil should be more than 10%. and

(iii) The share of clay in grading distribution of the soil should be less than 40%.

(c) Ground Water Level

The ground water level should be more than 0.5m below the bottom level of the infiltration facility.

(d) Environmental Influence

The infiltration facility should not be applied in the former compound of factory or reclamation area, where the polluted ground water could diffuse through the facility.

(e) Land Use Projection

The infiltration facility should not be installed in the area where land development is restricted and/or prohibited in the Local Structure Plan.

A typical infiltration system is conceptually illustrated as shown in Fig. 5.8. Materials for infiltration facilities are sand bed, gravel fill and synthetic fiber sheet. All of the materials should have the strength, percentage of void and permeability as specified below*[5-3]:

Fig. 5.7 General Layout of Storage System in Public Open Space

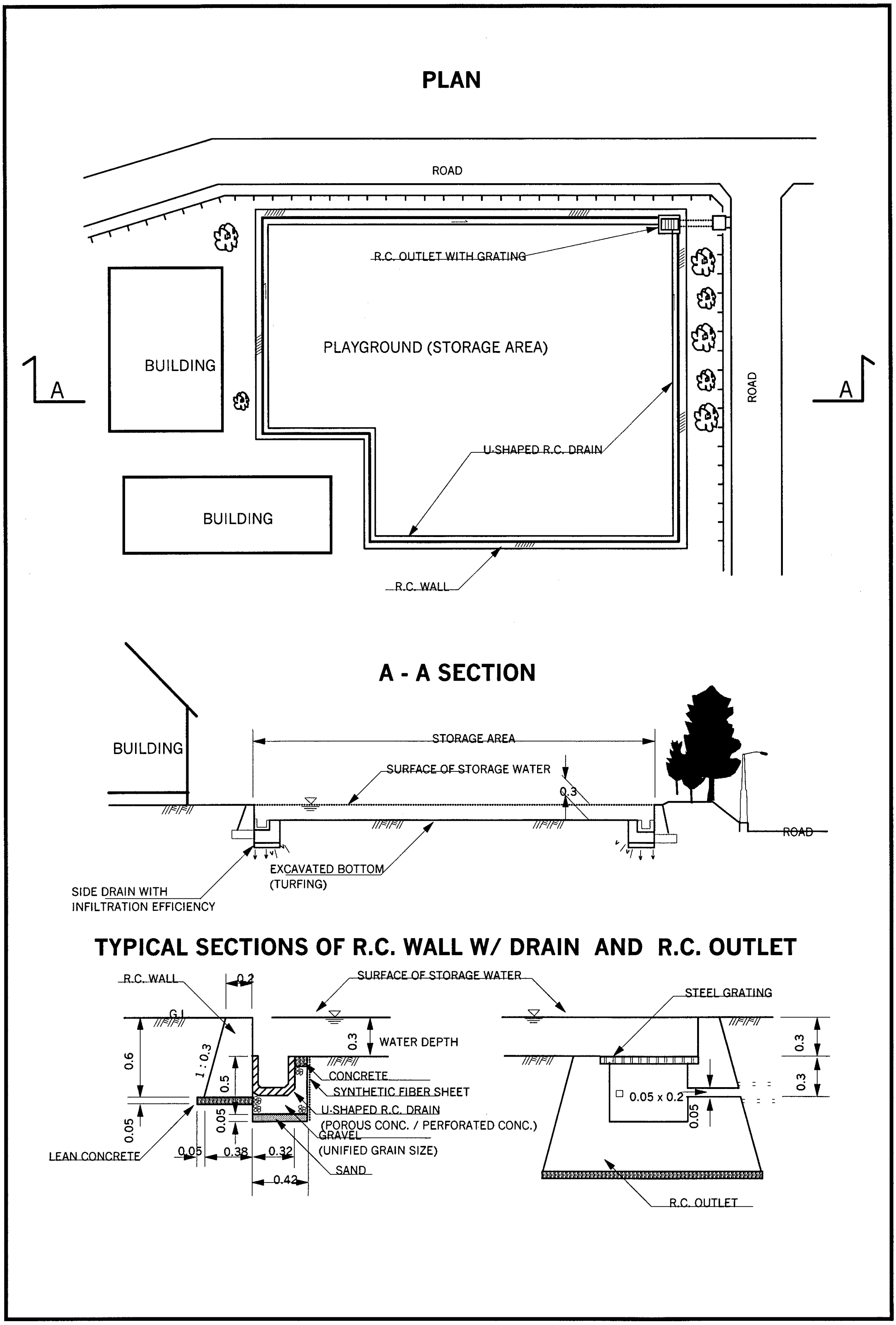
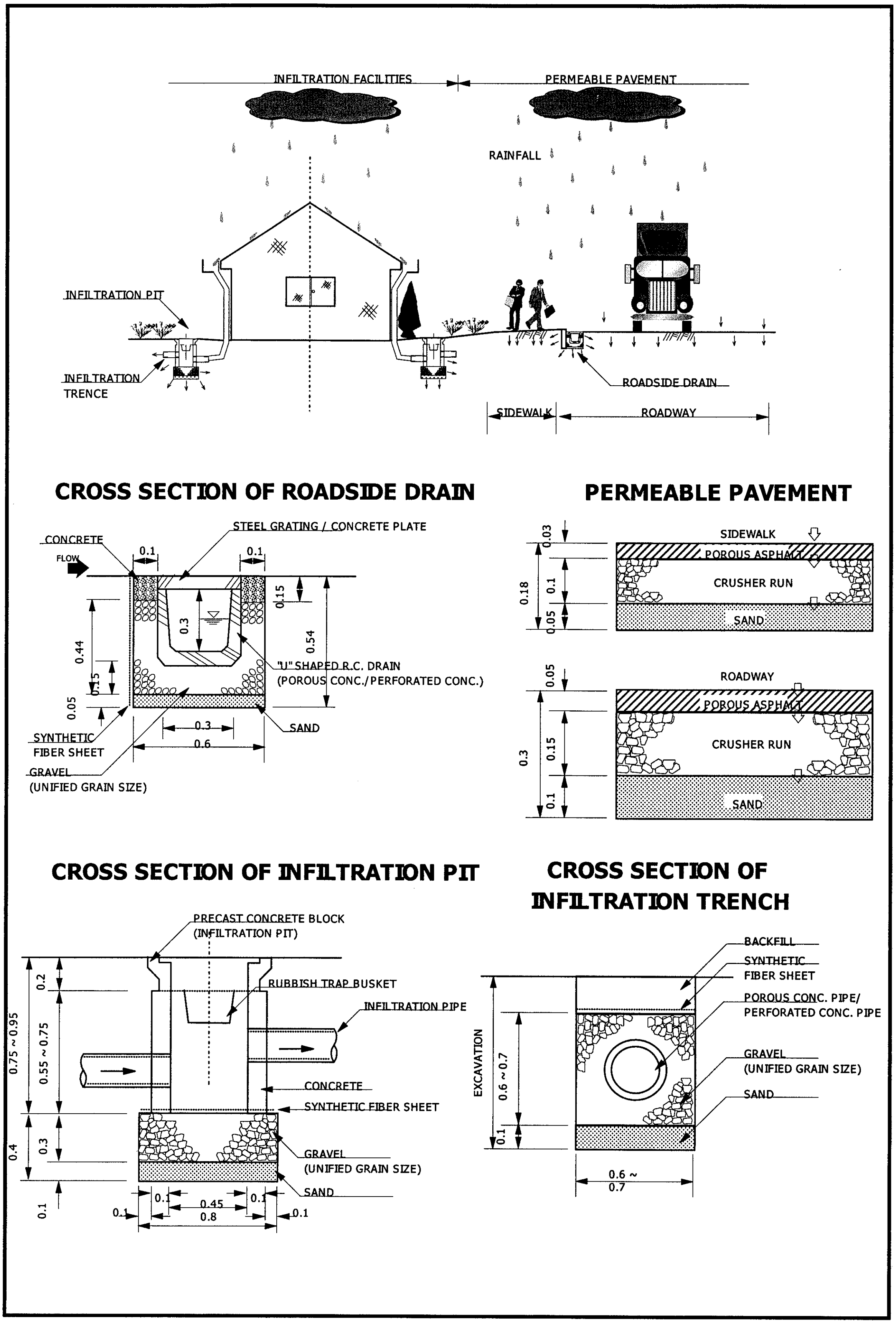


Fig. 5.8 Typical Infiltration/Permeable System



(5) Sand bed

Sand bed is used to prevent gravel fill from intrusion of fine particles. Relatively coarse particle of sand is preferable and the design percentage of void should be fixed at around 25%.

(6) Gravel fill

Gravel fill should be placed between the structure and the excavated surface to protect the plane of infiltration and ensure the storage volume and the design head. A size of gravel should be bigger than a diameter of perforated holes provided for the structure, ranging from 20 mm to 40 mm of crusher-run and gravel fill should contain with 30 % to 40 % of void.

(7) Synthetic fiber sheet

Synthetic fiber sheet prevents soil from coming into gravel fill and also prevent the ground surface from sinking. Generally, it should have the tension stress more than 30kgf per 5cm, the permeability more than 10-1 to 10-2 cm/sec and the thickness more than 0.1 to 0.2 mm.

5.5 Storage Tank in an Individual 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.

Explanation:

Rainwater storage tanks are installed on the ground or in the buildings to store rainwater, which is generally collected from roofs. In the view of "source control of flood", 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.

(1) Collection System of Rainwater

Rainwater from roofs will be transmitted to a storage tank through roof gutters, down pipes and connecting pipes. To collect rainwater effectively and surely the following technical points should be considered.

(a) The adoption of a wide roof area, a superelevated roof and an inclined wall could collect the utmost rainwater.

(b) The rainwater is transmitted to the storage tank through the extension of connecting pipe. This connecting pipe should be shortened as much as possible and be laid on the exterior wall or in the ceiling of a house.

(c) The diameters and gradients of rainwater pipes should be designed on the basis of the catchment and rainfall intensity.

(d) The plumbing for rainwater should be arranged adequately so that it would not be damaged by fluctuation of water pressure in heavy rain.

(e) In the case of using the long extension of rainwater pipe, an expansion or a flexible joint should be employed to absorb a stretch of plumbing.

(f) Since the quality of first rainwater is influenced by suspended particles in the air and harmful substances from cars and factories, the first rainfall of 3mm should be eliminated with the installation of a special device.

Rainwater pipes should be of chemically inert materials such as PVC and galvanized iron to avoid adverse effects on water quality. In the selection of rainwater pipe size closely related to roof area, the Japanese guideline, as introduced in the following "Reference" will be useful. A typical collection system of rainwater is illustrated in Fig. 5.9 which includes a particular a countermeasure against heavy rain. Fig. 5.10 shows the design concept of a device to separate the first flash rainwater which contains suspended particles.

(2) Storage System of Rainwater

Storage system of rainwater is basically categorized by the location of storage tank, on the roof, on the ground and under the ground. The underground storage type is further classified into a gravitational drain of overflow and a mechanical drain of overflow. Their features and characteristics are summarized as shown in Fig. 5.11, and their advantages and disadvantages are as enumerated below:

Type	Advantage	Disadvantage
Storage Tank on the Roof	1. Gravity drain could be made. 2. Water supply could be made with the minimum motive power. 3. Someone from outside could hardly do a mischief to the storage tank.	1. The type may spoil the appearance of the house. 2. Size and shape of storage tank is highly restricted according to conditions of roof. 3. Installation cost is in general higher than those of other types. 4. Installation of facility may require reinforcement of the existing house structure.
Storage Tank on the Ground	1. Gravity drain could be made. 2. The type require the minimum installation cost among all types. 3. The type is easily maintained and operated as compared with other types. 4. Installation could be made without any modification of the existing house structure. 5. The lager storage capacity of the tank could be easily installed.	1. A part of open space on the ground is occupied by the facility. 2. The type may spoil the appearance of the house. 3. The motive power is required for water supply. 4. Size and shape of storage tank could be restricted according to available open space within the house compound. 5. Someone from outside could do a mischief to the storage tank.
Storage Tank under the Ground	1. The open space on the ground is not occupied by the facility. 2. The type does not spoil the appearance of the house. 3. Someone from outside could hardly do a mischief to the storage tank.	1. Overflow from the tank could be hardly drained. 2. The water supply requires the motive power. 3. The type requires the highest installation cost. 4. The operation and maintenance for the facility is difficult. 5. It is difficult to increase the storage volume, once the facility is installed.

The type of storage system could be selected in due consideration of the above advantages and disadvantages which are finally attributed to the particular conditions of the house. As for the storage tank, the following consideration should be taken according to the structural characteristics.

(a) Structure of Storage Tank

The prefabricated tanks of FRP, galvanized steel and stainless steel on the ground can be suited for private house lots, while for office buildings and condominiums, relatively large size of reinforced concrete tanks should be constructed under ground with water proof painted interior.

(b) Storage Capacity

A storage tank capacity in an individual house lot exclusively for flood detention function will be decided considering the availability of the roof catchment according to the drainage improvement plan. For example, in the JICA study of "the Study on Integrated Urban Drainage Improvement for Melaka and Sungai Petani" a storage tank capacity of 2000 liters is proposed to the roof catchment of $100m^2$. As for the storage capacity for rainwater utilization, the "Rainwater Guideline for Installing a Rainwater Collection and Utilization System" [*5-4] recommends a storage capacity of 1120 to 1800 liters by building type. The storage tank with the multifunction of flood detention and rainwater utilization is conceptually illustrated as shown in Fig. 5.12.

(c) Storage Tank with Infiltration Function

Providing that an overflow from the storage tank can be released to infiltration pit, infiltration trench and roadside drain, the higher efficiency of "source control of flood" can be achieved in own way. A conceptual diagram of the storage tank with infiltration function is as illustrated in Fig. 5.13. This diagram explains that rainwater from rainwater down pipe is conveyed into the storage tank through screen, and then automatically poured into a well. When storage tank is full of rainwater, the overflow will be transmitted to soak away pit and infiltrate into the ground. In the event of heavy rain, the overflow will be released to roadside drain.

(3) Supply System of Rainwater

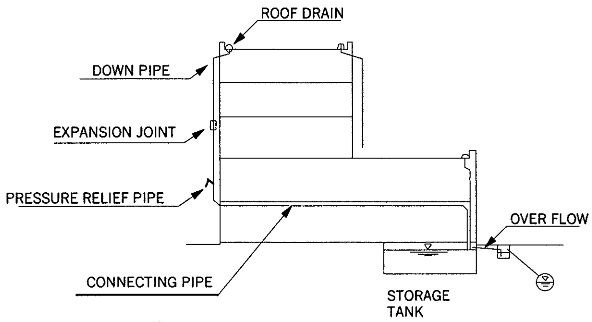
The supply system of rainwater depends on the location of storage tank. If the storage tank is installed in roof-tops, roof-terrace and balconies, the water can be supplied by gravity. In the case of that the storage tank is installed on the ground level and underground, it is necessary to provide pump equipment to supply to upper levels (refer to Fig. 5.10).

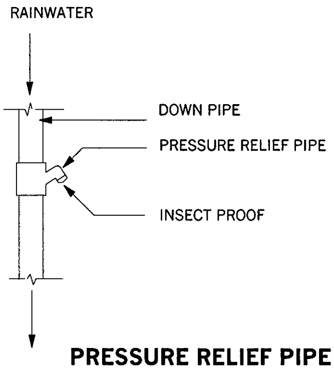
The pipe for supply of rainwater should be separated from the treated piping system in order to prevent contamination of the treated water. For easy identification the rainwater, supply pipe should be painted with a different color from the treated pipe. The details of rainwater use are compiled in the aforesaid "Rainwater, Guideline for Installing a Rainwater Collection and Utilization System" [*5-4].

Reference:

As for a rainwater down pipe and a connecting pipe, the relations between allowable maximum roof area and adopted pipe diameter are provided in Japanese Guideline [5-5] in Japan, as shown in Tables 5.4 and 5.5.

Fig. 5.9 Typical Pipe Arrangement for Heavy Rain Fall





PRESSURE RELIEF PIPE

Fig. 5.10 Device to Separate First Flash Rainwater

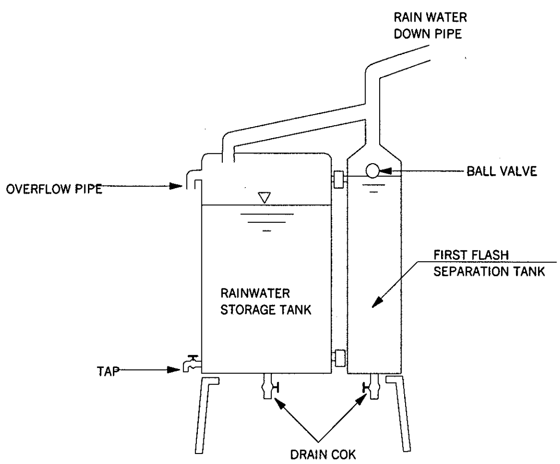
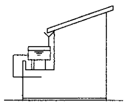
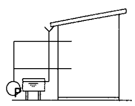
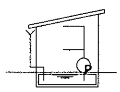
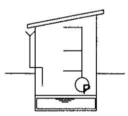
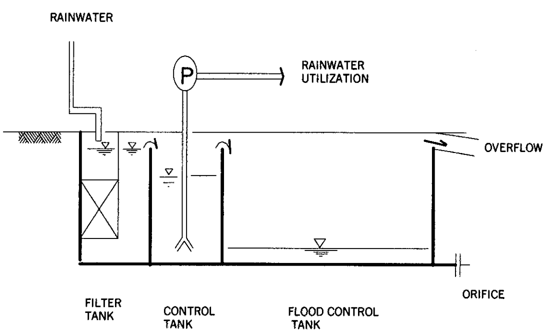


Fig. 5.11 Location of Storage Tank

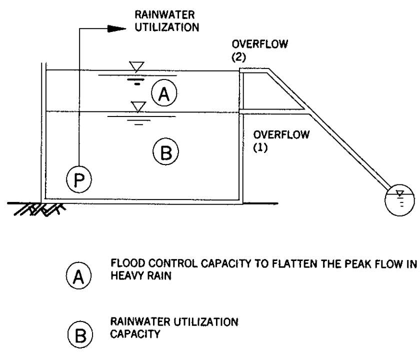
LOCATION OF STORAGE TANK	MODEL	BUILDING	REMARKS
On the roof top		House, condominium	1) Save energy type, water supply can be done 2) Easy maintenance 3) Tank load should be considered for structure calculation
On the ground		House, office building	1) Easy maintenance 2) Water supply can be done with power
At the basement (Overflow can be drained gravitationally)		House, school and office building	1) Suitable for relatively big building 2) Underground structure can be used
At the basement (Overflow can not be drained gravitationally)		Office building, underground parking space	Safety control system shall be provided to store a constant volume of rainwater in the underground storage tank

Source : Air harmony and Samitary engineering Vol. 59, no. 2, by k, sato

Fig. 5.12 Storage Tank with Multifunction



R.C. CONCRETE TANK (UNDERGROUND)



R.C. CONCRETE TANK (ON THE GROUND)

Fig. 5.13 Storage Tank with Infiltration Function

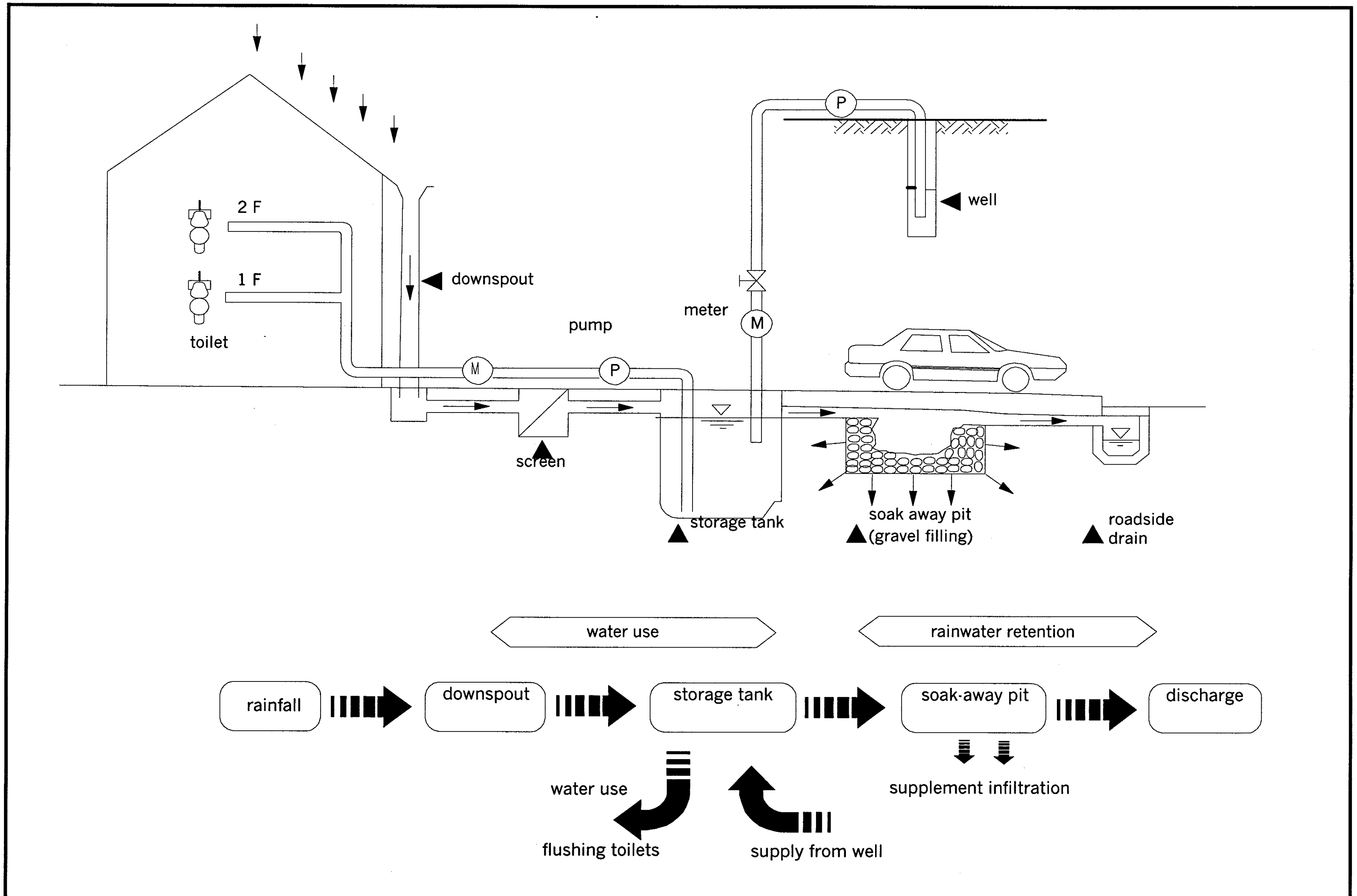


Table 5.4 Down Pipe's Diameter and Corresponding Roof Area

Diameter (mm)	Allowable Max. Roof Area (m2)
50	67
65	135
75	197
100	425
150	1250

Table 5.5 Connecting Pipe's Diameter and Corresponding Roof Area

Diameter (mm)	Allowable Maximum Roof Area (m2)						
	Setting Gradients of Connecting Pipe						
	1/25	1/50	1/75	1/100	1/125	1/150	1/200
65	127	90	73	-	-	-	-
75	186	131	107	-	-	-	-
100	400	283	231	20	179	-	-
125	-	512	418	36	324	296	-
150	-	833	680	58	527	481	417
200	-	-	1470	127	1130	1040	897

Note : (a) A roof area presents a projected area.
(b) An allowable maximum roof area is estimated based on the rainfall intensity of 100mm/hr. For other rainfall intensities the allowable maximum roof area is estimated multiplying the above values by the ratio of 100/(rainfall intensity).
(c) All flow velocities applied for the above range from 0.6 m/sec to 1.5m/sec.