CAPRICORN MUNICIPAL DEVELOPMENT GUIDELINES

STORMWATER DRAINAGE DESIGN

D5

DESIGN GUIDELINES

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Keeping the Capricorn Municipal Development Guidelines up-to-date

The Capricorn Municipal Development Guidelines are living documents which reflect progress of municipal works in the Capricorn Region. To maintain a high level of currency that reflects the current municipal environment, all guidelines are periodically reviewed with new editions published and the possibility of some editions to be removed. Between the publishing of these editions, amendments may be issued. It is important that readers assure themselves they are using the current guideline, which should include any amendments which may have been published since the guideline was printed. A guideline will be deemed current at the date of development approval for construction works.

GENERAL

D05.01. SCOPE

D05.01.01. This section sets out the guidelines for the design of stormwater drainage systems for urban and rural areas.

D05.01.02. The following order of priority for interpretation of documents will apply: (Please note that reference to a Guideline or Standard, is reference to the latest version of the relevant document, unless specifically a version number is specifically stated)

Order of Priority

1. CMDG D5 Stormwater Design Specification
2. Queensland Urban Drainage Manual (QUDM)
3. AUSTROADS
4. DTMR Specifications and Standard Drawings
5. Australia Rainfall and Runoff
6. Australian Standards

D05.02. OBJECTIVES

D05.02.01. The objectives of stormwater drainage design are as described in the Queensland Urban Drainage Manual (QUDM).

D05.03. REFERENCE AND SOURCE DOCUMENTS

(a) CMDG Specifications

C220 - Stormwater Drainage - General
C221 - Pipe Drainage
C222 - Precast Box Culverts
C223 - Drainage Structures
C224 - Open Drains including Kerb & Gutter

(b) Australian Standards

AS1254 - PVC-U pipes and fittings for stormwater and surface water applications.
AS2032 - Installation of PVC pipe systems.
AS3725 - Design for installation of buried concrete pipes.
AS4058 - Precast concrete pipes (pressure and non-pressure).
AS4139 - Fibre reinforced concrete pipes and fittings.
AS1597.1 - Precast reinforced concrete box culverts - Small culverts (not exceeding 1200mm span and 1200mm height).
AS1597.2 - Precast reinforced concrete box culverts - Large culverts (exceeding 1200mm span or 1200mm height and up to and including 4200mm span and 4200mm height).
AS3500.3 - Plumbing and drainage - Stormwater drainage.

(c) Other

Queensland Government
- Land Act 1994
- Land Title Act 1994

Department of Energy and Water Supply

- Queensland Urban Drainage Manual (QUDM), latest edition.

Department of Environment and Heritage Protection
- Queensland Water Quality Guidelines 2009

Department of Infrastructure, Local Government and Planning
- State Planning Policy 2017

Department of Transport and Main Roads.
- Manual Road Drainage (2015)
- Standard Drawings

Geoscience Australia
- Australian Rainfall and Runoff (ARR) 2016.

AUSTROADS
- Guide to Bridge Technology series
- Guide to Road Design
- Part 5: Drainage - General and Hydrology Considerations
- Part 5A: Drainage - Road Surface, Networks, Basins and Subsurface.
- Part 5B: Drainage - Open Channels, Culverts and Floodways

Engineers Australia - .
- Australian Runoff Quality - A Guide to Water Sensitive Urban Design.

Institute of Public Works Engineering Australasia, QLD Division.
- Standard Drawings, 2013

Healthy Waterways
- MUSIC Modelling Guidelines
- Practice Note - MUSIC Modelling of Bioretention Systems with Infiltration
- Bioretention Technical Design Guidelines
- Concept Design Guidelines for Water Sensitive Urban Design.
- WSUD Technical Design Guidelines for South East Queensland.
- Deemed to Comply Solutions - Stormwater Quality Management
- Construction and Establishment Guidelines: Swales, Bioretention systems and Wetlands International Erosion Control Association
- Best Practice Erosion and Sediment Control document

Concrete Pipe Association of Australia
- Hydraulics of Precast Concrete Conduits.
- Colebrook White Charts

Australian National Conference On Large Dams, Leederville WA.
- ANCOLD 1986, Guidelines on Design Floods for Dams.

HYDROLOGY

D05.04. DESIGN RAINFALL DATA

D05.04.01. Design rainfall shall be determined in accordance with Book 2 of Australian Rainfall & Runoff (ARR) - A Guide to Flood Estimation (2016). Intensity-Frequency-Duration (I-F-D) data is to be derived from information obtained within the Bureau of Meteorology (BOM) website. The assessment must be

I-F-D Data

based on latitude and longitude of the location under design. Refer to www.bom.gov.au/water/designRainfalls

D05.04.02. Design Annual Exceedance Probability (AEP) shall be in accordance with Table D05.04.1**Error! Reference source not found.**. ***ARI and AEP***

Table D05.04.1 - Design Annual Exceedance Probabilities

Development Category		**Major System**		**Minor System**	
		ARI (yrs)	AEP (%)	ARI (yrs)	AEP (%)
Central Business & Commercial		100	1	10	10
Industrial		100	1	2	39
Urban Residential (High Density – greater than 20 dwelling units/ha)		100	1	10	10
Urban Residential (Low Density – 6 & up to 20 dwelling units/ha)		100	1	2	39
Rural Residential – 2 to 5 dwelling units/ha		100	1	2	39
Open Space – Parks, etc.		100	1	1	63
Major Collector / Distributor and higher	Kerb and channel flow	100	1	10	10
	Cross drainage (culverts)	100	1	50	2
Minor road	Kerb and channel flow	20	5		
	Cross drainage (culverts)	20	5	10	10

Notes:

1. The design AEP for the minor drainage system in a major road shall be that indicated for the major road, not that for the Development Category of the adjacent area.
2. Cross drainages should be designed to accept the flow for the minor system AEP shown. In addition, the designer must ensure that the major system backwater does not enter properties upstream. If upstream properties are at a relatively low elevation, it may be necessary to install culverts of capacity greater than that for the minor system AEP design storm to ensure flooding of upstream properties does not occur. In addition, the downstream face of the causeway embankment may need protection where overtopping is likely to occur.
3. The terms used in this table are described in the QUDM Glossary and/or Table 7.3.3 of QUDM 2013.
4. Council specific or refer to development category.
5. VDg, flow depth and width limitations are applicable in accordance with QUDM.

D05.05. CATCHMENT AREA

D05.05.01. The catchment area of any point is defined by the limits from where surface runoff will make its way, either by natural or man-made paths, to this point. Consideration shall be given to likely changes to individual catchment areas due to the development of the overall catchment. ***Catchment Definition***

D05.05.02. The catchment boundary shall be determined by using the most accurate information available subject to Local Government approval. A catchment boundary plan shall be presented to the Local Government on a contour map along with the source of the information.

D05.05.03. Design discharge from a catchment area shall be based on a fully developed catchment in accordance with the current Planning Scheme or Strategic Plan and other available information on developments within the catchment. Developers need to obtain guidance from the local government as to what flow conditions should be assumed for the fully developed upstream catchment. ***Design Discharge***

D05.06. HYDROLOGY AND HYDRAULICS

D05.06.01. The Rational Method shall be used for regular shaped catchments and as long as requirements for QUDM are met. Where catchments are an irregular shape or run-off characteristics vary considerably within the catchment, partial area calculations may be required to determine peak flows to be used in design. Rational Method calculations to determine flows shall be carried out in accordance with QUDM.

Rational Method

D05.06.02. All calculations shall be carried out by a qualified person experienced in hydrologic and hydraulic design under the supervision of a Registered Professional Engineer of Queensland (RPEQ) experienced in this field.

Qualified Person

D05.06.03. Coefficients of discharge shall be calculated in accordance with QUDM. Unless agreed otherwise with the local Council, the following Table D05. 06.1 - Fraction Impervious for **Development** shall be used to determine C_{10}.

Runoff Co-efficient

Table D05. 06.1 - Fraction Impervious for Development Categories

Zones	Fraction Impervious
Central business areas (including in the Principal centre zone and Major centre zone)	1.00
Industrial uses and other commercial uses (including in the District centre zone and Neighbourhood centre zone)	0.90
Significant paved areas (e.g. roads and car parks)	0.90
High Density Residential land uses (> 20 dwelling units per hectare) Townhouse type development Multi-unit dwellings High-rise residential development	 0.80 0.85 0.90
Medium, Low-Medium, and Low density residential area (including roads) Average lot ≥750m^2 Average lot ≥600m^2 < 750m^2 Average lot ≥450m^2 < 600m^2 Average lot ≥300m^2 < 450m^2 Average lot <300m^2	 0.60 0.75 0.80 0.85 0.90
Medium, Low-Medium, and Low density residential area (infill subdivision excluding roads) Average lot ≥ 750m^2 Average lot ≥ 600m^2 < 750m^2 Average lot ≥ 450m^2 < 600m^2 Average lot ≥ 300m^2 < 450m^2 Average lot <300m^2	 0.55 0.60 0.65 0.75 0.80
Rural/ environmental protection areas (2-5 dwellings per ha)	0.20
Open space areas (e.g. parks with predominately vegetated surfaces)	0.20

D05.06.04. Where the flow path is through areas having different flow characteristics or includes property and roadway, then the flow time of each portion of the flow path shall be calculated separately.

D05.06.05. The maximum time of concentration in an urban area shall be 20 minutes unless sufficient evidence is provided to justify a greater time.

Time of Concentration

D05.06.06. The minimum time of concentration shall be 5 minutes for any catchment to its point of entry into the drainage network.

D05.06.07. Flow paths to pits shall be representative of the fully developed catchment

considering such things as fencing and the likely locations of buildings. Consideration shall be given to likely changes to individual flow paths due to the full development of the catchment.

D05.06.08. Mannings 'n' surface roughness co-efficient shall be derived from information contained in QUDM. ***Manning's 'n'***

D05.06.09. For large and/or complex drainage situations, detention basins, situations nominated as important by a delegated officer from Council, and / or where the Rational Method is not suitable as described in QUDM, an appropriate computerised hydrological model shall be used to determine peak flow rate and peak volume utilising recognised software packages for runoff routing and drainage analysis. Book 5 of ARR shall be used for estimation of flood hydrograph and losses.

D05.06.10. The full electronic files associated with any computerised modelling works shall be provided to Council as a part of Site Based Stormwater Management Plan. Computer model shall be prepared by a qualified person experienced in the use of the program and under the supervision of a Registered Professional Engineer of Queensland (RPEQ) experienced in this field. The accuracy of the model shall be verified by a RPEQ experienced in this field. The model shall be calibrated and a sensitivity analysis shall be completed. Acceptable software packages are identified in Table D05.06.02 – Acceptable Modelling Packages.

Table D05.06.02 – Acceptable Modelling Packages ***Computerised Models***

	Banana Shire	Central Highlands Regional	Gladstone Regional	Isaac Regional	Maranoa Regional	Livingstone Shire	Rockhampton Regional
Runoff Routing:			XP Raft/ TUFLOW				
Drainage Analysis:			Drains (ILSAX)/ PCDRAINS				
Steady Flow			HEC-RAS				
Unsteady flow			MIKE 11/ XPSWIM/ TUFLOW				
Water Quality			MUSIC				

HYDRAULICS

D05.07. HYDRAULIC GRADE LINE

D05.07.01. Hydraulic calculations shall generally be carried out in accordance with QUDM and shall be undertaken by a qualified person experienced in hydrologic and hydraulic design and under the supervision of a RPEQ experienced in this field. ***Qualified Person***

D05.07.02. The hydraulic calculations shall substantiate the hydraulic grade line adopted for design of the system and shown on the drawings. Summaries of calculations are to be provided with the design including listings of all program input and output. ***Calculations***

D05.07.03. The "major" system shall provide safe, well-defined overland flow paths for infrequent (for meanings, refer to Ch 3 of Book 2, Australian Rainfall and Runoff: A Guide to Flood Estimation) storm runoff events while the "minor" system shall be capable of carrying and controlling flows from frequent runoff events. Refer to Table D05.04.1 for major and minor storm event AEP's.

D05.07.04. Downstream water surface level requirements are given below: - ***Downstream Control***

(a) Known hydraulic grade line level from downstream calculations including pit losses at the starting pit in the design event.
(b) Where the downstream starting point is a pit and the hydraulic grade line is unknown, a level of 0.15m below the invert of the pit inlet in the downstream pit is to be adopted.
(c) Where the outlet is an open channel or natural watercourse, the tailwater level shall be established by calculation of the coincident rainfall event in the open channel or natural watercourse.

D05.07.05. The water surface in drainage pits shall be no higher than 0.15m below the gutter invert for inlet pits and 0.15m below the underside of the lid for junction pits. ***Water Surface Limits***

D05.08. PIPES / BOX CULVERTS

D05.08.01. Minimum culvert sizes are given below: ***Minimum Culvert Sizes***

- The minimum pipe size shall be 375mm diameter.
- The minimum box culvert size shall be 600mm wide x 300mm high.

D05.08.02. Minimum cover to pipes shall be in accordance with the manufacturer's specifications, wherever possible a minimum cover of 600mm is preferred.

D05.08.03. Maximum culvert depth/diameter to be located beneath the kerb alignment is 600mm. Culverts above this size are required to be located within the road carriageway. ***Maximum Culvert Size***

D05.08.04. Culvert classes shall be determined in accordance with manufacturer's recommendations. Appropriate consideration should be taken for loadings from construction traffic when determining culvert class. ***Culvert Classes***

D05.08.05. Maximum construction loads for each compaction layer of stormwater trench must be nominated and included on design (Intended to avoid cracking of concrete structures). ***Maximum Compaction Loadings***

D05.08.06. The minimum vertical and horizontal clearance between stormwater culverts and other services is to be 0.3m except for sewer that requires 0.3m and 0.6m respectively. ***Clearance***

D05.08.07. In areas where any part of the pipe is below AHD RL 5.0, exposed to saltwater or aggressive soil, culverts shall have cover to reinforcement in accordance with AS3600, AS3735 and AS5100.5. ***Exposure Classification & Clear Cover to Reinforcement***

D05.09. PITS

D05.09.01. Inlet Pits shall be spaced so that the gutter flow width is limited to be in accordance with QUDM and so that the inlet efficiency is not affected by adjacent inlet openings. Preference shall be given to the location of drainage pits at the upstream side of allotments. ***Spacing***

D05.09.02. Access chambers shall be provided in accordance with QUDM.

D05.09.03. Gully inlets shall be local authority approved proprietary inlet structures. Current approved products are stormwater gully inlet from "C-M Concrete Products. Alternative products may be utilised subject to approval by the Local Authority. ***Gully Inlet Capacity***

D05.09.04. Lip-in-Line gully inlets are to be utilised.

D05.09.05. Inflow capacities shall be in accordance with the manufacturer's specifications with Blockage Factor applied in accordance with QUDM.

D05.10. OVERLAND FLOW

D05.10.01. The major system shall be designed generally in accordance with QUDM. Where overland flow is to be transferred from the road network into drainage reserve, open space or parkland, dedicated drainage flow paths must be provided in accordance with QUDM with a minimum width of 5m. For unlined flow path or channel, it shall be designed to allow access to facilitate maintenance activities. The widths of the access and maintenance berms are required to be a minimum of 4.5m. The transfer of overland flow from road reserve to open space shall not be permitted within private property. ***Overland Flow***

D05.10.02. Overland flow paths shall be located in accordance with QUDM.

D05.10.03. Drainage flow paths do not generally count as useful park contribution areas. Refer to the relevant Local Governments planning scheme policies for this information.

D05.11. OPEN CHANNELS

D05.11.01. Open channels shall be designed to have smooth transitions with adequate access provisions for maintenance and cleaning. Where the Local Authority permits the use of an open channel to convey flows from a development site to the receiving water body, such a channel shall comply with the requirements of this Guideline, QUDM and Australian Rainfall and Runoff (ARR).

D05.11.02. Safety fencing shall be provided at dangerous sections in accordance with CMDG specification and standard drawings, and QUDM, AS1926.1, and AS1926.2. Fence height of 1.2m is considered to be appropriate. ***Safety***

D05.11.03. Where the product of average velocity and average flow depth at the design flow rate is greater than 0.4m²/s, the design will be required to specifically provide for the safety of persons who may enter the channel.

D05.11.04. Design of open channels shall be generally in accordance with QUDM. Open channels will be designed to contain the major system flow for 1% AEP (100 year ARI) less any flow that is contained in the minor system (if applicable), with an appropriate freeboard for open channel and allowance for blockage of the minor system in accordance with QUDM. Freeboard shall be calculated in accordance with QUDM. Access and maintenance berms are to be provided in accordance with Section D05.10 of the specification. ***Design Flow and Freeboard Access and Maintenance berm***

D05.11.05. A minimum longitudinal grade for an open channel shall be based on the minimum permissible velocity. The minimum permissible velocity shall be such that it prevents deposition of the sediment.0.5% applies for open channels. ***Minimum Grade / velocity***

D05.11.06. Friction losses in open channels shall be determined using Mannings "n" values given below: - ***Channel Roughness***

Mannings "n" Roughness Coefficients for open channels shall generally be derived from information in Chapter 2 of Book 6, Australian Rainfall & Runoff 2016.

Mannings "n" values applicable to specific channel types are given below: -

Concrete Pipes or Box Sections	0.013
Concrete (trowel finish)	0.014
Concrete (formed without finishing)	0.016
Sprayed Concrete (gunite)	0.018
Bitumen Seal	0.018
Bricks or pavers	0.015
Pitchers or dressed stone on mortar	0.016
Rubble Masonry or Random stone in mortar	0.028
Rock Lining or Rip-Rap	0.028
Corrugated Metal	0.027
Earth (clear)	0.022
Earth (with weeds and gravel)	0.028
Rock Cut	0.038
Short Grass	0.033
Long Grass	0.043

Mannings 'n' values for Landscaped open channels shall be determined on an individual basis subject to approval by the Local Authority

D05.11.07. Maximum side slopes on grassed lined open channels shall be 1(V) in 4(H) for maintenance purposes, unless otherwise approved by the Local Authority. Channel inverts shall generally have minimum cross slopes of 1 in 20. ***Side Slopes***

D05.11.08. Low flow provisions in open channels (man-made or altered channels) will require low flows to be contained within a pipe system, or low flow channel at the invert of the main channel. In the case of low flow pipe, a minimum size of 375mm is required. Scouring velocities in the pipe shall be obtained at AEP 39% (2 year ARI). Channels shall be designed to prevent waterlogging of the channel bed. The width of the invert shall be sufficient to accommodate the full width of a tractor and slasher. Local Authority approval is required for situations where low flow pipes are not required and subsoil drainage will suffice. ***Low Flows***

D05.11.09. Channels shall be designed for sub-critical flow. Transitions in channel slopes are to be designed to avoid any hydraulic jumps due to the nature of the transition. ***Hydraulic Jumps***

D05.11.10. Armouring shall be provided in accordance with the requirements of QUDM and shall be designed to suit the design flow velocity. Refer to the CMDG Standard Drawing ***Armouring***

D05.11.11. The preferred solutions for open channel treatments are natural treatments including the use of rock lining, vegetation treatments and soft engineering solutions.

D05.12. MAJOR STRUCTURES

D05.12.01. Refer to D3 STRUCTURES & BRIDGE DESIGN for the requirements on stormwater drainage design in relation to these structures. ***Major and Minor Structures***

D05.13. WATER SENSITIVE URBAN DESIGN (WSUD)

D05.13.01. Water Sensitive Urban Design (WSUD) shall be implemented in accordance with the respective Council's Planning Scheme and/or policy. ***Implementation of WSUD***

D05.13.02. Design guidelines for implementing WSUD shall be in accordance with Australian Runoff Quality: Guide to Water Sensitive Urban Design by Engineers Australia and Water Sensitive Urban Design: Healthy Waterways WSUD Technical Design and Bioretention Technical Design Guidelines. ***Design Guidelines***

D05.13.03. Bioretention Basins shall be designed in accordance with Bioretention Technical Design Guidelines by Healthy Waterways. ***Bioretention Basin Design***

D05.13.04. Plant species for a bioretention basin shall be selected in accordance with Annexure D05A. Climatic regions are in accordance with State Planning Policy Interactive Mapping System, Department of Infrastructure, Local Government and Planning (known as SPP Interactive Mapping System), and Climate Classification of Australia (Köppen maps), BOM. Table D05.13.01 provides climatic region in accordance with SPP Interactive Mapping System for participating local government areas. For lists of plants, refer to Annexure D05A. ***Plant Species***

Table D05.13.01: Climatic Regions for Local Government Areas

Local Government	Climatic Region
Banana Shire Council	Western Queensland
Central Highland Regional Council	Western Queensland
Gladstone Regional Council	Central Coast (South)
Livingstone Shire Council	Central Coast (South) and Western Queensland
Maranoa Regional Council	Western Queensland
Rockhampton Regional Council	Central Coast (South) and Western Queensland

Table D05.13.02 shows a correlation between the State Planning Policy Interactive Mapping System, Köppen maps and the climatic regions specified in the Bioretention Technical Design Guidelines. ***Detention and Retention Basin design.***

Table D05.13.02: Correlation between Climatic Regions

Climatic Region in accordance with SPP Interactive Mapping System	Equivalent Climatic Region Köppen maps in accordance with Bureau of Meteorology	Regions as specified in Bioretention Technical Design Guidelines, v1.1 by Water by Design
South East Queensland	Subtropical	Subtropical (ST)
Central Queensland (North)	Subtropical	Subtropical (ST)

Central Queensland (South)	Subtropical	Subtropical (ST)
Dry Tropics	Tropical	Dry Tropics (DT)
Wet Tropics	Tropical	Wet Tropics (DT)
Cape York / Far North Queensland	Equatorial	Wet Tropics (WT)
Western Queensland	Grassland and Desert	Arid (A)

D05.13.05. Detention and retarding Basins shall be designed in accordance with QUDM, Austroads Guide to Road Design - Part 5A.

D05.13.06. For all Stormwater Quality Improvement Devices (SQID), RPEQ certifications are required to be provided to Council for design, construction, and stormwater quality compliance. ***Design and Installation of SQIDs***

D05.13.07. The Manufacturer's supplied maintenance plan for proprietary devices and/or RPEQ certified maintenance plan for vegetated devices shall be submitted to Council. ***Maintenance Plan for SQIDs***

D05.13.08. Approved information signage shall be installed for all Stormwater Quality Improvement Devices. Signage shall be educative and shall focus on habituated created and local habitat. Signage strategies should consider following key issues:

- Signage should be kept simple and easy to understand for general people.
- Location of signage should be selected such that it attracts people attentions;
- Location of signage should be at key areas requiring interpretation
- Signage materials need to be low maintenance and durable, resistant to UV and graffiti and easily installed.

D05.14. RURAL DESIGNS

D05.14.01. For developments in rural areas refer to “Queensland Department of Transport and Main Roads Manual: Road Drainage (2015) or Local Government specific guidelines.

D05.15. LAWFUL POINT OF DISCHARGE

D05.15.01. All discharge points from developments are required to be a Lawful Point of Discharge (LPOD). A Lawful Point of Discharge shall be determined in accordance with the test as specified in QUDM. ***Lawful point of discharge***

D05.16. INTERALLOTMENT DRAINAGE

D05.16.01. Inter allotment drainage shall be provided to any lot where it cannot be satisfactorily demonstrated that roofwater drainage associated with building construction on that lot, could be reasonably connected directly to the kerb and channel. The inter allotment drainage system shall be in accordance with the QUDM Design Class set out in Table D05.16.1 - Inter Allotment Drainage Requirements below. ***Inter allotment Drainage Requirement (QUDM Design Classes)***

Table D05.16.1 - Inter Allotment Drainage Requirements

Local Government	QUDM Level	Special Requirements
Banana Shire	II (Note 1)	Connection to main is permitted. No grated inlets.
Central Highlands Regional	II (Note 1)	
Gladstone Regional	III (Note 2)	Connections must be to pits.
Isaac Regional	II (Note 1)	Connection to main is permitted. No grated inlets.
Maranoa Regional	II (Note 1)	
Livingstone Shire	II (Note 1)	
Rockhampton Regional	II (Note 1)	

Note 1: Level III inter allotment drainage may be required by the Local Authority in some instances (e.g. steep slopes).

Note 2: GRC may consider level II inter allotment drainage in low risk circumstances.

Drainage Easements

D05.16.02. Inter allotment drainage shall be provided where lands are developed such that

- lots do not drain to Council infrastructure(s),
- developing lands are located at the higher side and lower side is developed prior to higher side. Refer to figure D05.15.01 as an illustration:

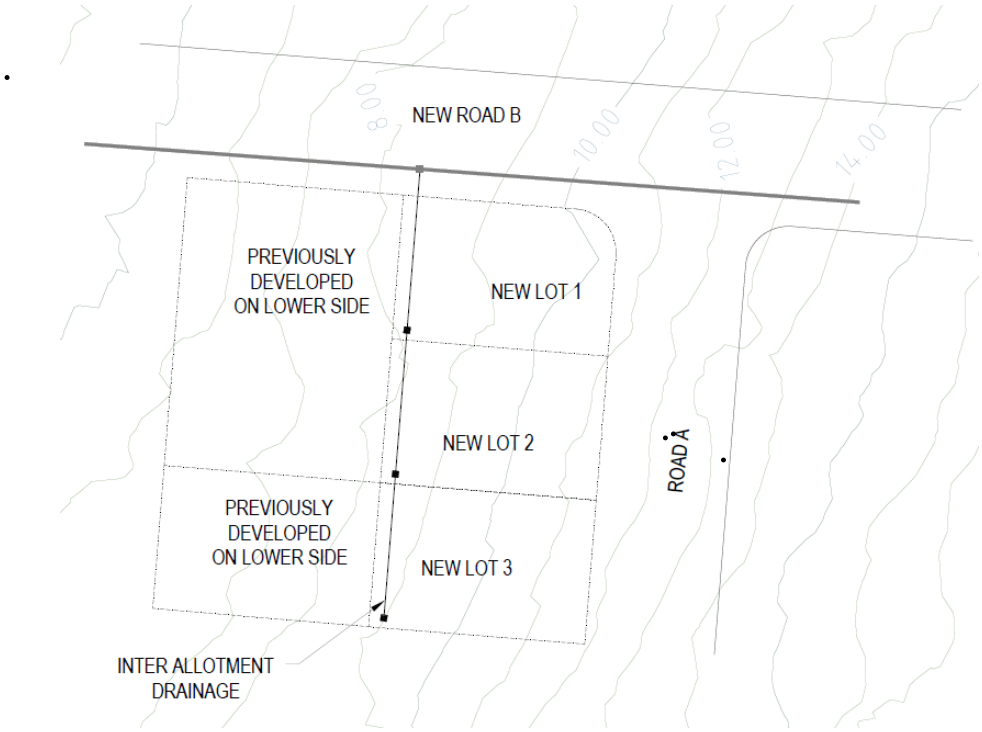

Figure: D05.15.01: Higher Side Development

- Developing lands are located at the lower and higher side is developed prior to lower side. Refer to figure D05.15.02 as an illustration: two choices either connect upstream existing roofwater to new pipe (level II) OR INSTALL LEVEL III DRAINAGE.

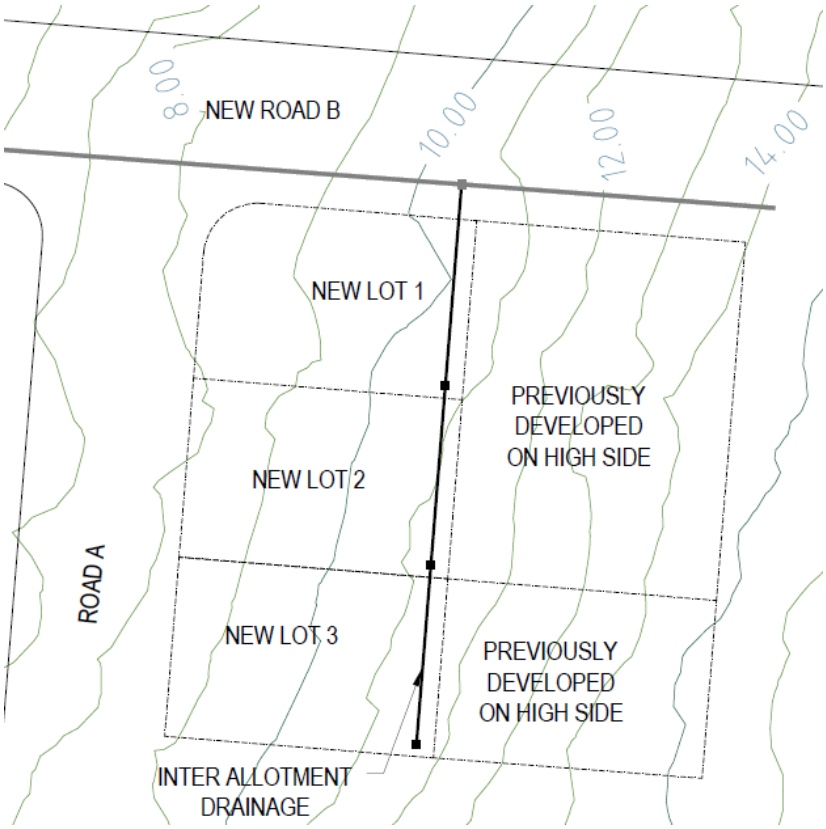

Figure: D05.15.01: Lower Side Development

D05.16.03. All inter allotment drainage systems shall be covered by a drainage easement, in favour of the Local Authority, of a minimum width in accordance with Table D05.15.2**Error! Reference source not found.**. If the easement is to form part of an overland flow path for Level 3 inter allotment drainage, then the width of the easement must be extended to encompass the full flow width.

Table D05.16.2 - Inter Allotment Drainage Easements

Local Government	Easement Widths (m) min[1]
Banana Shire	3
Central Highlands Regional	4
Gladstone Regional	4
Isaac Regional	4
Livingstone Shire	3
Maranoa Regional	4
Rockhampton Regional	3

[1] Easement widths mentioned in the above table are the minimum, as a wider easement may be required for larger drainage infrastructure, additional services, and for ease of maintenance.

D05.16.04. The inter allotment drainage pipe shall be generally on a minimum 1.0m alignment clear of the outer edge of a pipe from the rear boundary of the allotment and shall be designed to accept the concentrated drainage from buildings on each allotment for flow rates having a design AEP (ARI) the same as the "minor" street drainage system. ***Alignment***

D05.16.05. Inter allotment drainage pits shall be located at all changes of direction, horizontal and vertical. Pits shall be constructed of reinforced concrete (steel or fibre reinforcement). Pits shall be constructed with a concrete lid finished flush with the surface of works. ***Pits***

D05.16.06. Inter allotment drainage pipes shall have a greater of longitudinal gradient of 0.5% or grade required to achieve self-cleansing velocity. ***Grade***

D05.16.07. Where inter allotment drainage and sewer mains are laid adjacent to each other, a minimum horizontal clear distance of 0.60m and a minimum vertical clear distance of 0.30m, between the outer edges of pipes and / or pits shall be maintained. ***Sewer***

D05.16.08. All drainage pipes within an easement shall maintain a minimum of 1.0m clear distance from the edge of the easement to the outer edge of the pipe.

OTHER DESIGN ELEMENTS

D05.17. STORMWATER DISCHARGE

D05.17.01. Scour protection at culvert or pipe system outlets shall be designed constructed to minimise erosion. Generally, erosion protection shall, as a minimum, be designed in accordance with QUDM. The design outlet flow velocity for an outlet scour protection shall be the design storm event for the subject culvert or pipe. ***Scour***

D05.17.02. The discharge protection shall be subject to the performance standard such that the requirements of the Environment Protection Act with regard to water quality are fulfilled. ***EPA***

D05.18. PIPE MATERIAL

D05.18.01. The following pipe materials are approved subject to minimum cover and installation requirements stated by the manufacturer: ***Pipe material***

- Steel reinforced concrete pipe and culverts to AS4058; and
- Fibre Reinforced pipes to AS4139.; and
- Other pipes will be considered subject to individual Council approval.

D05.18.02. All joints between pipes shall be Rubber Ring Joints (RRJ).

D05.19. SUBSURFACE DRAINAGE

D05.19.01. Subsurface drainage shall be designed in accordance with the D4 – Subsurface Drainage. ***Subsoil Drain at Pits***

D05.19.02. The upstream end of the subsoil drain shall be sealed with cement mortar and the downstream end shall discharge through the wall of the pit or headwall.

D05.20. EASEMENTS AND AGREEMENTS

D05.20.01. All drainage infrastructure (including overland flow paths) within private property shall be encumbered by drainage easements. Each easement shall include a deed of agreement that outlines each party's rights as the grantor and the grantee. ***Easements and Agreements***

D05.20.02. Evidence of any Deed of Agreement necessary to be entered into as part of the drainage system will need to be submitted prior to any approval of the engineering plans. Easements are to be created prior to sealing of the survey plans.

SITE BASED STORMWATER MANAGEMENT PLAN

D05.21. SITE BASED STORMWATER MANAGEMENT PLAN (SWMP)

D05.21.01. Where required by Council, the developer is obliged to submit Site Based Stormwater Management Plan addressing Quantity and Quality aspects of stormwater management.

D05.22. STORMWATER QUALITY

D05.22.01. The developer shall submit MUSIC model and output from MUSIC model as a part of Site Based Stormwater Management Plan demonstrating stormwater quality objective is achieved in accordance with State Planning Policy 2016, Department of Infrastructure, Local Government and Planning and Queensland Water Quality Guidelines 2009, Department of Environment and Heritage Protection.

D05.22.02. A development is required to comply with Water Quality Objectives both in construction and operational phase.

D05.22.03. The developer shall submit Erosion and Sediment Control (ESC) plan as required by Council. Plans are to be certified by an appropriate RPEQ experienced in this field or Certified Professional in Erosion and Sediment Control (CPESC). ESC plans are to be updated, certified and submitted to Council as construction works proceed. ***ESC Plan***

D05.22.04. The developer is required to submit to Council on-maintenance and off-maintenance schedule for stormwater quality treatment devices. For bio-retention basins, wetlands, vegetated swales etc., guidelines published by Healthy Waterways should be used as primary documents. For other treatment devices, for example, Gross Pollutant Traps, the developer is required to submit manufacturer's maintenance schedule and instructions. ***Water Quality***

D05.23. BIO-RETENTION SYSTEMS

D05.23.01. Bio-retention systems are shallow depressions in the urban landscape designed to collect and treat stormwater by way of filtration through various media. Bio-retention systems shall be designed in accordance with Water by Design – Bio-retention Technical Design Guidelines (2014).

D05.24. VEGETATED STORMWATER ASSETS

D05.24.01. All proposed vegetated stormwater assets (swales, bio-retention systems, constructed wetlands and sediment basins etc.) are to be designed to allow for efficient and effective maintenance. Refer to Water by Design - Maintaining Vegetated Stormwater Assets (2012) for typical maintenance activities.

D05.24.02. An inspection and maintenance schedule shall be prepared and submitted for approval by Council. The Inspection and Maintenance Schedule should detail the following:

a) Inspection Frequency
b) What is to be inspected
c) Normal maintenance procedures (removal of sediment build up, clearing of trash racks etc.)
d) Frequency of maintenance procedures

Consultation with Council shall be carried out to determine acceptable inspection and maintenance frequencies once Contractor defects liability periods have expired.

ANNEXURE D05A

Table D05.22.1 - Core functional bio-retention plant species - Gladstone Regional Council

Species Name	Common Name	Type[3]	Region
Carex Appressa	Tall Sedge	Groundcover Sedge	ST, WT
Ficinia Nodosa	Knobby Club-Sedge	Groundcover Sedge	ST
Lepidosperma Laterale	Variable Sword-Sedge	Groundcover Sedge	All
Lomandra Hystrix	River Mat-Rush	Groundcover Herb	ST, DT, WT
Lomandra Longifolia	Spiny-Headed Mat-Rush	Groundcover Herb	All
Lomandra Leucocephala	Woolly Mat-Rush	Groundcover Herb	DT, A
Poa Labillardierei	Common Tussock Grass	Groundcover Grass	ST, A
Themeda Australis	Kangaroo Grass	Groundcover Grass	All
Callistemon Sieberi	River Bottlebrush	Shrub	ST
Leptospermum Liversidgei	Olive Tea-Tree	Shrub	ST
Melaleuca Thymifolia	Thyme Honey Myrtle	Shrub	ST, DT
Banksia Robur	Swamp Banksia	Small Tree	ST
Melaleuca Linariifolia	Flax-Leaved Paperbark	Small Tree	ST
Melaleuca Viridiflora	Broad Leaved Tea-Tree	Small Tree	ST, WT, DT
Casuarina Glauca	Swamp Oak	Tree	ST, WT, DT
Casuarina Cunninghamiana	River Sheoak	Tree	ST
Lophostemon Suaveolens	Swamp Mahogany	Tree	ST, WT, DT
Melaleuca Bracteata	Black Tea-Tree	Tree	ST, WT, DT
Melaleuca Quinquenervia	Broad-Leaved Paperbark	Tree	ST, WT, DT

1. The list of core plant species has been derived from research conducted by FAWB (http://www.monash.edu.au/fawb), its successors, other research organisations and observations of healthy bioretention systems.
2. Pennisetum alopecoroides is strongly self-seeding. Local authority advice should be sought regarding its use
3. WT = wet tropics; DT = dry tropics; ST = subtropics; A = aridzones; All = occurs in all regions.

Table D05.22.1 - Supplementary bio-retention plant species - Gladstone Regional Council

Supplementary Species	Common Name	Type	Region[2]
Cymbopogon Refractus	Barbed Wire Grass	Groundcover Grass	DT, WT, ST
Fimbristylis Dichotoma	Common Fringe Sedge	Groundcover Sedge	All
Fimbristylis Ferruginea	Rusty Fringe Sedge	Groundcover Sedge	All
Fimbristylis Tristachya	Fimbry	Groundcover Sedge	DT, WT, ST
Fuirena Umbellata	Yefen	Groundcover Sedge	DT, WT, ST
Gahnia Aspera	Saw Sedge	Groundcover Sedge	ST, WT, DT
Gahnia Seiberiana	Red-Fruit Saw-Sedge	Groundcover Sedge	ST, WT, DT
Juncus Polyanthemus	Striated Rush	Groundcover Sedge	DT, WT, ST
Juncus Usitatus	Common Rush	Groundcover Sedge	DT, WT, ST
Lomandra Confertifolia	Dwarf Mat Rush	Groundcover Sedge	ST
Rhynchospora Corymbosa	Matamat	Groundcover Sedge	All
Alphitonia Excelsa	Red Ash	Shrub	All
Austromyrtus Dulcis	Midgen Berry	Shrub	ST
Breynia Oblongifolia	False Coffee Bush	Shrub	All
Cordyline Manners-Suttoniae	Giant Palm Lily	Shrub	ST, WT
Hibiscus Heterophyllus	Native Rosella	Shrub	DT, WT, ST
Leptospermum Polygalifolium	Wild May	Shrub	DT, WT, ST
Melastoma Malabathricum	Blue Tongue	Shrub	ST, WT
Myoporum Acuminatum	Coastal Boobialla	Shrub	All
Xanthorrhoea Fulva	Swamp Grass Tree	Shrub	ST
Casuarina Equisetifolia	Coast She Oak	Tree	DT, WT, ST
Callistemon Viminalis	Weeping Bottle Brush	Tree	All

Chionanthus Ramiflora	Native Olive	Tree	DT, WT, ST
Corymbia Tesselaris	Moreton Bay Ash	Tree	DT, WT, ST
Cupaniopsis Anacardioides	Beach Tuckeroo	Tree	DT, WT, ST
Eucalyptus Tereticornis	River Blue Gum	Tree	DT, WT, ST
Eugenia Reinwardtiana	Cedar Bay Cherry	Tree	DT, WT, ST
Livistona Decora	Weeping Cabbage Palm	Tree	DT, ST
Melaleuca Dealbata	Blue Leaved Paperbark	Tree	DT, WT, ST
Waterhousea Floribunda	Weeping Lily-Pily	Tree	ST
Bothriochloa Pertusa	Indian Couch	Turf[1]	DT, ST
Paspalum Distichum	Water Couch	Turf[1]	DT, ST
Paspalum Vaginatum	Salt Water Couch	Turf[1]	DT, ST, WT
Sporobolus Virginicus	Marine Couch	Turf[1]	DT, WT, ST
Zoysia Macrantha	Zoysia	Turf[1]	ST

1. Turf species are not as effective at stormwater treatment due to their shallower root systems and shoot length. If there is a landscape amenity objective that is driving the response, then plant with appropriate plant species (avoid dense canopies) for a deeper root distribution.
2. WT = wet tropics; DT = dry tropics; ST = subtropics; A = arid zones; All = occurs in all regions.

Planting density

PERFORMANCE OUTCOMES
Planting densities must:

- Provide rapid coverage to out-compete weeds
- Have a uniform root zone through the filter media
- Enable bio-retention performance objectives to be met
- Have 90% coverage in two growing seasons

RECOMMENDED APPROACH
High plant density in bio-retention systems is beneficial to:

- Facilitate rapid establishment of vegetation cover
- Exclude weeds
- Ensure a uniform root zone throughout the filter media
- Maintain filter media porosity
- Maximise pollutant removal
- Distribute flows evenly across the surface of the bio-retention system
- Prevent scour, establishment of preferred flow paths, and re-suspension of deposited sediments.

A suitable planting density should be used to ensure vegetation covers at least 90% of the bio-retention surface after the establishment period (i.e <10% soil of much visible from above). The planting density to achieve this outcome will vary depending on the species used. Table 2 provided typical planting densities required to achieve 90% coverage rapidly. Over many years, as plants mature and expand, some plants may die. Densities may reduce, however the high initial densities will ensure that in the long term coverage is maintained.

Direct seeding may be useful alternative to the use of seedlings, particularly in large bio-retention systems where it is important to establish vegetation cover quickly to minimising week ingress. Direct seeding is commonly used for establishing grass cover in bush reconstruction projects. It can be used to establish shrubs and trees.

As the success rate of direct seeding cannot be guaranteed, direct seeding should be used to complement plaiting seedlings.

Table D05.22.3: Typical Planting Densities Required to Achieve 90% Cover

Vegetation Type	Planting density
Groundcovers (including grasses, herbs and sedges)*	Six to eight plants per m²
Shrubs**	One plant per 2 - 20 m²
Trees**	One plant per 20 - 100 m²

* Groundcover densities of up to 12 plants per m² may be required for bushland layouts

** Suitable plant densities for shrubs and trees depend on the size and form of individual plant species and overall landscape objectives sought