Shellharbour City Council

Shellharbour Drainage Design Handbook

shellharbour.nsw.gov.au

19/11/2019

TABLE OF CONTENTS

1 DRAINAGE DESIGN

1.1 INTRODUCTION

CONTEXT

This section of the Engineering Design Specification for Civil Works outlines Shellharbour City Council's recommended practice for the drainage design. It is in no way a comprehensive "Design Manual," rather it is intended to be read in conjunction with and as a supplement to the following references:

- Australian Rainfall and Runoff;
- NSW Floodplain Development Manual
- Shellharbour Local Environmental Plan
- Shellharbour Development Control Plan
- Austroads and RMS Supplements to Austroads
- AS3500.3 Plumbing and Drainage - Stormwater Drainage;
- Aspects of the Queensland Urban Drainage Manual

Flood Studies and Floodplain Risk Management Plans adopted by Council and other relevant state agencies are available on Councils Website. Detailed flood level information for individual properties are available from Council on request

It should be noted that the Design Coefficients defined in the Tables and Figures within this specification are applicable only to the Shellharbour City Local Government Area. It covers design aspects for the full range of municipal stormwater drainage assets with consideration to the Total Water Cycle Management philosophy for management of stormwater.

OBJECTIVES

The drainage design shall reflect the following objectives:

(a) A high level of safety for all users;

(b) Acceptable levels of amenity and protection from the impact of flooding;

(c) Retention of the natural stormwater system where possible and as required by other statutory authorities;

(d) Efficient conveyance of stormwater and surface runoff from public and private property to ensure public safety and property protection;

(e) Controlled rate of stormwater discharge to reduce downstream flooding and environmental impacts by making maximum use of open spaces and other available areas to detain drainage;

(f) Ensure that the design capacity of downstream drainage systems are not compromised;

(g) Ensure that the stormwater drainage design has considered infrequent floods greater than the

design flood. ie up to the PMF;

(h) Minimise construction and maintenance costs and avoid the need for future property acquisition;

(i) Protection of the environment from adverse impacts of development by stabilising the landform, controlling erosion and maintaining/ enhancing regional water quality;

(j) Protection of aquatic biota and riparian vegetation;

(k) Meet water quality objectives and incorporate the principles of Water Sensitive Urban Design; and

(l) Ensure low maintenance and economically sustainable in the long term in relation to operation, maintenance and replacement costs.

DESIGN LIFE

All stormwater infrastructure is to have a design service life of 100 years. This applies to pipes, pits and all structural elements. It is understood that natural/ naturalistic systems will be subject to natural impacts from weather and nature which are beyond the ability of the designer to account for. In respect of these elements of the stormwater system the above requirements regarding maintenance will apply.

1.2 HYDROLOGIC AND HYDRAULIC DESIGN CONSIDERATIONS

DETERMINATION OF DESIGN RAINFALL AND RUNOFF

As indicated in Chapter 5 of Book 9 Australia Rainfall & Runoff (AR&R) 2019, due to the limited rainfall runoff data available in urban areas, there is concern about the reliability in characterising the parameters underpinning the Rational Method.

Where catchments are large (ie generally greater than 2 residential lots) and reasonably accurate levels of flow rate prediction is necessary, peak flow rates must be determined using a recognised runoff routing computer model to produce hydrographs.

When defining hydrologic parameters in hydrologic models, the following will apply:

- All parameters used in hydrological models, including antecedent conditions, initial and continuing losses, Aerial Reduction Factors, Design rainfall information (IFD depths), percent imperviousness and temporal patterns, must be selected in accordance with those values adopted as part of Council's catchment wide Flood Study for your study area;
- Documentary evidence of the parameters used must be supplied with any submission to Council; and
- Where computer programs are used, electronic copies of the final data files are to be provided on submission of the design to Council. Where values other than those recommended are used, their use must be justified.

A hydrological report is to be submitted stating all the parameters used to calculate the flows. A hardcopy is to be submitted to Council. Electronic copies of final input and output computer files together with accompanying catchment and layout plans, for hydrological, hydraulic and

water quality models must be provided for Council's records at the time of lodging detailed engineering plans.

All computer models shall be calibrated against the results of Councils adopted design flood information if available, otherwise against other historical flood information available within the catchment.

Consideration is to be given to likely changes to individual catchment areas due to the development of the catchment. Catchment area land uses are to be based on current available land zonings or proposed future land zonings where applicable.

Catchment topography can be obtained from the NSW Land Registry Services (LRS) website. Details of Council's drainage network is available upon request from Council. For further information, please contact Council's Asset Management Department on (02) 4221 6111. Any information that Council provides is indicative only and must be validated on site by appropriate investigation and survey.

DETERMINATION OF DOWNSTREAM BOUNDARY CONDITIONS (TAIL WATER LEVELS)

Subject to the condition at the point of connection / outflow and whether the design flood level at this location in known, tail water level of the stormwater drainage system shall be adopted to be the Design AEP water / flood level. In the case of which this Design AEP water / flood level is unknown, tail water level shall be assumed in accordance with the following criteria:

Connection / Outlet Condition	Tail Water Level
Free outlet	Obvert of the discharge pipe
Kerb and gutter	Top of kerb
Kerb inlet pit	Top of kerb (1% AEP) 150mm below the grate of pit (5% AEP)
Junction pit	Surface level at the pit
Stormwater channel	Top of channel
Water body	1% AEP Top water level
Natural watercourse	Top of bank
Retention / Detention basin	Top of spillway

Where determination of the tail water level is in doubt, Council's Engineer shall be contacted to confirm the level prior to proceeding.

HYDRAULIC DESIGN METHODS

Hydraulic calculation shall generally be undertaken by a suitably qualified hydraulic engineer experienced in hydrologic and hydraulic design. The calculations shall substantiate impacts to hydraulic grade line adopted for design of the system and shown on the engineering construction plans. Summaries of calculations are added to the plan and details of all calculations are given including listings of all programme input and output.

Hydraulic Grade Lines (HGL) analysis in accordance with Chapter 5 of Book 9 Australia Rainfall & Runoff (AR&R) 2019 shall be used to design the stormwater drainage system in the following instances:

- All existing and proposed street stormwater drainage system;

- All existing and proposed public stormwater drainage system;
- All existing and proposed inter-allotment stormwater drainage system;
- Any extension / relocation / diversion of existing public / Council's stormwater drainage system;
- Any connection to the existing public / Council's stormwater drainage system;
- In situations where determination of hydraulic control is critical as determined by Council's Engineers.

(**Note:** In case where determination of the HGL is critical to the successful implementation of a design, such an analysis will be required to be submitted with the development application.)

In addition, the following issues shall be considered in the HGL analysis:

1) The analysis shall be conducted as an overall system, not in isolation.
2) The hydraulic influences of the upstream and downstream system and the hydraulic losses, as a result when stormwater passes through conduits, inlet structures, junctions and outlet structures, shall be considered.
3) Where the hydraulic calculations are performed by the use of computer model:
    a. electronic files of computer input data and results shall be provided to Council for checking and approval.

The results from computer models such as DRAINS, HEC-RAS shall be calibrated against measured flows, depth etc. If the calibration of the model is not possible due to lack of data, outputs from the model shall be checked against output from manual method of calculation or the output from another model.

1.3 ROAD DRAINAGE DESIGN SPECIFICATIONS

DESIGN APPROACH

A design approach referred to as a 'major and minor stormwater management system' is adopted for urban drainage design. According to Australia Rainfall & Runoff (AR&R) 2019, *a major and minor stormwater management system has two parts*:

- The minor system manages nuisance runoff during smaller frequent storm events. This runoff is conveyed in a manner that maintains safety, minimises nuisance and damage to property. The infrastructure is also provided to avoid potential maintenance problems such as ponding and saturation of designated areas. Importantly, the minor system also includes volume management measures that aim to hold water within urban landscapes and sub-catchments – these solutions may include ponding of stormwater within a defined area. The minor system must withstand the effects of regular stormwater inundation.

- A major system includes overland flow paths on roads and through open space, and trunk conveyance infrastructure. This system conveys additional stormwater runoff produced during larger less probable and rarer storm events with the intent of managing the potential for flood disaster. Overland conveyance of stormwater from large events is potentially hazardous due to the velocity and depth of flows, and must be safely contained within a defined corridor of major system flows.

MINOR SYSTEM DESIGN AEP

The minor system (including road drainage system) shall be capable of controlling flows from the rainfall events up to and including the following Design Annual Exceedance Probabilities (AEP):

Street/ Road Type	Design Annual Exceedance Probability (AEP)
Local / Collector / Access street / Access Place	20%
Major Collector	5%
Arterial	1%
Industrial	5%
Rural (ie no Kerb & Gutter)	10%

Note: blocked and unblocked scenarios for drainage pits are to be considered when designing the minor system in order to comply with the criteria in the table above.

MAJOR SYSTEM DESIGN AEP

Major System in the form of overland flow paths shall be designed to safely convey, control and accommodate 1% AEP flow rate when the minor system blocks / fails or its capacity is exceeded. The safety design criteria shall be considered in designing the Major System and shall be in accordance with Australian Rainfall & Runoff. Where the major system does not meet the safety design criteria, the minor system shall be upgraded to ensure the compliance of safety criteria. Note that the 1%AEP High Provisional hazard flows must be conveyed in designated floodways in accordance with the NSW Floodplain Development Manual.

LAYOUT OF PROPOSED MAJOR / MINOR STORMWATER MANAGEMENT SYSTEM

An assessment of the topography will determine the location of proposed drainage paths. Once the location of a proposed network is defined, trial pit locations should be determined in accordance with the appropriate rainfall events of Design AEP. Generally, pits shall be spaced so that there is minimal bypass flows in the rainfall events of Design AEP.

Catchment areas to each pit can then be determined from design contour information and proposed property boundaries. A site inspection should always be made to check the contour information and assess the likelihood of any flow path deviations which may occur as a consequence of existing or proposed developments.

As a result of different construction phase of the subdivision, changes to the design of major / minor stormwater management system and flow paths may occur. As such, the impact of these changes to the system network shall be considered and submitted to Council for assessment in the design stage of first phrase of the subdivision.

Development sites that are impacted by overland flows from upstream catchments need to account for the following:

- The proposed development is not to have an adverse impact on adjoining properties through the diversion, concentration or damming of such flows;
- The proposed development is to accommodate the passage of overland flow through the site and where applicable is to be designed to withstand damage due to scour, debris or buoyancy forces so that the risk of incidental damage is minimised;
- The proposed development is not to be sited where flows will create a hazardous situation for future occupants in terms of depth and velocity of flows through the property;
- Floor levels within the development are to be set to comply with councils flood risk management policy; and
- The proposed development is compatible with any future mitigation strategies to be implemented by Council in terms of such overland flows.

1.4 MINOR SYSTEM DESIGN CRITERIA

The minor system shall be designed generally in accordance with Chapter 5 of Book 9 Australia Rainfall & Runoff (AR&R) 2019, taking into consideration of an assessment of major system flows. In addition, the following requirements shall also be complied with:

PIT DESIGN - GENERAL

1) All kerb inlet pits and grated surface inlet pits shall be designed and constructed in accordance with Council's Standard Drawings and AS 3996.

2) The minimum clearance from the top of the pit to the design water level in the pit shall be 150mm for the rainfall events of design AEP.

3) Benching, with a minimum 1% constant fall, shall be provided to the base of the pit to streamline flows and avoid ponding of water.

4) Pipe junctions where the deflection angle of the larger flow is 90° or more, should be avoided;

5) Where the depth of the pit exceeds 1.0 metres, galvanised or other approved step-irons are to be provided at a spacing of 300mm with the first step no deeper than 300mm from the surface to provide access for inspection and cleaning;

6) Where pits exceed 1.5 metres in depth, the pit shall be constructed of reinforced concrete.

7) Pits shall be constructed with sufficient internal dimensions to have pit walls perpendicular to the centreline of the inlet and outlet pipes (i.e. avoid "birdsmouthing" of pipes in the corners of the pit).

8) Full details of non-standard pits shall be included in the Engineering Construction Plans.

9) All pits shall be sized in accordance with the following requirements:

Pit depth	Minimum internal dimension of pit (for full depth)
⩽ 300 mm	300 mm x 300 mm
300mm – 600mm	450 mm x 450 mm
600mm – 600mm	600 mm x 600 mm
900mm – 1200 mm	900 mm x 600 mm (with step irons)
>1200 mm	1200mm x 1200 mm with walls and bottom to be reinforced in all direction

10) Pits deeper than 2.0m shall be designed by a professional structural engineer

11) Inter-allotment drainage pits shall have minimum internal dimensions of 600mm x 600mm.

12) Cast in-situ pit walls are to be minimum 150mm thick and shall be formed on both the inside and outside faces.

13) Pits with 'butterfly' type grates may be permitted on a case by case basis and at the discretion of Council.

PIT DESIGN - LOCATION / SPACING / FLOW WIDTHS

Location

Inlet pits shall be provided at the following location:

- at the sag points
- at the location to intercept flow to comply with the requirements of this specification.
- immediately upstream / downstream of tangent point of kerb return

In addition, pit shall also be provided:

- at the pipe junctions
- at where there are changes in grade, level, direction, size or class of pipe

1) To enable access for maintenance.

2) Additional inlet pits may be required at the discretion of the Council's Engineer if blocking of a single pit could cause serious flooding.

Spacing and clearances

3) Maximum spacing between directly connected pits shall not exceed 75m.

4) Kerb inlet pits shall be located:

a. at a minimum of 1m from the proposed / existing vehicular crossings;
b. within 2 m either side of the prolongation of common property boundaries;
c. clear of any pedestrian desire lines;
d. Clear of any curves and kerb returns

5) Bypass from any kerb inlet pit on grade shall not exceed 15% of the total gutter flow at the pit (full capture desirable). The actual value of bypass shall be shown in the Engineering Construction Plans;

Flow width requirements

Kerb Inlet pits shall be provided to ensure the flow width in the gutter (measured from the invert of kerb and gutter):

a) Does not exceeding 0.45m at bus stops, pedestrian ramps and kerb returns; and
b) Does not exceed 1.0 m where parking lanes may become an acceleration, deceleration or turning lane.
c) Does not exceed 1.0 m where road falls towards a median.
d) Does not exceed 1.0 m at intersection kerb returns (including entrances to commercial buildings)
e) Does not exceeding 2.5m in all other locations.

Note that a minimum of 3.5 m of clear vehicle passage must be maintained on all roads at the peak of the design storm. The clear vehicle passage may straddle the crown of the road for narrow roads if necessary.

Drainage reserves, Public reserves and Dedicated overflow paths

1) Grated surface inlet pits shall be provided in drainage reserves, overflow paths and parks.

2) Maximum spacing between directly connected pits shall not exceed 75m.

PIT DESIGN – INLET CAPACITIES

Pits shall be designed in accordance with to accommodate the design inflow.

a) The inlet capacities shall be calculated and designed in accordance with Chapter 5.5.2 of Book 9 Australia Rainfall & Runoff (AR&R) 2019.

b) The following theoretical capacity of pit shall be applied in order to consider pit blockage.

Pit Condition	Pit Inlet type	Percentage of Theoretical Capacity
Sag	Side entry	80%
Sag	Grated	50%
Sag	Combination	Side inlet capacity only. Assume grate is completely blocked

Sag	Letterbox	50%
On Grade	Side entry	80%
On Grade	Grated	50%
On Grade	Combination	80%

c) The minimum lintel size for on grade inlet pits is 1.8 metres (internal dimension)

d) The minimum lintel size for sag inlet pits on grade is 3.0 metres (internal dimension), with slotted grates to conform with Weldock GGSB94SD (or equivalent)

PIT DESIGN – HYDRAULIC LOSSES

In order to approximate the reality of entry losses to the pit, losses within the pit and exit losses from the pit, a single pressure change coefficient shall be used in determining hydraulic loss of a pit in Hydraulic Grade Line (HGL) analysis.

Procedure to calculate hydraulic loss of a pit shall be taken in accordance with Chapter 5.5.3 of Book 9 Australia Rainfall & Runoff (AR&R) 2019. In addition, it should be noted the following:

1) All inlet structures, pits and transition structures shall generally be designed to minimise the hydraulic losses in stormwater management system.

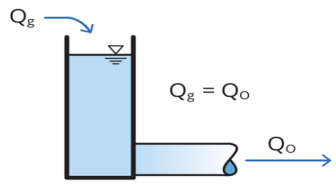
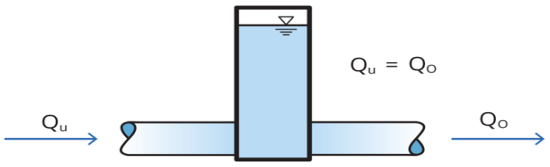
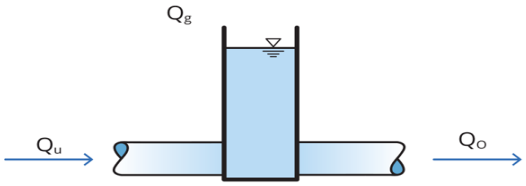
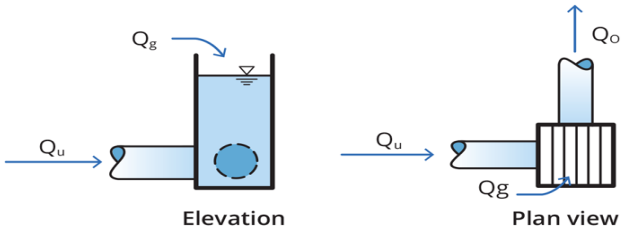
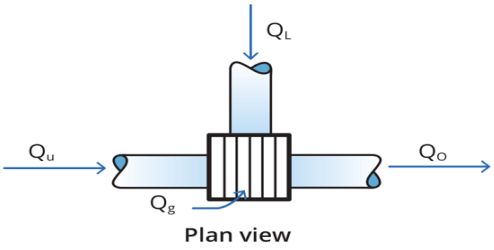
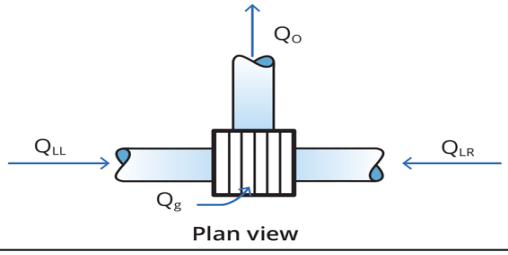
2) The pressure change coefficient (k_u) for each pit configuration can be determined from the Missouri Charts and the result from Hare, 2016 or Appendix 2 of Queensland Urban Drainage Manual 2013. Figure 9.5.14 of Book 9 Australia Rainfall & Runoff (AR&R) can be used for initial estimates of the pressure change coefficient;

3) Default pressure change coefficients in computer programs are not acceptable unless they are consistent with the above requirements;

4) The water level in a pit may be assumed to be coincident with the highest HGL level in the pit for steady flow model;

5) When the water level (i.e. HGL) calculated is below the obvert level of the upstream pipe, the obvert level of the upstream pipe is to be adopted as the water level for calculation of upstream pipe HGL;

6) For drop pits with more than 600mm drop, the length of the pit is to be designed to avoid direct discharge onto the facing wall which may induce scouring.

Pit Configuration	Initial k_u	Pit Sketches
First pit at the top of a line	4.0	
Well-aligned junction pit with straight through flow, no sidelines, no grate inflow	0.2	
Well-aligned pit With straight through flow, no sidelines, 50% grate inflow	1.4	
Pit with a 90° right angle direction change, no sidelines, 50% grate inflow	1.7	
Pit with a straight through flow, one or more sidelines	2.2	
Pit with a right angle direction change from two opposed inflow pipes	2.0	

Approximate pressure change coefficients, k_u, for inlet structures (Figure 9.5.14 of Chapter 5.5.3 of Book 9 Australia Rainfall & Runoff (AR&R) 2019)

PIPELINE DESIGN – GENERAL

1) Consideration must be given to appropriate pipe class as per AS3725

2) Minimum cover over pipelines in roads and public reserves shall be such as to withstand the maximum load combination from construction plant or in-service traffic.

The absolute minimum cover for any pipe in a road or public reserve shall be 450 mm from top of pipe collar to finished surface level.

3) For pipelines under road pavements, the required cover shall be measured from top of pipe to pavement subgrade level. In the absence of detailed pavement design the pavement depth should be assumed to be not less than 450 mm.

4) The maximum depth to invert of pipelines shall be 6 m.

5) Pipelines in roadways and public reserve area shall be minimum 375mm diameter Class 3 rubber ring jointed reinforced concrete (RC) pipes.

6) Pipelines shall cross roads so as to minimise deflection angles and pit losses (45^{o} desirable maximum).

7) The length of pipelines without provision of junction pits shall not be greater than 75m.

8) Pipelines shall be designed to ensure the downstream pipe will have greater or equal diameter than the upstream pipe.

9) Pipelines shall be provided in straight line between pits. Curved pipelines would not be accepted.

10) The minimum and maximum flow velocities in stormwater pipes shall be 0.6m/s and 8m/s respectively.

11) An absolute minimum grade of 1% for all pipelines shall be adopted.

12) Pipes with a grade greater than 12% will require anchor blocks at the top and bottom and at intervals not exceeding 3.0m.

13) The inlet and outlet drains to pipelines shall be carefully designed so as to avoid either scouring or silting velocities during storm flows, and adequate scour protection satisfactory to Council's Engineer is to be provided at the outlet of all stormwater management systems.

14) Pipelines shall not be laid longitudinally within the footway area.

15) The pipeline is to be designed so that the depths of the pits are sufficient to induce the designed velocity.

16) All pipelines in the road reserve are shall generally be located under and parallel to the kerb.

17) Pipeline provided in the drainage easement shall be centrally located within the easement.

18) All pipelines shall be designed to drain by gravity to an existing road network or Council's drainage system or approved discharge point.

19) Pipe inverts are to be designed taking into consideration of undeveloped upstream lands, minimum pipe cover, physical constraints and hydraulic grade requirements.

PIPELINE DESIGN – FRICTION LOSSES

Pipe friction losses shall be determined using the Colebrook-White equation (flowing full but not under pressure) or Mannings Equation (flow full but not under pressure). AS2200-2006 Design Charts for Water Supply and Sewerage shall be referred to for design coefficients of roughness.

Since pipe bends and sudden expansions or contractions in stormwater pipelines are not permitted, consideration of these losses is not required.

PIPELINE DESIGN – CLEARANCES FROM OTHER SERVICES AND WORKING WITHIN THE ZONE OF INFLUENCE

Minimum clearances have been established to reduce the likelihood of damage to stormwater pipelines or other services, and to protect personnel during construction or maintenance work.

Under no circumstances shall stormwater pipelines be cranked to avoid other services or located longitudinally directly above or below other underground services in the same trench.

Where stormwater pipeline crosses or is constructed adjacent to an existing service, the design shall be based on the work-as-executed location and level of service. The design documents shall direct the Contractor to verify the location and level of existing service prior to constructing the stormwater pipeline in question.

Minimum clearances from services shall be sought from the utility owner. In addition to the requirements of the utility owner, minimum clearances between stormwater pipelines and other services shall be in accordance with the following table.

Service	**Horizontal Clearance** (mm)	**Vertical Clearance** (mm)
Sewers	500	50
Water Mains	500	150
Telephone	500	75
High Pressure Gas	500	300
Low Pressure Gas	500	150
High Voltage Elect	500	300
Low Voltage	500	150

Note: Clearance shall be calculated from the outside of the pipe collar.

When undertaking excavation, construction or demolition work over or adjacent to public drainage infrastructure the following guidelines must be adhered to in order to ensure the serviceability and asset life of Councils drainage infrastructure:

- Sydney Waters Technical Guidelines for Building Over and Adjacent To Pipe Assets.
- Sydney Water Building over or adjacent to Sydney Water Stormwater Assets.

Note that in some circumstances concrete encasement or a bridging slab may be required to protect Councils drainage assets.

PIPELINE DESIGN – OUTLET DESIGN AND TREATMENTS

The treatment of stormwater outlets must be carefully designed to prevent damage to the receiving water way from changes to flow behaviour and velocity. In this regard, scour prevention measures and stormwater energy dissipation structures may be required.

Design of stormwater outlets is to be undertaken I accordance with the procedures outlined in the 'Stormwater Outlets' chapter of the Queensland Urban Drainage Manual. Treatment of stormwater outlets to riparian corridors are to be undertaken in accordance with Sydney Waters' standard treatment for stormwater connection to natural areas.

DRAINAGE EASEMENTS – PUBLIC DRAINAGE

In cases where there is no other alternative, but the minor system for road drainage requires to be located within the nearly created lots for subdivision developments, Council's drainage easement shall be created over the minor road drainage system, burdening the affected lots and in favour to Council. Where it is intended to create drainage easements for a new road provided in a subdivision, a notation shall appear on the linen plan creating the easement or easements pursuant to Section 88B of the Conveyancing Act 1919.

The width of Council drainage easement created shall fully accommodate overland flows discharging from the roads to the affected lots for all storm events up to and including the 1% AEP design storm event. The minimum width of the required stormwater drainage easement shall be as follows:

Minimum width of Council drainage easement	
Pipe Diameter (D) (mm)	*Easement Width (m)*
375-1050	3.0
1200-1500	3.5
1650-1800	4.0
> 1800	D + 1m on each side of the pipe[(1)]
Twin Pipes	2D + 2.5m + distance between pipes
Culvert	D + 1m on each side of the culvert[(1)]
Open Channels	2m + top width of 1% AEP design flow with 500mm freeboard

Notes:
[(1)] Measured from the outer edge of the pipe / culvert / culvert slab.

LARGE HYDRAULIC STRUCTURE DESIGN

Large Hydraulic Structures are those that are required for a road to cross a natural watercourse. All large hydraulic structures, including culverts and bridges, shall be designed to comply with the following requirements:

1) All large hydraulic structures shall be designed for the 1% AEP storm event without increasing afflux and / or velocities of flow in urban areas. Some afflux and upstream inundation may be permitted in certain rural and urban areas provided the increased upstream flooding is minimal and does not inundate private property.

2) The effects of the Probable Maximum Flood (PMF) shall be investigated during the design of the major structures and where necessary, the design may require to be modified accordingly to ensure that the failure of the major structure will not result in human injury, loss of life and property damage.

3) A minimum clearance of 0.5m between the 1% AEP flood level and the underside of any major structure is required to allow for passage of debris without blockage.

4) The design of large hydraulic structures shall be structurally certified. As such, a structural certification, prepared by a practicing NPER registered structural engineer, shall be submitted to Council. It should be noted that all bridges shall be structurally designed in accordance with AS (/NZS) 5100:2017.

5) All major structures shall be designed to facilitate the movement of fauna and comply with flora and fauna requirements imposed by the other government agencies.

6) Culverts (either pipe or box section) shall be designed in accordance with the Austroads publications - *Guide to Road Safety Part 5B: Drainage – Open Channels, Culverts and Floodways*.

7) Bridges hall be designed in accordance with the Austroads publications - Guide to Bridge Technology.

8) Where culverts are used for road crossings the following additional design criteria shall apply:

    - The box culvert shall be minimum 600mm wide x 300mm wide.
    - The surface of roads and embankments shall have a minimum freeboard of 500mm above the 1% AEP top water level.
    - Headwalls, surface inlet pits and surcharge pits shall incorporate scour protection on the upstream and downstream ends of the culvert. Scour protection measures are to be appropriate for design conditions and ensure integrity of the downstream conveyance.
    - Culvert inlets must be designed with consideration to blocked and unblocked scenarios, with blockage criteria to be sought from Councils adopted Flood Study.
    - A causeway shall be provided over the culvert for PMF events or when the culverts are blocked. Consideration must be given to vehicle trafficability in accordance with AR&R2019
    - Base slabs for box culverts shall be cast-in-situ and designed by a practicing NPER registered structural engineer structural engineer.

SUB-SOIL DRAINAGE

Subsoil drainage shall be applied according to the following:

1) Subsoil drainage shall generally be provided under all kerb and gutter where no drainage pipes are to be installed, at the end of road construction, at low spots, at

location where required by the pavement design report, and where directed by Council's Development Engineer.

2) The location of subsoil drains and rises (inlets/outlets) shall be shown on the Engineering Construction Plans.

3) The subsoil drain shall be provided adjacent to every inlet stormwater pipe at each pit for a distance upstream of 3 metres, with upstream end of the subsoil drain is suitably capped and the downstream end discharges through the wall of the pit or headwall, and finishes flush with the inside wall.

4) The subsoil drain is to consist of 100mm diameter perforated corrugated or smooth wall UPVC, Class 400, confirming to *AS2439.1 (2007) –Perforated Drainage Pipes and Associated Fittings* or, slotted 100mm diameter PVC and shall be fitted with approved geotechnical filter socks for the full length of the pipe

5) The absolute minimum grade of subsoil drain shall be 1%;

6) Flushing points are to be installed at the ends of lines and at intermediate points such that the distance between pits and/or rises not exceeding 50 metres.

1.5 MAJOR SYSTEM CRITERIA

All urban stormwater drainage designs shall incorporate an assessment of major system flows to ensure that the flow generated from the larger storm events will have a safe and adequate "escape route" to the downstream receiving water body when the minor system fails.

GENERAL

1) Generally, roads shall be designed to convey all major system flows that cannot be carried by the minor system up to 1% AEP storm event.

2) The Probable Maximum Flood (PMF) may also be required to be analysed to ensure that any failure of the major system in events greater than the 1%AEP will not result in an unacceptable risk to life.

3) The major system flow / overland flow path shall generally be provided along or as close as possible to the alignment of natural waterways, existing natural watercourses and drainage depressions and where opportunities exist, it shall be provided in a more natural state.

4) Other than roads, the major stormwater conveyance system shall be located within the parks/ public reserves / drainage reserves wherever possible to ensure the ease of maintenance.

5) High hazard flows within the major system must be conveyed in designated floodways in accordance with the NSW Floodplain Development Manual.

6) Flood warning signs shall be provided to all locations where floodwaters may pond or flow.

7) The design analysis carried out is to take into account the possibility of special damage or danger to life and property which might occur in specific situations.

8) In order to ensure all future development are generally free from inundation from all flood events up to and including 1% AEP flood, the following requirements shall be complied with:

   a. For urban residential, all private lots created from new subdivision shall generally be free from inundation of overland flow paths and mainstream flooding up to and including 1% AEP plus freeboard;

   b. For rural residential, all lots created from new subdivision shall show the location and dimension of future building footprint that is free from inundation of mainstream flooding up to and including 1% AEP and in an area minimum 500mm above the 1% AEP flood / top water level. Flood safe internal access from/to the public road shall also be provided.

   c. Where there is no other alternative but a major stormwater conveyance system, including overland flow paths, is to be located within the newly created lots and / or the new properties, (i.e. there are trapped low points where the overland flow path may divert surcharge into lots / properties), Council may consider, at its discretion, to allow the overland flow diverting surcharge into these lots / properties subject to the following:

      - The proposed major system overland flow path is fully complied with the safety design criteria stated in Australian Rainfall and Runoff.

      - The PMF is to be considered in the design of the overland flow path. All potential building locations are to be located away from hazardous flood conditions that would compromise the structural integrity of buildings in the PMF.

      - Building envelopes are to be located outside of the 1%AEP flood extent.

      - The extent of proposed major system overland flow within the flood affected lots shall be identified and registered on the subdivision plans as a drainage easement.

      - Building footprints shall be shown on the subdivision plans

      - A Restriction on the Use of Land and Positive Covenant shall be created for the flood affected lots to:

        - Protect the overland flow path from alteration of surface levels and limit the fencing across the overland flow path to be an open type fence.

        - Ensure the habitable floor levels of any future development in the lots to be minimum 0.5m above the 1% AEP flood level.

FLOOD HAZARD LIMITS

Chapter 7 of Book 6 Australia Rainfall & Runoff (AR&R) 2019 provides safety design criteria associated with flood hazard. It states that the flood hazard assessment can be divided into three categories: people stability, vehicle stability and structural stability in determining the risk arising from flooding events. The combined set of hazard vulnerability curves, with hazard classification, is shown below:

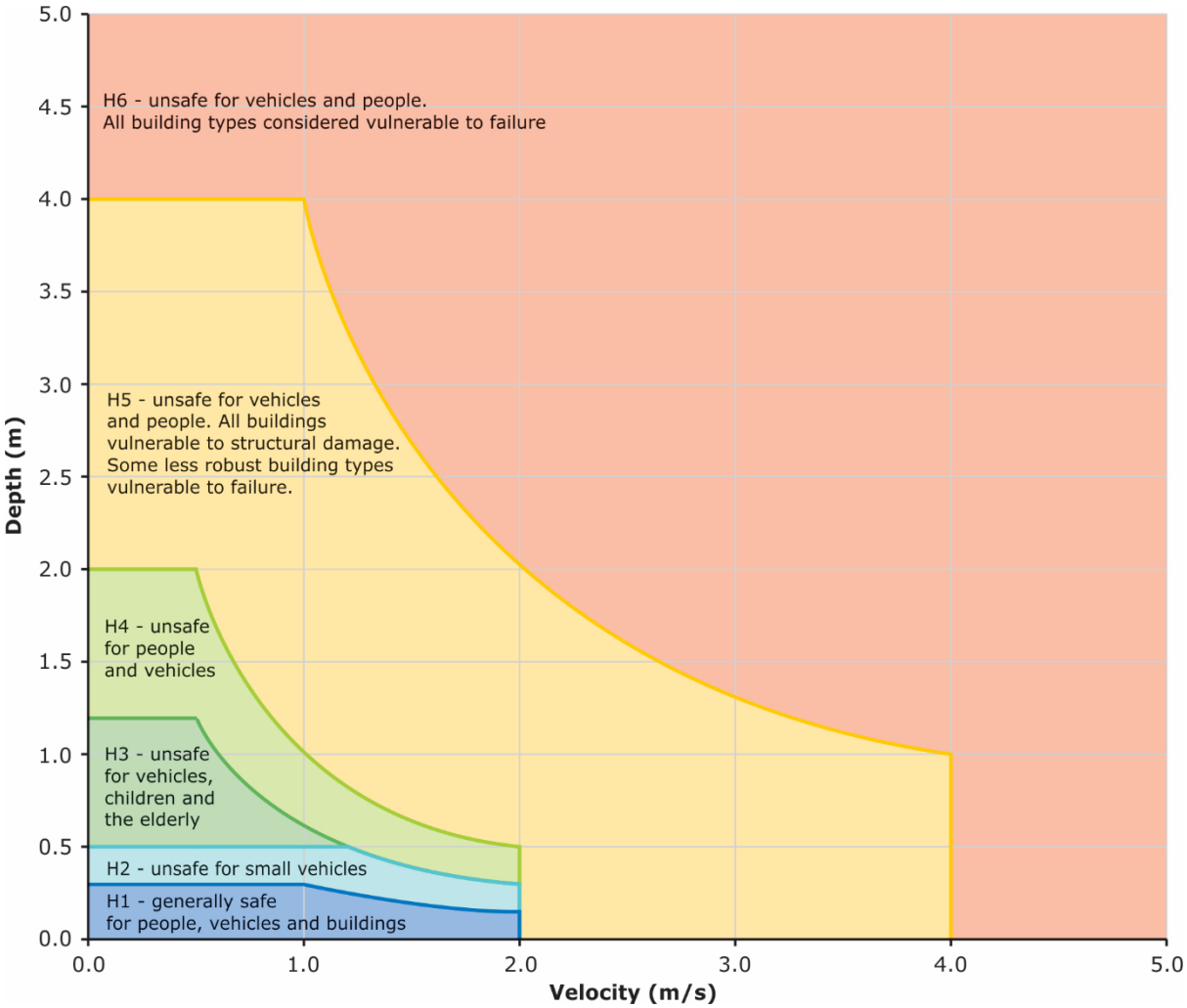


Figure 6.7.9. Combined Flood Hazard Curves (Smith et al, 2014) – AR&R Book 6 Chapter 7.2.7

All roads, open channels and stormwater surcharge paths (including overland flows) shall be designed in accordance Hazard Vulnerability Classification H1, in which:

- The product of depth and velocity of floodwaters shall not be more than 0.3; and
- The depth of floodwaters shall not be more than 0.3m; and
- The velocity of floodwaters shall not be more than 2m/s.

ROADWAYS

1) The maximum depth of flow in the existing / new roadway shall not exceed 200 mm for the 1% AEP flow. The maximum depth shall be reduced to 150mm if the existing / new roadway is a major traffic route.

2) Minimum one full trafficable lane for each direction shall remain clear of water in the existing / new roadway for the 1% AEP flow.

3) If the roadway capacity is inadequate or the safety design criteria cannot be complied with, the minor stormwater management system shall be redesigned to increase its capacity to accommodate the major flow conditions. Pit capacities shall be calculated using the appropriate blocking factors, and pipe capacities estimated with trial diameters and head levels no greater than 150mm below the surface levels / invert of kerb (applicable up to the design ARI for the respective pipeline reach).

PARKS / PUBLIC RESERVES

1) Wherever possible, the major stormwater management system for overland flow path is to be located within parks / public reserves.

2) The major stormwater management system for overland flow path in parks / public reserves shall be provided in a form of grassed/ vegetated swales. Consideration shall be given to minimise erosion and scouring.

3) Tree and shrub planting shall be taken into account when designing the major stormwater management system in the parks / public reserves.

4) Any overland flow path in the parks / public reserves shall be designed to comply with the safety design criteria stated in AR&R2019. Where the safety design criteria cannot be met, an alternative solution must be determined in consultation with Council's Development Engineering Section.

5) Footpath paving in the parks / public reserves shall generally not to be used in conveying the overland flows. Where there is no other alternatives, the depth of ponding in the footpath paving shall comply with the safety design criteria stated in AR&R2019 and appropriate flood warning signage shall be provided.

FLOODWAYS AND NATURAL WATERCOURSES

A **floodway** is defined as either a natural watercourse or artificial channel, which conveys concentrated flow with a High Provisional Hazard. They shall be designed to cater for flows up to and including 1%AEP. Note that the major stormwater system conveying the 100 year ARI is not a floodway.

Floodways shall be provided along the alignment of existing watercourses and drainage depressions. Diversion of floodways away from their natural paths **will not** be permitted other than with the written concurrence of Council.

Generally, only minor modifications for flood conveyance control may be permitted to be carried out for the natural creek lines and natural watercourse. Where there is no other alternative, the flood conveyance control shall be designed to simulate the nature conditions and integrate into adjoining natural environments as much as possible. In cases where there is high potential impacts to environment, such as significant trees, archaeological sites etc., appropriate bank erosion protection measures shall be applied.

The following design criteria shall apply:

(a) The urbanised peak flow rates and shape, timing and volume of hydrographs shall generally match those for the undeveloped natural catchment as closely as possible for all storm events, particularly in more frequent storm events such as the 1EY storm. Strategies to achieve such a result may include drainage swales / bio-swales and other stormwater harvesting techniques, OSD and regional retardation basins and wetlands.

(b) A detailed examination of the effect of changes of alignment, grading and channel section shall be carried out to determine water profiles and to identify areas requiring scour protection.

(c) For uniform steady flow condition, the natural watercourses and open channels can be designed using the Manning roughness coefficient 'n' in accordance with AR&R2019 and Councils Adopted Flood Study. Considerations shall be given to increase Manning roughness coefficient if the channel is likely to be obstructed by debris.

(d) For open channel, the top of channel shall be designed to incorporate the minimum 500 mm freeboard above the top water level of 1% AEP event.

(e) The open channels, natural watercourses and floodplain areas shall be designed to comply with the safety design criteria stated in AR&R2019 unless suitable safety measures approved by Council are implemented.

(f) In order to ensure there is adequate scour protection, energy dissipaters such as stilling basins or drop structures shall be designed and provided for all discharge points into and out of the channel and / or at any point in the channel where there is a significant change in flow conditions.

(g) For maintenance and safety reasons, the batter slopes of open channels shall be a maximum of 1(V):4(H).

(h) Minimum longitudinal crossfall in open channel shall be 2% with a depressed channel invert.

(i) Provision of access for maintenance staff and machinery shall be incorporated in the design of all watercourses and channels, particularly near the energy dissipaters.

(j) For connection to natural creeks, the stormwater outlet into the creek shall not be more than 2 m from the existing creek bank and the invert level of the outlet shall not be more than 100 mm above the bed of the watercourse. The end of the apron should be same level as the bed of the watercourse.

(k) Consideration shall be given for the potential of adjoining properties to drain to the creek or natural watercourse at a common location. The outlet to the creek or natural watercourse maybe required to be sized for this scenario.

(l) The open channel, watercourses and floodplain areas shall be designed to ensure it is low maintenance, naturalised and revegetated.

(m) Concrete structures are to be avoided wherever possible in favour of more natural rock walls, riprap scour protection etc. However, rock outcrops are only to be used where potential or existing scouring of creek beds and banks require such measures. Suitable select sandstone is preferred to igneous rock such as granite, basalt, dolerite etc. and

interlocking loose packed rock walls and riprap is preferred over gabion or mattress type structures.

(n) Revegetation must be conducted using plant species to replicate the structure and species composition of the natural riparian environment of the surrounding area.

(o) The design should aim to achieve a slow moving, steady flow regime to minimise scouring potential and maximise safety outcomes. Rock drop structures, incorporating low flow riffle zones, and dense (increasing floodplain roughness) riparian plantings may help achieve these outcomes on steeper sections of some watercourses.

MANNING ROUGHNESS COEFFICIENTS

Open Channel Capacity shall be calculated using the Manning Equation,

$Q = A\,R^{2/3}\,S^{1/2} / n.$

Where:

Q = Flow in m^3/s
A = Flow area in m^2
R = hydraulic radius (= A/P where P is the wetted perimeter)
S = the stream slope in m/m
n = Manning's roughness coefficient (dimensionless)

Selection of floodplain materials roughness coefficients, such as riparian areas shall be in accordance with AR&R2019 and Councils adopted flood study. In the absence of information for a specific material type, the following table provides the values for recommended Manning roughness coefficients:

Surface Types	Manning roughness coefficient (n)
Smooth Concrete	0.012
Asphaltic Concrete	0.013
Bitumen Seal	0.018
Bricks or pavers	0.015
Gravel	0.030
Rock Lining or Rip-Rap	0.060
Short Grass	0.035
Long Grass	0.050

1.6 INTER-ALLTOMENT DRAINAGE SYSTEMS

Where the land falls away from the road or there is no provision for drainage to the street, the developer will be required to provide inter-allotment drainage to carry the stormwater from the development to Council's drainage system unless the land drains to an area of Public Reserve or open space. Approval from Council is required for discharge to pipes within Council owned land.

The design of inter-allotment drainage system within the new subdivision, the following shall be complied with:

1. The design of inter-allotment drainage system, together with its associated overland flow path shall be shown on the Engineering Construction Plans

2. The inter-allotment drainage system shall be designed and constructed in accordance with AS/NZS 3500.3. The design capacity for all interallotment drainage systems must be equal to the 5%AEP or higher.

3. The inter-allotment drainage system for must be designed to cater for potential changes to land uses upstream.

4. The inter-allotment pipeline shall be minimum of 150mm diameter.

5. Minimum size of 450 x 450mm grated pit shall be provided at each slope junctions, at each bend and at the location just before crossing property boundaries.

6. The applicant shall submit hydraulic grade line (HGL) analysis to ensure the capacity of the inter-allotment drainage system is adequate to accommodate the future developments in the proposed newly created lots.

7. Adequate provision shall be made for overland flow when the inter-allotment drainage system is blocked or during storm events larger than the design AEP.

8. An inter-allotment drainage easement shall be created over the inter-allotment drainage system, burdening all the affected downstream lots and in favour to the upstream lots.

9. The location and dimension of inter-allotment drainage easement shall be shown on the subdivision plans.

10. No filling or other works will be permitted in the drainage easement which will adversely impact on:

    - The conveyance of surface flows;
    - The condition and loading on the drainage infrastructure; and
    - The rights and costs of the beneficiaries to access, maintain and replace the drainage infrastructure as required.

11. The width of drainage easement created shall fully accommodate overland flows from the upstream catchment up to and including the 1% AEP design storm event.

PRIVATE DRAINAGE EASEMENTS

Drainage easements are to be created in situations where stormwater is concentrated or discharged onto adjoining lands other than an existing easement or natural watercourse. It shall be the responsibility of the owner/applicant to obtain a drainage easement through such land, sufficient in dimension to convey the drainage to an easement or natural watercourse, and to transfer easement rights to Council or to the entities that benefit from the proposed drainage easement.

Where a drainage easement lies within a development which does not involve the opening of a new road, the owner/applicant shall transfer to Council or to the entities benefiting from the proposed drainage easement, any drainage easement provided in the subdivision and

execute a transfer and grant of easement in favour of Council or the benefiting entities, pursuant to Section 88B of the Conveyancing Act 1919.

The Subdivision Certificate will not be released until the above requirements have been complied with, and all fees and contributions have been paid.

The minimum width of the required stormwater drainage easement shall be as follows:

Minimum width of Inter-allotment drainage easement	
Pipe Diameter (D) (mm)	*Easement Width[1] (m)*
150[2]	1.5[3]
225-300[2]	2.0
375-600	2.5
675-1050	3.0
1200-1500	3.5
1650-1800	4.0
> 1800	D + 1m on each side of the pipe[4]
Twin Pipes	2D + 2.5m + distance between pipes
Culvert	D + 1m on each side of the culvert[4]
Open Channels	1m + top width of 1% AEP design flow with 500mm freeboard

Notes:
[1] Subject to the depth of proposed pipes, the easement width may need to increase
[2] Not applicable to Council piped drainage system.
[3] Under exceptional circumstance, such as constraints of the site, lesser width down to absolute minimum of 1.0m may be considered by Council subject to the assessment and approval from Council's Engineers.
[4] Measured from the outer edge of the pipe / culvert / culvert slab.

Notwithstanding the requirements outlined above, creation of a drainage easement must consider the following hierarchy:

(a) The use of natural waterways, watercourses and drainage depressions as drainage easements must be maximised;

(b) Where a manmade system is required, it shall be designed as a 'soft' engineered system such as grass lined channels; and/or

(c) Where it can be demonstrated that all alternative options have been considered and the above cannot be provided a piped drainage system may be considered.

Structures adjacent to an easement shall be designed to utilise a beam and pier system of footing or other approved method designed by a suitably experienced person and certified on the plans by a suitably qualified Structural Engineer. The load shall be transferred to below the invert of existing pipelines within the easement. The zone of influence is considered to be defined by an envelope 45 degrees from a tangent line at the level of the invert of the structure (generally the footings).

No fencing, masonry or retaining structures will be permitted to be constructed within or across an easement other than fencing on boundaries. Any section of wall spanning the easement must be constructed to enable its easy removal without resulting in failure of the remainder of the structure. The footings must be constructed to prevent any loading imposed on the pipe.

1.7 REGIONAL FLOOD DETENTION BASINS

Regional Flood Detention basins are basins that are required to manage post development flood flow rates from new subdivisions. One of the objectives is to control peak discharges and volumes discharging from a catchment. This is to ensure the peak flows generated from the development are reduced to the natural ('pre-development') condition or where required by Council, to a better condition, so that a net benefit or an offset from an impact elsewhere can be attained. One of the common configuration to achieve this objective is the provision of detention / retention basins.

Detention / Retention basins are used to store stormwater temporarily in order to delay the stormwater runoff leaving a site, so that peak flows resulted from the development or urbanisation can be controlled and reduced for a short period of time. They are to be designed as an integral part of the major stormwater management system in new development areas. The provision of detention / retention basins should be planned and designed as part of an overall catchment drainage strategy.

The use of stormwater detention basins should be avoided if at all possible, however when they are required, the following design criteria shall apply to the design of detention / retention basins:

General

- All retention basins and ponds involving the damming of waters are to be assessed by the designer under Dams Safety Committee Guidance Sheets, the assessment report submitted to Council for concurrence and referred by the designer to the Committee where required.

- All detention / retention basins and other water quantity control structures shall be designed and constructed as an off-line system from the natural watercourses and open channels.

- The detention / retention basins shall be located in an area designated as community lands, public reserves or adjacent to riparian corridors.

- The rate of rise of flood waters within the basin must be considered for basins that serve a dual purpose of recreation and flood control. The rate of rise within basins that are open and accessable to people and serve as active or passive recreation must be limited to 0.5m per hour.

- To gain maximum land use benefit, detention / retention basins should be designed for multi-purpose use wherever possible. Recreational uses such as sporting fields and open space are considered most suitable. Sporting fields shall be provided with local drainage and a low flow by-pass for the minor stormwater management system.

- All detention / retention basins shall be designed utilising flood hydrograph estimation and flood routing modelling approaches for multiple storm durations in order to ascertain the critical duration. A range of storm magnitudes up to and including 1% AEP must modelled in order to determine the maximum storage requirements and the size of outlets for the basin, so that the post-development discharge from the site does not exceed the pre-development conditions.

- The Probable Maximum Flood (PMF) must also be analysed to ensure that the performance of the basin in all flood events is considered and failure of the basin will not result in human injury, loss of life and property damage. In this regard, embankments shall be designed and constructed such that they will not breach in an uncontrolled manner in all events up to the PMF.

- The modelling of the detention / retention basins shall demonstrate that the basin will not have any adverse impact to the existing flooding regime of the catchment, particularly due to the changes in timing of the peak flows at the confluence of downstream reaches.

- It is inappropriate to consider the impact of a single development in isolation from the cumulative effects of full catchment development. The cumulative effects of stormwater detention / retention should be determined by modelling the hydraulic conditions that would exist if all future land developments were conducted in accordance with the current environmental planning instruments.

- Sensitivity analysis must be undertaken for a range of variables (catchment roughness, link lags, etc) to gauge how sensitive the design is to minor changes in these variables.

Storage

- Minimum 500mm freeboard for the 1% AEP storm event shall be provided and incorporated into the basin embankment (except at the spillway).

- The basin floor shall have a minimum 1% fall to the outlet structure.

- Due consideration shall be given to geotechnical aspects in the design of the embankments of detention / retention basins to ensure the embankments will not breach under any operating conditions for all flows up to and including 1% AEP flood event. Where required, Council may require submission of a full geotechnical report prepared by a suitably qualified Geotechnical engineer.

- For maintenance and safety reasons, the slopes of the basins shall not exceed 1:4 (v:h).
- The ponding depth in the basin shall be limited to 1.2m, if possible. Where this requirement cannot be achieved because of the site constraints, the design of basin shall take into consideration of the surrounding terrain and development. Council may require provision of safety fencing surrounding the basin.

- In urban areas, childproof safety fences will generally be required when the ponding of water in the retention basins / dams exceeds 0.3m.

- Low flows shall be allowed to pass through or around the detention / retention basin via a Water Sensitive Urban Design (WSUD) measures or low flow conveyance system.

- WSUD measures or low flow conveyance system shall be designed to convey 50% of 1 Exceedances per Year (EY) flow or as determined by Council's Engineers.

Inlet and Outlet Structure

- The outlet structure must take into account the upstream catchment land uses in consideration of potential blockage, in accordance with the blockage assessment procedures within Australian Rainfall and Runoff. A minimum blockage factor of 50% is to be assumed for pit grates of pits that contain the orifice or weir (ie the discharge control measure). This is to ensure that the flows arriving at the discharge control measure are not impacted by debris being carried by floodwater affecting the performance of the discharge control measure.

- For the reasons of maintenance, the inlet structure of the detention / retention basins shall be located above the designated sediment clean-out level to avoid submerged outlet conditions

- Emergency spillway of the basin shall be defined and provided in the form of overflow weir with the top of the weir at the 1% AEP water level of the basin.

- The capacity of the emergency spillway shall be designed to convey minimum 1% AEP flow from the catchment to downstream. Subject to potential hazard of the structure, additional spillway capacity may be required to ensure there is no catastrophic failure of the embankment.

Landscaping

- Detention basins should be designed to be sympathetic to the urban setting in which they reside. This is not a hydrologic consideration, but it is a consideration the community will use to judge these facilities. Aesthetics of the finished facility is therefore extremely important.

- The storage component of basin shall be vegetated and grassed;

- Wherever possible, designs should incorporate naturally shaped basins with landscaped banks, footpaths, and selective planting of vegetation including locally endemic grasses, sedges and rushes as well as rocks and logs to create fauna habitat to help enrich the area and provide a focal point for surrounding development. The resulting improvement in local visual amenity will also encourage the public to accept detention basins as an element of the urban natural environment and not as a target for vandalism.

- Trees and shrubs shall not be planted on basin embankments as they may increase the danger of embankment failure by ‘piping’ along the line of the roots.

Maintenance

- Adequate construction and maintenance access for vehicles and excavators shall be provided to the basins to allow machinery access the basin and carry out maintenance. Where an excavator cannot reach all parts of the basin, a concrete access ramp, with maximum slopes of 1:10, into the lowest area of the basin is required.

- Erosion and scour protection shall be provided on the spillways and the surrounding embankments.

- Debris control and scour protection shall be provided to all inlet and outlet structures of the basin.

- Any proposed erosion and scour protection measures shall be accessed and approved by Council's Engineer.

- The designer shall provide a Management Plan setting out the operation and maintenance requirements of the detention / retention basin. The following maintenance activities may be required for detention basins:
    - Maintenance of vehicular access.
    - Removal of sediment deposits.
    - Removal of debris and rubbish after storm events.
    - Repair of cracking, erosion, leakage.
    - Removal of tree growth on embankment.
    - Mowing.

  As such, the Management Plan shall provide information such as frequency of inspection, likely clean-out frequency, procedures, access, occupational health and safety requirements, and likely annual maintenance costs.

Other

- Any properties adjacent to the basin shall not be affected by the overflow or ponding of water from the basin. The finished floor level of these properties shall be minimum 500mm above the 1% AEP water level in the basin.

- Depth indicators are to be provided indicating the maximum depth in the basin.

  Appropriate warning signs shall be provided for the basins to ensure the safety of the public. The locations of signs shall be in an area clearly visibly at public access points and at entrances and exits to inlet and outlet structures.

- The design of gratings and trash racks at the inlet and outlet structures shall ensure that a person will not be held under the water against the grating or trash rack.

- Safety fencing shall be provided on steep or vertical drops, such as headwalls and wing walls, at the inlet and outlet structure to prevent accidental entry.

- Bunds or shrubs should be considered to be provided as a screening of outlet structures in order to discourage public access into the outlet structures.

1.8 DIVERSION DRAINS

Diversion drains are temporary or permanent constructed swales that are required to control and/or divert stormwater runoff away from a proposed or existing development. Where the development consent requires diversion drains to be installed they shall be installed in accordance with the following:

- Diversion drains shall be sized for flows up to and including 1%AEP.
- Diversion drains shall divert surface runoff to discharge into the nearest natural watercourse, floodway or overland flow path.
- Diversion drains shall be located adjacent boundaries.
- Discharge points shall be provided at intervals not exceeding 200m.

- Longitudinal grades shall be not less than 0.5% to minimise the likelihood of ponding and siltation within the drain.
- The maximum longitudinal grade shall be selected such that the average flow velocity in the drain does not exceed 2m/s for unlined drains and 4m/s for lined drains
- The maximum side slopes shall be in accordance with the following table:

	Private Land	Public Land
slope in fill	1 v:2h	1v : 4h
slope in cut	1 v:2h	1v : 4h
rock 1 in 0.25	1v : 0.25h	1v : 0.25h

h. Diversion drains shall be designed to allow for ease of maintenance, including ready access for maintenance machinery. In general, cut-off drains shall be designed so that mechanical grass cutting equipment (ie. motor mowers or tractor mounted mowers) can be used to control grass and weed growth. Maintenance of the drain cross section should be possible using conventional earthmoving equipment such as backhoes, front-end loaders, and trucks. Where conditions do not permit ready access, diversion drains shall be designed for minimum maintenance by providing such measures as concrete lining or stone pitching.

1.9 BUILDING AND PROPERTY DRAINAGE DESIGN

A system for collecting and conveying surface water runoff must be provided that will prevent water entering buildings or damaging improvements on the site, minimise nuisance for people accessing buildings, prevent long term surface water ponding, prevent erosion, and protect adjoining and downstream properties from any adverse stormwater impacts resulting from the proposed development.

A system of overland flow paths must be provided to ensure fail-safe protection of buildings on the property and protection to adjoining and downstream properties in the event of pipe blockage or storm events that generate runoff greater than the pipe capacity.

GENERAL REQUIREMENTS

Stormwater from roof, landscaped and paved areas must be conveyed to the street or other approved system. Design of roof guttering systems and downpipes is to be in accordance with AS3500.3 Plumbing and Drainage - Stormwater Drainage.

The system shall be planned and designed so as to generally conform to natural drainage patterns and discharge to natural drainage paths in the catchment. Suitable means to ensure the quality of stormwater leaving the does not have adverse impact upon the receiving waters must be provided.

LANDSCAPING

Runoff from landscaped areas must be collected and piped to Council's system where:

- Regrading or other improvements may concentrate runoff or increase the rate of flow onto adjoining properties or across a public footway (flows across a public footway should not create a nuisance) or

- Long-term ponding of water may occur that could constitute a health hazard or significant nuisance for property users.

MANAGING STORMWATER ENTERING PROPERTIES FROM UPSTREAM LOTS

Runoff currently entering a site from upstream properties should not be obstructed from flowing onto the site nor redirected so as to increase the quantity or concentration of surface runoff entering adjoining properties.

MANAGING RUNOFF FROM EXISTING PROPERTY IMPROVEMENTS

Where the efficiency of an existing drainage system on the property will be compromised by proposed additional site improvements, the existing system is to be suitably modified/upgraded to offset any adverse impacts.

The applicant has obligations at common law not to do any work on their property that will create nuisance on other properties. Any work that involves redirecting, concentrating or increasing the quantity of stormwater runoff over an adjoining property has the potential to create nuisance on that property. This responsibility remains with the property owner and is not transferred to Council or any other party with the approval of stormwater plans for the property or by the undertaking of inspections on the property. The property owners must satisfy themselves that the property improvements will not result in adverse drainage conditions on other properties.

PROVISION FOR FAILURE

It is important to ensure that the combined system can cope with surcharge due to blockages and flows in excess of the design AEP and up to the 1%AEP design storm. If failure of the system increases the risk to life and property, the design needs to be reviewed and amended to cater for this risk. All designs must incorporate fail-safe features.

COMPATIBILITY WITH LANDSCAPE PLANS

The detailed drainage plan is to be compatible with the landscape plan approved in conjunction with the development approval. To achieve compatibility the following matters need to be resolved:

- Conflict between the location of drainage pipelines and tree roots is to be minimised. This may be achieved by locating pipelines outside of the drip line of all significant trees.
- There should be no loose landscaping material (especially bark) within any overland flow path or onsite stormwater detention basin.
- No trees or gardens should be planted within any overland flow path that will significantly reduce the storage capacity of the overland flow path in the long term.

STORMWATER DISCHARGE LIMITS AND ONSITE DETENTION

For large scale Commercial, Industrial, multi-dwelling residential developments and other developments with site area greater than 1000m2 where the receiving stormwater system is old or undersized, amplification works to the receiving stormwater system may be required to accommodate the higher stormwater discharge rates, or alternatively, Onsite Detention may be required to limit flow rates to predevelopment conditions.

Where no public pipeline exists in the immediate vicinity of the development within the street, disposal must be via a suitably designed and constructed pipeline to the nearest available Council stormwater pit in accordance with Council's Drainage design requirements. The minimum pipe size for the pipe extension must be 375mm in diameter. The pipeline must be design by a suitably qualified hydraulic/civil engineer and submitted for assessment with the development application for the proposal.

On-site stormwater detention (OSD) is an element incorporated into the property drainage system, whereby discharge of stormwater during large storm events is restricted by an outlet control that allows excess stormwater runoff to be temporarily stored within the site. The provided storage could be in the form of a holding tank (part of a rainwater tank), oversized pipe or surface depression. This storage is called the site storage requirement, while the stored runoff discharge into downstream drainage system is called the permissible site discharge. This discharge is estimated so that a development does not increase the risk of flooding on downstream properties.

Development may be exempt from onsite stormwater detention when:

- The discharge from the property does not pass through any drainage structure before reaching the receiving water body. Eg kerb and gutter, pipe, culvert, lined channel or other restrictive structure.
- The property is wholly within a flood-affected area. For properties which are partly flood affected by the 100 year design flood, the flood effected area would be exempted from the provision of OSD.
- The total coverage by of impervious areas is less than 50% of the site area. The impervious area for the site should include roofs, paving and driveways.

Where possible, the drainage system shall be designed to direct runoff from all the impervious area of the site to the OSD system. If this is not feasible, then up to 15% of the impervious area of the site can bypass the OSD system provided that all the roof runoff is directed to the OSD and the discharge control relationship is modified to maintain the equivalent site discharge required.

The starting hydraulic grade line level for connections, whether to the underground drainage system or to the kerb and gutter, is the top of the kerb and gutter at the discharge point to the street drainage system. All active storage should be above this level.

Storage may be provided below ground in tanks or oversized pipes, or above ground as a shallow pond on a driveway, landscaped area, or combination of above and below ground storage.

The following design issues for below ground storage need to be considered:

- The storage facility must be designed to withstand all service loads.
- A sediment sump and trash screen must be installed immediately upstream of the outlet pipe. An area of 600mm x 600mm and depressed 200mm below the invert level of the outlet pipe is recommended. Sumps shall be provided with adequate weepholes to drain out to the surrounding soil, and shall be founded on a compacted granular base.
- The storage facility should be graded to drain completely using a minimum slope of 1% towards the outlet. Unless used as part of a rainwater tank, long-term ponding of water over the floor of the basin is not acceptable.

- An inspection/access opening shall be provided above the location of the outlet with minimum pit size dimensions at least 900 mm × 900 mm or 600 mm diameter for storages up to 1200 mm deep and 1200 mm × 1200 mm minimum pit size for storages greater than 1200mm deep. There shall be no impediments to the removal of debris through this opening. Inspection shall be possible without residents or owners having to remove heavy access covers.
- When storages are not sufficiently deep to work in (i.e., less than 1.5 m deep), access shall be provided at intervals of approximately 10 m to allow the system to be flushed to the storage outlet. Adequate access shall be provided at the outlet.
- Where the depth of the tank exceeds 1.2 m, step irons shall be installed.
- The storage facility should contain an overflow outlet, an inspection/access grate (600mm x 600mm) over the outlet and if the tank depth is more than 1.2m, step irons should be provided.
- All below ground OSD tanks must be accessible for maintenance purposes in accordance with the provisions for safe working conditions in confined spaces.

The following design criteria for above ground storage in landscaped areas need to be Considered:

- Minimum slope for all surfaces draining to an outlet should be 1:50 including OSD tanks, and an absolute minimum slope be 1:100 may be allowable in some areas.
- The desirable maximum depth of ponding under design conditions is 300 mm. This can be increased to 1200mm provided that side slopes of the basin are 1:6 or more or the provided storage is fenced off.
- Required storage volumes in landscaping areas be increased by 20% to allow for vegetation growth, construction inaccuracies and possible filling.
- Subsoil drains be provided around outlets to prevent the ground becoming saturated during prolonged wet weather
- Where the storage is located in areas where frequent ponding could cause maintenance problems or inconvenience, the first 15% of the storage required to be in an area which can tolerate frequent inundation, such as a paved outdoor entertainment area, a small underground tank, a permanent water feature, or a rockery.
- Storage facilities must not restrict pedestrian access from the public road to buildings.

The following design criteria for above ground storage in driveway and car park storages needs to be considered:

- Depths of ponding to not exceed 200 mm under design conditions
- Transverse paving slopes within storages be not less than 1:100
- Where the storage is located in commonly used areas where ponding would cause inconvenience, the first 15% of the storage required be provided in an area or form which will not cause a nuisance.
- Storage facilities must not restrict pedestrian access from the public road to buildings.

If external flows enter the storage, it will take less time to fill, causing it to surcharge more frequently than designed and creating a nuisance to occupiers. In some cases Council may approve an overland flow path to ensure the runoff from outside the site bypass's the on-site detention storage.

The Discharge Control Pit is the component of the detention system that controls the rate of discharge for the storage facility. It should include an orifice specially designed to control the

rate of discharge and must include screens with the following characteristics at each orifice outlet:

- For orifices up to 150 mm diameter, a fine aperture-expanded metal mesh screen (BHP Maximesh Rh3030 or equivalent) with a minimum area of 50 times the area of the orifice.
- For larger diameter orifices, a coarser grid mesh with a minimum area of 20 times the orifice area may be used as an alternative.
- Steel screens be of stainless steel or hot-dipped galvanized.
- Where aperture-expanded mesh screens are employed, they be positioned so that the oval-shaped holes are horizontal, with the protruding lip angled upwards and facing downstream. A handle may be fitted to ensure correct orientation and easy removal for maintenance.
- Screens be located so that they are at least 1.5 times the orifice diameter from the orifice, or 200 mm from the orifice plate, whichever is the greater.
- Screens be placed no flatter than 45° to the horizontal in shallow storages up to 600 mm deep. In deeper or more remote locations, the minimum angle should be 60° to the horizontal.

Orifice plates are required to be machined to the required dimension from 3mm thick stainless steel sheet and cast in the pit walls or permanently fixed in the pit with stainless steel bolts so that they cannot be easily removed. A sediment collection sump is to be provided below the orifice outlet of the stormwater detention system. This sump is to have a minimum depth of 200mm below the invert of the orifice.

FILLING OF LAND TO ACHIEVE FALL TO THE STREET

Minor filling of a site to achieve a fall to the street may be considered in circumstances where it can be demonstrated that there will be negligible impact on neighbouring properties. Prior to Council approval of any filling of the site, the developer shall satisfy Council that the proposed filling will have no significant effect upon flood risk, both upstream and downstream of the site.

STORMWATER DISCHARGE REQUIREMENTS – KERB & GUTTER

A maximum of two pipes of 100mm diameter may be used to discharge to the kerb and gutter. Galvanized steel pipe, sewer grade UPVC pipe or ‘Corflow’ spirally reinforced PVC pipe must be used from the property boundary to the kerb and gutter. The kerb and gutter connection must be a 100mm diameter galvanised steel section (for
150mm kerb and gutter) or a 150mm x 50mm galvanised rectangular steel section for roll kerb, ensuring that the galvanised section is fully encased by concrete.

The minimum cover for a pipeline in the footpath reserve between the property boundaries and kerb and gutter is 50mm. For dual connections a minimum separation of 100mm is required to maintain the structural integrity of the kerb. Pipes must cross the footpath reserve within the immediate property frontage.

STORMWATER DISCHARGE REQUIREMENTS – KERB INLET PITS

Where connection is to be made directly to Council’s underground drainage system, a minimum 150mm diameter pipe must be used (sewer grade PVC, fibre reinforced, or concrete). The connection must be made good with a concrete mix with any damage to the existing pipeline repaired to Council’s satisfaction. The new pipeline must finish flush with the internal wall of the existing Council pipe.

LOW LEVEL PROPERTIES – DISCHARGE TO DRAINAGE EASEMENTS

For large scale Commercial, Industrial, multi-dwelling residential developments where it is impractical to drain stormwater to a roadway by gravity flow, discharge to a dedicated drainage easement is required and must be sought by the applicant prior to commencement of construction.

Where an interallotment drainage easement is to be created, a letter of agreement to the creation of the easement from all the affected property owners must accompany the development application. This is to demonstrate to Council that a suitable easement/s can be obtained. The letter/s must be accompanied with a plan of the location of the proposed easement/s also signed by all the affected property owners. The letter/s is/are not to contain any conditions that may preclude the creation of the easement.

LOW LEVEL PROPERTIES – DISCHARGE TO NATURAL WATERCOURSE

Discharge to a suitable natural watercourse or creek may be allowed subject to approval by Council. The watercourse is to be protected against erosion at the point of discharge.
In this regard, an outfall apron or energy dissipation structure is to be provided. Stabilising a small length of the watercourse in the vicinity of the outlet is not appropriate as it can cause problems of erosion upstream and downstream of the stabilised section. Only a single discharge point to the watercourse from the development will be permissible.

Given the proposed method of discharge, the development will be classified as Integrated Development and will therefore require referral to the relevant state government agency to obtain a Part 3A Permit under the Rivers and Foreshores Improvement Act, 1948.

Where a water course/channel is nominated as community land an easement must be created over the pipe, headwall and scour control. This is subject to final ministerial approval.

For land adjacent to Lake Illawarra and the ocean it is preferable for stormwater outlets and associated scour control to be contained wholly within the subject site.

LOW LEVEL PROPERTIES – DISCHARGE TO INFILTRATION SYSTEMS

Single residential dwellings that cannot pipe runoff to the street or do not have access to a suitable interallotment or Council drainage pipeline, may under certain conditions be permitted to discharge stormwater runoff into an infiltration system.

If it is proposed to use an infiltration system, then the following requirements must be complied with:

a. The property must not be located within any areas identified, by a qualified geotechnical engineer, as containing soil types that are predominately not conducive to the dispersion of stormwater or likely to induce landslip. The applicant must determine whether or not the property is so affected before further proceeding with any detailed drainage design.
b. Evidence must be supplied by the applicant that all relevant downstream property owners have been approached and are unwilling to grant a private drainage easement that will allow the piping of stormwater to a Council street.

c. The base of the facility must be at least 1 to 1.5m above the seasonal high water table, bedrock, or a low permeability layer.
d. The facility must not be constructed on potential high salinity soils, hazard soils, fill or contaminated land.
e. The total plan area of all impervious areas such as roofs, driveways, paths and paved courtyards on the property do not exceed 35% of the total site area and there is an area downslope of the dwelling at least equal to the impervious areas draining to it on which to construct the infiltration trench. Note, this applies to the site cover for existing lots only. New land subdivisions will not be permitted to dispose to infiltration systems.
f. The extent of driveways and other paving near to the system is to be kept to a minimum.
g. A design and supporting calculations, prepared by a suitably qualified and experienced engineer, of a stormwater management system that will cater for runoff from the site to the system must be supplied by the applicant with the Development Application. This is to include any necessary geotechnical information required to support the design, an assessment of the in-situ infiltration of the soil profile, consideration of antecedent moisture conditions and performance over a variety of rainfall events. The design is to be accompanied with a report by a geotechnical engineer attesting to the infiltration capacity of the system, groundwater table level, reactivity of the soil, and clearly demonstrating that the proposal will not have an adverse impact upon adjoining and/or downstream properties by the direction or concentration of stormwater on those properties.
h. Any onsite infiltration structures are to be located as far as practicable from the downstream property boundary (minimum 5m) and a minimum of 3m from buildings. If the system is being constructed in conjunction with any new structure (including residential dwellings), the foundations of the structure are to consist of pier and beam and the piers are to be to a solid stratum. The system should not be placed over any paved surfaces.
i. A debris/silt collection pit must be constructed immediately upstream of the underground system, a capped observation riser installed over the underground system and area downstream is to be landscaped in a manner that will ensure a reduction of sub-soil flows into the adjoining property.
j. A positive covenant is to be placed on the Property Title to ensure that the system is adequately maintained according to the approved maintenance schedule. A Restriction as to User is to be placed on the Property Title to ensure that no additional impervious areas are created on the property. The authority to vary the Restriction is to be Council.
k. In cases where the infiltration system adjoins bushland, the infiltration trench may be constructed no closer than 2m from the boundary adjoining the bushland and run parallel with the contours.
l. When constructing structures in the rear yards of existing dwellings that already discharge runoff into an onsite infiltration system, it must be demonstrated that the structure will not have an adverse impact upon the operation of the infiltration system. This will generally require a report prepared by a suitable qualified and experienced engineer, of the existing stormwater management system and its capacity to handle the total (existing and proposed development) runoff. The design is to be accompanied with a report by a geotechnical engineer attesting to the infiltration capacity of the system and demonstrating that the proposal will not have an adverse impact upon adjoining and/or downstream properties by the direction or concentration of stormwater on those properties. In instances where it is not possible to modify the existing system, the applicant must pursue other approved means of stormwater disposal in accordance with this document.

LOW LEVEL PROPERTIES – LEVEL SPREADERS

Developments that naturally drain directly to public or crown land, such as the lake Illawarra foreshore, may (in some circumstances and at Councils discretion) be allowed to discharge stormwater over a Level Spreader. A level spreader system captures the stormwater from all impervious areas on site and releases it at the bottom of the site as a controlled sheet flow reducing the likelihood for rutting and erosion.

Where existing level spreader is being utilised prior to the development additional conditions may apply depending on the scope of the development and will be assessed on a case-by-case basis.

The property must not be located within any areas identified, by a qualified geotechnical engineer, as containing soil types that are likely to induce landslip. The applicant must determine whether or not the property is so affected before further proceeding with any detailed drainage design.

The design and supporting calculations must be prepared by a suitably qualified and experienced engineer.

In order to prevent erosion, suitable treatment downslope of the level spreader must be provided (grassed, reinforced turf, rock, etc) based on the velocity and depth of flow and length of level spreader. All required treatment must be within the subject property.

The level spreader must be placed parallel to contours and be either straight or convex (not concave as concentration of flow is not allowed).

Any level spreader system must be located a minimum of 3m from buildings or other load bearing structures.

A debris/silt collection pit must be constructed immediately upstream of the level spreader system and maintained by the property owner. The preferred design is to be either a slotted drain, grated drain or concrete kerb with turfed/grassed dish drain. Other designs may be considered if submitted and justified.

LOW LEVEL PROPERTIES – CHARGED SYSTEMS

Charged lines will be generally permitted for single occupancy residential developments when associated with rainwater tanks. In these systems, pipes are completely sealed from the tank overflow to the point of discharge, where stormwater flows under pressure during the storm event. Following the storm event, part of the system (lower than the point of discharge) will stay completely wet.

The following design guidelines are applicable:

- A full hydraulic analysis of the system should be undertaken including a hydraulic grade line and calculations must be submitted with the application. Adequate head should be provided (generally a minimum of 1.5 m) between the pipe discharge inlet (the rainwater tank overflow) and the invert of the discharge point (the isolation pit).
- All gutters and pipes in the system must be designed for a 1 in 100 year ARI storm event.
- There must be a gravity flow across the footpath from an isolating pit within the property. The isolation pit is the property owner's responsibility to maintain.

- All pipes must be a minimum of 100 mm with all joints must be solvent welded.
- A cleaning eye must be provided at the low point in the system within a pit that can be drained to an onsite absorption system.

LOW LEVEL PROPERTIES – USE OF PUMPS

Pumps may only be used to drain seepage and a minor amount of direct runoff from a basement car parking area. The area directing runoff to the pumped system must not be greater than 10% of the total basement area.

Wet wells must be designed and constructed in accordance with AS 3500.3.2 – 1998 (or subsequent amendments). The pumps must be dual submersible pumps and must be sized and constructed in accordance with AS 3500.3.2 – 1998 (or subsequent amendments).

Direct connection of a pump's rising main directly to the kerb will not be permitted. Where connection to the kerb is proposed, the pumped water must be treated prior to discharge to remove any pollutants before being piped across the public footway by gravity flow.

The design must include calculations showing that the maximum ponding depth for a 1% AEP storm event (in the event of a 3 hour power failure) is not greater than 300mm.

SEDIMENT ARRESTORS

Sediment arrestors are be installed to remove sediment, oil and other contaminants from the stormwater before it discharges into the receiving system.

Sediment arrestors must be installed for the following developments:

• Residential developments of more than three dwellings.

• All commercial developments that may involve the use/transportation of contaminants.

• Commercial developments on allotments greater than 1500m2. Where developments directly involve more than one allotment, then the total area of allotments directly involved is to be considered.

• Sediment and oil arrestors must be installed for all industrial developments.

Any sediment and/or oil arrestors must be designed in accordance with AS3500.3:2003 (Standards Australia 2003) and must have an opaque pit lid to prevent sunlight entering into the pit thereby reducing the likelihood of mosquito breeding.

1.10 WATER SENSITIVE URBAN DESIGN (WSUD)

DESIGN CONSIDERATIONS

For new development, any requirement to include Water Sensitive Urban Design (WSUD) measures will be addressed as part of the documentation prepared with the Development Application. All WSUD measures must be designed to achieve the stormwater quality improvement targets identified in Councils various Stormwater Quality Improvement

Strategies (where such strategies exist) and any Coastal Management Programs (where such programs exist) within the Shellharbour Local Government Area.

When WSUD measures are required to be integrated into a proposed development, the technical specification defined in this document will apply. Engineering details of all WSUD and associated treatment measures shall be shown on the Engineering Construction Plans and must be in accordance with the stormwater concept design and stormwater treatment train developed as part of the approved Water Cycle Management Plan.

All Vegetated Stormwater Systems, including constructed wetlands and bioretention systems are to be designed and located such that velocity of flows travelling through the system are to be less than 0.5 m/sec in all design events up to and including the 10% AEP and less than 2 m/sec for all remaining events up to and including the 1% AEP.

Any modifications or works within or adjacent to a creek line or stream must be in accordance with the NSW DPI and Water NSW Guidelines for Riparian Corridors on Waterfront Land. This includes identification of the Stahler Stream Order and identification of the Riparian corridor width which must be clearly marked on construction plans. Any proposed modification within or adjacent to the creekline or proposed works within the Riparian Corridor, that does not constitute minimal harm as detailed in Table 2 of the guidelines, must be referred to Water NSW for a Controlled Activity Approval.

GROSS POLLUTANT TRAPS (GPTS)

GPTs are efficient ways of removing gross pollutants and course sediments from the stormwater system. They are often the first treatment measure in a treatment train. They can be used upstream of wetlands and other water bodies to protect them from sedimentation and gross pollutants or they can be located immediately downstream of commercial, industrial or other development types that have a high probability of gross pollutants being washed into the stormwater system.

Gross pollutant capture efficiency varies between different types of GPTs, as does coarse sediment removal. Most GPTs cannot remove fine sediments, nutrients or other pollutants to any significant degree.

The following design aspects must be considered:

- A Flood Impact Assessment report must be provided by a suitably qualified hydraulic engineer to support the installation of GPTs. The report must include design detail for any diversion channel or weir system as well as bypass operation system. The Flood Impact Analysis shall be assessed in accordance with the requirements of Councils Floodplain Risk Management Policy and the Hydrologic and Hydraulic Considerations chapter of this technical design specification document. In this regard, the operation of the GPT, either in or not in Bypass mode, shall not impact on the performance of the upstream stormwater drainage system.
- The size of the catchment to be treated, and the flow rate that must pass through the GPT must be considered. GPTs are to be sized to treat a target flow of 1 in 3 months.
- The types of pollutants and loads in the catchment, for example, commercial areas are likely to generate higher loads of litter than residential areas.
- The types of pollutants the GPT is designed to collect. For example, as pre-treatment to a wetland, it is important to remove coarse sediment loads. However at other

locations, it may be undesirable to trap sediment, in case it impacts on natural sedimentation deposition downstream.

- The GPT's efficiency in trapping pollutants that will affect the frequency and magnitude of cleanouts, and the volume of waste material requiring disposal. Sump volumes for GPT's must be designed with sufficient pollutant holding capacity to cater for the 50% AEP design storm.
- All GPTs must be designed so that they automatically operate in bypass mode when the pollutant sump reaches capacity.
- Suitable access must be provided to enable efficient and effective cleanout of GPTs. In this regard, safe and reliable truck/plant access must be considered and details provided on plant, including any pavement/structural specification for heavy machinery. Access must not require traffic control or any specialist equipment to enable maintenance of the GPT.
- A maintenance period of up to 3 years may be required of the developer to maintain the GPT whilst other stages of development upstream are still taking place.
- Operation and Maintenance Manuals are to be provided for each GPT prior to handover to Council. The manuals are to include any monitoring information that may have been collected during establishment phase of operation.

VEGETATED SWALES AND BUFFER STRIPS

Vegetated swales and buffer strips are vegetated minor overland flow paths designed to "disconnect" otherwise directly connected impervious areas from a receiving waterbody, thereby assisting in protecting waterways from damage caused by frequent storm events. They do this by reducing flow velocity compared with piped systems and provide removal of coarse and medium sediments. Vegetated Swales and Buffer Strips shall be designed generally in accordance with Chapter 4.5.7 of Book 9 Australia Rainfall & Runoff (AR&R) 2019 and the Heathy Waterways Water Sensitive Urban Design Technical Design Guidelines for South East Queensland.

Unlike conventional stormwater systems, Vegetated Swales and Buffer Strips have specific establishment requirements that need to be adhered to in order for them to operate as designed. In regards to this, the Heathy Waterways Water Sensitive Urban Design Construction and Establishment Guidelines for swales, Bioretention systems and wetlands must be considered and adhered to. For WSUD in large subdivision sites where there is large amounts of land upstream that is being disturbed by construction activity, it is recommended that vegetated stormwater systems are not brought to full establishment phase until at least 85% of the land upstream has been stabilised.

BIO-RETENTION SYSTEMS

Bio-retention system, bio-swales and rain gardens are all shallow depressions with a network of perforated under-drainage and a soil-based filter media designed to treat stormwater runoff. They use vegetation to absorb nutrients in the water and filtration through filter media to reduce downstream impacts. In addition, it may provide reduction in outflow or allow stormwater detention. The bio-retention systems / rain gardens shall be designed generally in accordance with Chapter 4.5.4 of Book 9 Australia Rainfall & Runoff (AR&R) 2019 and the Heathy Waterways Water Sensitive Urban Design Technical Design Guidelines for South East Queensland.

Unlike conventional stormwater systems, Bio-Retention systems have specific establishment requirements that need to be adhered to in order for them to operate as designed. In regards to this, the Heathy Waterways Water Sensitive Urban Design Construction and Establishment Guidelines for swales, Bioretention systems and wetlands must be considered and adhered to. For WSUD in large subdivision sites where there is large amounts of land upstream that is being disturbed by construction activity, it is recommended that vegetated stormwater systems are not brought to full establishment phase until at least 85% of the land upstream has been stabilised.

CONSTRUCTED WETLANDS

Constructed wetland is a system of waterbodies that store water and sustain a range of aquatic macrophytes and semi-aquatic plants. It is designed to retain nutrients, heavy metals, bacteria and other pollutants and to be implemented as a component of WSUD in conjunction with other WSUD measures to achieve the water quality and water quantity targets. In addition, it can also provide passive recreation, increase visual appeal of an area and provide wildlife habitat. The design of constructed wetland shall be carried out in accordance with Chapter 4.5.5 of Book 9 Australia Rainfall & Runoff (AR&R) 2019 and the Heathy Waterways Water Sensitive Urban Design Technical Design Guidelines for South East Queensland.

Unlike conventional stormwater systems, Bio-Retention systems have specific establishment requirements that need to be adhered to in order for them to operate as designed. In regards to this, the Heathy Waterways Water Sensitive Urban Design Construction and Establishment Guidelines for swales, Bioretention systems and wetlands must be considered and adhered to. For WSUD in large subdivision sites where there is large amounts of land upstream that is being disturbed by construction activity, it is recommended that vegetated stormwater systems are not brought to full establishment phase until at least 85% of the land upstream has been stabilised.

PROPRIETY PRODUCTS AND DEVICES

In some circumstances, Council may consider propriety WSUD devices where it can be demonstrated that such devices can achieve the desired treatment performance and there are long term maintenance benefits from opting for such a device.

In these circumstances it must be clearly demonstrable that:

- The ongoing short, medium and long term maintenance costs of the proprietary is less than that of an equivalent conventional treatment measure. This includes the long term full replacement cost of the device if it has an end of life. All cost estimates are to be submitted to Council for consideration and scrutiny.
- The proprietary device must not need any specialist equipment to carry out maintenance activities.
- Maintenance of the proprietary device must not require a significant ongoing cost to Council for the ongoing purchase any major consumable parts on a regular basis in order for the device to operate as designed. e.g. cartridges, filters, etc. as these consumable parts are subject to possible price rises over the long term that are unable to be confirmed. Discussion with Council at DA stage is recommended for any proprietary WSUD devices.

RAINWATER TANKS

Rainwater Tank installation is to be undertaken in accordance with HB 230—2008 Rainwater Tank Design and Installation Handbook.

In addition the following requirements will apply:

- Water collected within the tank is to be used for domestic purposes only and does not replace the requirement for a stormwater detention system. Overflow from any tank must be piped to the approved drainage system.
- Plumbing from the tank must be separate from the reticulated Sydney Water supply system. Taps associated with the tank are to be clearly marked indicating the source of the water.
- The water tank inlet must be screened to prevent the entry of any animal/foreign matter into the tank and must be designed to preclude or discourage the breeding of mosquitoes.
- No part of any water tank structure must be higher than the roof water guttering of the dwelling/associated structure.

The design of any water tank support structure (other than a modular style) must be in accordance with the requirements of a qualified practising structural engineer.

WSUD STANDARD DRAWINGS AND CONSTRUCTION SPECIFICATION

Standard design and construction specification for WSUD devices and treatments shall be in accordance with Shellharbour City Councils Standard Drawings for Water Sensitive Urban Design available for download from the Council website.

WSUD OPERATION AND MAINTENACE MANUALS AND CHECK LISTS

Draft Wetland Management, Operation, Maintenance and Monitoring Manual/s ('Manuals') for permanent water quality facilities shall be provided for approval by the Principal Certifying Authority prior to construction. The Manuals shall be prepared by a suitably qualified person in accordance with this specification. The final adopted Manuals for the permanent water quality facilities must be submitted to the Principal Certifying Authority. The manuals must be prepared by a suitably qualified professional in accordance with the objectives and criteria identified in the approved Water Cycle Management Plan.

Compliance checklists are to be prepared by the design engineer designing the Stormwater Treatment Facility and submitted to Council prior to issue of a construction certificate. The checklists must incorporate all checks and certifications that are required to be carried out during the civil construction phase, asset protection phase, landscape practical completion phase and final compliance inspection prior to final handover.

The proponent is responsible for all maintenance of the wetlands and vegetated stormwater assets during the maintenance period and upon Councils acceptance that the wetlands and vegetated stormwater assets are of a satisfactory condition at the end of the maintenance period. Approaching hand over at the conclusion of the maintenance period, a site meeting with Council must be arranged by the proponent. The objective of the meeting will be to identify any outstanding actions that require rectification by the proponent before asset hand over. Annual reports documenting implementation measures and containing all monitoring results are to be submitted to Council during this phase.

TEMPORARY STORMWATER MANAGEMENT FACILITIES

Since staged construction is common in most of the land subdivision developments, particularly in the new release area, stormwater treatment/ management facilities may not be practically finalised and implemented until the time when the land subdivision development is nearly completed and most houses are built. As such, temporary stormwater treatment / management facilities will be required for each stage of development in order to limit the peak discharges, volumes and sediments discharging from the site and / or act as sediment basins to control stormwater quality.

The design of temporary stormwater treatment / management facilities shall comply with the following:

- These facilities shall be sited in the same final location of the stormwater volume management facilities approved in the land subdivision development.
- The storage capacity and the inlet and outlet structures of these facilities shall match final design of stormwater volume management facilities.
- The internal batters of these facilities shall not exceed 1:4 (v:h).
- Temporary maintenance access shall be provided generally in according to the final approved maintenance access design. The temporary maintenance access shall be stabilized for all-whether access.
- The sediment & erosion control in these facilities shall be implemented and maintained by the Applicant until the completion of the approved stormwater management facility.
- Debris control and scour protection shall be provided to all inlet and outlet structures.
- Embankments shall be grassed or turfed.
- If these facilities are intended to be used for other functions, such as parks / recreational facilities, they shall not be opened to the public and the area shall be fenced until the entire stormwater management facility is fully completed.

When the construction of a WSUD measure is proposed to be deferred by a developer to enable release of land to the market, a bond based on 200% of estimated cost of final design of the stormwater treatment /management facility shall be provided and approved by Council prior to the issue of subdivision certificate. An appropriate documentation detailing how the value of the outstanding works has been calculated must be submitted and accepted by Council. The bond may only be released upon practical completion of the stormwater treatment/management facility to the satisfaction of Council.

1.11 SAFETY IN DESIGN

To address public safety from a criminal standpoint all drainage design structures and system elements must be assessed using the NSW Police **'Safer by Design'** or **Crime Prevention through Environmental Design (CPTED) principles and protocols**. The development proposal must demonstrate how public safety and risk will be managed. The following will be considered in the assessment of proposals (this list is not exhaustive

and requirements will vary from site to site):

(a) System elements which provide concealment opportunities will not be permitted;

(b) Vegetation which provides opportunities for concealment adjoining pedestrian areas will not be permitted; and

(c) Underground pipe and pit systems which are large enough for children to get into must be designed using a risk based framework to determine if inlet/outlet screening is required.

Council also endorses the use of Safety-in-design principles developed as part of the Queensland Urban Drainage Manual (QUDM). Safety measures, such as inlet/outlet screens or exclusion bars may be required pending the outcome of a risk assessment carried out in accordance with the procedures in the QUDM.