7.00 Urban drainage

7.01 Planning issues

7.01.1 Space allocation

At the earliest stages of development planning it is important to allow adequate space for the installation of both the stormwater conveyance and treatment systems. Preliminary subdivision and development layouts should be drafted with appropriate consideration of required space allocations for stormwater systems, including:

- location of overland flow paths;
- width requirements for both constructed drainage channels and the protection of existing waterway corridors;
- stormwater detention/retention and treatment systems.

In some circumstances, the width of an existing drainage corridor may not satisfy the requirements of current Best Management Practice. For example, an existing overland flow easement on an undeveloped property sized on the width requirements of a concrete lined channel. Wherever practical, the width and location of an existing overland flow easement should not limit the application of current Best Management Practice.

7.01.2 Drainage system form and layout

Stormwater designers are encouraged to incorporate the principles of Water Sensitive Urban Design (also refer to Section 11.03) when planning an urban drainage system. The form and layout of an urban drainage system are influenced by a number of key issues, including:

(a) the preferred location of major overland flow paths;

(b) the retention of "natural" drainage channels and waterways;

(c) the preferred location of major stormwater detention/retention and treatment systems.

(a) Locating major overland flow paths

The location and design of major overland flow paths is often recognised as the most important part of the drainage system. The location and anticipated width of major overland flow paths should be identified and mapped during the planning phase of land developments.

Wherever practical, major overland flow paths should be maintained along their natural flow paths. These overland flow paths need to be contained within a drainage easement either managed by a Body Corporate or government body.

In this context, a "major overland flow path" is defined as an overland flow path that drains water from more than one property, has no suitable flow bypass, and has a water depth in excess of 75mm during the major design storms; or is an overland flow path recognised as "significant" by the local government.

Locating major overland flow paths through residential properties is strongly discouraged, especially in greenfield developments. Designers need to consider the following issues:

(i) Major Design Storm overland flow paths should be one of the first networks defined on a development layout.

(ii) Special care must be taken in the design of overland flow paths at locations where "noise control fencing" may be required.

(iii) Wherever practical, overland flow paths should follow the "natural" drainage paths of the catchment.

(iv) Diverting major overland flows away from their natural flow path may result in significant property damage during storms in excess of the design major storm, or when unexpected debris blockage of the drainage system occurs.

(v) Wherever practical, the spacing/density of overland flow paths within the developed landscape should be similar to the spacing/density of the natural gully lines.

(vi) It cannot be assumed that an overland flow path passing under a residential property fence will be maintained in proper working order. Such flow paths may be blocked by garden beds, garden mulch and/or post-development fencing modifications used to contain domestic pets.

(vii) Overland flow paths within residential properties may also transport excessive quantities of organic matter, including grass clippings and garden mulch. Such debris may result in debris blockages of downstream drainage systems and waterway pollution.

Some of the above issues may not apply to rural residential areas.

Designers shall ensure that wherever practical, the operation of overland flow paths will not compromise emergency access to essential equipment and infrastructure.

(b) Provision of piped drainage systems

Water Sensitive Urban Design does not exclude the use of piped drainage systems, rather it focuses on limiting their use and minimising the "direct connection" of impervious drainage surfaces to piped drainage.

Consideration should be given to the piping of minor flows in the following circumstances:

(i) when it is unsafe, impractical, or otherwise undesirable to carry minor storm flows within an open channel or overland flow path;

(ii) when flow passage within an open drain or overland flow path exceeds the design standards of the flow path (e.g. depth*velocity product, flow width, channel capacity or allowable flow velocity);

(iii) where a piped drainage system is provided in association with a swale or overland flow path to maintain desirable soil-moisture conditions within the drain.

Local authorities should give consideration to the adoption of a maximum desirable catchment area (appropriate for their region) for piped drainage systems.

(c) Provision of grassed and vegetated drainage channels

The application of grassed channels is generally limited by design standards such as the allowable flow velocity, depth*velocity product, or maximum desirable bed width (typically 2.5 metres).

Consideration should be given to the incorporation of the principles of Natural Channel Design (NCD) for the design of constructed drainage channels in the following circumstances:

(i) channels required to have a *natural* appearance;

(ii) when it is necessary to incorporate aquatic or terrestrial habitat, or when the channel forms part of a fauna corridor;

(iii) when rehabilitating a natural drainage channel or waterway within a heavily modified catchment.

For further discussion on vegetated channels and Natural Channel Design, refer to Section 9.06 of this Manual.

(d) Retention of "natural" drainage channels and waterways

Consideration should be given to the retention of existing *natural* channels in the following circumstances (also refer to Section 9.02):

(i) waterways identified as important within a Waterway Corridor Plan, Catchment Management Plan, or similar strategic plan;

(ii) natural waterways with well-defined bed and banks, and associated floodplain/s or riparian corridors.

(e) Planning of drainage schemes within potential acid sulfate soil regions

Guidelines for the planning of drainage systems located within potential acid sulfate soils are presented in Section 9.07.9.

7.02 Design storms – average recurrence interval

The Average Recurrence Interval (ARI) as used in this Manual is the expected long-term average value of the period between exceedances of a given rainfall intensity or discharge.

Throughout this Manual the ARI of the design flood is assumed to be the same as the ARI of the rainfall intensity/duration relationship used to estimate that design flood.

The selection of a design ARI for the minor and major drainage systems is influenced by many factors, including:

- required level of service for hydraulic performance;
- construction and operating costs;
- maintenance requirements;
- safety;
- aesthetics;
- regional planning goals;
- legal and statutory requirements; and
- convenience or nuisance reduction requirements.

Table 7.02.1 shows recommended ARIs for minor and major rainfall events associated with a range of land uses and development categories.

Examples where a higher ARI might be preferred are:

(a) Where runoff from an up-slope catchment is piped through private property and there has been no allowance for, nor opportunity to, protect the property from inundation by floods that exceed the desired standard of service of the pipeline.

(b) Where higher residential densities are likely as a result of long-term infill and population growth, and nuisance flooding may lead to more severe consequences.

(c) Where mixed residential and commercial development is proposed.

In order to determine the desired standard of service (i.e. minor and major ARI values) it will be necessary to assess the Development Category or land use for the catchment and apply that to determine the appropriate ARI values from Table 7.02.1.

Development Categories are broadly defined in Table 7.02.2.

A local government may use different terminology to that presented in Table 7.02.2 in the Planning Scheme for that area. It is the responsibility of the designer to check with the relevant local government to determine the actual

Development Category which is applicable to the land use or zoning, or the potential land use or zoning for the catchments under consideration.

ARI values presented in Table 7.02.1 are RECOMMENDED values for the design of new works and the upgrading of existing systems. The design standard for relief drainage (Section 13.01) may or may not be consistent with Table 7.02.1 depending in part on cost-benefit analysis, site conditions and site constraints.

A local authority may vary the design ARIs shown in Table 7.02.1 to suit local conditions. However, it is recommended that the Minor System ARI should not be reduced below 2 years in respect of the Residential and Industrial Development Categories, nor below 1 year for Open Space, Parks, etc.

Note that in selecting the appropriate ARIs for design, local authorities should consider a number of factors including:

Major System ARI – *Immunity from flooding (including the recommendations of State Planning Policy 1/03), safety, construction costs, and community costs and benefits.*

Minor System ARI – *Convenience and safety of pedestrians and vehicles, construction costs, maintenance costs.*

Discussion on the Major/Minor Flood Management Concept is provided in Section 7.03 of this Manual.

Reference should be made to Table 2.1 of Argue (1986) for design immunity recommended for strategic facilities e.g. Hospitals, Civil Defence Headquarters, Police, Fire and Ambulance.

Table 7.02.1 Recommended design average recurrence intervals

(i) MAJOR SYSTEM DESIGN ARI (years)	50 or 100 [1]

(ii) MINOR SYSTEM DESIGN ARI (years)		
Development Category		
Central Business and Commercial		10
Industrial		2
Urban Residential High Density – greater than 20 dwelling units/ha		10
Urban Residential High Density – greater than 5 & up to 20 dwelling units/ha		2
Rural Residential – 2 to 5 dwelling units/ha		2
Open Space – Parks, etc.		1
Major Road	Kerb & Channel Flow	10 [2]
	Cross Drainage (Culverts)	50 [3]
Minor Road	Kerb & Channel Flow	Refer to relevant development category
	Cross Drainage (Culverts)	10 [3]

Notes:

[1] Refer to relevant local authority for confirmation of required Design Storm ARI. The 50 year ARI is adopted by some local governments for drainage paths where there is expected to be good control of surface roughness (e.g. roadways and well-maintained grass channels). The 100 year ARI is commonly adopted for the design of major waterways and drainage paths where it is difficult to predict actual flow conditions (e.g. channels subject to complicated 3D hydraulics, or drainage paths likely to be subject to significant physical change) or where the surface roughness can be highly variable (e.g. vegetated channels). *State Planning Policy 1/03* recommends adoption of the 100 year ARI flood frequency for waterway flood management planning.

[2] The design ARI for the minor drainage system in a major road shall be that indicated for the major road, not that for the Development Category of the adjacent area.

[3] Culverts under roads should be designed to accept the full flow for the minor system ARI shown. In addition the designer must ensure adequate public safety controls (e.g. d*V product) exist and that the nominated Major Storm flow does not cause unacceptable damage to adjacent properties, or adversely affect the use of the land. If upstream properties are at a relatively low elevation, it may be necessary to install culverts of capacity greater than that for the minor system ARI design storm to ensure unacceptable flooding of upstream properties does not occur. In addition, the downstream face of causeway embankments may need protection where overtopping is likely to occur.

[4] The terms used in this table are described in the Glossary and Table 7.02.2.

Table 7.02.2 Development categories

Central Business:	A section of a city or town where the primary use is for business or retail activities and where buildings are commonly built up to the property boundaries, awnings overhang the footpaths and landscaping is minimal or non-existent. Central business areas are often encapsulated within the older parts of a city or town.
Commercial:	A building or group of buildings where primary uses include retail sales, business activities, health activities, hospitality functions, etc. It may include regional shopping centres, business centres, hospitals, medical facilities, food outlets, sports centres, car sales yards, entertainment facilities, nurseries and the like.
Industrial:	Areas where the primary activities carried out are manufacture, processing, trade sales or storage facilities, etc. e.g. motor vehicle repairs, manufacture, wholesale, warehouses etc.
Urban Residential High Density:	Residential areas which have greater than 20 dwelling units per hectare, including multi-unit residential and cluster housing.
Urban Residential Low Density:	Residential areas which have over 5 and up to 20 dwelling units per hectare e.g. normal detached houses on residential allotments.
Rural Residential:	Rural residential areas which have between 2 and 5 dwelling units per hectare e.g. a house on 2000m^2 to 5000m^2 allotment.
Open Space and Parks:	Open areas primarily used for recreation or drainage including parks, golf courses, trunk drainage channels etc.
Major Road or Minor Road:	Consult the relevant local authority for the appropriate road classification to be adopted i.e. major or minor. Guidance in this regard is given in Section 7.04 and the Glossary. Examples of major roads are: highways, arterial & sub-arterial roads and trunk collector roads. Examples of minor roads are: access places and access streets.

7.03 The major/minor system

7.03.1 General

Design of the drainage system should be in accordance with the Major/Minor Flood Management Concept which recognises the dual requirements of the drainage system to provide for convenience and the protection of life and property for all storms up to the nominated major storm event.

The appropriate Average Recurrence Intervals (ARIs) for design are detailed in Section 7.02 and are applicable to normal design situations. The local government may direct that certain developments or sections of developments be designed for greater or lesser immunity than those outlined. Argue (1986) provides guidance on appropriate "Design Flood Frequency for Strategic Facilities" such as hospitals, Civil Defence Headquarters, ambulance stations etc.

The flow depth and flow spread should be limited by whichever of the criterion in Table 7.03.1 is the most restrictive. These criteria are shown diagrammatically in Figures 7.03.1 (a) and 7.03.1 (b) whilst the manner in which these criteria and those of Section 7.04 restrict flow depth and width within road reserves are detailed in Table 7.04.1 and Figure 7.04.1.

In a system designed in accordance with the Major/Minor Flood Management Concept the flow under both minor and major storm conditions is conveyed partly by the minor surface drain or underground pipe system, and partly by the major surface flow components of the system. As a consequence, it would not be reasonable to say that an underground system has been designed to convey the peak discharge from a storm of given ARI. Rather the system as a whole will convey the flows under both minor and major storm conditions.

Designers should note that constraints on the safe management of the major system discharge may require that the capacity of kerb inlets and underground pipes be increased beyond that required by the design discharge for the minor system alone.

7.03.2 Major drainage system

The major drainage system is that part of the overall drainage system designed to convey a specified major flood event. This system may comprise:

(a) Open space floodway channels, road reserves, pavement expanses and other flow paths that can act as overland flow paths for flows in excess of the capacity of the Minor Drainage System.

(b) Natural or constructed waterways, detention/retention basins and other major water bodies.

(c) Major underground piped systems installed where overland flow is either impractical or unacceptable.

Local governments may adopt a "Defined Flood Event" for waterway flooding in accordance with *State Planning Policy 1/03*. It is strongly recommended that the 100 year ARI is adopted as the Defined Flood Event. It is noted that the nominated Major System Design ARI for such things as overland flow paths may be different from the Defined Flood Event.

The procedures for planning and designing the major drainage system should:

(a) account for the flow conveyed in the underground minor drainage system and for the consequences of malfunctions or blockages in that system;

(b) demonstrate that it is possible to design and construct an inlet system for the minor drainage network that can operate under appropriate levels of debris blockage, otherwise appropriate adjustments must be made to the design discharge of the major drainage system in accordance with (a) above.

The design of major underground pipe systems with no overland flow component is strongly discouraged, and should only be adopted where overland flow is either *impractical* or *unacceptable*. In circumstances where a major underground pipe system is used with no overland flow component, the designer shall prepare a report for the local government. As a minimum, this report shall discuss the following issues:

(i) analytical justification that demonstrates design flows can enter the underground drainage system under appropriate blockage conditions;

(ii) potential effects of flows in excess of the design flow including the consequences of the Probable Maximum Flood (PMF);

(iii) allowances made in the design for debris blockage of inlets;

(iv) potential effects of debris blockages in excess of that allowed for in the design.

When assessing the potential effects of debris blockage, or flows in excess of the design flow, consideration must be given to at least the following:

- floor level flooding;
- adverse affects on the "use" of adjacent land;
- potential, unrepairable property damage (e.g. damage to historical sites, or severe erosion that threatens the structural integrity of major structures).

In cases where potential flow restrictions or diversions are introduced to an overland flow path, then the consequences of such restrictions or diversions shall be considered for flows in excess of the specified Major Storm. The regulating authority may require consideration of flows up to the PMF. If it is not practical to determine the PMF, then a nominal flow rate of four times the 1 in 100 year ARI peak discharge may be accepted by the regulating authority. The assessed consequences shall be discussed with the relevant regulating authority.

7.03.3 Minor drainage system

The minor drainage system includes kerbs and channels, roadside channels, grass or vegetated swales, inlets, underground drainage, junction pits, access chambers and outlets designed to fully contain and convey a design minor stormwater flow of specified "Average Recurrence Interval".

This arrangement may also include:

(a) Field or kerb inlet pits installed to collect surface runoff from within allotments, as well as the roof-water drainage provisions for buildings.

(b) Cross drainage under minor roads where delay or inconvenience during major flows is acceptable. This also includes low flow pipes or box culverts installed under floodways.

(c) Low flow pipes installed under drainage reserves or park areas.

7.03.4 Flow depth and width limitations

The drainage system should be designed so that the flow depth, flow width and pedestrian/vehicle safety limitations are met for the required major and minor design storm conditions. These limitations are detailed in Tables 7.03.1 and 7.04.1 and Figures 7.03.1 and 7.04.1.

Accordingly the underground piped drainage system and the inlets etc. leading to it must be designed to accept that part of the flow which cannot be contained in surface flow paths such as roads, channels and overland flow paths operating under major and minor storm conditions respectively whilst complying with the flow depth/width limitations.

7.03.5 Freeboard

General freeboard recommendations are provided in Table 7.03.1 and Figure 7.03.1. Freeboard requirements for open channel are provided in Chapter 9.

Local governments that choose a Major Design Storm ARI less than 100 years may choose to adopt higher freeboard requirements. Alternatively, the local government may require additional hydraulic checks to ensure floor levels are at least above the anticipated 1 in 100 year peak water level.

Local governments should consider setting minimum floor levels in critical areas to minimise the risk of future building works being constructed below the anticipated 1 in 100 year peak water level.

Table 7.03.1 Flow depth and width limitations

Major system design criteria:

(a) Freeboard not less than 300 mm below Floor Level of an adjacent building (see glossary) where the building is located on ground that is above street level.

(b) Water Surface not greater than 50 mm above top of kerb, where the floor level of an adjacent building is less than 350 mm above top of kerb and the fall across the footpath towards the kerb is greater than 100 mm. Otherwise the flow depth must be restricted to top of kerb in conjunction with a footpath profile that prevents flow from the roadway entering onto the adjacent property. Where no kerb is provided the above depths shall be measured from the theoretical top of kerb.

(c) The product of flow depth and velocity shall be limited by the formula:

$$d_g.V_{ave} \leq 0.6\ m^2/s \qquad (7.01)$$

where: d_g = maximum flow depth (e.g. at kerb invert) (m)

V_{ave} = average flow velocity within the flow path (m/s)

Where the risk to life is reasonably foreseeable, then $d_g.V_{ave} \leq 0.4\ m^2/s$.

(d) The total overland flow for the major flood event shall be entirely contained within a road reserve, drainage reserve, park or open space and shall be limited to such depth to ensure a minimum 300mm freeboard below the floor level of an adjacent building.

(e) Maximum flow depth of 250 mm at kerb in roadways. Maximum flow depth of 200 mm in car parks and other trafficable (vehicular) areas where the flow depth is near uniform across its width or the width of the trafficable area.

(f) Maximum energy level of 300 mm above roadway surface for areas subject to transverse flow (e.g. causeways and overtopping flows at roadway culverts).

(g) Where flow is contained in an open channel, freeboard in accordance with Section 9.03.4.

(h) Such other limitations or relaxations as may be set by the local authority.

Minor system design criteria:

(a) The underground drainage system together with associated inlets, access chambers, outlets, etc. shall be designed to convey the discharge for the design minor storm with road flow limited as detailed in (c) below.

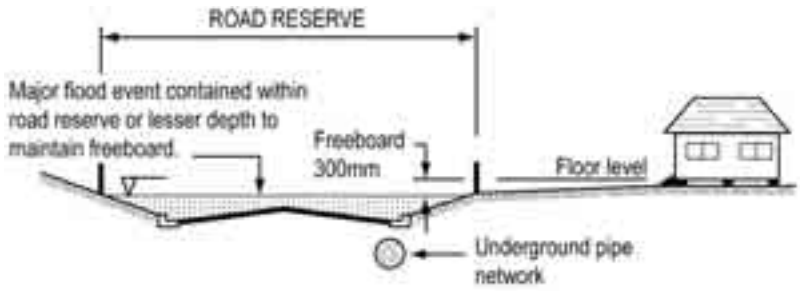
(b) Field inlets shall be provided to collect allotment runoff as detailed in Section 7.13.

(c) Road flows shall be restricted by:

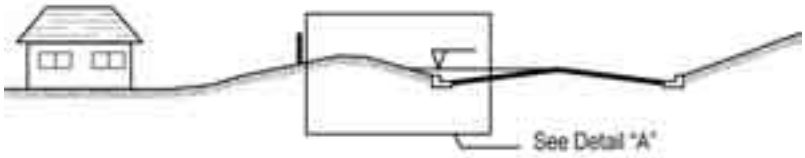
(i) Flow spread limitations on the road pavement and the positioning of kerb inlets as detailed in Sections 7.04 and 7.05.

(ii) Flow conditions limited by; $d_g.V_{ave} \leq 0.4\ m^2/s$ for flow transverse to the road alignment where the risk to life is reasonably foreseeable.

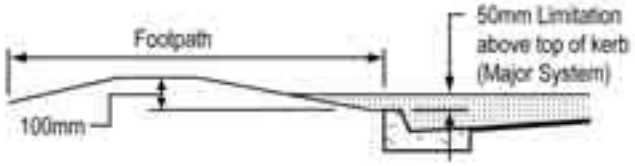
(d) The total flow for the minor flood event shall be contained within the drainage easement or drainage reserve provided through a park or open space.



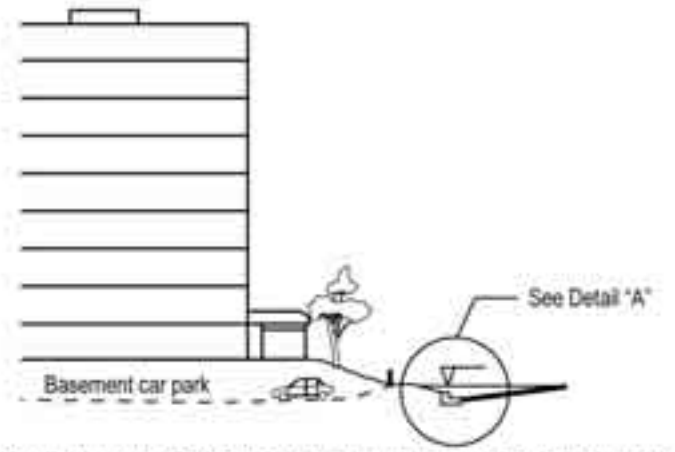
BUILDING ABOVE TOP OF KERB & CHANNEL



BUILDING BELOW TOP OF KERB & CHANNEL

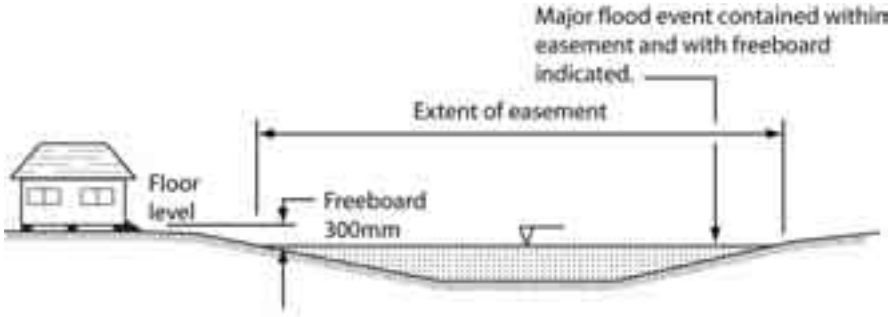


DETAIL "A"

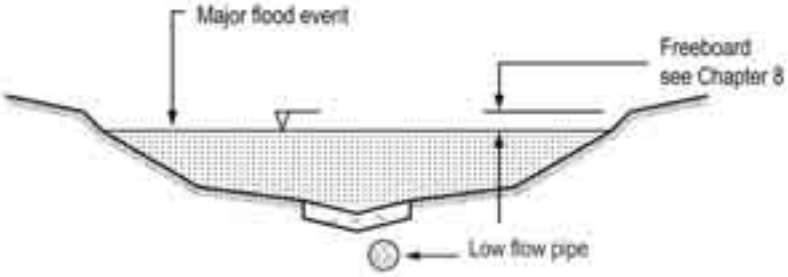


MULTI-UNIT OR COMMERCIAL DEVELOPMENT WITH BELOW GROUND CAR PARKING, OR BUILDING SERVICES

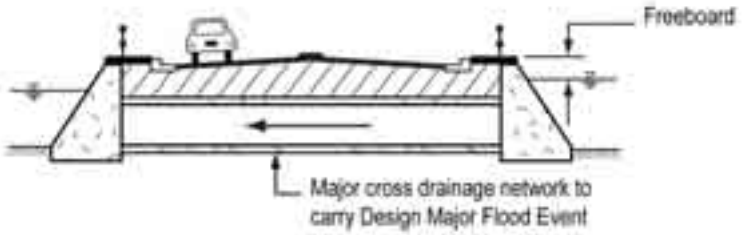
Major storm flow design criteria
Figure 7.03.1 (a)



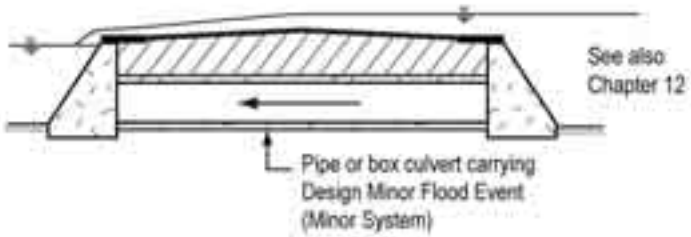
OVERLAND FLOW PATH – EASEMENT WIDTH REQUIREMENTS



CHANNEL WITH OR WITHOUT LOW FLOW PIPE



CROSS DRAINAGE – MAJOR ROAD



CROSS DRAINAGE – MINOR ROAD

Major storm flow design criteria
Figure 7.03.1 (b)