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1.0 INTRODUCTION

This chapter should be read in conjunction with the Water Quality Management Guidelines in Part C of this document. The planning, design and implementation of stormwater drainage should integrate the two distinct components of stormwater management, ie water quantity and water quality. The stormwater drainage system should:

- Prevent or minimise adverse social, environmental, and flooding impacts on the City's waterways, overland flow paths and constructed drainage network.
- Ensure that the design of channel works as part of the development maximises the use of natural channel design principles where possible.
- Achieve acceptable levels of stormwater runoff quantity and quality by applying total water cycle management and water sensitive urban design principles.

Unless stated otherwise in this document, the planning and design of urban stormwater drainage systems should conform to the requirements of the latest version of *Queensland Urban Drainage Manual* (QUDM).

2.0 GENERAL

2.1 LAWFUL POINT OF DISCHARGE

It is a matter of settled law that any owner of a property through which stormwater flows who develops or alters their property in any way owes a duty of care to any property owner receiving those stormwater flows to ensure that any additional flows caused by the development do not cause unreasonable damage. The duty of care extends not just to the owners of immediately adjoining lands but also to owners downstream from the adjoining land.

That duty of care can be satisfied by:

- Diverting the flows around the property that would otherwise be adversely affected.
- Obtaining the consent of the downstream owner/s to that flow.
- Providing infrastructure on the downstream property that mitigates the adverse effects of the increased flow.

When land is subdivided or developed, the roof and surface water runoff from that land and any external catchment (through the development site) must be discharged to a lawful point of discharge acceptable to Council.

Designs which result in concentration of water onto an adjoining property or rely on the construction of drainage through an adjoining property will not be accepted unless written approval is obtained from downstream owner/s of any affected property. **Evidence of a lawful point of discharge should accompany the engineering drawings for any approval to be given**. If a satisfactory lawful point of discharge cannot be achieved the development cannot proceed. The lawful point of discharge and full details at the outlet should be shown on the engineering drawings.

The effects of the discharge (up to and including the Q_{50} or Q_{100} storms) from a development site on other properties by virtue of increased runoff, increased concentration of runoff, change to the existing overland flow, or change to the existing point of concentration, must be assessed in the design. Any of these effects as well as increased flow depth for the same Average Recurrence Interval (ARI) will require a lawful point of discharge to be obtained. In addition to obtaining the downstream owner's permission, easements may be required over the drainage systems within the downstream properties.

The **lawful points of discharge** may be one of the following, depending on the site situation.

1. To concrete kerb and channel, gullies or existing enclosed stormwater drainage system abutting the allotment. The applicant should also demonstrate compliance with the permissible flow width, flow depth and depth velocity product.
2. To the road reserve provided the concentration of stormwater does not adversely affect the drainage capacity of the road and/or adjoining properties.
3. Through adjoining private property at the rear of the allotment to concrete kerb and channel or existing enclosed drainage system providing written permission is obtained from the downstream adjoining property owner.
4. To an existing enclosed drainage system (excluding any foul water lines) within 50 metres of the site provided the system has the capacity required. Calculations should incorporate future upstream developments.
5. To concrete kerb and channel and thence to a new stormwater inlet to be provided by the Developer at a location removed from the site.
6. To an existing stormwater drain within the property or by written permission of the adjoining property owner, to a stormwater drain in adjoining properties.
7. To kerb and channel or existing enclosed drainage system higher than the allotment from a drainage pit within a site by pumping. This method will only be considered in developments pertaining to material change of use, refer to Section 2.5.

2.2 STORMWATER OUTLETS

The publication *Stormwater Outlets in Parks and Waterways Guidelines* (Brisbane City Council, 2003) sets out the requirements for stormwater outlets in parks to achieve the best possible balance between the diverse competing opportunities and the constraints of parks, waterways and wetlands.

The applicant should not assume that drainage channels, overland flow paths, drainage outlets, energy dissipators or stormwater detention/polishing basins will automatically be permitted in public space (newly created Council asset or existing Council asset). Further, it is unlikely that filling of existing natural drains/watercourses would be permitted without Council approval. Prior to the design of any stormwater discharge facility into Council controlled land, the applicant should consult with the relevant Development Assessment Officers, usually the Open Space Planner or Ecologist, to:

- Ensure that the proposal is accepted.
- Ensure that the proposal complies with the park character plans and park objectives.
- Ensure that the proposal complies with the Park Code and Waterway Code of the *Brisbane City Plan*.
- Determine the levels of impact assessment required.

Stormwater outlets in any public space (existing or newly created Council asset) must be addressed at the initial application (conceptual design) stage, and not be deferred to the operational works assessment stage, as the method of stormwater conveyance and treatment could influence the development's design, layout and cost.

CHAPTER 2 STORMWATER DRAINAGE

The applicant must submit concept drawings to Council for initial review at the time of assessing the development application and obtain subsequent preliminary approval during this time. Detail calculations and drawings can be submitted at the later stage of operational work assessment. A site inspection will probably be required prior to construction.

Where the stormwater discharge is across a public space designated for active recreation, piped drainage must be provided for the minimum Q_1 storm to ensure that the function of the amenity is not diminished.

Where the open space function is not governed by spatial constraint and the catchment area exceeds 30 hectares, the opportunity to construct or enhance a natural self sustaining drainage channel (as opposed to enclosed pipe drainage) must be maximised.

Where piped drainage is installed, and wherever practical, vegetated swales may be required downstream from the pipe outlet to provide additional treatment to stormwater runoff. Vegetated swales should be placed along the interface of the riparian vegetation and the park. The location of discharge point at the riparian corridor must be selected to minimise disturbance and intrusion.

2.3 PIPE CONNECTION TO COUNCIL INFRASTRUCTURE

Permits

A permit must be obtained from Council before any pipe connection can be made to Council infrastructure. Prior to backfilling, the works at the connection must be photographed from different angles to gain a full picture of the connection, and inspected by a Registered Professional Engineer in Queensland. The inspection report and photographs must be forwarded to Council for consideration and records.

Connection to kerb and channel

Refer to Section 5.1.2 and Section 5.2.1 for prefabricated kerb adaptors and hot dipped galvanised RHS.

Connection to existing stormwater pipe

This method can be used where the diameter of the entry pipe is less than 200 mm, and the host pipe diameter is at least 4 times larger than the entry pipe diameter. The connection should be made in the top half diameter of the host pipe by core drilling (for steel reinforced concrete pipe) or installing a saddle junction (for fibre reinforced concrete or steel reinforced concrete pipes or polypropylene/polyethylene pipes). The entry pipe must be installed flush with the internal wall of the host pipe and the connection sealed using an appropriate epoxy resin in a manner acceptable to Council and the pipe manufacturer.

Note: It is unacceptable to break into the existing pipe by physically punching a hole with a hammer or jackhammer. This method can create a hole that is irregular and oversized. The exposed reinforcement and unnecessary spalling to the inside of the pipe surface can damage the pipe structure.

Connection to existing gully pit

This method can be used where the diameter of the entry pipe is ≤ 300 mm and surcharge of the gully does not occur. The connection should be repaired using cement mortar and finished flush with the internal wall. Unless approved otherwise by Council, the pipe connection must be located below the lintel and where the entry pipe diameter exceeds 200 mm, this pipe must be installed at the pit invert.

Connection to existing manhole

This method can be used where the diameter of the entry pipe is ≤ 675 mm. The connection must be repaired using cement mortar and finished flush with the internal wall. A minimum 150 mm clear distance is required between the inlet pipes. For complex manholes with more than two inlet pipes, benching is required to the floor of the manhole (to half the diameter of the outlet pipe). For the larger diameter entry pipes, new manholes must be constructed.

2.4 EASEMENTS

2.4.1 When are Easements Required

Drainage easements are corridors registered on a certificate of title for the purpose of underground drainage pipes and/or overland flow paths. Any construction within the drainage easement and/or near/over stormwater infrastructure must be avoided whenever possible. This approval process is outlined in Section 2.6 Building Over/Near Stormwater Facilities. Pipe drainage easements are required over any pipe 225 mm diameter or larger.

2.4.2 Types of Easements

Roofwater reticulation

Roofwater drainage reticulation pipes of 225 mm and 300 mm diameter must be provided with an easement 1.5 m wide in favour of Council. Roofwater reticulation drainage of 150 mm diameter (ie servicing up to 3 single house lots of nominal 180 m^2 roof area each) does not require an easement.

Underground pipe drainage

This easement allows for the construction and/or maintenance of underground drainage. Approval to build over an easement should be in writing and does not alter the terms of the easement agreement.

The minimum easement widths required for underground pipe drainage other than roofwater lines must be the greater of 3.0 m or the outside pipe diameter/culvert box width plus 1.0 m clearance distance from edge of pipe/culvert. For example, 3 m easement widths apply to single pipes 300 mm to 900 mm diameter.

Open cut drainage

This type of easement allows for the construction and maintenance of an open drain or channel within the easement. The easements must be wide enough to incorporate berms along the top of open channel. See Section 5.6.7 for berm requirements.

Overland flow

This provides for passage of stormwater along the easement and prohibits the erection of structures, the alteration of surface levels, and any activity within the easement which may obstruct the flow of storm runoff, eg debris retentive fences, landscaping, walls, filling. The easement must be the full design flow width and vegetated or paved to prevent potential scouring.

Access

Access easements permit Council to have access from a surveyed road to an easement to facilitate construction and/or maintenance of the drainage facility. (Unless agreed otherwise by the property owner, the access is usually the most direct route through the property.) This will normally form part of all underground open cut and overland flow easements.

Combined underground/aboveground drainage

Combinations of the above easement types will often be required eg underground and overland flow where there is an overland flow associated with piped drainage.

Portion of land subject to waterway inundation

A waterway (including those indicated on the Planning Scheme Maps) is defined as any element of a river, creek, stream, gully or drainage channel, including the bed and banks. Easement over the 100y ARI inundation extent is required to preserve hydraulic conveyance and floodwater storage.

2.4.3 Variation to Easement Terms

There is no statutory procedure for the variation of a registered easement except by decision of Council. A variation or modification of the terms of the easement agreement can be achieved by surrendering the existing easement and by the granting of a new easement. All costs are the responsibility of the applicant.

2.4.4 Extinguishment of Easements

To have an easement extinguished, the owner of the property has to obtain the agreement of the grantee (ie the Council) to execute a surrender of the easement and have that surrender document registered by the Registrar of Titles. Council may also wish to recover previously paid compensation monies at the present market value. All costs are the responsibility of the applicant.

2.5 PUMPED STORMWATER DRAINAGE

2.5.1 General

A pumped drainage system is only permitted in developments pertaining to material change of use such as Community Titles Scheme, commercial and industrial developments. Council will only consider a pumped stormwater drainage system if:

- Council is satisfied all other avenues have been exhausted.
- Letters of refusal are received from all property owners through which the roofwater line could be taken by gravity to the street, including acknowledgement that significant overland flow will occur at times of power or mechanical failure.
- It is part of a comprehensive stormwater recycling system.

Further, the applicant must satisfactorily address the following requirements.

- A suitably experienced Registered Professional Engineer in Queensland (RPEQ) should be engaged to prepare and certify the design. Further the RPEQ should inspect the works during construction to ensure that the design intent is achieved and certify same. Refer to Chapter 1 of Part D of this document.
- Demonstrate that the overspill can take the form of sheet flow and reflect pre-development conditions when the pump capacity is exceeded.
- Demonstrate that in the event of malfunction, the consequences are not catastrophic. For example overflows should leave the site in a safe manner and not inundate habitable or non-habitable areas within and external to the site.

2.5.2 Pumps and Storage

The pump well storage and pump capacities must be designed for the minimum 10 year ARI critical storm burst. The critical storm burst is the storm duration that dictates the maximum active storage size, and this storm duration is usually independent of the sub-catchment time of concentration. Typically pumping and storage characteristics during smaller storm events (eg 2, 5 and 10 year ARI) for a range of duration (say up to 2 hours) would need to be investigated, to ensure that the pump operates within the manufacturer's recommendations.

In some instances the 10 year ARI design event maybe inadequate. For example, pumps may need to be sized for more extreme storm events when dewatering basement carparks or where overland sheet flows cannot be achieved.

Council prefers that the pumped systems be discharged directly to a gully, a manhole or a drainage line. Direct discharge to a kerb and channel is not permitted. Where the kerb and channel is the only lawful point of discharge, the outlet from the pump should feed to a storage manhole which then drains by gravity to the kerb and channel. Regardless of these disposal methods, a check of road capacity and existing drainage system is required to demonstrate that there are no adverse impacts.

Storage areas can be a combination of underground and aboveground areas, for example, shaped car park or landscaped area to hold water till pumping system restarts. However care needs to be exercised with aboveground storage area that public safety or amenity is not compromised.

The pump well design must consider the following factors.

- Minimise deposition of solids.
- Excessive foaming and air entrainment (usually caused by stormwater dropping from a high level inlet pipe) in the wet well to be avoided.
- Structural design to resist uplift, soil and water pressures.
- Suitable openings to enable pump removal, and for electrical and pipework access.
- Sufficient space to be provided around the chamber for maintenance access and sufficient headroom for lifting tackle to be erected so as to raise the pumps if necessary.

The pump design must consider the following factors.

- In addition to the operating duty pump, an equivalent standby pump (ie of equal size to duty pump) must be installed to safeguard against mechanical failure.
- In order to assure reliability of the standby pump, the pumping system must be set up by automatic rotation to ensure that the hours run by both the duty and standby pumps are approximately similar.
- The most likely stormwater pump station configuration is usually the submersible wet well centrifugal type pumps normally employed in the wastewater industry. These pumps are available off the shelf and come in an extensive range of sizes and configurations. They are also not self priming ie they require a positive head at their inlet in order to commence pumping without initial priming (removal of air from the pump casing).
- Pump sizing calculations must incorporate the system resistance, pump duty point, frequency of pump motor starts, etc.

The property owner is responsible for all costs associated with installation, operation and maintenance; and is liable for all damages as a result of system malfunction.

2.6 BUILDING OVER/NEAR STORMWATER FACILITIES (BONSW)

2.6.1 General

The primary objective of BONSW approval is to protect existing stormwater facilities from damage. It is preferred that buildings and structures are located clear of stormwater facilities either on the existing or diverted alignment. In the context of this document stormwater facilities are defined as any component, whether by way of natural topography (eg gully or depression forming the overland flow path) or constructed infrastructure (eg open cut channel, pipe, conduit, manhole), that forms part of a stormwater drainage system. BONSW approval must be obtained from Council prior to the issuance of any building/development approval.

Approval of building/development applications without due consideration of the likely adverse impacts on stormwater facilities can often lead to undesirable outcomes including:

- Nuisance flooding. This can occur when a slab on ground building is constructed in or across the overland flow path thereby blocking flows and leading to flow diversion to neighbouring properties or when the floor level is set below an acceptable inundation level from adjacent overland flow paths.
- Degradation or damage to the stormwater infrastructure. This can occur when the stormwater infrastructure (eg pipe, manhole, pipe trench) is disturbed during construction, or when additional loads are transferred to the pipe system eg through inappropriate foundation design, or accidental damages incurred due to lack of knowledge of the presence of any underground infrastructure.
- Unexpected costs and time delays. This can occur when stormwater infrastructure is discovered during advanced excavation thus requiring redesign of foundation, or repair costs to damages sustained during construction.
- Inadequate provision of accessibility for future maintenance.
- Development of properties in overland flow paths where insufficient flood free land is available for a building pad.

For development constraints on aboveground facilities, refer to Chapter 1 of Part A of this document. Building work proposed over or near underground stormwater facilities (BONSW) is not permitted under one or more of the following criteria.

- The creation of a new lot (typically reconfiguring a lot in an established area eg 1 lot into 3 lots) containing stormwater pipe infrastructure outside the statutory boundary clearances[1].
- It is viable to relocate stormwater facilities clear of the development without creating adverse hydraulic impacts.

[1] The statutory boundary clearances are generally in accordance with the Building Act 1975. For the purpose of assessment, these measurements are taken to be:
- 6.0 m road boundary clearance.
- 1.5 m side and rear boundary clearances.

2.6.2 Assessment Triggers

For **aboveground stormwater facilities** with or without drainage easements, a Building Over/Near Stormwater (BONSW) application will be required if the site is subject to any one or more of the following conditions.

- Any proposed works contravening the drainage easement terms. The easement conditions usually prohibit any part of the building extending over the drainage easement.
- Open cut channel for the passage or conveyance of stormwater traversing the site.
- Overland flow path traversing the site, whether natural or excavated/engineered grassed or landscaped swales.
- Overland flow path over underground drainage system on site, as commonly encountered in city streets and developments such as carparks, estates and shopping centres.
- Combined underground drainage and overland flow on site. This is the most common basis for conveyance of stormwater in new estates whereby minor flows are piped and excess flow is channelled via an engineered or landscaped topography.
- Stormwater pipes strapped to the underside of building basements or aboveground pipes fixed to roof and wall. Aboveground pipes can occur on rare occasions where it is not possible to relocate the pipe clear of the structure, generally because the building is constructed right to the side boundaries. The risks of consequential pipe failure should be assessed. (Note: In a few areas of Brisbane, stormwater drains are visible and in some cases partially above surface levels).

For **underground stormwater facilities** with or without drainage easements and where pipes or conduits are greater than or equal to 150 mm in diameter or width, a Building Over/Near Stormwater (BONSW) application will be required if the site is subject to any one or more of the following conditions.

- Any proposed works contravening the drainage easement terms.
- Any earthworks (filling or excavation) proposed directly over or adjacent to the stormwater drainline or manholes that will result in changes to surface levels or loading conditions over these stormwater facilities. (Note: Typical minimum covers over pipes are 600 mm in non-trafficked areas, 750 mm in vehicular trafficked areas, 300 mm under bridging or concrete slabs.)
- Any building work proposed over the stormwater drainline or manholes. This is generally not permitted, refer Section 2.6.1 for details.
- Any proposed footing system that is bored or excavated (eg beams, slabs, footings, and piers) within 2 metres (edge to edge distance) of the stormwater drainline or manhole.
- Any proposed footing system that is driven or vibrated or jacked (eg piles and piers) within 6 metres (edge to edge distance) of the stormwater drainline.
- Any proposed works that will affect the structural integrity of the drainline or its trench.
- Proposed changes to the loading conditions on an existing manhole cover, for example, changing the use of a non-vehicular trafficable area to a vehicular trafficable area.
- Proposed use of rock bolts or ground anchors within 2 metres of the stormwater drainline.
- Proposed property access width of less than 2 metres from the front entrance or access road to any manhole or property connection located on site.

- Proposed driveways or concrete pavements over manholes or property connections.
- Clashing of services or utilities (other than sewers) with the stormwater drainline that may affect the structural integrity of the stormwater drainline or its trench, or sewers larger than 150 mm diameter crossing any stormwater drainline.

The following information must accompany the BONSW application.

- Payable fees.
- Photographs if desired.
- Site plan (layout and elevation) showing existing and/or proposed elements such as location, size, and depth of pipe and manholes; structure clearances; foundation details, etc. (Note: Bridged footing details should be designed and certified by a suitably experienced Registered Professional Engineer Queensland).
- Title search details to confirm the presence or absence of any drainage easement.
- If a drainage easement is present, the applicant must supply a copy of survey plan and title deed detailing the extent and terms of the easement. The applicant can obtain these details from the Land Interests and Titling Office, Queensland Department of Natural Resources and Mines.
- Appropriate hydrologic and hydraulic assessments by a suitably qualified and experienced Registered Professional Engineer in Queensland (RPEQ). A hydraulic grade line analysis report is required to assess head losses and surcharge characteristics, in particular, when the proposal involves the raising and lowering of manholes or where additional manholes and bends are added to the stormwater drainage system on a diverted alignment.
- Pre construction pipe surveys. (Note: The post construction and any subsequent pipe surveys should be submitted prior to the issuance of a Certificate of Classification (where there are no contributed assets) or prior to the acceptance Off Maintenance (where contributed assets are involved)).

2.6.3 Pipe Surveys

<u>General</u>

Pipe surveys are required to determine the pipe condition at the pre and post construction stages. (Note: In older areas of Brisbane, some 150 mm and 225 mm diameter pipes discharge from street gullies, traversing private properties). The applicant must submit both a hardcopy report and a video display of the closed circuit television camera (CCTV) inspection.

The CCTV inspection report and video must be viewed by an RPEQ prior to submission to Council. Any additional defects should be identified and remedial measures recommended by the RPEQ. Remedial measures for all additional defects must be submitted to Council for approval. Once the remedial measures have been completed, a follow up survey is required to demonstrate that they have been carried out to Council's satisfaction.

To achieve a high level of consistency, it is recommended that the same contractor be engaged to undertake both the pre and post construction (and any subsequent) surveys. All costs must be borne by the applicant.

CCTV inspections of pipes can be arranged through Local Asset Services, Brisbane City Council (Contact: Coordinator Asset survey, officer code LCAS, telephone 3403 8888) or other service providers. Any person entering Council's stormwater drains must fulfil the requirements of the Workplace Health and Safety Act 1995 (eg confined space training).

Survey protocol

The CCTV pipe survey must conform to Brisbane City Council's standard inspection and reporting protocols, achieved by using the WinCan CCTV data capture and asset management software customised to Council standard format.

If longitudinal cracks are observed at the obvert of the pipe, particular attention should be paid to the invert and the 3 o'clock and 9 o'clock positions for evidence of crushing. All cracks should be closely monitored whilst the camera is in motion. All joints should be fully scanned (over 360°) whilst the camera is stationary. Particular attention should be paid to possible infiltration at joints and connections. All connections should be closely inspected; their diameter, type and position being recorded.

The video display and hardcopy report should show all the faults, features and connections in the line. The typical example given below illustrates the reporting format to Council's standard procedures and fault codes.

Manhole 133 → Manhole 132 (upstream), Line 125, 900 mm cast-in-situ concrete.
Distance:

1.6 m	-	start survey
29.0 m	-	spalling, position 9 o'clock, width 50 mm, length 100 mm, depth 40 mm
49.3 m	-	minor faulty 100 mm connection, position 1 o'clock
53.7 m	-	protruding 150 mm connection, position 12 o'clock, depth 400 mm
70.8 m	-	change in pipe material, length 1500 mm
70.8 m	-	minor longitudinal crack, position 12 o'clock, depth 1000 mm
73.2 m	-	minor tree roots up to 25%, position 3 o'clock, length 3000 mm
80.4 m	-	up to 25% debris, width 200 mm, length 1500 mm, depth 20 mm
85.0 m	-	major eroded invert, length 13500 mm, width 700 mm, depth 100 mm
105.0 m	-	survey completed

2.6.4 Pipe Rehabilitation

Following assessment of the pre construction pipe survey information, Council will advise the applicant if there are any repairs or future works required prior to construction within the site. Council may require that degraded pipe be repaired, replaced or diverted as part of the BONSW approval conditions. Council may also seek appropriate cost contribution from the applicant.

2.6.5 Access and Clearance

General

The provision of an unimpeded access corridor to the stormwater infrastructure is required to facilitate pipe maintenance, relining, rehabilitation or replacement. It is preferred that structures are located clear of aboveground and underground stormwater facilities either on existing or diverted alignment (refer Case 1). Where there is combined underground and aboveground drainage facilities, the more stringent access and clearance criteria will apply.

Manhole clearance

Manholes must remain accessible when the development is completed ie a minimum 2.0 m radius from centre of cover must be maintained. Suitable and permanent access must be provided from the front boundary or access road to all manholes without having to pass through buildings. The access way must be at least 3.0 m wide and achieve a minimum height clearance of 2.5 m. Manholes must be raised or lowered to match the finished surface level.

Access corridor over pipe

Where the building structure is built over existing stormwater pipes, a minimum 3.0 m wide corridor (or the greater dimension comprising the nominal pipe diameter plus 1.0 m horizontal clearance each side) should be provided over the affected pipe length to facilitate future pipe maintenance and replacement.

For suspended structures over pipes (refer Case 3), a 2.5 m undercroft[2] height clearance (3.0 m height if finished floor levels are referenced) is also required. Where the vertical height clearance cannot be achieved or for slab on ground structures (refer Case 2), piers (founded at least 0.6 m below the pipe invert and 1 m horizontally clear of the pipe) are required to support a minimum 3.0 m span bridging slab. The bridged foundation allows the option of future pipe replacement by tunnelling or boring.

Foundation clearance

An adequate buffer zone is required between the edge of the foundation system and the edge of the stormwater infrastructure to minimise structural damage during excavation, boring or piling operations. The following minimum horizontal clearances may need to be increased if it is anticipated that the pipe bedding will be affected.

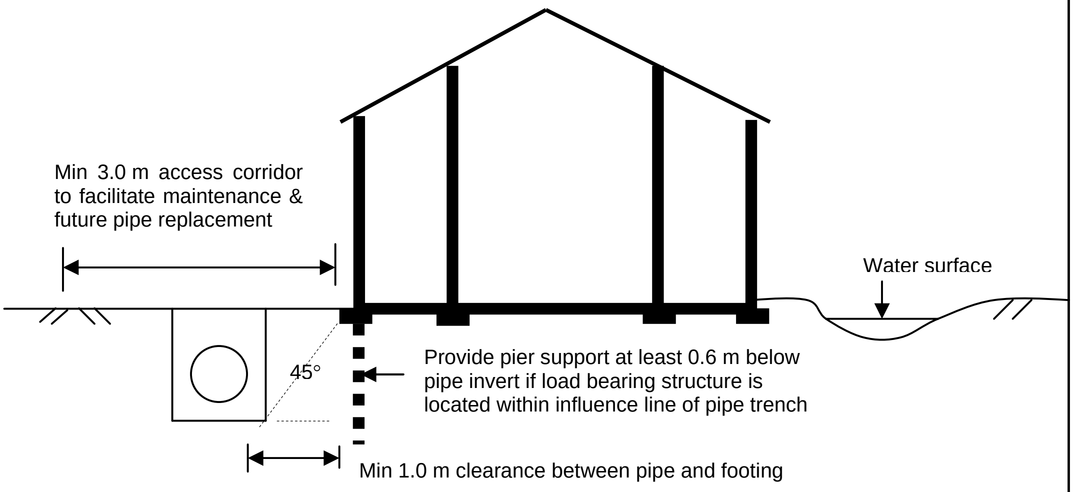
- 1.0 m clearance applies to an excavated footing system such as piles, beams and pad footings, excavated by backhoe or similar.
- 1.0 m clearance applies to bored piers.
- 6.0 m clearance applies to driven or vibrated or jacked piles.

Aboveground stormwater facilities

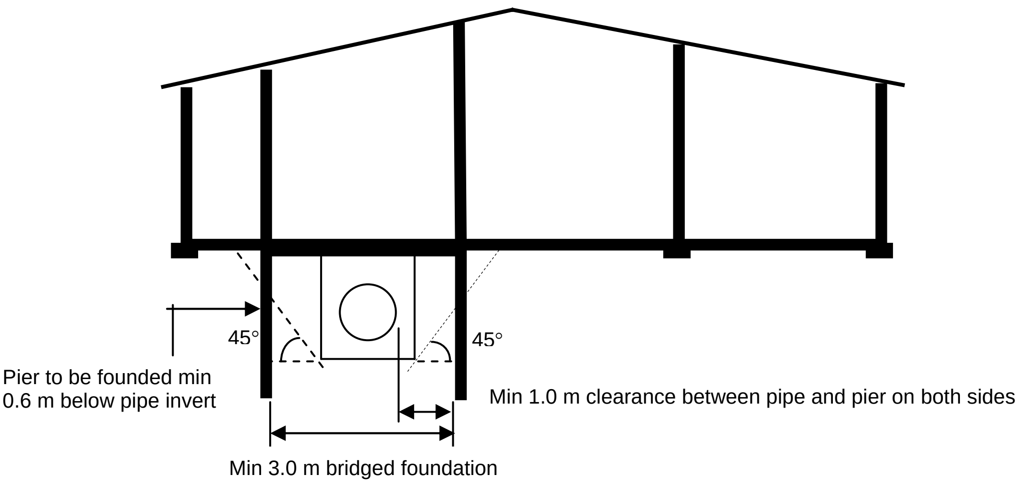
For development constraints on aboveground stormwater facilities, refer to Chapter 1 of Part A of this document. For suspended structures over aboveground stormwater facilities such as overland flow paths, a 2.0 m undercroft height clearance (2.5 m height if finished floor levels are referenced) is required for unimpeded flow conveyance and for maintenance purposes. Inundated areas under the buildings must paved and adequate scour protection provided elsewhere.

[2] Undercroft is measured from the floor to the lowest appurtenance on the ceiling ie bearers, fire sprinklers, overhanging pipe systems, light fixtures, signs, etc.

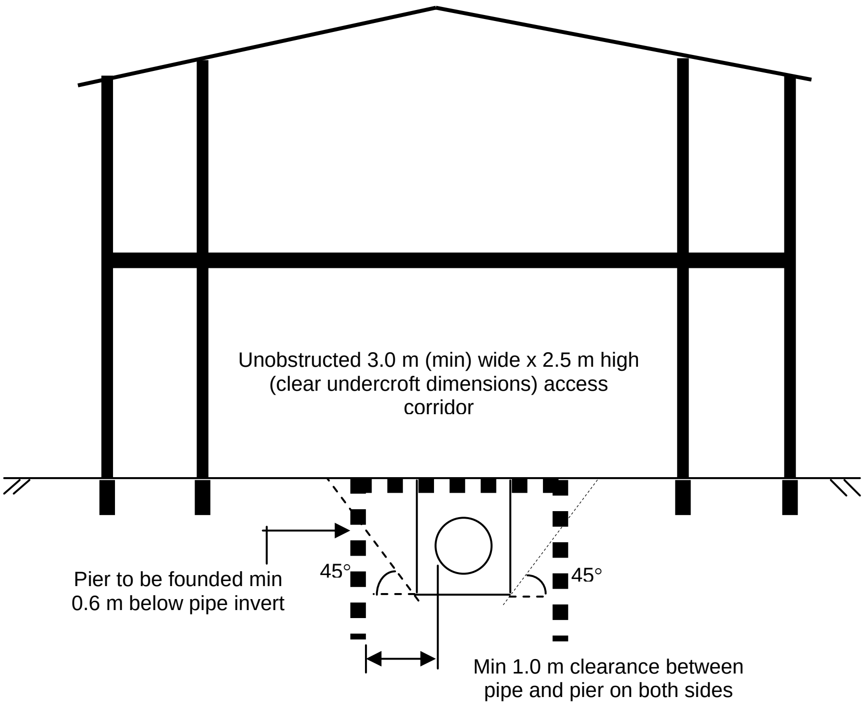
Case 1 (preferred): Structures located clear of aboveground and underground stormwater facilities either on existing or diverted alignment



Case 2: Slab on ground structures built over stormwater pipe



Case 3: Suspended structures built over stormwater pipe



3.0 DESIGN PARAMETERS

3.1 GENERAL

The following factors must be considered in the design and selection of the final drainage treatment:

1. Design discharges based on the ultimate development in the catchment.
2. Future maintenance requirements to ensure the drainage facility continues to meet its design performance.
3. Safety of persons particularly children.
4. Erosion and siltation both within and on adjoining properties not increased as a result of the development.
5. The existing treatments of other sections of the drainage system.
6. The general amenity of the area and particular use of parkland.
7. Environmental issues, including vegetation protection orders (VPOs), maintenance of natural channels and buffer vegetation, preservation and rehabilitation of flora and fauna habitats, riparian vegetation, archaeological values, heritage values, water quality and existing features such as wetlands.
8. Integration of total water cycle management.

3.2 DESIGN STORMS

In certain situations where no internal road dedications are proposed, drainage of stormwater from road reserves fronting the site may discharge onto and through the subject subdivision toward or along a defined natural watercourse. This stormwater must be managed in such a way as to preserve the amenity of the allotments that are affected. Easements are required over drainage outlets from road reserves (minimum 10 metres in from the property alignment by 3 metres wide).

The major and minor drainage systems as described in Section 5.03 of *QUDM* forms the basis of the drainage system within the urban area. The design standards are given in Table B2.1.

The major drainage system is that part of a drainage system in a catchment that is designed to convey rare design storms. The system may comprise open space floodway channels, road reserves, pavement expanses, overland flow paths, natural or constructed waterways, detention/retention basins and other major water bodies. Where the major system is within the road reserve, the design standard is the 50 year ARI storm event.

The minor drainage system is that part of a drainage system in a catchment that controls flows from the minor design storm such as the 2 year ARI and 10 year ARI events. The system usually comprises kerbs and channels, roadside channels, gully inlet pits, underground pipes, manholes and outlets.

TABLE B2.1 DESIGN STANDARDS FOR MAJOR/MINOR DRAINAGE SYSTEMS

Development category	**Design parameter**	**Design standard**
2-5 dwelling units per hectare (typically in Rural/Environmental Protection Areas where predominant uses include house on large allotment and farm)	Minor drainage system Major drainage system	Minimum 2y ARI Minimum 50y ARI (less piped flow if applicable)
>5 and ≤ 20 dwelling units per hectare (typically in Low Density Residential Area comprising mainly one or two storey single houses)	Minor drainage system Major drainage system Roofwater drainage	Minimum 2y ARI Minimum 50y ARI (less piped flow if applicable) Level II *QUDM* Section 5.13.4
>20 dwelling units per hectare (typically in Low-medium to High Density Residential Areas comprising multi-unit dwellings)	Minor drainage system Major drainage system Roofwater and lot drainage	Minimum 10y ARI Minimum 50y ARI (less piped flow if applicable) Level III and IV *QUDM* Section 5.13.4
Industrial areas	Minor drainage system Major drainage system Roofwater and lot drainage	Minimum 2y ARI* Minimum 50y ARI (less piped flow if applicable) Level IV *QUDM* Section 5.13.4
New use centre activities (incorporating a wide range of commercial, retail and residential uses)	Minor drainage system Major drainage system Roofwater and lot drainage	Minimum 10y ARI Minimum 50y ARI (less piped flow if applicable) Level IV and V *QUDM* Section 5.13.4
Major roads (district access, suburban route, arterial route, major industrial access through road)	Kerb and channel flow Cross drainage (culvert) flow Roadway flow width & depth limits	Minimum 10y ARI To suit flood immunity requirement of Chapter 1 of Part A of this document Refer *QUDM* Table 5.04.1
Minor roads (local access, neighbourhood access, minor industrial access)	Kerb and channel flow Cross drainage (culvert) flow Roadway flow width & depth limits	Refer relevant development category, minimum 2y ARI To suit flood immunity requirement of Chapter 1 of Part A of this document Refer *QUDM* Table 5.04.1

* For industrial roads that will be major through roads, the minor drainage design will need to increase to 10 y ARI.

3.3 URBAN DRAINAGE

3.3.1 Fraction Impervious

The coefficient of runoff for the 10 year ARI storm event is given in Table B2.2.

TABLE B2.2 C_{10} VS DEVELOPMENT CATEGORY

Development category	**C_{10}**
Central business	0.90
Commercial and industrial	0.88
Significant paved areas (eg roads and carparks)	0.88
Low-medium to high density residential areas (Note 2)	0.87 (Note 2)
Low density residential area (mainly one or two storey single houses, including roads) Average lot ≥ 750 m^2 Average lot ≥ 600 m^2 < 750 m^2 Average lot ≥ 450 m^2 < 600 m^2 Average lot ≥ 300 m^2 < 450 m^2	 0.82 0.85 0.86 0.87
Low density residential area (mainly one or two storey single houses, excluding roads) Average lot ≥ 750 m^2 Average lot ≥ 600 m^2 < 750 m^2 Average lot ≥ 450 m^2 < 600 m^2 Average lot ≥ 300 m^2 < 450 m^2	 0.81 0.82 0.83 0.85
Rural/ environmental protection areas (2-5 dwelling units per hectare)	0.74
Open space (eg parks)	0.70

NOTES:

1. Table B2.2 above combines *QUDM* Tables 4.05.1 and 4.05.2.
2. This area is designated for mainly multi-unit dwellings with density >20 dwelling units per hectare. The designer can determine the actual fraction impervious for the particular development under consideration and calculate the coefficients of runoff from these values. Alternatively use C_{10} = 0.87.

3.3.2 Time of Concentration

Refer *QUDM* Section 4.06. The time of concentration should take due account of partial area effects in accordance with *QUDM* Section 4.03.2, particularly where there is open space within a residential area or for developments with significant directly connected impervious areas.

Standard inlet times (*QUDM* Section 4.06.4) should be used in an urban catchment starting in a developed area. The standard inlet time represents the time taken for runoff from the extremes of the catchment boundary to reach the underground drainage system. The referenced average slopes are the slopes along the predominant flow paths for the catchment in its developed state.

The kinematic wave and the Bransby-Williams equations should not be used to estimate overland flow time. Similarly the Friend's equation should be used with caution for urban catchment starting in bush or parkland. The Friend's equation should not be used if flow concentration is expected to occur, even if this flow concentration occurs as a result of minor rill erosion.

Unless the actual velocity in the drainage system upstream is determined, the adopted pipe velocity should not be less than 3 m/s for the purpose of estimating pipe travel time.

For small open creek catchments (< 100 ha), minor channel or creek flow times may be initially determined by assuming an average stream velocity of 1.5 m/s. For medium sized open creek catchments (100-500 ha), the Department of Main Roads stream velocity method (*QUDM* Table 4.06.5) or the modified Friend's equation (*QUDM* Section 4.06.11) may be used. For large open creek catchments (> 500 ha), the Rational Method should be used with extreme caution. However, detailed hydrological modelling of Brisbane's major creeks indicate that the Rational Method provides a reasonable peak flood discharges if an average flow velocity of 0.9 m/s is assumed.

3.3.3 Pipe and Material Standards

Refer *Reference Specification S160 Drainage*. Materials that will be accepted for use in stormwater pipes include:

- Steel reinforced concrete pipe, minimum Class 2.
- Fibre reinforced concrete pipe, minimum Class 1.
- Type B flexible polypropylene/polyethylene pipe, minimum stiffness Class SN8 (PP SDR 23 or PE SDR 21).
- UPVC sewer pipe minimum Class SN6 for roofwater drainage.

3.3.4 Roof and Allotment Drainage

Refer Section 3.2 and *QUDM* Section 5.13. See Standard Drawing UMS 351 for conventional residential subdivisions and Standard Drawing UMS 154 for WSUD residential subdivisions. See Standard Drawing UMS 353 for developments pertaining to material change of use such as Community Titles Scheme, commercial and industrial developments.

3.3.5 Public Utilities and Other Services

Refer *QUDM* Section 5.14. See the relevant Standard Drawings UMS 121, UMS 122, UMS 123, UMS 124 or UMS 151 for the recommended locations of public utilities.

3.3.6 Rainfall Intensity

Refer *QUDM* Section 4.07.

TABLE B2.3 RAINFALL INTENSITY FOR BRISBANE

Duration (Minutes)	Average Recurrence Interval						
	1 year mm/h	2 year mm/h	5 year mm/h	10 year mm/h	20 year mm/h	50 year mm/h	100 year mm/h
5.0	117	151	191	215	248	291	325
5.2	116	149	189	212	244	287	320
5.4	114	147	186	209	241	283	316
5.6	113	145	184	207	238	279	312
5.8	111	143	181	204	235	276	308
6.0	110	141	179	202	232	273	304
6.2	108	139	177	199	229	269	300
6.4	107	138	175	197	227	266	297
6.6	106	136	173	195	224	263	294
6.8	105	135	171	193	222	261	291
7.0	103	133	169	190	219	258	288
7.2	102	132	167	189	217	255	285
7.4	101	130	166	187	215	253	282
7.6	100	129	164	185	213	250	279
7.8	99	128	162	183	211	248	277
8.0	98	126	161	181	209	246	274
8.5	96	123	157	177	204	240	269
9.0	94	121	154	173	200	236	263
9.5	92	118	150	170	196	231	258
10.0	90	116	147	167	192	227	253
10.5	88	113	145	164	189	222	249
11.0	86	111	142	161	185	219	244
11.5	85	109	139	158	182	215	240
12.0	83	107	137	155	179	212	237
12.5	82	105	135	153	176	208	233
13.0	80	104	133	150	174	205	229
13.5	79	102	131	148	171	202	226
14.0	78	100	129	146	169	199	223
14.5	77	99	127	144	166	196	220
15.0	75	97	125	142	164	194	217
15.5	74	96	123	140	162	191	214
16.0	73	95	122	138	160	189	211
16.5	72	93	120	136	158	186	209
17.0	71	92	118	134	156	184	206
17.5	70	91	117	133	154	182	204
18.0	69	90	115	131	152	180	201
18.5	68	88	114	129	150	178	199
19.0	68	87	113	128	148	176	197
19.5	67	86	111	126	147	174	195
20.0	66	85	110	125	145	172	193

Duration (Minutes)	**Average Recurrence Interval** 1 year mm/h	2 year mm/h	5 year mm/h	10 year mm/h	20 year mm/h	50 year mm/h	100 year mm/h
20.5	65	84	109	124	143	170	191
21.0	64	83	108	122	142	168	189
21.5	64	82	106	121	140	166	187
22.0	63	81	105	120	139	165	185
22.5	62	81	104	118	137	163	183
23.0	62	80	103	117	136	161	181
23.5	61	79	102	116	135	160	179
24.0	60	78	101	115	133	158	178
24.5	60	77	100	114	132	157	176
25.0	59	76	99	113	131	155	174
26.0	58	75	97	111	128	152	171
27.0	57	74	95	108	126	150	168
28.0	56	72	94	107	124	147	165
29.0	55	71	92	105	122	145	162
30.0	54	70	90	103	120	142	160
31	53	68	89	101	118	140	157
32	52	67	87	100	116	138	155
33	51	66	86	98	114	136	152
34	50	65	85	96	112	133	150
35	49	64	83	95	111	131	148
36	49	63	82	94	109	130	146
37	48	62	81	92	107	128	144
38	47	61	80	91	106	126	142
39	47	60	79	90	104	124	140
40	46	59	77	88	103	123	138
45	43	56	72	83	97	115	129
50	40	52	68	78	91	108	122
55	38	49	64	74	86	103	115
60	36	47	61	70	82	97	110
90	28	36	47	54	63	76	85
120	23	29	39	45	52	62	71
150	19	25	33	38	45	54	61
180	17	22	29	34	39	47	53
210	15	20	26	30	35	42	48
240	14	18	24	27	32	39	44

Based on coefficients issued by the Bureau of Meteorology(Ref FN2615) for 27475 S 152025 E
Calculated in accordance with Australian Rainfall and Runoff (1997 Edition)

3.3.7 Drainage Calculations

Refer _QUDM_ Section 5.16. Hydraulic calculations must be included on all drawings in tabular form, generally in accordance with Figure B2.1.

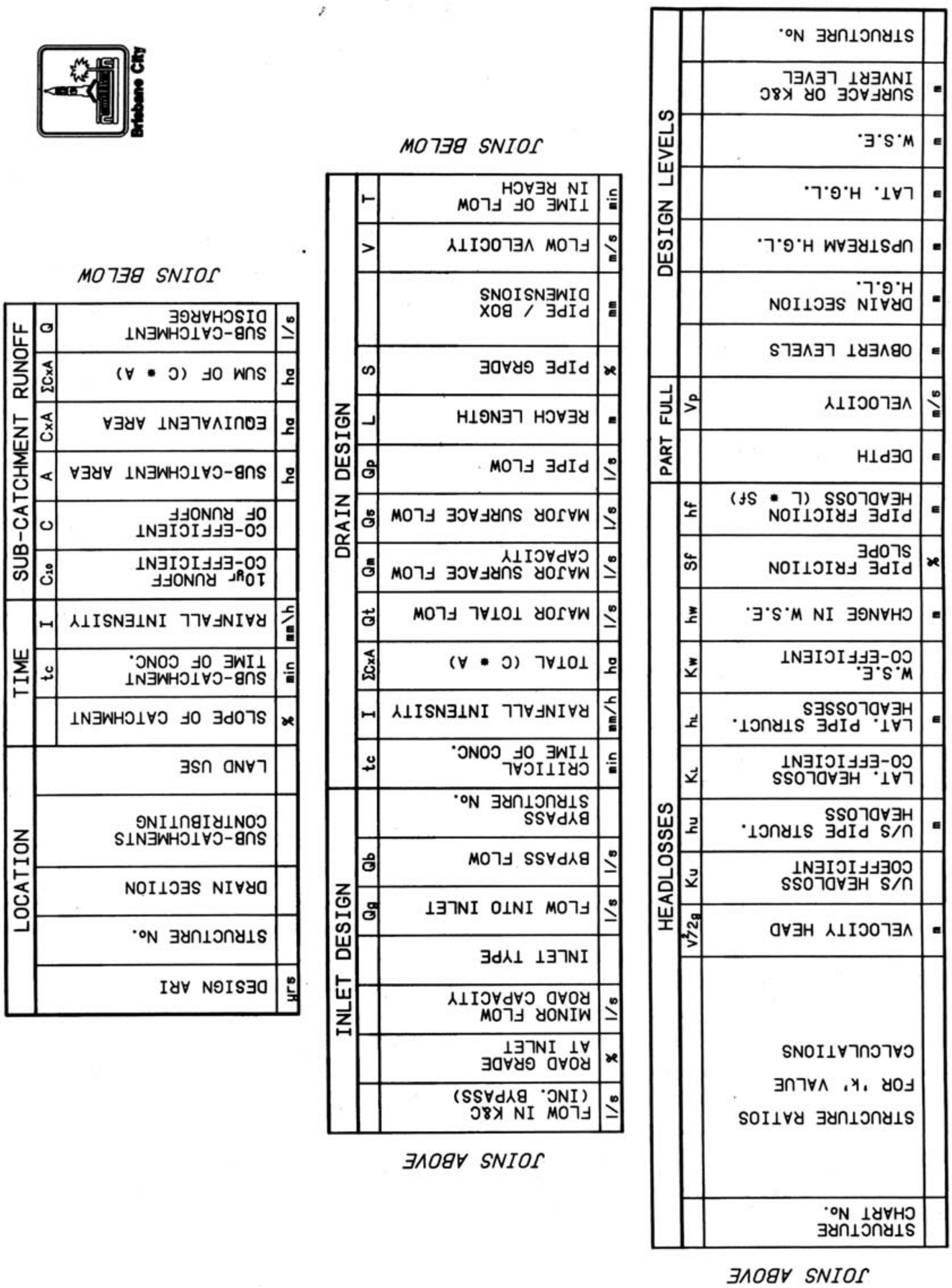


FIGURE B2.1
DRAINAGE CALCULATIONS

3.3.8 Gully Inlet Capacity Charts

Refer Standard Drawings UMS 381 to UMS 392 for the relevant hydraulic capture charts.

3.4 TAILWATER LEVEL

Tidal outfalls (ocean and bays)

Refer *QUDM* Section 7.03.1. The design tailwater level is the Mean High Water Springs (MHWS) plus 0.3 m to offset the potential effects of climate change, for all storm events.

Non-tidal outfalls

Refer *QUDM* Section 7.03.3. The design tailwater level is the maximum level determined by the following methods:

- The combined peak discharge is determined from rainfall intensity corresponding to the time of concentration for the side drain.
- The combined peak discharge of the side drain and main stream is determined from rainfall intensity corresponding to the time of concentration of the receiving waters.

Tidal outfalls (rivers and creeks)

Refer *QUDM* Section 7.03.2. Design tailwater level should include an appropriate flood surcharge corresponding to the combined discharges (as per non-tidal outfalls above) to the MHWS. An additional allowance of 0.3 m is required to offset the potential effects of climate change.

Drowned outlets

Drowned outlets should not be used without the approval of Council Delegate.

4.0 WATER SENSITIVE URBAN DESIGN

4.1 GENERAL

Water Sensitive Urban Design (WSUD) incorporates the sustainability principles of water conservation, waste minimisation, and environmental protection, to the management of the urban water cycle. At various points along the drainage system, controls or combination of controls are used to manage the quality and quantity of stormwater so that the impact on the environment and existing drainage systems are managed. Also refer Chapter 1, Part C - Water Quality Management Guidelines, in this document.

4.2 RAINWATER TANKS

Brisbane City Council actively supports the use of rainwater tanks as they provide a simple and effective means for property owners to manage stormwater at the source, whilst providing a major benefit to the management of the urban water cycle through reduced water demand and improved water quality. The application of rainwater tanks is particularly suited to new and existing houses, small-scale residential developments of four dwelling units or less. Council has developed an information kit that provides the minimum requirements for garden watering or connection to toilets, hot water system, or the laundry. Overflows from rainwater tanks are usually connected to soakage or rubble pits.

The combined rainwater tank/soakage pit system is also suited to older areas of the city where there is no stormwater connection point and the lot falls away from the street. The proposed stormwater disposal method should mitigate any potential impacts of worsening the existing conditions either by ponding, concentrating or increasing the flow onto adjoining properties. The acceptable solution may include soakage trenches or a combination of gravity feed pipe via a drowned outlet to the kerb and channel and/or rainwater tank under the house. The soakage pit should be located at least 3 metres from any building or boundary, and to provide every opportunity for the stormwater flow to broad sheet across the lawn. The removal of stormwater by adsorption or infiltration into permeable soils should be designed to suit the topography and soil type.

4.3 ROAD DESIGN

Conventional road drainage consists of kerb and channel and gully pits that drain the road surfaces and adjoining lots into an underground pipe system. This system efficiently collects and conveys stormwater runoff into the underground drainage system.

With the water sensitive design approach, runoff from more frequent storms is collected and treated within WSUD devices (such as swales and bio-retention systems) to allow for some attenuation of the flow and to facilitate the retention of contaminants prior to these flows discharging to receiving waterways. Refer to publication *Water Sensitive Urban Design Engineering Guidelines: Stormwater* (Brisbane City Council, August 2005) for details on design principles and application.

4.4 NATURAL CHANNEL DESIGN

The basic principles of Natural Channel Design (NCD) are to maintain the hydraulic conveyance requirements of engineered or affected channels, while improving environmental values. NCD is important in all waterways (whether natural in formation or constructed to appear and operate as natural channels), especially where the waterway provides a link with bushland reserves or forms an important part of an aquatic or terrestrial movement corridor. An **extended maintenance period** may be required until the channel has sufficiently stabilised and vegetative cover is well established. Refer to publication *Natural Channel Design Guidelines* (Brisbane City Council, 2003) for details on design principles and application.

Where rock armour is required to control erosion, partially embedded or grouted natural rocks/boulders should be used. Planting between rocks can soften visual impacts. Boulders placed on the bed of the watercourse can promote habitat diversity. Boulders recessed into the low flow channel or the pools can increase the total submerged surface area, thus increasing the available food supply for aquatic life. Concrete lining is generally unacceptable to Council as this solution does not protect nor enhance environmental values.