Armidale
Regional Council

ENGINEERING DESIGN CODE

Supplement to D5

HANDBOOK OF STORMWATER DRAINAGE DESIGN

Amendment Record for this Specification Part

This Specification is Armidale Regional Council's edition of the AUS-SPEC generic specification part D5 and includes Council's primary amendments to the specification.

Details are provided below outlining the clauses amended from the Council edition of this AUS-SPEC Specification Part. The clause numbering and context of each clause are preserved. New clauses are added towards the rear of the specification part as special requirements clauses. Project specific additional script is shown in the specification as italic font.

The amendment code indicated below is 'A' for additional script 'M' for modification to script and 'O' for omission of script. An additional code 'P' is included when the amendment is project specific.

Amendment Sequence No.	Key Topic addressed in amendment	Clause No.	Amend Code	Author Initials	Amend Date
1	Major Revision of specifications for adoption by Armidale Regional Council	All	AMO	SPM	June 2016

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APPENDICES

STANDARD DRAWINGS

REFER ARMIDALE REGIONAL COUNCIL STANDARD DRAWINGS – STORMWATER

Drawing No	Description of Drawing	Amendment Date
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080- 026	Interallotment property drainage connections	31 Aug 16
080-027	Property stormwater connection to kerb and pipe	31 Aug 16
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1. INTRODUCTION

1.01 GENERAL

1. This document forms part of the Engineering Standards of the Armidale Regional Council.
2. All external civil works shall be in accordance with and completed under the supervision of an engineer or surveyor approved by a delegated officer from Council's Engineering Section.
3. The purpose of this supplement is to provide additional information, expanding on the elements addressed in and the requirements of – 'Section D5 Stormwater Drainage Design'.
4. The supplement will be referred to as the 'Handbook of Stormwater Drainage Design'.
5. Other relevant documentation (but not limited to) which shall be referenced and considered in preparing storm water drainage designs for submission to Council are :
    - Applicable Council DCP
    - Australian Rainfall & Runoff – 1987 version & the current version
    - Queensland Urban Drainage Manual (QUDM) – current version
6. Developers and consultants are encouraged to consult with Council to discuss applications and obtain an initial assessment of a development proposal
7. Development design will have regard to the existing natural soils, vegetation, topography and drainage paths of the site.
8. Information is required by Council to enable a proper assessment of an application for development that complies with Ecologically Sustainable Development (ESD), Council's engineering standards and Water Sensitive Urban Design (WSUD) principles.
9. The information and detail required may vary dependant for specific development projects, as determined by a delegated officer from Council, and where subject to the requirements of Council's applicable Development Control Plan (DCP).
10. Development application plans and documentation are to be sufficiently detailed to allow the feasibility of a Stormwater Management Plan (SWMP) to be assessed and confirmed by Council (refer Section 1.3).
11. Construction Certificate applications must contain all required engineering drawings and documentation to allow an approval of a SWMP to be issued.
12. Works which may impact on the quality and quantity of stormwater runoff discharging from a development site requires the preparation and submission for approval by Council, of a SWMP that demonstrates how post-development flow volumes and stormwater quality are controlled to mimic pre-development conditions by achieving neutral or beneficial effect (NorBE) on the natural environment and receiving constructed system, waters or wetlands.
13. If NorBE cannot be achieved an upgrade of the downstream drainage system will be required, subject to Council approval.

14. Development works include (but are not limited to) :

- Subdivisions
- Buildings and structures
- Earthworks, dams, lakes, roadworks and drainage works
- Site works, such as vehicular access roads, car parks, pedestrian / bicycle paths, landscaping, signage, fencing and other structures
- Quarrying, mining and other industrial / commercial activities

1.02 CONDITIONS OF APPROVAL AND PRINCIPLES TO BE FOLLOWED BY DEVELOPERS

1. The developer, under the supervision of an approved engineer or surveyor, is responsible:

   - for costs relating to alterations and extensions of existing roads, drainage and services for the purposes of the development
   - to construct, at own cost, all works required for the development, in accordance with the Development Application determination consent conditions and the Construction Certificate issued.

2. Three (3) full size sets of the Engineering Drawings are to be submitted. One approved set will remain in Council's records and the other stamped sets returned to the Applicant. Council also requires a full set of plans at A3 size and electronic copies of drawing files in both pdf and autocad dxf or dwg format (or compatible).

3. The consultant is also to submit copies of all modelling data files in electronic format (e.g. DRAINS, PCDRAIN, RAFTS, HECRAS, MUSIC).

4. Approval of Engineering Plans will be current for a period of two years from the Construction Certificate approval by Council, after which time Council may require alteration to Engineering Design to comply with standards current at that date

5. All stormwater is to be collected within the property and discharged in accordance with Council's standards. Effective measures are to be undertaken to prevent the obstruction of surface drainage, the disruption of amenity, damage or deterioration of any other property. Retention of the natural stormwater system is desirable where possible.

6. CCTV inspection, including the provision of a detailed certified report and DVD by an appropriately qualified and experienced person, is required on newly constructed stormwater lines at the developers cost.

7. Changes to design during construction may require the re-submission of design calculations and any associated computer software analysis.

8. Undeveloped catchment design flows to the minor system may be used due to the limiting of flows from a development to the pre-development conditions. This must be supported by design calculations which accurately model the system and a SMP which has been submitted to and approved by a delegated officer from Council's Engineering Section (Refer Appendix D).

9. Infiltration devices, swales and 'Water Sensitive Urban Design' (WSUD) components shall be designed in accordance with Council requirements. Careful consideration must be given to site characteristics such as soil type, slope, water table, rainfall characteristics, potential salinity and the scale and density of development. Council is keen to work with developers on individual proposals which incorporate water sensitive urban design features.

Accepted design guidelines are sourced from Water-By-Design (S18.01 ref 14).

The following requirements apply to infiltration systems :

- to be wholly located within the development and an adequate distance, as approved by a delegated officer from Council's engineering section, from adjacent property or structures;
- to be discharged to a swale, piped stormwater system or other location as approved by a delegated officer from Council's Engineering Section;
- to be designed by a appropriately qualified professional consultant (civil engineer or licensed surveyor) approved by a delegated officer from Council's engineering section; and
- site testing is to be undertaken to determine soil permeability and water table depth.

The minimisation in costs of Council ownership/maintenance and demand on both natural and financial resources shall be a high priority in the consideration and operation of works and associated community assets. The nature of the Armidale Region soils and inconsistent growing seasons between winter and summer generally restrict options for WSUD design and will be considered in the assessment of any proposal.

1.03 STORMWATER MANAGEMENT PLANS (SMPs)

A full and detailed SMP for the site is to be submitted to Council for assessment and approval, prior to the issue of the Construction Certificate. The plan may need to include an analysis of the upstream contributing area and overland flow paths considering all impacted drainage flows, adjacent and/or downstream properties, structures, infrastructure and downstream receiving systems. The level of detail required in the SMP will depend upon the scale and type of proposed development and the likely environmental impacts increased stormwater flow will have on both upstream and downstream properties and infrastructure. All developments will require some form of SMP to show how stormwater can be controlled around, through and from the site.

Items to consider in the development of a SMP may include:

a. Sensitivity Analysis to consider reasonable performance criteria over the lifetime of a stormwater system (to consider such issues as variable Manning's 'n', determination of time of concentration (S18.01 ref 9,10), hydraulic jumps, link lags).

b. Documentation of inflow rates at all contributing points

c. Consideration of floods greater than the design flood such as the Probable Maximum Flood (PMF), (S18.01 ref 2,3,4,5)

d. Consideration of the capacity of any downstream system. Note that the developer may be required to upgrade downstream facilities, at their cost, where the development impacts directly on the facility even though the post development flow does not exceed pre development flow. Each case will be considered on its merits.

e. Identification of the 1 in 100 year Average Recurrence Interval (ARI) or 1% Annual Exceedance Probability (AEP) flood flow lines. Field location by survey may be required.

f. Confirmation that post-development peak flows leaving the development do not exceed the pre-development peak flow rates for the required design storm events, unless advised otherwise by Council.

g. Provision of 1% AEP major overland flow paths (natural and diverted) for the development, considering proposed development flows and adjacent/ downstream property is required. Easements may be required.

h. Control of stormwater volume & quality leaving the site and Control / protection against Erosion (S18.01 ref 9)

i. Minimization of the depth of table drains by the use of box / cross drainage culverts

j. Where overtopping of the road pavement is expected for the design ARI event or lesser return period, the pavement edge shall be strengthened through the provision of concrete edge strips on the downstream side of the pavement. The pavement in this location shall be provided with a one way crossfall of 3% rising toward the downstream side of the road. (S18.1 ref 6,8,10).

k. The road reservation is to be widened where necessary, due to the width of WSUD drainage swales, to ensure footpaths have a minimum of 2.4m width suitable for use by pedestrians and the provision of services.

l. Maximum cross-falls on drainage swales of 1 in 6 is preferred.

m. Show capacity, flow rates and velocities at pertinent points in drainage swales and for access pipes at critical points

n. Details of proposed detention basins and associated works

o. Public safety, amenity and maintenance considerations

p. Fencing considerations

q. Effluent disposal areas

10. Both major (1% AEP) and minor system (determined by zoning / use) stormwater flows upstream of, adjacent to, within, through and flowing from the development site are to be considered by the SMP.

11. The SMP should include the following information providing justification of any assumptions and / or decisions made (where appropriate, but not limited to):

a. Site and catchment description:

- Site location
- Contour plan (identifying all contributing catchments)
- Description of contributing catchments and land uses (existing &
- future)
- Available water supplies
- Geology and soil types (including permeability, erodibility, ASS)
- Hydrology
- Stormwater discharge locations
- Downstream waterways, wetlands and ecosystems
- Tidal influences
- Water table and groundwater effects
- Vegetated buffer zones

b. A risk assessment of the proposed development drainage system considering site location (ecosystems, wetlands, waterway, floodway, floodplain, zoning, surrounding development / structures, existing overhead and underground services) with regard to the safety and protection of persons and property. This may include consideration of construction, maintenance and 'handover' phases of a project.

c. Summary of WSUD design objectives / performance criteria:

- Apply DCP requirements for water quality
- Infiltration capability of in-situ soils
- Comply with NSW Environmental Protection Authority (EPA) water quality requirements

d. Maintenance Measures and Life Cycle Costing (does apply if dual reticulation re-use system is installed):

- Estimate of required maintenance measures (i.e. type & frequency)
- Assessment of annualised maintenance cost

e. Potable water consumption:

- Water consumption assumptions
- Description of proposed water management measures
- WSUD components and measures used
- Details of water balance analysis to demonstrate compliance

f. Stormwater quality:

- Water quality objectives
- Description of proposed water management measures
- WSUD components and measures used
- Details of stormwater quality modelling to demonstrate compliance

g. Stormwater quantity (discharge frequency, flow rate and volume):

- Description of proposed water management measures
- Details of hydraulic structures
- WSUD components and measures used
- Details of hydrologic / hydraulic analyses to demonstrate compliance

h. Computer modelling results ('DRAINS', 'PCDRAIN', 'XPSTORM', 'HEC-RAS', 'MUSIC' or other Council accepted software)

i. Ecological protection and management including details of strategies proposed to protect / enhance identified ecological habitats or species

j. Details of road reservation widths in accordance with the Council's requirements, plus additional width to contain proposed WSUD components.

k. Details of management plan/s identifying the qualifications, responsibilities and roles of consultants, contractors and project managers. The plans are to indicate project timelines, staging, supervision, construction, inspection, testing, establishment, maintenance, commissioning (including but not limited to):

- WSUD management components and measures (separate maintenance / staging plans may be required
- Proposed methods for transferring responsibility of WSUD components located on private property to the property owners (if applicable)

- Proposed methods for transferring responsibility of WSUD components to Council (if applicable)

l. To assist the assessment process, designers and consultants may include other design information in the SMP. The detail required for a SMP may also vary according to type, location, size, complexity, staging and other relevant factors for a specific development project application.

1.04 WATER SENSITIVE URBAN DESIGN (WSUD)

1. Water Sensitive Urban Design (WSUD) is the application of 'Best Practice' stormwater management principles to maintain, protect and improve waterway health and mitigate the impact of development on the natural water cycle. This shall achieve neutral or beneficial effect (NorBE) on the natural environment, adjoining property or infrastructure and the receiving constructed system, waters or wetlands.
2. Stormwater flows from development projects may cause pollution, erosion and sedimentation in wetlands and waterways, including increased frequency and magnitude of flooding. Impermeable surfaces (roads, buildings and driveways) reduce soil infiltration.
3. Planning, design and construction of built environments should result in healthy ecosystems through the management of water quality and quantity to mitigate any impact on the natural water cycle.
4. Traditional stormwater management involves piped discharge from development projects and provision of stormwater detention for flood mitigation and drainage asset protection purposes. By contrast, management of the urban water cycle may consider stormwater as a resource for re-use ensuring the appropriate treatment and attenuation of stormwater flows, prior to discharging into receiving waters.
5. 'WSUD' utilises on-site collection, treatment and harvesting of stormwater flows as part of an integrated 'treatment train'. It provides opportunity for detention and harvesting of stormwater, reducing potable water demand, discharge volume and pollutant load of stormwater discharge.
6. 'BASIX' (S18.01 ref 11) is a web-based design tool that ensures residential developments meet the NSW Government's targets for reductions in water consumption and greenhouse gas emissions. Proposed stormwater management detention volumes must be in addition to that required for 'BASIX'.
7. The following guidelines may be used in the design and construction of WSUD drainage systems for development projects and subdivisions:
   a. Queensland 'Water-By-Design' (WbD) program provides guidelines (S18.01 ref 12), complying development examples and fact sheets to assist with the design and delivery of WSUD. These technical guidelines and objectives for water conservation and stormwater management are based on Queensland government legislation and must be considered with respect to the requirements of NSW legislation.
   b. Prior to preparing any development or construction certificate applications the developer should obtain advice from a delegated officer representing the local government authority regarding the use and application of the WbD information.

c. The Sydney Catchment Management Authority‘s ‘Interim Reference Guidelines (S18.01 ref 12) for the ‘South East Queensland Concept Design Guidelines for WSUD’ provide advice on the differences between NSW and QLD legislation / terms.

d. The Soils and Construction ‘Blue Book’ Guidelines from the NSW Office of Environment & Heritage (S18.01 ref 9) WSUD provide reference material applicable to New South Wales.

1.05 OBJECTIVES OF SMPs AND WSUDs

1. The objectives of stormwater management are to :

   a. ensure traditional and/or WSUD principles (as approved by Council) are applied to the design and construction of development projects.

   b. reduce demand for potable water from the town water supply.

   c. ensure stormwater discharge from development projects is controlled to mitigate adverse impact of volumetric discharge and water quality to achieve ‘NorBE’ – neutral or beneficial effect on the natural environment, adjoining property or infrastructure and the receiving constructed system, waters or wetlands.

   d. utilise natural flow paths and incorporate on-site treatment.

   e. ensure water management is a key consideration in the urban design process to maximise opportunities for water reuse and ensure stormwater management infrastructure is integrated within the surrounding environment.

   f. protect and maintain ecosystems, property and infrastructure within, adjacent to and downstream of the development site.

   g. Provide both major (1% AEP) system flow paths and minor system drainage.

2. ensure the purpose of the stormwater drainage and flood protection elements are not compromised and that buildings and infrastructure are protected from flooding or damage by construction of incompatible or inappropriate stormwater systems.

1.06 STORMWATER QUALITY IMPROVEMENT DEVICES (SQIDs)

1. All SQIDs for subdivisions and development projects are to be sized to treat a minimum of a 1 in 3 month rainfall event, or as determined by a delegated officer from Council. They are to be designed with overflow / bypass arrangements that accommodate a 1% AEP storm event without causing erosion, scouring or structural damage in accordance with the technical design guidelines.

2. They may not be required where :

   a. the total development area is < 150 m² or as determined by the local authority DCP.

   b. no impervious areas, road works or drainage works are proposed.

   c. A risk assessment is provided with the SMP demonstrating they are not required.

3. Major Stormwater treatment devices that utilise ‘soft’ engineering treatment solutions that can be contained within either existing or proposed public reserves

require Council agreement. Treatment areas within private lands may be considered subject to registration of appropriate land title encumbrances, approved by Council, upon the private land. A Maintenance Management Plan is required to be submitted to Council for approval.

4. All proposals should provide sufficient information to demonstrate:

   a. proper consideration of public safety;

   b. proposed infrastructure design levels and grades will fit within existing site contours; and

   c. maintenance of proposed infrastructure can economically and feasibly be undertaken.

5. Solutions that propose provision of publicly owned ‘hard’ engineering treatment devices that may fail due to insufficient maintenance levels or that require the use of specialist equipment for maintenance that may not be available locally, are generally not supported.

2. AVERAGE RECURRENCE INTERVAL (ARI) & ANNUAL EXCEEDANCE PROBABILITY (AEP)

1. The average recurrence interval (ARI) is known as the return period, this is the mean time between occurrences of some event, such as a flood or rainfall event. It is used as the foundation of many design procedures based on acceptable frequencies of occurrence. For urban stormwater drainage design the "event" will be the exceedance of some rainfall intensity and quantity over time and the resulting stormwater flows.

2. In general, the ARI can be considered to be the inverse of the probability of exceedance. If the ARI is in years, the corresponding probability is in terms of the event occurring in an annual period (i.e. a 20 year ARI is equivalent to a 1 in 20 year event or 5% AEP).

Table 2.01 – ARIs & AEP

AVERAGE RECURRENCE INTERVAL (ARI) years	ANNUAL EXCEEDANCE PROBABILITY (AEP) %
100	1
50	2
20	5
10	10
5	20
2	50
1	100

3. In Council’s Development Control Plans, the general term ‘1 in x years’ will be used to define particular events, e.g. 1 in 100 year flood event, 1 in 10 year rainfall event. In each case these terms relate to the statistical terminology above.

3. DESIGN IFD RAINFALL (D5.04)

1. Design Intensity-Frequency-Duration (IFD) Rainfall relationships shall be derived in accordance with Australian Rainfall & Runoff 1987. The consultant shall provide the rainfall figures and parameters used if they differ from those provided in **Appendix A** – IFD Data. The ARIs for Local Environmental Plan Zonings are presented in Table 3.1:

Table 3.1 – ARIs for LEP zonings

DESCRIPTION	ARI 1 in X years
MAJOR SYSTEM (ARI 1 in X years)	100
MINOR SYSTEM (ARI 1 in X years)	
Parks & Reserves	1
Rural Residential	5
Urban Residential	5
Commercial / Industrial	10
MAJOR ROAD (Sub-arterial)	
Kerb & Gutter	10
Cross Drainage – Culverts, Bridges etc	50
MINOR ROAD (Collector & Local)	
Kerb & Gutter	5
Cross Drainage – Culverts, Bridges etc	20

The above Design ARI's are subject to the following conditions:

a. The design ARI for the minor drainage system in a major road / traffic route shall be that nominated for the major road, not the zoning of the adjacent area.

b. Culverts under roads should be designed to accept the full flow for the minor system ARI shown and the minimum freeboard permitted shall be up to the subgrade level. In addition, the consultant must ensure that the 100 year ARI backwater does not enter adjacent or upstream properties. If upstream properties are at a relatively low elevation it may be necessary to install culverts of capacity greater than that for the minor system ARI design storm to ensure flooding of upstream properties does not occur. In addition causeway embankments may need scour protection where overtopping is likely to occur

c. Notwithstanding, Council may require a higher recurrence interval based on particular locality considerations that may generally include:

- Ability to accommodate the major event
- RMS or other authority's flood requirements

- Afflux considerations
- Future strategic planning considerations
- Counter disaster planning considerations
- Historical records of flood events
- Safety considerations in flood events
- The ability to access isolated or single entry communities

d. Consideration must be given to the overland flow path, should the capacity of any drainage system be exceeded. A design-controlled overland flow path is to be provided, together with the necessary easements / restrictions 'as-to-user', to ensure that the overland flow path is not blocked by residents. The designer must consider future structures such as boundary fencing, changed ground levels, rezoning etc which may have an adverse impact on continued operation of the overland flow path.

4. RUNOFF COEFFICIENTS & TIME OF CONCENTRATION (D5.06)

4.01 RUNOFF COEFFICIENTS

1. Council may determine that an investigation of the Runoff Coefficient and time of concentration for a particular development / location is necessary due to development type, strategic planning or zoning requirements. They shall not be less than the values determined for the existing catchment conditions and must take into account future planning. In these cases, the designer shall provide calculations to determine the fraction impervious for those developments. Partial area effects and Peak flows must be considered.

2. Consultants may provide calculations to determine the fraction impervious and coefficients of runoff (refer QUDM) to the satisfaction of a delegated officer from Council's Engineering Section. The following table lists acceptable Ten Year Runoff Coefficients versus Zoning with consideration of existing landform. Existing Water table and groundwater conditions are to be considered

Table 4.1 – C_{10} runoff coefficients

ZONING / TYPE	TEN YEAR RUNOFF COEFFICIENT C_{10}		
	Ground Slope		
	<1%	1% - 5%	>5%
Rural Residential			
Bare Rock	0.82	0.88	0.94
Rocky/Clay Soils	0.68	0.78	0.90
Open Forest/Grass/Crops	0.47	0.62	0.80
Average to Heavily Timbered	0.30	0.40	0.58
Cleared Sand Soils #	0.15	0.25	0.40
Urban Residential			
<600m^2	0.80	0.85	0.90
600m^2 to 1000m^2	0.75	0.80	0.85
>1000m^2	0.65	0.70	0.75
Industrial / Commercial	0.95	0.95	0.95
Parks / Reserves	0.55	0.65	0.75

3. For events of an ARI other than ten years the frequency factors shall be:

ARI	1	2	5	10	20	50	100
F_y	0.8	0.85	0.95	1.0	1.05	1.15	1.2

4. Unless otherwise approved the design rainfall used for the sizing of pollution control devices is to be based on IFD data and the following table.

Design ARI (months)	1	2	3	4	6	9
Proportion of 1 in 1 year ARI	0.25	0.40	0.50	0.60	0.75	0.9

(Source Gold Coast City Council)

5. An assessment of the capacity of the downstream receiving system or waterway, to accept a pollutant load, and an investigation of the hydraulics of the drainage system is required.

4.02 TIME OF CONCENTRATION

1. The minimum time of concentration for a catchment shall be five minutes.

2. The maximum time of concentration used in an urban area shall be 20 minutes, unless a greater time can be justified by calculations acceptable to a delegated officer from Council's Engineering Section.

3. The suggested method of calculating time of concentration for certain scenarios is listed below. It is up to the consultant to select an appropriate method (which may not be listed, but is documented and considered accepted engineering practice). Determination and calculation of time of concentration is to be acceptable to a delegated officer from Council's Engineering Section.

4. Time of concentration may be calculated using:

   a. The **Probabilistic Method** (for Rural Catchments up to 250km^2 in area) may be used to estimate time of concentration for a catchment.

$$t_c = 0.76A^{0.38} \text{ (hours)}$$

Where A is in km^2

   b. **Modified Friend's Equation** may be used for shallow sheet flow over plane surfaces up to 200m length in rural areas and up to 50m length in urban areas. Thereafter an assessment of concentrated flow time by an approved standard method, supported by calculation shall be carried out.

$$t_c = (107nL^{0.333}) / S^{0.2} \quad \text{(minutes)}$$

Table 4.2 – Values of Manning's 'n'

LAND USE	'n'
Paved Surface	0.015
Bare Soil	0.0275
Poorly Grassed	0.035
Average Grassed	0.045
Densely Grassed	0.060

c. The **Kinematic Wave Method** may be used for planes of flow in homogenous catchments similar in nature, slope and roughness (such as paved areas) and shall not be applied to large heterogeneous catchments dissimilar in nature, slope and roughness. *(ref AR&R Technical Note 3(i))*

$$t_c = 6.94\ (Ln)^{0.6})\ /\ I^{I0.4}\ S^{0.3}$$

where t_c is expressed in minutes

5. Acceptable Roughness/Retardance Coefficient 'n' values (similar to but not identical to Manning's 'n') are as follows:

Table 4.2 – Roughness Coefficient 'n'

LAND USE	n
Parkland	0.350
Rural Residential	0.300
Urban Residential	0.210
Medium Density Urban Residential	0.110
Industrial	0.060
Commercial	0.040
Paved Area	0.010
Asphalt Roadway	0.020
Gravel Areas	0.020

5. HYDROLOGICAL & HYDRAULIC CALCULATIONS (D5.07 & D5.08)

1. Hydrological and hydraulic calculations shall be based on the methods outlined in AR&R. Results shall be provided in accordance with requirements of AR&R 1987 and QUDM (refer Appendix E).

2. All information, including determination of pit pressure change coefficients and other relevant calculations, computer analysis program outputs and manual calculations, should be provided in a clear, concise format that allows Council to carry out any necessary design assessment in a timely manner

3. Computer analysis outputs must be consistent with the information shown on the plans and additional information (sketches and/or calculations) may be requested to fully describe the proposed system and it's operation for assessment purposes

4. Electronic copies of computer models are required if they are in a format that council possesses the software for. If not, the consultant may have to conduct a demonstration of the modelling with their computer's and software at Council nominated premises

5. Tail water Levels to be adopted are as follows:

   a. Pipe obvert for free outfalls

   b. Design ARI flood level or River Levels, as provided by Council, for receiving waters

   c. 150mm below kerb invert for existing systems with unknown HGL

   d. Surcharge height for surcharge outlet

   e. A nominal minimum freeboard of 150mm should be achieved between surface level and water surface elevation, determined by a hydraulic grade line design, in a stormwater structure

   f. The use of reinforced concrete box culverts should be considered in low flat areas

6. COMPUTER MODELLING

1. Where catchments are large, complex or nominated as important by a delegated officer from Council's Engineering Section for strategic planning or other purposes, accurate levels of flow rate prediction must be made and peak flow rates must be determined using an industry accepted runoff routing computer model.

2. The use of industry standard computer models by Professional Engineers for stormwater design is supported by Council. Designers should be aware of the need for model calibration (refer Appendix B) and sensitivity analysis. Council will advise on the modeling software they prefer. To enable timely assessment by Council the following industry standard modeling software is acceptable :

a. Runoff Routing Hydrological -	RORB
	RAFTS-XP
	DRAINS (ILSAX)
b. Drainage Analysis Hydraulics -	DRAINS (ILSAX)
	PCDRAIN
	XPSTORM
c. Steady State Hydraulics -	HEC-RAS
d. Unsteady Flow Hydraulics -	MIKE-11
e. Water quality -	MUSIC
	AQUALM-XP

3. Should Consultants wish to use a program not listed, details are to be submitted to Council prior to use. As a minimum a submission should be accompanied by:

   a. Basic parameters.

   b. Input data files.

   c. Output Summary files.

   d. Relevant documentation relating to the program to enable deciphering and interpretation of input and output data.

   e. Verification of models using industry standard techniques such as checking peak discharge using the rational method or checking peak flood levels with HEC-RAS.

4. Computer modeling shall be compatible with the latest version of the program.

5. A clear & concise report is to be submitted stating all the parameters used and assumptions made, including but not limited to:

   a. Rainfall loss values.

   b. Sub-catchment fraction imperviousness.

   c. Flow velocity estimates.

   d. Manning's 'n' roughness values.

   e. Flow contraction and expansion coefficients.

   f. Structure hydraulic head loss coefficients (software default values must be checked and certified by the designer).

   g. Other hydraulic head losses.

6. 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 for Construction Certificate approval.

7. MINOR SYSTEM CRITERIA

1. The Minor System comprises kerb & gutter, road table drains, gully pits, underground pipes manholes and outlets. The Major system (refer Section 9 – Major System Criteria) refers to overland flow paths designed to convey storm flows in excess of the minor system capacity. These systems are designed in accordance with Section 3 – Design IFD Rainfall

2. Criteria are as follows :

   a. Designs shall consider the convenience and safety of pedestrians and vehicles, construction and maintenance issues and freeboard to buildings for all types of development

   b. Kerb & gutter flow widths shall not exceed 2.0m nor over-top the kerb

   c. Designs shall consider table drain and driveway culvert capacities and minimization of erosion and sediment transport.

   d. Designs shall consider layback kerb / driveway levels for gutter capacity where there is a low level footpath.

e. Total flow for minor flood events shall be contained within easements and/or drainage reserves.

f. Velocity x Depth product requirements apply as for the Major System (refer Section 8 – Major System Criteria).

g. Longitudinal table and swale drains with grades greater than 4% and less than 0.7% are to be lined with an appropriate treatment having regard to the application. Examples may include but are not limited to:

- reinforced turf
- spraycrete
- hydromulch
- rock
- concrete

h. Low flow pipelines/inverts shall be required in channels with very flat grades.

8. PIT CAPACITIES - SYSTEM INLETS / OUTLETS (D5.10 & D5.11)

1. Inlet and outlet structures shall be provided in accordance with Council's standard drawings and flow capture charts as included in Appendix E – Flow Capture Charts

2. Hydraulic losses shall be calculated in accordance with the charts and methods described in QUDM, or other approved documentation acceptable to a delegated officer from Council's Engineering Section

3. Maximum pit by-pass flow shall be 30 l/s provided a gutter flow width of 2m is not exceeded;

4. Maximum spacing between directly connected pits shall be 75m

5. No trapped low points will be permitted

6. Structures are to incorporate safety measures, be low maintenance and fit within the amenity of the surrounding area. Non-standard structures will require the approval of a delegated officer from Council's Engineering Section

9. MAJOR SYSTEM CRITERIA

1. The Major system refers to overland flow paths comprising open space, floodway channels, road reserve, pavement areas, detention basins and lagoons, designed to convey storm flows in excess of the minor system capacity. These systems are designed in accordance with Section 3 – Design IFD Rainfall

2. Velocity x Depth product requirements within road reserve (and footpath) are as follows :

- Maximum depth of water 0.20m
- Velocity x depth product – pedestrian safety < 0.4 m^2/s
- Velocity x depth product – vehicle safety only < 0.6 m^2/s

3. Major channels must address safety requirements.

4. Freeboard between the 100 year ARI flood level and floor levels on structures and entrances to underground carparks shall be as presented in Section D5.12 of specification D5 Stormwater Drainage Design

5. Where roads are in fill or overtopping of kerbs and flow through property may occur, a 0.100m freeboard shall be provided between the ponding level of water in the road and the high point in the footpath. This shall be considered in the construction of driveways.

6. A Capacity Reduction Factor, F = 0.8, shall be applied in the calculation of flows within the roadway. Manning's 'n' values are as follows :

   - Concrete 0.012
   - Hot Mix 0.014
   - Flush Seal 0.018

7. The 100 year ARI flow path through a development, from any upstream catchments to an acceptable downstream flow path i.e. an 'escape route' for major system flood flows, must be demonstrated.

8. The Probable Maximum Flood (PMF) is defined as the peak flood derived from routing the Probable Maximum Precipitation (PMP) through the stormwater system. Safe passage of the PMF must be demonstrated on major systems where there is risk to property and / or life (S18.1 ref 2,3,4). Investigation is required for (but not limited to)

   - Detention basins / dams and spillways
   - Bridges / major culverts
   - Public infrastructure such as hospitals

10. OPEN CHANNELS

1. Approval by Council for the inclusion of open channels in a development is required. Safety issues and the maintenance of channels and associated low flow systems shall be considered.

2. Sensitivity analysis to consider such issues as variable Manning's 'n' and well-maintained / re-vegetated state may be required by Council (S18.1 ref 8,10,13). Generally acceptable Manning's 'n' Roughness Coefficient values are as follows:

Table 10.1 – Manning's Roughness coefficients

DESCRIPTION	'n'
Concrete Pipe or Box	0.011
Concrete (trowel finish)	0.014
Concrete (formed & unfinished)	0.016
Spraycrete (gunite)	0.018
Bitumen Seal	0.018
Brick or paved	0.015
Pitched / dressed stone in mortar	0.016
Rubble Masonry / Random stone in mortar	0.028
Rock lining / Rip Rap	0.028
Corrugated Metal	0.027
Earth (clear)	0.022
Earth (weeds & gravel)	0.028
Rock	0.038
Short Grass	0.033
Long Grass	0.043

11. MAJOR STRUCTURES

1. Major structures are those that are designed to take flows in excess of the minor system capacity or a major road cross culvert or bridge. A delegated officer from Council's Engineering Section may determine that a structure outside this definition warrants consideration as a major structure.
2. Culverts and Floodways shall be designed in accordance with 'Austroads Design Guides' (S18.1 ref 6,8,10) and consider the requirements of any relevant authorities such as the Roads Maritime Services (RMS).
3. A minimum freeboard of 300mm from the design ARI event to the underside of all structures is required (debris / blockage).
4. All major structures are to be designed for a 1 in 100 year ARI event without afflux. Some afflux and upstream inundation may be permitted provided calculations, to the satisfaction of a delegated officer from Council's Engineering Section, can demonstrate the effect is minimal and that private property is not affected.
5. Certified structural design is required on bridges, major culverts and other structures as determined by a delegated officer from Council's Engineering Section.

12. RETARDATION / DETENTION BASINS

12.01 MINOR STORAGE VOLUMES

1. For development projects larger than dual occupancy and for multi-unit, commercial and industrial developments, on-site detention (OSD) of stormwater is required.
2. Permissible Site Discharge (PSD) is the maximum discharge from the post-development site and shall not exceed the pre-developed flows for all storm events up to the 1 in 100 years ARI.
3. Concentrated flows must be managed to the satisfaction of Council
4. The methods to determine required storage volume may be a non-time translation hydrograph method (e.g. Wollongong method or Swinburne method) if the catchment area is no greater than 2500m^2 or 100m^3 storage otherwise a time translation hydrograph method (e.g. Runoff Routing method) shall be used. For both cases, the capacity of the existing drainage system must be checked to ensure no increase in flows occurs
5. PSD shall be determined considering the capacity of the existing system
6. The method of OSD shall be approved by a delegated officer from Council's Engineering Section, subject to the requirements / conditions of a particular development
7. The provision of OSD for a development shall address issues including (but not limited to) control of discharge, relief overflow, water re-use, dedicated detention volume, access, maintenance, ventilation, & safety. Methods of detention may include :
   - In-ground tanks
   - Above-ground storages (car parks / driveways)

- Above-ground storages (landscaped areas)
- Rainwater Tanks

8. All OSD's shall be fitted with an overflow which drains to a legal point of discharge. Overflows shall be designed for the 1 in 100 year ARI event without inundation of any floor levels or exceeding appropriate flow depths / velocities
9. OSD's shall be clearly marked by a suitable plate in a prominent position stating *'On Site Detention System – Do not reduce volume or interfere with orifice plate'*, or similar
10. The OSD storage is to be located clear of any overland flow paths
11. Wherever possible, the runoff from the whole development site is to be directed to the OSD storage
12. The preferred orifice diameter shall be 55 mm and is to be protected by a screening device to minimise blockage.
13. Minimum slope on storage areas are to be no less than 1% for turf areas and 0.5 % paved areas
14. Catchment areas, flows and storage details must be indicated on the drawings. Tabulated design calculations shall be provided. Refer Appendix D 'Sample OSD Calculation Sheet' *(Source - Byron Shire Council DCP 2002 – Part N5)*
15. Floor level freeboards from water surface levels shall be provided in accordance with Council requirements
16. Overflows shall be designed to cater for the 1 in 100 year ARI storm in accordance with Council requirements
17. Stormwater (rainwater tanks) shall be provided in accordance with Basix requirements and may be used for additional storage for roof water detention from building developments. Stormwater that requires detention and that cannot drain into a rainwater tank shall be separately detained on site in an ancillary structure.

12.02 MAJOR STORAGE VOLUMES

1. When Detention or Retention Basins are used to mitigate the impact of developed flows for developments with catchment areas greater than 2500m^2, or as determined by a delegated officer from Council's Engineering Section, a time translation hydrograph method such as a runoff routing method shall be used to determine required storage volume.
2. A detailed hydrological and hydraulic analysis is required.
3. Computer software used is to be 'recognized industry standard', acceptable to a delegated officer from Council's Engineering Section. A comprehensive list of 'set-up' parameters used to obtain results from the program is to be provided to Council (refer Section 6).
4. All computer analysis results shall be submitted in a clear, concise format that allows Council to carry out any necessary design checks. Explanatory sketches and notes may be required
5. Basins shall be designed so that the peak flow from the proposed development for the 5, 10, 20, 50 and 100 year ARI events, for durations from 5 minutes to 3

hours, does not exceed the existing peak flow from the site ie post-development flows must not exceed pre-development flows

6. Peak flows (pre and post-development) are to be calculated using the same methodology

7. Dedication of land to Council and / or easements in favour of Council for stormwater purposes are required over basins including a minimum 5m buffer to surrounding property / infrastructure. Council will be responsible for the ongoing maintenance of the basin.

8. Off-Line basins may reduce the risk of sequential over-topping

9. The consultant is to provide confirmation of the submission and assessment of the design plans for any proposed basins by the New South Wales Dam Safety Committee (S18.1 ref 7)

10. Design and installation of stormwater detention / retention is required on development sites in all areas where under-capacity drainage systems exist downstream of the site or where the proposed development will result in the existing infrastructure surcharging

11. A strategy plan documenting the maintenance of basins, acceptable to Council, is to be provided. This is to include consideration of the design and construction of the basin base and the top of the wall.

12. Public Safety Issues are to be considered and documented, including:

    a. Maximum water depth shall be 1.2m in the 1 in 100 year ARI event.

    b. Side slopes steeper than 6 H to 1 V are to have appropriate security / safety fencing.

    c. Internal basin side slopes shall be 6H to 1V as a preferred maximum slope.

    d. Internal basin side slopes of 4H to 1V shall be permitted as an absolute maximum subject to the approval of a delegated officer from the Council's Engineering Section.

    e. Internal basin side slopes steeper than 6H to 1V shall require safety / security fencing.

    f. Maximum velocity through the basin during the 1 in 1 year ARI event should not exceed 0.3 m/s.

    g. Inlet / Outlet structures shall be located at extreme ends of the basin with short-circuit of flow further minimized by use of baffles.

    h. Appropriate hazard / safety signage and depth indicators are to be installed.

    i. Flow intakes to be protected considering blockage and safety issues.

13. The high level outlet to a basin shall have the capacity to contain a minimum of the 1 in 100 year ARI flood event. Additional spillway capacity may be required. Spillway design shall be in accordance with the requirements for open channels (refer sections 9, 10 & 11).

14. Low flow pipe systems shall be rubber ring jointed (lifting holes appropriately sealed) and designed considering appropriate factors such as permeability, seepage and cut-off walls. Intakes shall be protected against blockage

15. Minimum basin floor slope shall be 1 %

16. Basins shall be designed, where possible, as water quality improvement facilities to meet the requirements of Australian Rainfall Quality (ARQ), Envrionmental Protection Authority (EPA), applicable Council DCP's and relevant authorities controlling receiving waters.

17. Any detention basin design must consider any worsening of upstream or downstream conditions due to :

    a. Backwater effects and possible raised upstream flood levels

    b. Extended periods of flow for minor ARI events

    c. Creation of flood peaks which occur at the same time as downstream tributary flood peaks

13. INTER-ALLOTMENT DRAINAGE

1. Inter-allotment drainage systems shall be designed to accept flow from buildings and impervious areas in accordance with the following conditions or as directed by a delegated officer from Council's Engineering Section

2. Pipe sizes shall be a minimum of:

    a. 150mm diameter for up to and including a maximum 2 lots

    b. 225mm diameter up to a maximum 375 diameter for greater than 2 lots in accordance with QUDM Level III (QUDM Table 5.18.6)

    c. For pipe sizes greater than 375mm diameter design is to be in accordance with minor system criteria and QUDM Level IV (QUDM Table 5.18.4)

3. Design of any inter-allotment drain shall consider the existing receiving system.

4. Inter-allotment drainage shall be provided for every allotment which does not drain directly to:

    - a street frontage or
    - existing pipeline of adequate capacity to accept additional flow or
    - natural watercourse.

5. Flooding effects shall be considered and allowed for in a design.

6. One residential lot only will be permitted to connect directly to the street. Connection to an underground system is preferred. Refer to Section 16 in this manual for guidance with respect to the provision of Section 88B easements.

7. In rural and rural residential areas inter-allotment drainage may be omitted if it can be demonstrated that there will be no adverse affects on downstream properties.

14. CONDUITS

1. Supply and installation of all Conduits shall conform with the appropriate Australian Standards (S18.2).

2. Pipe bedding shall be in accordance with the manufacturers recommendations.

3. Class of pipe shall be in accordance with the design depth, ground conditions, manufacturers recommendations and shall also consider construction loading.
4. Spigot and socket rubber ring jointed pipes shall be used for all pipe sizes.
5. Precast box culvert units shall be installed on cast in-place concrete slabs in accordance with AS1597.2 or on precast slabs.
6. Steel stormwater pipes shall not be used.
7. Use of fibre reinforced pipe or polyethylene pipe will require the approval of a delegated officer from Council's Engineering Section. Section 5.18(1) of specification D5 STORMWATER DRAINAGE DESIGN provides additional information on pipe types and selection.

15. PIT DESIGN & STANDARDS (D5.19)

1. Standard drawings for stormwater infrastructure may be accessed via the Council web-site. Non-standard structures will require the approval of a delegated officer from Council's Engineering Section;
2. For a list of relevant Australian Standards refer Section 18.02;
3. Road Gully Pits are to be aligned with property boundaries where possible and are to be clear of existing services, other infrastructure and driveways;
4. Desirable lintel size is 2.4m being 1.8m opening, but regardless the entry capacities and by-pass flows for pits shall be properly calculated and identified on the drawings. Pit entry openings less than 1.8m shall be permitted provided the designer can show that the design flow can be accommodated within the system without significate by-pass flows;
5. Stormwater pits are to be as follows :

   a. Structure sizes must increase with increased pipe sizes/configuration - design details may be required
   b. Step-irons are required over 1.2m depth
   c. Rectangular manholes are preferred
   d. Grated road gully pits greater than 1.5m deep and/or constructed over 600mm or greater diameter pipes are to be structurally designed and detailed in accordance with standard drawing 080-031/2.
   e. Pit lintels to be located on curved sections of road shall be curved to match the radius of the kerb and gutter the pit it to be positioned within

DEPTH (to invert mm)	MINIMUM INTERNAL SIZE mm		
	RECTANGULAR		CIRCULAR
	Width mm	Length mm	Diameter mm
d < 600	450	450	600
600 < d < 900	600	600	900
900 < d < 1200	600	900	1050
1200 and over	900	900	1050

(source AS/NZ3500)

Table 15.1 Gully pit sizes

6. Hydraulic grade lines (HGLs) shall be plotted on drainage longitudinal sections from pit to pit and shall take into account energy losses through pits. The procedure for calculating pit losses is detailed in Section 7.16.8 and Appendix 2 of QUDM. The manual is available from web site https://www.dews.qld.gov.au/water/supply/urban-drainage-manual free of charge. Appendix F of this Handbook provides the QUDM index of pit energy loss tables and Appendix G provides selected examples of QUDM pit energy loss tables

Pressure loss (or head loss) at pits may be expressed as a function of the velocity head of the flow in the pipe downstream of the junction:

$$V_o^2/2g \quad \text{thus} \quad h_s = K(V_o^2/2g)$$

where: h_s = pressure change at a structure
K = pressure change coefficient

The charts contained in Appendix 2 of QUDM provide pressure change coefficients for junction types commonly encountered in urban drainage design.

Note that where a structure has lateral as well as through flow the pressure change coefficient which applies to the through (main) line may be different to that for the lateral line i.e. K_U may not equal K_L.

The appropriate charts should be used to determine correct values of *KU* and *KL*. The pressure change coefficients K_U and K_L should be applied to the velocity head $V_o^2/2g$ in the **outlet** pipe from the structure.

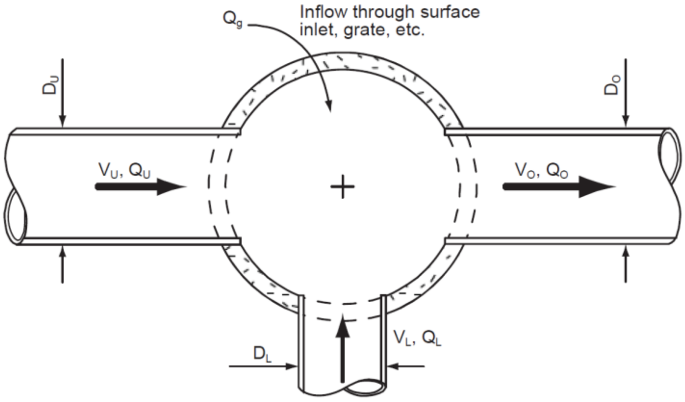


Fig 15.1 – Nomenclature at Pits

16. STORMWATER DISCHARGE & EASEMENTS

1. In any proposed development, especially those involving filling, consideration needs to be given to the existing and proposed overland flow paths in the design. New or re-configured stormwater easements may be required.

2. Roof, surface and piped stormwater flows from a development must be designed and directed to a legal point of discharge and be subject to landowners agreements, easements, 'restrictions as to user', dissipation of concentrated flow, water quality assessment and protection of adjoining and downstream property.

3. Any design solution must be acceptable to Council.

4. Section 88B instruments creating easements and 'restrictions as to user' must be drafted and checked by a surveyor or solicitor and shall be submitted to Council for approval.

5. Written evidence of approval of a 'Legal Point of Discharge' must accompany the design submission for an approval to be given by Council. Negotiations with the appropriate landowner or controlling authority are the responsibility of the developer and/or their representatives. Legal Points of Discharge include (but are not limited to) :

   a. existing Council infrastructure such as kerb & gutter, open channel or stormwater pipeline;
   b. unformed road reserve;
   c. public stormwater infrastructure through private property in an existing stormwater easement; or
   d. a defined natural waterway controlled by the NSW Department of Natural Resources.

6. All drainage structures must be contained within the relevant easement. Easements shall be a minimum width of 3m, or 2m plus the underground conduit width, or the area of influence of the trench, whichever is the greater. For private interallotment drainage lines 225mm in diameter or smaller, the easement width may be reduced to 1.5m, notwithstanding the requirements for the area of influence of the trench.

7. Easements are to be provided over:

   a. private roof water and inter-allotment drainage lines, in favour of upstream owners;
   b. inter-allotment drainage lines that receive flows from external public property (such as roads or reserves), in favour of Council; and
   c. overland flow paths through private property and open channels to contain the 1 in 100 year ARI flood flow plus a minimum 150mm freeboard (considering safety and maintenance access), in favour of Council.

8. A 'Restriction As to User' that identifies the natural waterway line and contains the 1 in 100 year ARI flood flow line may require an additional buffer of up to ten metres (10m) either side of the flow line. This shall be accurately identified by survey and noted on the survey plans to prevent the erection of structures or any other obstacle in overland flow paths.

9. Fencing shall not interfere with or inhibit overland flows.

10. Building platforms and effluent disposal are to be located at least 500mm above the 1 in 100 year ARI flood flow line.

11. Any form of development, the planting of trees, use as an effluent disposal area and the construction of structures is prohibited within the 1 in 100 year ARI overland flow path.

12. The development of the site is not to adversely affect adjacent properties or local drainage patterns (in particular detention basins). Provision is to be made for the free passage of surface stormwater away from affected sites.

13. Scour protection shall be provided at the outlet of all conduits and channels in accordance with the Landcom 'Soils and Construction – Volume 1, Chapter 5. Energy dissipators for major culverts shall be in accordance with Austroads Design Guides and the New South Wales Road and Maritime Services Road Design Guidelines (S18.1 ref 6, 8, 10, 13 &14).

14. All creeks and waterways are to be assessed under NSW state government legislation and any works must comply with the requirements of the relevant state authorities (DPI Water).

15. The above requirements do not apply to flood prone lands (i.e. land which is regularly inundated by river flooding events). These locations are covered by the requirements of the applicable Council DCP and any flood management plans.

17. RURAL RESIDENTIAL DESIGN CONSIDERATIONS

1. The following criteria shall be included in the design of any proposed rural residential development as a minimum requirement:

   a. longitudinal piped drainage;
   b. general wider road reservation to facilitate drainage and other infrastructure;
   c. localised wider road reservation;
   d. offset pavement grading;
   e. box culverts; and
   f. driveway and culvert arrangement and location.

2. Pipe or precast concrete box culverts, bridges or concrete causeways should be located at road crossings of all natural watercourses and extend to the limits of the road formation.

3. Depth of flow indicators and delineator posts shall be used to better define the areas of frequent inundation and where v x d exceeds 0.6.

4. Cross drainage design shall take into account the possible debris and impact load from the catchment and in this regard the provision of reinforced concrete box culverts is Council's preferred option.

5. Easements shall be provided on both sides of the road reserve to allow for necessary scour protection works to be undertaken and for future maintenance works as required. These easements shall:

   a. extend to a point where the outlet flow dissipates and spreads to sheet flow or to the natural watercourse flow regime; and
   b. encapsulate the water course and allow machine access to either side of the watercourse from the road reserve.

18. REFERENCES

18.01 DESIGN GUIDELINES & REPORTS (web sites last accessed June 2016)

1	Armidale Regional Council Design and Construction Specifications and Guidelines	
2	Australian Rainfall & Runoff	http://www.arr.org.au/
3	Bureau of Meteorology IFD Generator	http://www.bom.gov.au/water/designRainfalls/ifd/index.shtml
4	The Estimation of Probable Maximum Precipitation in Australia : Generalised Short Duration Method' - Commonwealth Bureau of Meteorology	http://www.bom.gov.au/water/designRainfalls/pmp/index.shtml
5	Floodplain Development Manual 2005 – NSW Department of Infrastructure, Planning and Natural Resources	http://www.environment.nsw.gov.au/floodplains/manual.htm
6	Austroads Design Guides	https://www.onlinepublications.austroads.com.au/collections/agrd/guides
7	NSW Dam Safety committee	http://www.damsafety.nsw.gov.au/
8	RMS NSW Road Design Guidelines	http://www.rms.nsw.gov.au/business-industry/partners-suppliers/aus-roads-guides/road-design.html
9	Soils & Construction Manual Department of Environment & Heritage NSW	http://www.environment.nsw.gov.au/stormwater/publications.htm
10	Queensland Department of Transport & Main Roads – Technical Guides	http://tmr.qld.gov.au/business-industry/Technical-standards-publications/Road-planning-and-design-manual-2nd-edition.aspx
11	NSW Department of Planning & Infrastructure 'BASIX' Guidelines	*https://www.planningportal.nsw.gov.au/planning-tools/basix*
12	DPI Water / Sydney Catchment Authority Recommended Practice Guidelines	*http://www.waternsw.com.au/about/pubs/crp*
13	Queensland Urban Drainage Manual 2013 (provisional)	https://www.dews.qld.gov.au/water/supply/urban-drainage-manual
14	Queensland 'Water-By-Design' / 'Healthy Waterways' Guidelines	*http://healthywaterways.org/resources*

18.2 AUSTRALIAN STANDARDS

AS1141	Methods of sampling and testing aggregates
AS1254	uPVC Pipes
AS1260	PVC Pipes and Fittings for Drain Waste and Vent Applications (sewer grade)
AS1289	Method of Testing Soils for Engineering Purposes
AS1303	Steel Reinforcing Bars for Concrete
AS1379	The specification and Manufacture of Concrete
AS1597	Small Precast Reinforced Concrete Box Culverts (Part 1)
AS1597	Large Precast Reinforced Concrete Box Culverts (Part 2)
AS1646	Elastomeric Seals for Waterworks purposes
AS1830	Iron Castings - Grey Cast Iron
AS2032	Installation of uPVC Pipe Systems
AS2758	Aggregates and rock for engineering purposes
AS/NZ 3500	Plumbing & Drainage (Stormwater Drainage)
AS3600	Concrete Structures
AS3678	Structural Steel - Hot-rolled Plates, Floor-plates and Slabs
AS3725	Loads on Buried Concrete Pipes
AS3996	Metal Access Covers, Road Grates and Frames
AS4058	Precast Concrete Pipes
AS4139	Fibre Reinforced Concrete Pipes and Fittings
AS4680	Hot-dipped Galvanised Coatings on Ferrous Articles

APPENDIX A - IFD DATA

Engineers Australia is currently revising a large suite of design flood estimation inputs which require the review of current IFD calculations. The 2013 IFDs are part of the review by Engineers Australia and will be released progressively over the next few years. Until all components of the Australian Rainfall and Runoff publication ‘A Guide to Flood Estimation’ are revised, the new IFDs can only be used in specific circumstances.

The AR&R87 IFDs will be available for a transition period of at least 18 months while the revision of other inputs to design flood estimation, including design temporal patterns, losses, areal reduction factors etc. is completed as part of the overall Australian Rainfall and Runoff (AR&R) revision being undertaken by Engineers Australia.

Both the AR&R87 IFDs and the new IFDs are available from the Bureau of Meteorology website. The website also includes advice from Engineers Australia as to when the old and the new IFD estimates should be used.

The IFDs presented in this manual are limited to the pre 2013 IFDs as it is considered that until the Australian Rainfall and Runoff (AR&R) revision is completed, this will reduce any design conflict and confusion as to the correct design methodology to be adopted by Council engineers and consultants working within the Armidale Regional Council area.

During the transition period, two versions of IFD design rainfalls will be available for use, the new 2013 IFD design rainfalls and the existing IFD design rainfalls (released in 1987). While the new IFDs are derived from a longer and more extensive dataset, careful consideration is needed before they are used with other existing inputs to design flood estimation techniques.

It can not be assumed that using the 2013 IFD design rainfalls with AR&R87 techniques and design parameters will deliver a more reliable estimate of the design flood.

In most cases it would be prudent to use the AR&R87 design parameters and conduct sensitivity testing with revised AR&R design parameters (including the 2013 IFD design rainfalls) as they become available. This will allow assessment of the impact of updated information on design decisions.

The 2013 IFD design rainfalls should definitely **NOT** be used in conjunction with the following techniques:

- Probabilistic Rational Method
- Other regional flood techniques based on AR&R87 IFD design rainfalls.

If consistency is sought across a number of flood estimation studies, the AR&R87 design parameters should be used and a sensitivity testing should be undertaken with the 2013 IFD design rainfalls, until the entire suite of new AR&R techniques and design parameters is available.

If a one-off flood estimation study is being undertaken choice may be made, on a case-by-case basis, to use the 2013 IFD design rainfalls and other revised AR&R design parameters as they become available.

A1 ARMIDALE (30.500 S, 151.650 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	62.3	82.3	111.	130.	155.	190.	219.
6 mins	58.1	76.8	103.	121.	144.	177.	204.
10 mins	47.4	62.5	83.4	97.1	115.	141.	162.
20 mins	34.5	45.2	59.5	68.9	81.4	98.9	113.
30 mins	27.9	36.5	47.7	55.0	64.8	78.4	89.4
1 hour	18.7	24.4	31.5	36.1	42.3	50.8	57.7
2 hours	12.2	15.8	20.2	23.0	26.7	31.9	36.0
3 hours	9.47	12.2	15.5	17.5	20.3	24.1	27.1
6 hours	6.08	7.81	9.73	10.9	12.6	14.8	16.6
12 hours	3.87	4.95	6.14	6.86	7.87	9.25	10.3
24 hours	2.40	3.08	3.85	4.31	4.96	5.85	6.55
48 hours	1.43	1.84	2.34	2.65	3.07	3.65	4.11
72 hours	1.02	1.33	1.69	1.93	2.24	2.68	3.03

A2 BALDERSLEIGH (30.264 S, 151.430 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	69.3	90.9	120.	139.	164.	199.	228.
6 mins	64.7	84.6	111.	129.	152.	185.	212.
10 mins	52.8	68.9	90.3	104.	123.	149.	170.
20 mins	38.6	50.2	65.2	74.8	87.8	106.	120.
30 mins	31.3	40.6	52.5	60.0	70.3	84.4	95.8
1 hour	20.9	27.0	34.6	39.3	45.8	54.7	61.9
2 hours	13.3	17.1	21.6	24.4	28.3	33.5	37.7
3 hours	10.1	12.9	16.2	18.2	21.0	24.7	27.7
6 hours	6.24	7.96	9.79	10.9	12.5	14.6	16.3
12 hours	3.86	4.91	6.00	6.65	7.58	8.83	9.81
24 hours	2.39	3.05	3.74	4.16	4.75	5.55	6.17
48 hours	1.44	1.85	2.30	2.58	2.97	3.50	3.92
72 hours	1.03	1.33	1.66	1.87	2.16	2.55	2.87

A3 BEN LOMOND (30.017 S, 151.658 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	68.3	89.3	117.	135.	160.	194.	221.
6 mins	63.8	83.4	109.	126.	149.	180.	206.
10 mins	52.1	67.9	88.4	101.	119.	144.	164.
20 mins	38.0	49.3	63.3	72.2	84.3	101.	114.
30 mins	30.8	39.8	50.8	57.7	67.2	80.1	90.6
1 hour	20.7	26.6	33.6	37.9	43.9	52.1	58.6
2 hours	13.4	17.1	21.4	24.1	27.8	32.8	36.8
3 hours	10.2	13.1	16.3	18.3	21.1	24.8	27.8
6 hours	6.46	8.25	10.2	11.4	13.1	15.4	17.2
12 hours	4.10	5.22	6.43	7.16	8.19	9.59	10.7
24 hours	2.62	3.32	4.07	4.51	5.15	6.00	6.66
48 hours	1.64	2.08	2.52	2.78	3.16	3.68	4.06
72 hours	1.21	1.53	1.84	2.03	2.30	2.67	2.95

A4 BOORALONG – (30.285 S, 151.556 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	65.0	85.3	113.	131.	156.	190.	218.
6 mins	60.7	79.6	105.	122.	145.	177.	203.
10 mins	49.5	64.8	85.1	98.3	116.	141.	161.
20 mins	36.1	47.1	61.0	69.9	82.0	98.8	112.
30 mins	29.3	38.0	48.9	55.8	65.3	78.4	88.8
1 hour	19.6	25.3	32.2	36.6	42.5	50.7	57.3
2 hours	12.6	16.2	20.4	23.1	26.7	31.6	35.6
3 hours	9.64	12.4	15.5	17.4	20.1	23.8	26.6
6 hours	6.05	7.75	9.61	10.7	12.3	14.5	16.2
12 hours	3.79	4.85	5.99	6.68	7.65	8.97	10.0
24 hours	2.36	3.02	3.74	4.18	4.80	5.64	6.30
48 hours	1.42	1.82	2.29	2.57	2.97	3.51	3.93
72 hours	1.02	1.32	1.66	1.87	2.16	2.56	2.88

A5 BLACK MOUNTAIN (30.308 S, 151.650 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	64.0	84.2	112.	131.	155.	190.	218.
6 mins	59.7	78.5	105.	122.	145.	177.	203.
10 mins	48.8	63.9	84.4	97.8	116.	141.	161.
20 mins	35.5	46.3	60.3	69.4	81.6	98.6	112.
30 mins	28.7	37.4	48.3	55.4	64.9	78.1	88.6
1 hour	19.3	25.0	31.9	36.3	42.3	50.6	57.1
2 hours	12.6	16.2	20.4	23.0	26.7	31.6	35.5
3 hours	9.72	12.5	15.6	17.5	20.2	23.8	26.7
6 hours	6.23	7.95	9.78	10.9	12.5	14.6	16.3
12 hours	3.96	5.03	6.15	6.83	7.79	9.08	10.1
24 hours	2.46	3.13	3.85	4.28	4.90	5.73	6.38
48 hours	1.46	1.87	2.34	2.62	3.03	3.57	4.00
72 hours	1.05	1.35	1.69	1.91	2.21	2.61	2.94

A6 BUNDARRA – (30.177 S, 151.068 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	72.9	95.9	127.	148.	176.	215.	247.
6 mins	67.8	89.2	119.	138.	164.	200.	230.
10 mins	55.3	72.7	96.5	112.	133.	162.	186.
20 mins	40.5	53.2	70.5	81.8	97.0	118.	136.
30 mins	32.8	43.1	57.0	66.1	78.4	95.6	110.
1 hour	21.9	28.7	37.7	43.5	51.4	62.5	71.5
2 hours	14.0	18.2	23.5	26.9	31.6	38.0	43.2
3 hours	10.6	13.7	17.5	20.0	23.2	27.8	31.4
6 hours	6.57	8.43	10.5	11.8	13.6	16.1	18.0
12 hours	4.06	5.18	6.39	7.12	8.16	9.56	10.7
24 hours	2.49	3.19	3.95	4.42	5.07	5.96	6.66
48 hours	1.48	1.91	2.41	2.73	3.16	3.75	4.23
72 hours	1.06	1.36	1.73	1.97	2.28	2.72	3.07

A7 EBOR (30.400 S, 151.650 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	62.8	82.9	111.	130.	155.	190.	218.
6 mins	58.7	77.3	104.	121.	144.	176.	203.
10 mins	47.9	62.8	83.6	97.2	115.	141.	161.
20 mins	34.8	45.5	59.8	69.0	81.3	98.6	112.
30 mins	28.2	36.7	47.9	55.0	64.7	78.1	88.9
1 hour	18.9	24.5	31.6	36.1	42.2	50.6	57.3
2 hours	12.3	15.9	20.2	22.9	26.6	31.6	35.7
3 hours	9.54	12.3	15.4	17.4	20.1	23.8	26.8
6 hours	6.12	7.84	9.71	10.9	12.5	14.6	16.4
12 hours	3.89	4.97	6.11	6.80	7.78	9.09	10.1
24 hours	2.42	3.08	3.81	4.26	4.88	5.73	6.39
48 hours	1.44	1.84	2.31	2.60	3.00	3.56	3.99
72 hours	1.03	1.33	1.68	1.89	2.19	2.60	2.92

A8 GUYRA (30.217 S, 151.668 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	64.5	84.8	113.	131.	156.	190.	218.
6 mins	60.2	79.2	105.	122.	145.	177.	203.
10 mins	49.2	64.5	84.9	98.1	116.	141.	161.
20 mins	35.8	46.7	60.6	69.6	81.6	98.5	112.
30 mins	29.0	37.7	48.6	55.5	64.9	78.0	88.4
1 hour	19.5	25.2	32.1	36.4	42.4	50.5	57.0
2 hours	12.7	16.4	20.6	23.2	26.8	31.7	35.6
3 hours	9.85	12.6	15.7	17.7	20.3	23.9	26.8
6 hours	6.32	8.06	9.92	11.0	12.6	14.8	16.5
12 hours	4.03	5.13	6.26	6.95	7.92	9.23	10.2
24 hours	2.53	3.22	3.94	4.37	5.00	5.83	6.48
48 hours	1.53	1.95	2.41	2.69	3.10	3.63	4.05
72 hours	1.11	1.42	1.76	1.97	2.26	2.66	2.97

A9 HILLGROVE (30.568 S, 151.907 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	66.0	86.4	114.	132.	155.	189.	215.
6 mins	61.7	80.8	106.	123.	145.	176.	201.
10 mins	50.4	65.8	86.0	98.9	116.	140.	160.
20 mins	36.6	47.4	61.2	69.9	81.6	97.6	110.
30 mins	29.7	38.3	49.1	55.8	64.9	77.4	87.3
1 hour	20.0	25.8	32.7	36.9	42.7	50.6	56.9
2 hours	13.2	16.9	21.2	23.8	27.4	32.3	36.1
3 hours	10.3	13.1	16.3	18.3	21.0	24.6	27.5
6 hours	6.66	8.48	10.5	11.6	13.3	15.6	17.3
12 hours	4.33	5.50	6.76	7.51	8.57	10.0	11.1
24 hours	2.79	3.56	4.41	4.91	5.63	6.59	7.34
48 hours	1.75	2.25	2.83	3.19	3.68	4.34	4.86
72 hours	1.30	1.67	2.12	2.40	2.78	3.29	3.70

A10 LOWER CREEK (30.720 S, 152.255 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	82.2	107.	137.	156.	182.	216.	243.
6 mins	77.3	100.	129.	147.	171.	204.	230.
10 mins	63.2	81.8	105.	120.	140.	166.	187.
20 mins	45.6	59.0	75.6	85.8	99.6	118.	133.
30 mins	36.9	47.8	61.2	69.5	80.6	95.6	108.
1 hour	25.4	32.9	42.2	47.9	55.6	66.0	74.3
2 hours	17.4	22.5	29.0	33.0	38.4	45.6	51.4
3 hours	14.0	18.1	23.4	26.6	30.9	36.9	41.5
6 hours	9.62	12.5	16.2	18.5	21.6	25.8	29.1
12 hours	6.59	8.60	11.3	12.9	15.2	18.2	20.6
24 hours	4.42	5.81	7.78	9.04	10.7	13.0	14.8
48 hours	2.87	3.81	5.26	6.21	7.45	9.19	10.6
72 hours	2.19	2.92	4.11	4.89	5.92	7.36	8.54

A11 THALGARRAH (30.403 S, 151.889 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	63.8	84.0	112.	131.	156.	190.	218.
6 mins	59.6	78.5	105.	122.	145.	177.	204.
10 mins	48.7	63.9	84.7	98.2	116.	141.	162.
20 mins	35.3	46.1	60.3	69.4	81.7	98.7	112.
30 mins	28.6	37.2	48.3	55.4	65.0	78.3	88.9
1 hour	19.3	25.0	32.1	36.6	42.6	51.0	57.7
2 hours	12.7	16.4	20.8	23.5	27.2	32.2	36.2
3 hours	10.0	12.8	16.0	18.0	20.7	24.4	27.3
6 hours	6.51	8.29	10.2	11.4	13.0	15.2	16.9
12 hours	4.23	5.36	6.55	7.26	8.27	9.61	10.7
24 hours	2.68	3.42	4.21	4.69	5.37	6.27	6.98
48 hours	1.64	2.11	2.65	3.00	3.46	4.09	4.60
72 hours	1.20	1.54	1.97	2.23	2.59	3.08	3.47

A12 TINGHA (29.939 S, 152.249 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	72.9	95.9	128.	149.	176.	216.	248.
6 mins	67.9	89.3	119.	138.	164.	201.	231.
10 mins	55.5	72.8	96.6	112.	133.	163.	187.
20 mins	40.6	53.2	70.5	81.7	96.9	118.	135.
30 mins	32.9	43.1	57.0	66.1	78.2	95.3	109.
1 hour	21.9	28.7	37.6	43.5	51.3	62.3	71.1
2 hours	13.9	18.1	23.5	26.9	31.5	37.9	43.1
3 hours	10.6	13.7	17.5	19.9	23.2	27.7	31.4
6 hours	6.53	8.38	10.5	11.8	13.6	16.1	18.1
12 hours	4.04	5.16	6.38	7.11	8.15	9.56	10.7
24 hours	2.49	3.19	3.94	4.40	5.05	5.94	6.63
48 hours	1.49	1.92	2.40	2.71	3.13	3.71	4.17
72 hours	1.07	1.37	1.73	1.95	2.26	2.67	3.01

A13 WANDSWORTH (30.066 S, 151.520 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	70.1	91.9	121.	140.	165.	201.	229.
6 mins	65.4	85.6	113.	130.	154.	187.	213.
10 mins	53.4	69.7	91.2	105.	124.	150.	171.
20 mins	39.0	50.8	65.8	75.4	88.4	107.	121.
30 mins	31.7	41.1	53.0	60.6	70.8	85.1	96.4
1 hour	21.1	27.4	34.9	39.7	46.3	55.3	62.5
2 hours	13.5	17.5	22.0	24.9	28.8	34.2	38.5
3 hours	10.3	13.3	16.6	18.7	21.5	25.4	28.5
6 hours	6.44	8.23	10.2	11.3	13.0	15.2	17.0
12 hours	4.01	5.11	6.27	6.97	7.96	9.30	10.3
24 hours	2.48	3.16	3.90	4.35	4.97	5.82	6.49
48 hours	1.48	1.90	2.38	2.67	3.07	3.63	4.07
72 hours	1.06	1.37	1.72	1.93	2.23	2.64	2.97

A14 WARDS MISTAKE (30.134 S, 152.005 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	65.2	85.6	114.	132.	156.	190.	218.
6 mins	60.9	79.9	106.	123.	146.	177.	203.
10 mins	49.7	65.0	85.6	98.9	117.	141.	161.
20 mins	36.1	47.0	60.9	69.8	81.7	98.2	111.
30 mins	29.2	37.9	48.8	55.7	64.9	77.7	87.9
1 hour	19.7	25.5	32.4	36.7	42.6	50.7	57.1
2 hours	13.1	16.8	21.1	23.8	27.4	32.4	36.3
3 hours	10.3	13.1	16.4	18.4	21.1	24.9	27.8
6 hours	6.74	8.60	10.6	11.8	13.5	15.8	17.6
12 hours	4.37	5.56	6.82	7.59	8.66	10.1	11.2
24 hours	2.72	3.49	4.31	4.82	5.52	6.46	7.20
48 hours	1.62	2.09	2.63	2.96	3.42	4.04	4.53
72 hours	1.17	1.50	1.91	2.16	2.51	2.98	3.36

A15 WOLLOMOMBI (30.400 S, 151.650 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	69.1	90.1	118.	135.	159.	191.	218.
6 mins	64.6	84.2	110.	126.	148.	179.	203.
10 mins	52.7	68.6	88.9	102.	119.	143.	162.
20 mins	38.4	49.7	63.5	72.1	83.8	99.8	112.
30 mins	31.1	40.1	50.9	57.7	66.8	79.2	89.1
1 hour	21.0	27.0	33.9	38.2	44.1	52.0	58.3
2 hours	13.8	17.7	22.1	24.7	28.4	33.4	37.3
3 hours	10.7	13.7	17.1	19.1	21.9	25.6	28.6
6 hours	6.96	8.88	11.0	12.2	14.0	16.3	18.1
12 hours	4.49	5.73	7.07	7.89	9.02	10.5	11.7
24 hours	2.84	3.64	4.56	5.12	5.89	6.93	7.75
48 hours	1.73	2.24	2.87	3.26	3.80	4.53	5.11
72 hours	1.26	1.64	2.13	2.44	2.85	3.43	3.88

A16 WONGWIBINDA (30.294 S, 152.169 E)

RAINFALL INTENSITY IN mm/h FOR VARIOUS DURATIONS AND RETURN PERIODS

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
5 mins	69.8	90.9	118.	136.	159.	192.	218.
6 mins	65.3	85.0	111.	127.	149.	179.	203.
10 mins	53.3	69.1	89.5	102.	119.	143.	162.
20 mins	38.8	50.0	63.9	72.4	83.9	99.7	112.
30 mins	31.4	40.5	51.3	57.9	66.9	79.1	88.8
1 hour	21.2	27.2	34.1	38.3	44.1	51.9	58.0
2 hours	13.8	17.7	22.0	24.6	28.3	33.1	37.0
3 hours	10.7	13.6	16.9	18.9	21.6	25.3	28.2
6 hours	6.81	8.68	10.7	12.0	13.7	16.0	17.8
12 hours	4.37	5.57	6.91	7.70	8.81	10.3	11.5
24 hours	2.80	3.60	4.50	5.06	5.83	6.86	7.67
48 hours	1.75	2.27	2.91	3.31	3.85	4.58	5.17
72 hours	1.29	1.68	2.18	2.50	2.92	3.50	3.97

APPENDIX B - STANDARD COMPUTER MODEL PARAMETERS & ASSUMPTIONS

B1 PARAMETERS TO BE USED IN RAFTS MODELLING

1. The use of RAFTS (Runoff Analysis & Flow Training Simulation) is permissible for catchment wide / detention basin analysis but not recommended for urban areas
2. Where a range of values is given, use of the value selected needs to be justified.
3. Where there is any possibility of variation in values, multiple runs to test sensitivity will be required.
4. RAFTS runs are to be carried out for a range of storms including (as a minimum) 2yr, 5yr, 10yr, 20yr, 50yr, 100yr ARI and PMP
5. A range of storm durations for each of these recurrence intervals must be modelled sufficiently to show that the peak flows at each sub-catchment node peak flows have been identified.
6. The fraction impervious is to be in accordance with QUDM Table 5.04.1 or other recognized reference and must be verified by site inspection. The value identified by site inspection will be the minimum value to use in any sensitivity analysis.
7. If the Initial and Continuing loss model is used :
    a. Impervious area losses are to be IL=1.5mm and CL=0mm/hr
    b. Pervious area losses are to be IL=15 mm and CL=2.5mm/hr
    c. PMF pervious and impervious areas losses are to be IL=0mm and CL=0mm/hr
8. ARBM (Australian Representatives Basin Model) water balance model parameters are given below. Use of values other than those given must be justified
9. PERN (Population-Environment Research Network) factors used to adjust the catchment routing factor to allow for catchment roughness values must be justified. Typical Values are as tabulated below :

PERN VALUE	DESCRIPTION
0.015	Impervious Area
0.025	Urban Pervious Area
0.05 – 0.07	Rural Pastures
0.10	Forested Catchments

10. The Old Urban option is not to be used.
11. BX =1.0 (Calibration factor similar to RORB's k_c)
12. Appropriate lags are to be calculated based on the type of catchment or channel routing is to be used.
13. Basins must be modelled by Stage-Storage and Stage-Discharge relationships
14. The split catchment option is to be used for separately modelling the pervious and impervious fractions of the catchment.

Table B1 - ARBM Parameters

Parameter	Description	Value	Unit
CAPIMP	Capacity of Impervious Area Storage	1.5	mm
ISC	Interception Storage Capacity	1.5	mm
DSC	Depression Storage Capacity	5	mm
USC	Capacity – Upper Soil Zone Storage	25	mm
LSC	Capacity – Lower Soil Zone Storage	100	mm
UH	Maximum Potential Evapo-transpiration from Upper Soil Zone	10	mm/day
LH	Maximum Potential Evapo-transpiration from Lower Soil Zone	10	mm/day
ER	Proportion of Evapo-transpiration from USC	0.7	
IDS	Initial Impervious Area Storage	0.5	mm
IS	Initial Interception Storage	0.5	mm
DS	Initial Depression Storage (pervious)	0	mm
US	Initial Upper Soil Zone Storage	20	mm
LS	Initial Lower Soil Zone Storage	80	mm
GS	Initial Groundwater Storage	0	mm
GN	Groundwater Recession Factor	1	mm
SO	Sorptivity of Dry Soil	3.0	mm/min
Ko	Saturated Hydraulic Conductivity	0.33	mm/min
LDF	Lower Soil Drainage Factor	0.05	
KG	Constant Rate Groundwater Recession Factor	0.94	
ECOR	Rate of Potential Evaporation from “A” Class Pan	0.70	
IAR	Proportion of Rainfall intercepted by Vegetation	0.70	

B2 PARAMETERS TO BE USED IN DRAINS MODELLING

1. Use of values other than those listed here requires the approval of a delegated officer from Council's Engineering Section.
2. Where a range of values is given, use of the value selected needs to be justified.
3. Where there is any possibility of variation in values, multiple runs to test sensitivity will be required.
4. Drains runs are to be carried out for an range of storms depending on the ARI of the minor system.

Table B2 – Drains Model Parameters

Parameter	Description	Value	Unit
	Model for Design and Analysis run	Rational Method	
	Rational Method Procedure	ARR87	
	Soil Type - Normal	3.0	
	Paved (Impervious) Area Depression Storage	1	mm
	Supplementary Area Depression Storage	1	mm
	Grassed (Pervious) Area Depression Storage	5	mm
AMC	Antecedent Moisture Condition (ARI = 1-5 years)	2.5	
AMC	Antecedent Moisture Condition (ARI = 10-20 years)	3.0	
AMC	Antecedent Moisture Condition (ARI = 50-100 years)	3.5	
	Sag Pit Blocking Factor (Major systems)	Refer charts in ARC design specifications	
	On Grade Pit Blocking Factor (Major Systems)		
	Inlet Pit Capacity		
	Minimum Pit freeboard	150	mm

APPENDIX C - DESIGN SUBMISSION CHECKLIST

This checklist is a guide and is not limited to the listed items. Consultants are expected to apply engineering 'best practice' and sound engineering judgement in the provision of information for development project applications and the submission of engineering design drawings.

Reports, plans and calculations are to be certified by a specialist professional consultant, civil engineer or approved licensed surveyor, to the satisfaction of a delegated officer from Council's Engineering Design Section or Council's Development Engineer.

PROJECT :	
COUNCIL FILE No:	
LOCATION :	
CONSULTANT :	

A1. DESIGN

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Stormwater Calculations submitted on standard forms to Council requirements as per AR&R or QUDM for Major & Minor systems		
2	Manual calculations provided in clear, concise format		
3	Computer files/Setup Parameters List provided		
4	Hydrologic and hydraulic models/results checked and verified by qualified person		
5	Locality Plan		
6	Catchment Plan to scale		
7	Hydraulic model plans, showing location and extent of model cross-sections.		
8	Existing and Proposed site plan including staging		
9	Associated buildings, structures and landscape plans /sections.		
10	Data in reports/plans matches calculations		
11	Legal point of discharge identified		
12	Downstream discharge landowner's agreements obtained (public & private)		
13	Public amenity, safety & aesthetics considered		
14	Sedimentation & Erosion Control Plans (to be consistent with Stormwater Design and Council requirements)		
15	Water Quality models/results checked and verified by qualified person		
16	Structural Certifications		
17	Survey by licensed surveyor		
18	Show lot and DP numbers		
19	Show DA numbers applicable		
20	Show adjacent developments where known		
21	All levels (survey, design and drawing) to Australian Height Datum		

A2. Hydrology and Hydraulics

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Approved design methodology		
2	Coefficient of Runoff		
3	Time of concentration		
4	Overland Flow paths		
5	Catchment area		
6	Partial area effects		
7	Flow velocities (flow paths, channels, outlets etc)		
8	Storm surge & tidal effects		
9	Calculations for Major / Minor systems		
10	Blockage factors applied to catch pits		
11	Coincident flow paths (flooding)		
12	Bridges, culverts, channels, structures, etc.		
13	Road flood immunity and trafficability		
14	Complies with AR&R / QUDM / Council DCP's		
15	Approvals from other relevant authorities (RMS etc)		
16	Setback / Buffer from existing watercourse / floodway		
17	Loss of flood storage		
18	Loss of conveyance area		
19	Compensation cut / fill earthworks plan & sections		

A3. Open Channels and Watercourses

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Roughness (values, sensitivity, vegetated buffer)		
2	Geometry (alignment, batters, grades, low-flow provision)		
3	Capacity		
4	Impact on flood levels of surrounding properties		
5	Tail water levels		
6	Tidal effects		
7	Freeboard		
8	Maximum velocities and scour protection		
9	Minimum velocities and siltation		
10	Impact on vegetation and wildlife		
11	Effect of landscaping		
12	Maintenance and safety berms (provision and access)		
13	Energy losses (including bends and drops)		

A4. Overland Flow Paths

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Depth (max 0.20m)		
2	Velocity (d x v product)		
3	Concentration of flows (capture, scour, re-direction)		
4	Freeboard		
5	Roughness (values, sensitivity, vegetated buffer)		
6	Impact on flood levels of surrounding properties		
7	Tail water levels		
8	Easement		

A5. Retention, Detention and Sedimentation Basins

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Safety including bank slope & depths, inlet/outlet works, structural integrity		
2	Referral to the NSW Dam Safety Committee		
3	Sizing		
4	Outflows		
5	Spillway		
6	Scour protection		
7	Maintenance (sediment basins)		
8	Freeboard		
9	Water quality		
10	Effect on catchment runoff hydrograph		
11	Batter slopes		
12	Minor flood flows		
13	Maximum flooded depth		
14	Inlet/outlet structures		
15	Earthworks		
16	landscaping		

A6. Bridges and Culverts

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Flood immunity (afflux and impact on property)		
2	Velocity and scour (u/s and d/s)		
3	Effect of overtopping and d/s flood levels		
4	Effect of road furniture (guardrail etc)		
5	Tail water level		
6	Allowance for fauna movement (wet and dry periods)		
7	Energy dissipation		
8	Maintenance		
9	Safety		

A7. Pipe Outlets

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Velocity and scour (u/s and d/s)		
2	Energy dissipation		
3	Tail water Level		
4	Configuration, location and skew		

B. DESIGN DRAWINGS

B1. Catchment Plan

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	North Point and scale		
2	Road Names		
3	Development boundary and lot/ road boundaries, lot & DP numbers		
4	Numbering as per calculations (areas and system)		
5	Catchment boundaries in bold line and clearly shown		
6	Existing and proposed contours, clearly shown		
7	Watershed direction (indicate longest time of concentration)		
8	Stormwater reticulation system clearly shown		
9	External catchments and details		
10	Drawn to scale with preferred scale 1 : 500		

B2. Detail Plans

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	North Point and scale		
2	Road Names		
3	Development boundary		
4	System Numbering		
5	Existing and proposed contours, clearly shown		
6	Pipe size, type and class		
7	Location (co-ordinate, road centerline chainage/offset, boundary offset)		
8	Structure type, details		
9	Lengths and grades		
10	Inter-allotment drainage		
11	Easements		
12	100 year ARI flood lines (existing and design) and buffers		
13	100 year ARI flow paths and easements		
14	Invert levels, surface levels		
15	Preferred scale 1: 500		

B3. Long Sections - Pipelines and Channels

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	System Numbering		
2	Pipe grade %, size, type and class		
3	Design ARI event and hydraulic grade line plotted		
4	Control HGL/Receiving Waters Water Surface Level		
5	Flows (actual & capacity) and velocities (structure to structure)		
6	Structure type, details and Junction line reference		
7	Existing and design surface level profiles		
8	Chainages, lengths and grades (structure to structure)		
9	Invert levels, surface levels, depths & HGL levels		
10	Utility Service crossing details		
11	Open Drain and Basin Details		
12	Inlet/outlet structure and lead-out/tail-in details		
13	Other Structures (drop, energy dissipators etc)		
14	Preferred scale – 1:500 horizontal / 1:50 vertical		

B4. Open Drains

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	System Numbering		
2	Design ARI event and hydraulic grade line		
3	Flows and velocities		
4	Cross sections at nominal 20m intervals		
5	Other Structures (drop, energy dissipators etc)		
6	Existing and design surface level profiles		
7	Chainages, lengths and grades		
8	Invert levels, surface levels, depths		
9	Inlet/outlet structure details		
10	Batter slopes and treatment		

B5. Detention Basins

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Plan		
2	Sections		
3	Details of Basin Wall		
4	Details of structures		
5	Extent of permanent storage (if any)		
6	Maximum storage level		
7	Spillway details		
8	Energy dissipation works and Scour protection		
9	Landscaping		
10	Earthworks		
11	Maintenance and access Plan		

B6. Water Quality & Water Sensitive Urban Design Measures

ITEM	DESCRIPTION	ACTION √ x	N / A √
1	Details of proprietary devices		
2	Details of non-proprietary devices		
3	Calculations and details of performance showing compliance with Council's requirements		
4	Maintenance Plan, costings & details considering access and safety		
5	Work Method statements for installed devices		

APPENDIX D - SAMPLE DETAILS & TABULATIONS

D1 CATCHMENT PLAN, HYDROLOGICAL & HYDRAULIC CALCULATION TABLES

FIGURE 1 - SAMPLE HYDRAULIC GRADE LINE CALCULATION SHEET

LOCATION				TIME			SUB-CATCHMENT RUNOFF						
1	2	3	4	5	6	7	8	9	10	11	12	13	14
						tc	I	C	A	(CxA)	+(CxA)	Q	
DESIGN A.R.I.	STRUCTURE NO.	DRAIN SECTION	SUB-CATCHMENTS CONTRIBUTING	SURFACE CONDITION (LAND USE)	SLOPE OF CATCHMENT	SUB-CATCHMENT TIME OF CONCENTRATION	RAINFALL INTENSITY	COEFFICIENT OF RUNOFF	SUB-CATCHMENT AREA	EQUIVALENT AREA	SUM OF CONTRIBUTING EQUIVALENT AREAS	SUB-CATCHMENT DISCHARGE	FLOW PAST PREVIOUS GULLIES
							From Intensity Chart			9 x 10	sum 11	(8x12)/360	sum 25
years					%	min	mm/h		ha	ha	ha	cumec	cumec

INLET DESIGN										
15	16	17	18	19	20	21	22	23	24	25
			Wf	dg	Vg				Qg	
FLOW IN K&C (INCLUDING BYPASS)	ROAD GRADE AT INLET	K - K WIDTH	FLOW WIDTH	FLOW DEPTH AT INVERT	GUTTER FLOW VELOCITY	dg x Vg	INLET NUMBER	INLET TYPE	FLOW INTO INLET	BYPASS FLOW
13 + 14						20 x 19		From Std. Drg.	From Charts	15 - 24
cumec	%	m	m	m	m/sec	m2/s			cumec	cumec

DRAIN DESIGN											
26	27	28	29	30	31	32	33	34	35	36	37
tc	I	+(CxA)	Ql	Qm	Qs	Qo	L	S		V	T
CRITICAL TIME OF CONCENTRATION	RAINFALL INTENSITY	TOTAL CONTRIBUTING EQUIVALENT AREA	MAJOR TOTAL FLOW	MAJOR SURFACE FLOW CAPACITY	MAJOR SURFACE FLOW	FLOW IN PIPE	REACH LENGTH	PIPE GRADE	PIPE / BOX DIMENSIONS	FLOW VELOCITY FULL (PIPE GRADE VELOCITY)	TIME OF FLOW IN REACH
	From Intensity Chart	sum of U/S 12								32/Area of Sect	33/ (36x60)
min	mm/h	ha	cumec	cumec	cumec	cumec	m	%	mm	m/sec	min

HEADLOSSES										PART FULL	
38 - 39	40	41	42	43	44	45	46	47	48	49	50
	V2/2g	Ku	hu	Kl	hl	Kw	hw	Sf	hf		Vp
STRUCTURE / RATIOS FOR 'K' / VALUE CALCULATIONS	VELOCITY HEAD	U/S HEADLOSS COEFFICIENT	U/S PIPE STRUCTURE HEADLOSS	LATERAL HEADLOSS COEFFICIENT	LATERAL PIPE STRUCTURE HEADLOSS	W.S.E COEFFICIENT	CHANGE IN W.S.E	FRICTION SLOPE	PIPE FRICTION HEADLOSS	DEPTH	VELOCITY
FROM Q.U.D.M. CHARTS VOLUME 2	36x36/2g	From Q.U.D.M. Volume 2	40 x 41	From Q.U.D.M. Volume 2		From Q.U.D.M. Volume 2		From Sect. 14.5.7 A.R.R. Vol. 1 1987	47 x 33/ 100		
	m		m		m		m	%	m	m	m/sec

DESIGN LEVELS							
51	52	53	54	55	56	57	58
OBVERT LEVELS	DRAIN SECTION H.G.L	U/S H.G.L	LATERAL H.G.L.	W.S.E.	SURFACE OR K&C INVERT LEVEL	FREEBOARD	STRUCTURE No.
U/S RL D/S RL	U/S RL D/S RL						
m	m	m	m	m	m	m	

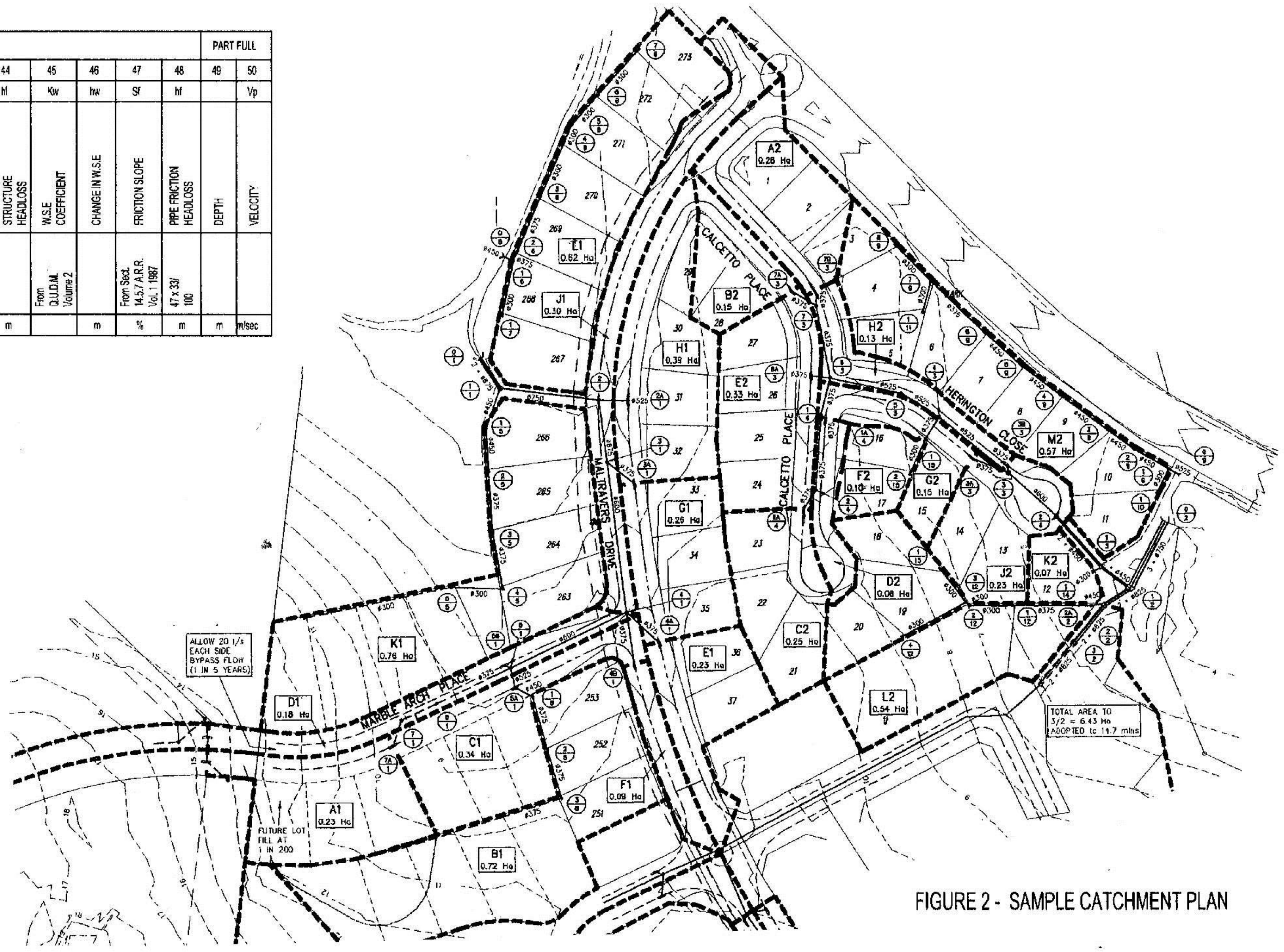


FIGURE 2 - SAMPLE CATCHMENT PLAN

D2 SAMPLE OSD CALCULATION SHEET

On -site Stormwater Detention Design Summary Sheet

Developed Area = m^2

Pre Development

Catchment Areas	(Must be shown on engineering drawings)		
Roof Area (A_r)	=	m^2	
Paved Area (A_p)	=	m^2	
Vegetated Area (A_v)	=	m^2	
Total Area	=	m^2	(Must equal post development area)
Stormwater Flows	(For 5 year storm event)		
Duration	=	5 min n	
Rainfall Intenisty ($^5I_5$)	=	mm/hr	(select from rainfall intensity charts)
Stormwater flow (Q_5)	=	$(A_r\,c_r + A_p\,c_p + A_v\,c_v) \times {}^5I_5 / 3600$	
	=	l/s	

Post Development

Catchment Areas	(Must be shown on engineering drawings)		
Roof Area (A_r)	=	m^2	
Paved Area (A_p)	=	m^2	
Vegetated Area (A_v)	=	m^2	
Total Area	=	m^2	(Must equal pre development area)
Stormwater Flows	(For 20 year storm event)		
Duration	=	5 min n	
Rainfall Intensity ($^{20}I_5$)	=	mm/hr	(select from rainfall intensity charts)
Stormwater flow (Q_{20})	=	$(A_r\,c_r + A_p\,c_p + A_v\,c_v) \times {}^{20}I_5 / 3600$	
	=	l/s	

Stormwater Detention Requirements

Storage Volume	=	$(Q_{20} - Q_5) \times 5 \times 60 / 1000$	
	=	m^3	
PSD	=	l/s	(Permissible Site Discharge = Q_5)

Orifice Plate Controlled Discharge (N/A if using choke pipe)

Head (H)	=	m	(max. water level to orifice centre)
Orifice Diameter	=	$1000 \times \sqrt{[(0.464 \times Q_5 / 1000) / \sqrt{H}]}$	
	=	mm	
Outlet Pipe Diameter	=	mm	

Outlet to be sized to convey 2 x orifice flow to next downstream structure.

Choke Pipe Controlled Discharge (N/A if using orifice plate)

Calculate by trial & error using the following formulas

Q_d (pipe capacity) = $1000\, A_p \sqrt{[2 \times 9.8\, (H/K_t)]}$ (l/s)

Where,

A_p	=	Cross-sectional area of pipe (m^2)
H	=	Head of water (m) from max. water level to tailwater level
K_t	=	$K_f + K_p$
K_f	=	L/(50 D)
L	=	Length of pipe (m)
D	=	Diameter of pipe (m)
K_p	=	$\sum$ pipe component head losses (Pipe entry = 0.5, Pipe Exit = 1.0, 45^o Bend = 0.35 & 90^o Bend = 0.9)

Storage Provided

Storage Volume = m^3

A separate sheet is to be attached showing all workings for the storage volumes proposed on the engineering drawings.

Confirmation for the application of the above method shall be obtained from a delegated officer from Council's Engineering Section prior to use. Calculation of inflow to the OSD shall be based on the 1 in 20 year ARI storm for the developed site. The maximum outflow from the OSD shall be based on the 1 in 5 year ARI storm for the undeveloped site.

$$\textit{Detention Volume } (m^3) = (Q^{20}_{dev} - Q^{5}_{undev}) \times t^{c}_{20\,dev} \times (60/1000)$$

(where Q is in l/s, t^c is in minutes)

The 1 in 100 year ARI developed flow from the site shall be checked to ensure it does not exceed the 1 in 100 year ARI undeveloped flow from the site, i.e.

$$Q^{100}_{dev} - Q^{20}_{dev} + \textit{Detention Outflow } (= Q^{5}_{undev}) \leq Q^{100}_{undev}$$

Provision must be made to allow the flow in excess of the 1 in 20 year ARI developed flow to exit the site through an overland flow path. In the urban situation this would normally be the road reserve or specific overland open drains designed for the 1 in 100 year ARI flow.

D3 OSD ORIFICE DIAMETER, DEPTH OF PONDING AND PSD

ORIFICE DIAMETER (mm)

RELATIVE TO DEPTH OF PONDING AND PERMISSIBLE SITE DISCHARGE

PSD l / s	DEPTH ABOVE CENTRELINE OF ORIFICE (m)																				
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	
2.0	55																				
3.0	67	56	51																		
4.0	77	65	59	55	52																
5.0	86	73	66	61	58	55	53	51	50												
6.0	95	80	72	67	63	60	58	56	55	53	52	51	50								
7.0	102	86	78	72	68	65	63	61	59	57	56	55	54	53	52	51	50	50			
8.0	109	92	83	77	73	70	67	65	63	61	60	59	58	56	55	55	54	53	52	52	
9.0	116	97	88	82	77	74	71	69	67	65	64	62	61	60	59	58	57	56	55	55	
10.0	122	103	93	86	82	78	75	73	70	69	67	66	64	63	62	61	60	59	58	58	
11.0	128	108	97	91	86	82	79	76	74	72	70	69	67	66	65	64	63	62	61	61	
12.0	134	112	102	95	89	85	82	80	77	75	73	72	70	69	68	67	66	65	64	63	
13.0	139	117	106	98	93	89	86	83	80	78	76	75	73	72	71	70	69	68	67	66	
14.0	144	121	110	102	97	92	89	86	83	81	79	78	76	75	73	72	71	70	69	68	150
15.0	150	126	114	106	100	96	92	89	86	84	82	80	79	77	76	75	74	73	72	71	dia
16.0	154	130	117	109	103	99	95	92	89	87	85	83	81	80	78	77	76	75	74	73	
17.0	159	134	121	113	106	102	98	95	92	90	87	86	84	82	81	80	78	77	76	75	
18.0	164	138	124	116	110	105	101	97	95	92	90	88	86	85	83	82	81	80	78	77	
19.0	168	141	128	119	113	108	103	100	97	95	92	90	89	87	86	84	83	82	81	80	
20.0	173	145	131	122	115	110	106	103	100	97	95	93	91	89	88	86	85	84	83	82	
21.0		149	134	125	118	113	109	105	102	99	97	95	93	91	90	88	87	86	85	84	
22.0		152	138	128	121	116	111	108	105	102	99	97	95	94	92	91	89	88	87	86	
23.0		156	141	131	124	118	114	110	107	104	102	99	97	96	94	93	91	90	89	88	
24.0		159	144	134	126	121	116	112	109	106	104	102	100	98	96	95	93	92	91	89	
25.0		162	147	136	129	123	119	115	111	109	106	104	102	100	98	97	95	94	92	91	
26.0		166	150	139	132	126	121	117	114	111	108	106	104	102	100	98	97	96	94	93	
27.0		169	152	142	134	128	123	119	116	113	110	108	106	104	102	100	99	97	96	95	
28.0		172	155	144	137	131	126	121	118	115	112	110	108	106	104	102	101	99	98	97	
29.0			158	147	139	133	128	124	120	117	114	112	109	107	106	104	102	101	100	98	
30.0			161	150	141	135	130	126	122	119	116	114	111	109	107	106	104	103	101	100	
31.0			163	152	144	137	132	128	124	121	118	115	113	111	109	107	106	104	103	102	
32.0			166	154	146	140	134	130	126	123	120	117	115	113	111	109	108	106	105	103	225
33.0			168	157	148	142	136	132	128	125	122	119	117	115	113	111	109	108	106	105	dia
34.0			171	159	151	144	138	134	130	127	124	121	119	116	114	113	111	109	108	106	
35.0				161	153	146	140	136	132	128	125	123	120	118	116	114	112	111	109	108	
36.0				164	155	148	142	138	134	130	127	124	122	120	118	116	114	112	111	110	
37.0				166	157	150	144	140	136	132	129	126	124	121	119	117	116	114	112	111	
38.0				168	159	152	146	141	137	134	131	128	125	123	121	119	117	116	114	113	
39.0				170	161	154	148	143	139	136	132	130	127	125	122	121	119	117	115	114	
Minimum Discharge Pipe Diameter				300 dia									225 dia								

(Source Newcastle City Council DCP50 Appendix 3 & Lake Macquarie City Council Handbook of Drainage Design Criteria March 2004 & Byron Shire Council DCP2002 – Part N)

Note: Linear interpolation between values is permitted

APPENDIX E - FLOW CAPTURE CHARTS

Refer to ARC Standard Drawings

1. The adopted hydraulic flow capture charts are from Brisbane City Council (BCC) and based on BCC standard 'Lip-in-Line' Gully Pits, Grates and Lintels. (Refer to Armidale Regional Council (ARC) Standard Drawings 080-045/1, 080-045/2 and 080-046)

2. Data for the charts was based on testing undertaken at the Urban Resource Centre, University of South Australia for Brisbane City Council, Gold Coast City Council, and Queensland Department of Main Roads in March 2001 and November 2002. No extrapolation beyond the limits of the charts should be undertaken

3. 2.4m (Small), 3.6m(Medium) and 4.8m(Large) are the industry standard overall lintel lengths (NOT the opening size)

4. Appropriate use of bicycle-safe grates shall be considered in gully pit grate selection

5. Bicycle-safe grates, smaller standard lintels or proprietary grates / pre-cast lintel and grate units may be accepted by a delegated officer from the Council's Engineering Section, subject to the provision of acceptable gully pit flow capture charts

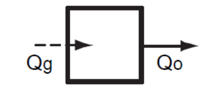
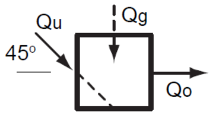
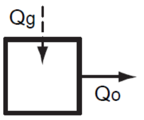
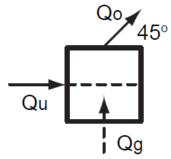
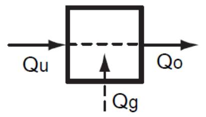
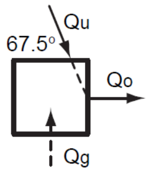
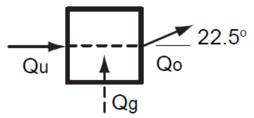
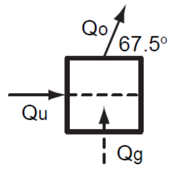
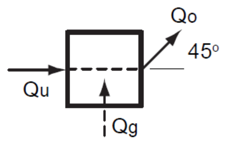
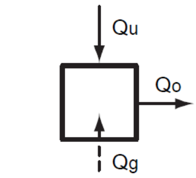
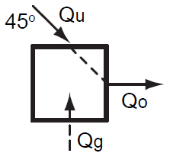
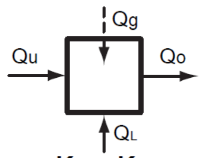
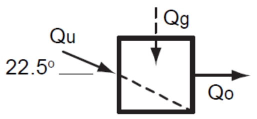
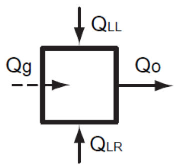
6. Road crossfall, longitudinal grade and side-entry opening size are considered the major influence on gully pit inlet capture

7. Design flow heights should not exceed side-entry opening heights

8. The ARC standard kerb and gutter profiles are similar to BCC kerb and channel Types 'D' (drive-over) and 'E' (upright) profiles. Refer to Armidale Regional Council (ARC) Standard Drawing 030-065 for specific dimensions.

APPENDIX F – QUDM INDEX OF PIT ENERGY LOSS TABLES

□ Denotes a structure with grate (gutter) inflow

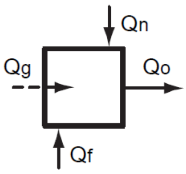
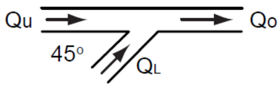
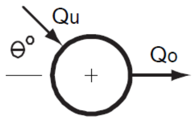
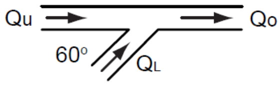
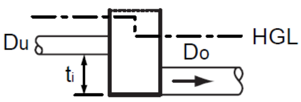
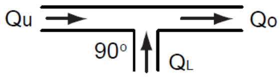
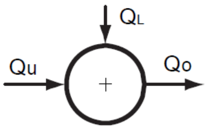
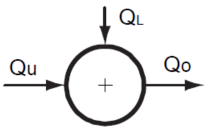
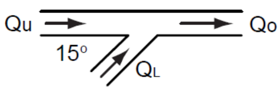
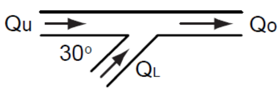
Structure schematic diagram	Applicable chart		Structure schematic diagram	Applicable chart	
	K_u	K_w		K_u	K_w
 $K_g = K_w$	A2-3	A2-3	 $K_u \neq K_w$	A2-12 and A2-13	A2-14 and A2-15
 $K_g = K_w$	A2-3	A2-3	 $K_u \neq K_w$	A2-16 and A2-17	A2-18 and A2-19
 $K_u = K_w$	A2-4	A2-4	 $K_u \neq K_w$	A2-20 and A2-21	A2-22 and A2-23
 $K_u = K_w$	A2-5	A2-5	 $K_u \neq K_w$	A2-24 and A2-25	A2-26 and A2-27
 $K_u = K_w$	A2-6	A2-6	 $K_u \neq K_w$	A2-28 and A2-29	A2-30 and A2-31
 $K_u = K_w$	A2-7	A2-7	 $K_u = K_w$	A2-32	A2-32
 $K_u \neq K_w$	A2-8 and A2-9	A2-10 and A2-11		A2-33	A2-33

Index to pressure change coefficient charts

Chart No. A2-1

□ Denotes a structure with grate (gutter) inflow

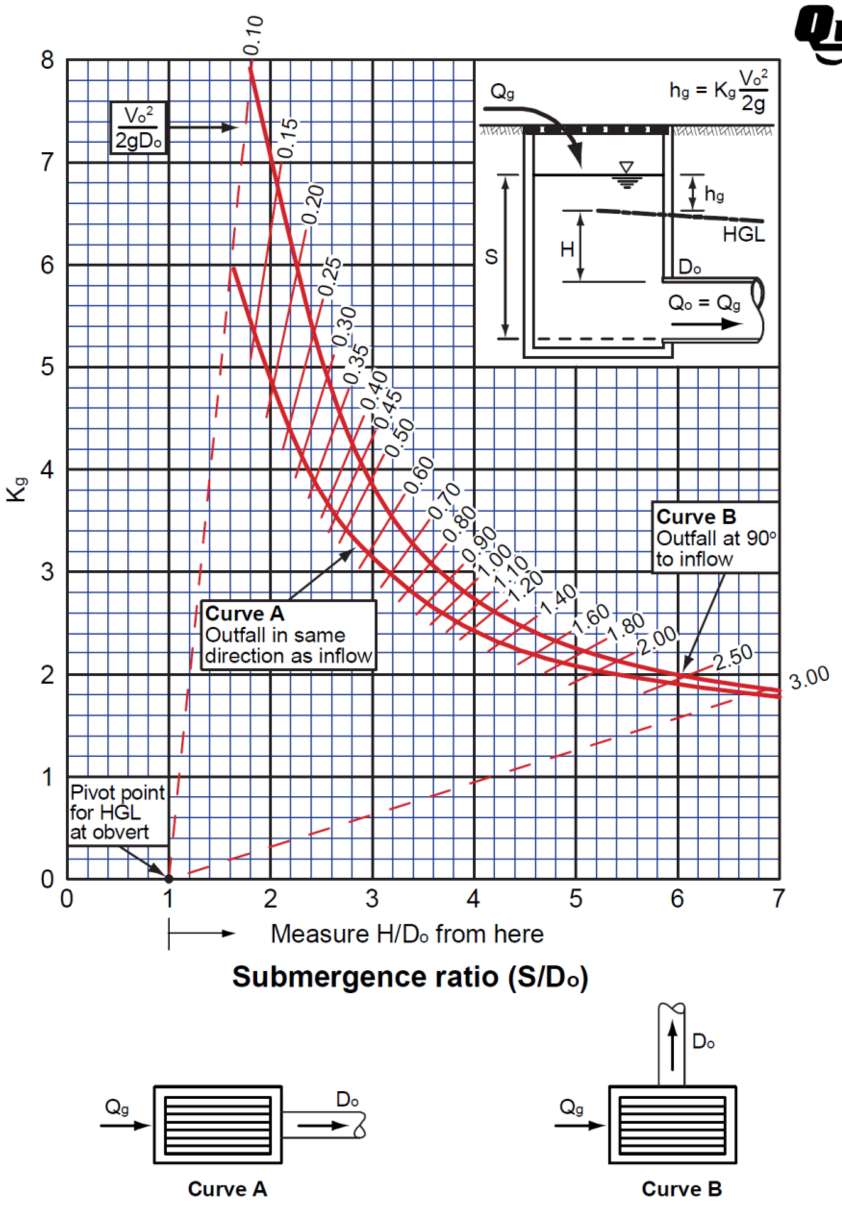
○ Denotes a structure with no grate (gutter) inflow

Structure schematic diagram	Applicable chart		Structure schematic diagram	Applicable chart	
	K_u	K_w		K_u	K_w
 $K_u \neq K_w$	A2-34	A2-34		A2-42	N/A
 $K_u \neq K_w$	A2-35	A2-35		A2-43	N/A
 $K_u \neq K_w$	A2-36	A2-36		A2-44	N/A
 $K_u = K_w$	A2-37 and A2-38	A2-37 and A2-38			
 $K_u = K_w$ For $Q_u/Q_o \times D_o/D_u > 1$ For $D_L/D_o < 0.6$	A2-39	A2-39			
	A2-40	N/A			
	A2-41	N/A			

Index to pressure and energy loss analysis charts

Chart No. A2-2

APPENDIX G – SELECTED EXAMPLES OF QUDM PIT ENERGY LOSS TABLES

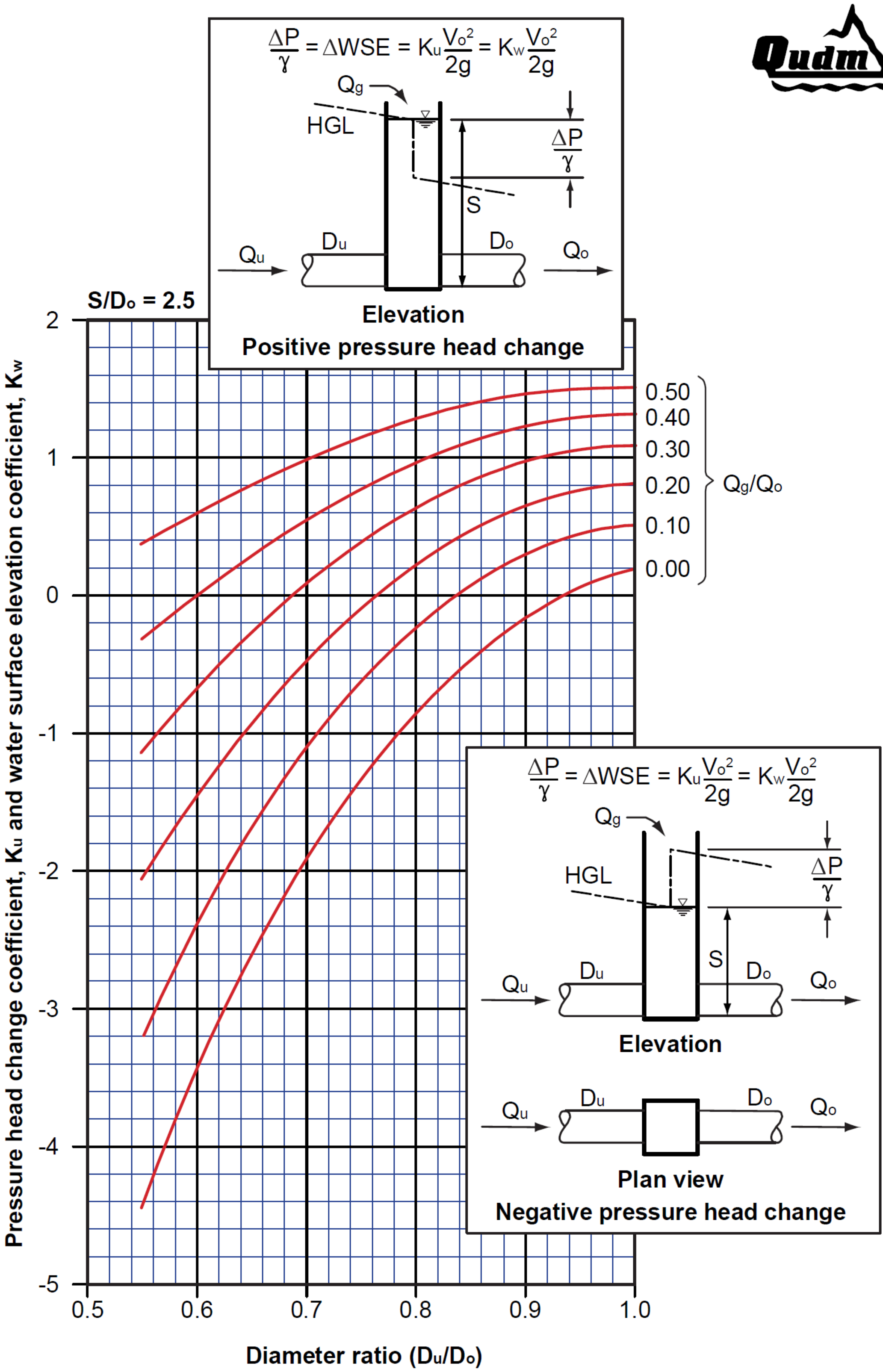


Pressure head change coefficients for rectangular inlet with grate flow only modified from DOT (1992)

Notes:

1. For a ***Side inlet,*** the inflow direction should be taken as the direction of flow in the kerb and channel.
2. Where the outflow direction is within 15 degrees of the direction of the direction of inflow, use ***Curve A***.
3. Where the outflow direction is greater than 15 degrees from the direction of inflow, use ***Curve B***.
4. $K_w = K_g$

Chart No. A2-3



Pressure head change and water surface elevation coefficients for straight through flow for submergence ratio, $S/D_o = 2.5$ (Source: Hare, 1980)

Chart No. A2-4

To interpolate the Hare charts for $0.0 < Q_g/Q_o < 0.5$ the following equation is used:

$$K_w = K_{0.0} + C_g (K_{0.5} - K_{0.0})$$

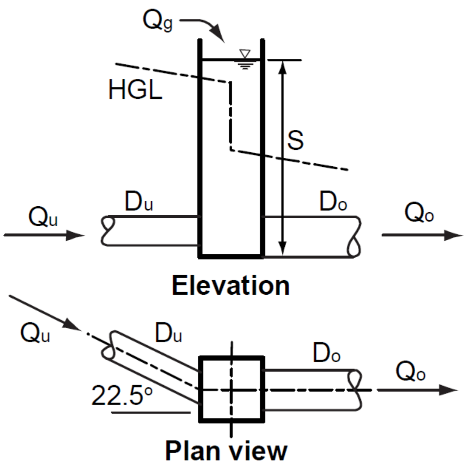
where:

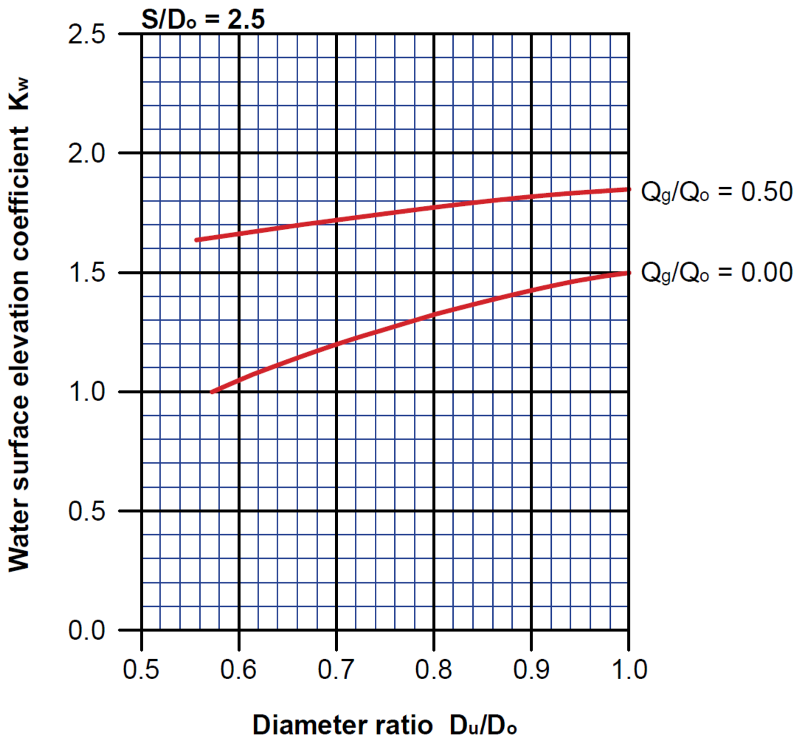
$C_g = 1.33 [1 - (Q_u/Q_o)^2]$

$K_{0.0} = K_w$ for $Q_g/Q_o = 0.0$

$K_{0.5} = K_w$ for $Q_g/Q_o = 0.5$

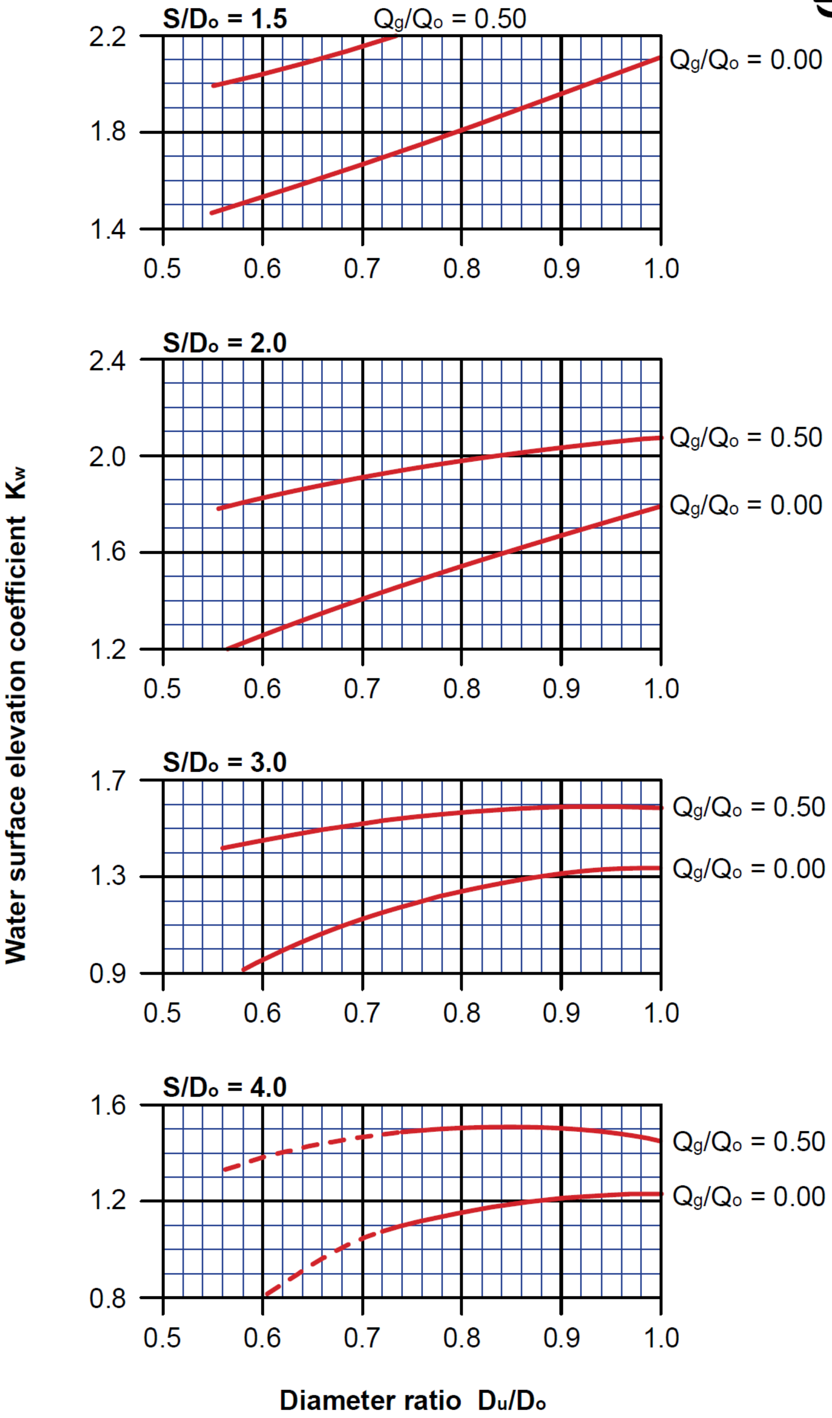
Q_g/Q_o	Q_u/Q_o	C_g
0.50	0.50	1.00
0.45	0.55	0.93
0.40	0.60	0.85
0.35	0.65	0.77
0.30	0.70	0.68
0.25	0.75	0.58
0.20	0.80	0.48
0.15	0.85	0.37
0.10	0.90	0.25
0.05	0.95	0.13
0.00	1.00	0.00





Water surface elevation coefficients (K_w) for 22.5° bends at pit junctions with branch point located on the upstream face of pit for a submergence ratio S/D_o = 2.5 (Source: Hare, 1980)

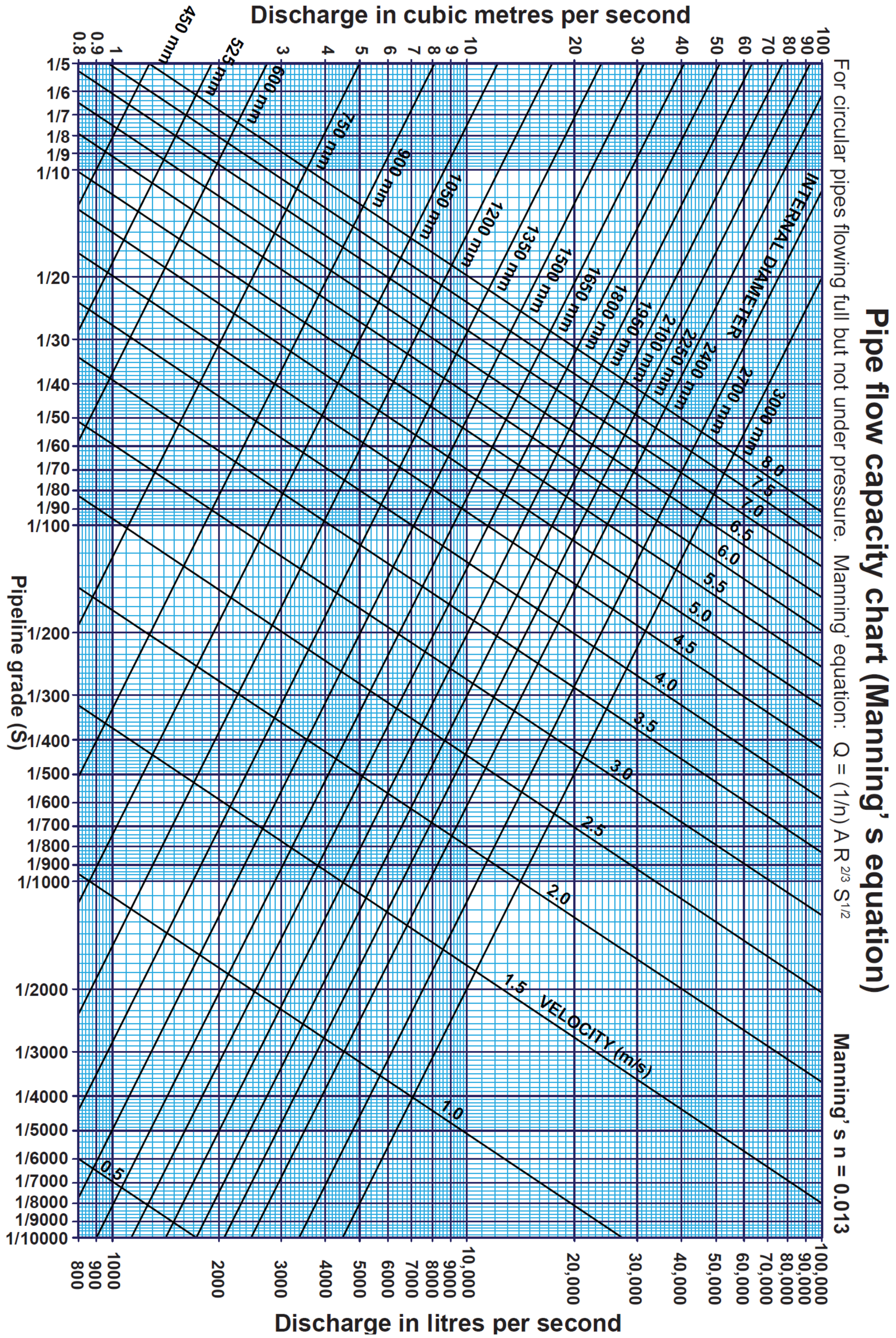
Chart No. A2-10



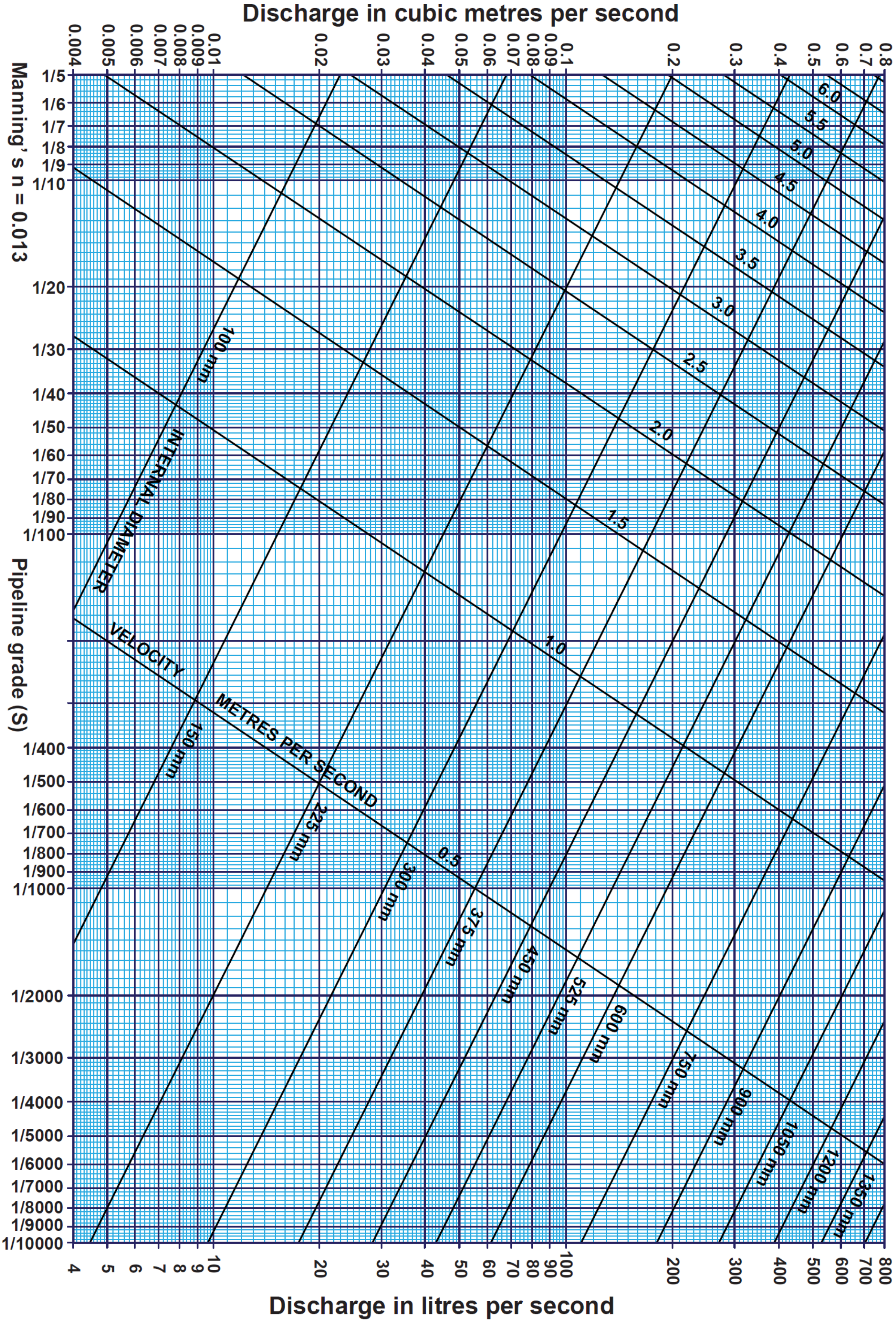
Water surface elevation coefficients (K_w) for 22.5° bends at pit junctions with branch point located on the upstream face of pit for submergence ratios S/D_o = 1.5, 2.0, 3.0 and 4.0 (Source: Hare, 1980)

Chart No. A2-11

APPENDIX H – PIPE FLOW CHARTS



Source: QUDM Chart No A1.1



Source: QUDM Chart No A1.2