VOLUME 1 –
CIVIL WORKS DESIGN GUIDELINE

Wyong Shire Council

Wyong Shire Council
CENTRAL COAST

Contents

TABLE OF REVISIONS

Revision	Date	Remarks
Exhibition Draft	24/12/2011	Final draft following internal reviews
Final Version	21/9/2012	Final Version
Revision 1	6/8/2013	Refer to Appendix E for table of revisions

PART 1 – APPLICATION OF DESIGN GUIDELINE

The provisions of this guideline apply to all developments but do not override any conflicting provisions of other Chapters of Wyong Shire Council's Development Control Plan or any consent issued applying to a particular development.

This guideline and referenced documents provide minimum requirements or references for the design of civil works associated with development. Civil works may include but will not be limited to:

- Roads.
- Intersections.
- Pavements.
- Footpaths.
- Cycle ways.
- Traffic facilities.
- Earthworks.
- Storm water drainage.
- Water quality facilities.

PART 2 – INTERPRETATION

The interpretation of any terminology used herein shall firstly be as defined by relevant legislative or regulatory definition applying to the matter, then by common use, or in the case of referenced documents shall be made in accordance with the following in priority order:

1 A definition within the relevant document,

2 A definition within a related document produced by the same author,

3 A relevant legislative or regulatory definition appropriate to the matter (where the legislation or regulation does not control the matter),

4 Common industry use.

Reference documents include but are not limited to:

- "Austroads" documents for which there is a specific "Glossary of Terms" publication and also incorporate some definitions in individual documents,
- "Roads and Maritime Services" documents which incorporate definitions,
- "Australian Standards" documents for which there are is a specific "Glossary of terms -Road and traffic engineering," and incorporated definitions in individual documents,
- Engineers Australia Publications.

In any instance, where because of terminology, the interpretation of a Council's guideline requirements is in dispute, definitions shall be clarified by Council's Principal Development Design Engineer or Principal Development Construction Engineer as appropriate.

Reference to "Roads and Traffic Authority"(RTA) shall also mean the "Roads and Maritime Services"(RMS)

PART 3 – GENERAL MATTERS

3.1 Introduction

This guideline and Volume 2 - Civil Works Construction Specification, has been compiled to outline Council's general procedures and practices in respect of design and construction requirements for future public infrastructure assets and various private site works for developments within Wyong Shire.

Council's basic objective is to preserve, enhance and develop the amenity of the Shire with specific reference to safety, minimising environmental impact, convenience and long term cost effectiveness. This guideline has been prepared to assist the Applicant to proceed with development by informing them of Council's requirements with respect to the design and construction of assets which will eventually be vested in, and maintained by Council, to ensure that such works are provided to appropriate and sustainable standards.

3.2 Project Personnel

The Developer is to nominate to Council the persons who will hold key roles for the development. These key roles shall include the Project Manager, any Accredited Certifier, the Engineering Designers, Registered Surveyors and the Geotechnical Consultant.

3.3 Limitations on Accredited Certifiers

Accredited Certifiers when appointed by a Developer operate under Section 109D of the Environmental Planning and Assessment Act 1979. Accredited Certifiers may not certify design plans/drawings in respect of works which the Council needs to approve under alternative legislation, even though those works are required by a condition of a Development Consent under the Environmental Planning and Assessment Act 1979.

These works include:

- Water and sewer works or works which affect water and sewer works pursuant to Section 306 of the Water Management Act 2000.
- Works on public roads requiring an approval under the Roads Act 1993.
- Drainage works requiring an approval under the Local Government Act 1993.
- Works where Wyong Local Environment Plan(WLEP) may preclude an Accredited Certifier from being appointed.

Council is responsible for the issue of relevant plan approvals involving these works excepting works on Classified Roads where the Roads and Maritime Services(RMS) is the approval authority.

Compliance Certificates for development consent conditions involving such approvals can only be issued by Council once Council is satisfied the condition has been complied with.

Persons accredited or acting under the Environmental Planning and Assessment Act as private accredited certifiers are specifically excluded from varying the requirements of this guideline in any way.

3.4 Works Subject to Approvals by Other Authorities

Where conditions have been imposed under an integrated approval or where the Developer is required by legislation to obtain approval from others the following applies:

- The design and construction of works shall be carried out to meet those Authorities specifications in addition to those of Council.
- The Developer is responsible for obtaining any permits and licences, achieving required inspection and works standards and gaining final approval of relevant Approval Authorities.
- Copies of approvals, permits and licences to be obtained from Approval Authorities by the Developer are to be provided to Council prior to commencement of site activities.
- Copies of final approvals of works and documentation verifying compliance of requirements of Approval Bodies is to be provided to Council by the Developer before the completed works are accepted by Council.

3.5 Classified Roads and Applicable Standards

Roads and Maritime Services (RMS) controls works on Classified Roads under the Roads Act 1997.

Designers shall obtain from RMS the current design and project requirements applicable to the subject works.

Designers shall contact the RMS at the beginning of the design process to clarify administration processes for design and works agreements (Works Authorisation Deeds-WAD).

RMS has adopted Austroads and some Australian standards related to roads design. However it should be noted that RMS has their own supplements to these documents which detail departures and additional requirements.

3.6 Bushfire Prone Areas (BPAs)

In carrying out the design and construction of new developments including subdivision works designers are to ensure that bush fire protection measures required by conditions of consent or other approvals or other Authorities requirements are incorporated into design plans and specifications. Designers must also ensure that all works designed for the development do not create previously unidentified bush fire protection issues. This may include the impact of fully established landscaping on fire protection measures.

Designers shall reference relevant current documents published by the NSW Rural Fire service, current Australian Standards and the Building Code of Australia when designing for provisions related to bush fire protection.

3.7 Conflicting Standards and Guidelines

Where within this manual reference is made to a guide, standard or specification from an external source e.g. Austroads, and there arises conflict over the use of some part of this document and the external referenced document then the referenced document shall have priority in so far as the resolution of the point of conflict is concerned.

Where this specification makes reference to an Australian Standard, Austroad Guideline or AS/NZS standard that has been superseded by a new or updated version, then the new or updated version shall apply.

3.8 Lapsing of Civil Design Approvals and Subdivision Works Construction Certificates

The Design guideline requirements and Construction Specification requirements shall be those current at the time of issuing of the Subdivision Works Construction Certificate and/or Civil Design Approval. (Approvals with an SCC reference number).

A Construction Certificate and/or Civil Design approval for subdivision works and/or development related works shall lapse with the Development Consent. A Development Consent for a subdivision involving subdivision works or other Development involving civil works will normally lapse after a set time following the issue of the Development Consent. In this event, should a new Development Consent be obtained, a submission of updated engineering plans will be required for a new Construction Certificate and/or Civil Design Approval related to the new consent.

A Civil Design Approval for civil engineering works associated with a Building Development shall lapse with the Development Consent.

3.9 Constructability and Safety in Design

The designer should consider options and implications of work methods and practices, means of transport and practicality of construction, particularly in built up areas or where other constraints exist such as environmental management controls, limitations on access or site manoeuvrability and materials availability.
The designer shall consider in the design the safety of construction persons during the construction stage and the end users of the assets being designed.

3.10 Road Safety Audits

Road Safety Audits or Road Safety Checks in accordance with Roads & Maritime Services(Transport for NSW) (& Austroads) requirements are to be carried out by accredited auditors (Transport for NSW - Road Safety Auditors Register) . The level and number of accredited auditors involved in any audit is to be as identified in the "Guidelines for Road Safety Audit Practices". This is a minimum of one Level Three (Lead) Auditor and one Level Two (Senior) Auditor. Generally, the requirement for an Audit or a Check will be identified by a consent condition and will be based on the type, value and complexity of the proposal. However, if the project relates to proposal that is not subject to a consent condition such as a Master Plan, a Rezoning or where the consent is silent regarding the requirement, the following intervention levels shall apply.

Please note that the intervention levels below are minimum intervention levels. The developer may elect to arrange a concept Road Safety Audit to provide greater confidence prior to the commencement of a detail design. The intervention levels below do not preclude Council or the RMS carrying out inspections at any time.

Table 3.1 Road Safety Audit and Check Intervention Levels

Development / Work Type	Total Project Cost[2,9]	Road Safety Audit[3] (RSA) or Road Safety Check[4] (RSC)			
		Concept Design	Detail Design	Roadworks[5,6]	Pre-Open / Finish
Subdivision with new roads	≤$500,000		RSA		RSC
Subdivision with new roads	>$500,000		RSA		RSA
Intersection	≤$300,000		RSA		RSC
Intersection	>$300,000 up to $4million		RSA	RSC	RSA
Intersection	>$4million	RSA	RSA	RSA	RSA
Major Road Works	≤$750,000		RSA		RSC
Major Road Works	>$750,000		RSA	RSC	RSA
Traffic Control Facility[1]	≤$50,000		RSC		
Traffic Control Facility[1]	>$50,000[7]		RSC		
Shared Path systems	≤$100,000		RSC		RSC
Shared Path systems	>$100,000		RSA[10]		RSA[10]
Development Access			RSC		RSC
Developments[8]			RSA		RSA
Rezoning/Master Plan, etc		RSA			

Notes:

1 *As defined by the Transport Administration Act 1988.*

2 *Excluding Council fees and contributions and consulting fees.*

3 *As defined by Austroads.*

4 *As defined by the RMS (Guidelines for Road safety Audit Practices).*

5 *Only required where traffic controls applied and mix of traffic.*

6 *These are in addition to any OH & S routine checks.*

7 *Where value exceeds $0.5 million apply same requirement as intersection.*

8 *Inclusive of tourist, shopping/commercial or industrial, master planning, educational/sporting and recreational facilities, places of worship, hospitals or other developments depending on traffic generation and/or development layout.*

9 *Project values shall be indexed in accordance with CPI amounts.*

10 *Either a Detail Design or a Pre - Opening Audit is required, not both.*

Any corrective action or treatment identified for change resulting from the audit or check will require resolution in consultation with Council's Development Engineering Section prior to approval.

Subject to availability a Level 3 Auditor from Council may be required to be involved in any audits/checks carried out.

3.11 Design in Flood Affected Area

Reference is to be made to other chapters of Council's Development Control Plan and Council's Flood Risk Management Plans when carrying out design in areas that are or may be flood affected.

Filling of Flood Plains and Floodways is not permitted.

Flood Planning Levels (FPL), Flood Levels or Floor Levels with appropriate allowances for climate change (including sea level rise) can be provided by Council following a Flood level enquiry made through Council's Customer Contact Section.

Where no reliable information is held by Council and where Council's records indicate that the land has flood controls, or if the land is likely to be flood affected, the determination of the flood extent must be supported by a flood study, supplied by the Developer and prepared by a qualified engineer experienced in flood modelling. This study shall be provided to Council for consideration.

3.12 Council's Standard Drawings

Standard Drawings referred to in these guidelines can be found in the appendices of Volume 2 "Civil Works Construction Specification".

PART 4 - MAKING AN APPLICATION FOR CONSTRUCTION CERTIFICATE FOR CIVIL WORKS / CIVIL WORKS DESIGN APPROVAL/COMPLIANCE CERTIFICATES.

4.1 General Description

A **Construction Certificate** must be obtained prior to commencement of any site establishment and construction works to which a development consent relates. The Construction Certificate normally relates to works only within the properties to which the development consent relates.

A **Civil Works Design Approval** must be obtained prior to commencement of any site establishment and construction works in relation to works where the approval for the design and construction of those works is required under the Roads Act 1993 or the Local Government Act 1993 or the Water Management Act 2000.

In addition to the preparation of engineering plans and specifications, the issuing of a Construction Certificate or Civil Works Design Approval may involve compliance with a range of matters which may include:

- Development Consent Conditions.
- The Development Application and accompanying Documents.
- Integrated Development Approval requirements.
- Utility Suppliers information.
- Affected landowner requirements.

Applications to Council for Construction Certificates involving civil works and for civil works design approvals are to be made using an application form for **Civil Development and Subdivision Works** which may be obtained from Councils Web Site (http://www.wyong.nsw.gov.au/about-council/forms/). This application form is to be accompanied by all documentation relevant to the application.

Fees relating to assessment of the application and compliance inspections during construction will be quoted to the applicant following lodgement of the application. Fees for assessment of the application will be payable prior to commencement of any assessment. Fees for compliance inspection will be required to be paid prior to the release of the Construction Certificate or Civil Works Design Approval.

A Compliance Certificate for Complying Civil Works is only issued by Council where Council has been engaged to carry out compliance inspections as the Certifying Authority.

4.2 Consultation with Council

Various enquiries to complete engineering designs plans and specifications to satisfy consent conditions will be required to be made by the various project personnel.

It is recommended that the Project Manager and their Design Consultant meet with Council prior to commencement of the design process to gain an understanding of critical aspects of the Development Consent, the approval processes relevant to design issues.

Printed copies of other Council documents containing relevant information for design purposes may be available from Council's Customer Contact counter.

Fees in accordance with Council's Annual Plan will apply for documentation and consultations.

4.3 Development Consent

The Development Consent may require:

- Obtaining approvals from other authorities.
- Obtaining further approvals from Council regarding aspects of the development.

It is the responsibility of the Project Manager to make enquiries and meet any additional requirements to enable the detailing of drawings and preparation of specifications as required for such matters as:

- Integration of Environmental and Professional Report information.
- Integrating requirements of other Council approvals.
- Location, protection or relocation of Utility Mains and Installations.
- Provision of Utilities and Street Lighting.
- Approval Body compliance.
- Affected Private Landowner agreement.

Council may require copies of appropriate documentation for any consent, licence, permit, permission or any form of authorisation prior to the issuing of a Construction Certificate or Civil Works Design Approval.

4.4 Preparation of Engineering Design Submission to Council

Plans and documentation which are to accompany an application for **Civil Development and Subdivision works** are to be prepared in accordance with this Design Guideline, the Civil Works Construction Specification, Standard Drawings and the Development Consent.

Design plans and documentation are also to serve as the reference plans for detailing other site activities or controls required by conditions of the Development Consent. E.g. Wildlife and Heritage protection. Where supplementary plans, documentation or studies are required to appropriately detail other site activities or controls, notes are to be included on the appropriate design base plans referencing the supplementary requirements.

It is necessary that engineering plans for civil works incorporate all necessary details for all approved development activities. It may not be sufficient to reference environmental or other reports without incorporating relevant report recommendations into the design.

Please also refer to Appendix A – Preparation and Presentation of Design Drawings.

4.5 Submission of Preliminary Engineering Plans to Council

A preliminary set of plans and supporting information may be submitted for examination with a view to resolving technical issues. Subsequent submissions shall comprise of a full application for a Construction Certificate and/or Civil Works Design Approval, a Compliance Certificate or other required approval.

Fees will be applicable for preliminary reviews and resolving technical or other design related issues in accordance with Council's adopted fees and charges.

4.6 Other Approval Applications Required by Council

A range of applications to Council may be required where Council is responsible for approvals outside the Environmental Planning and Assessment Act 1979 or where Council controlled land is affected.

These approvals may include:

- Local Approvals under the Local Government Act 1993.
- Water and Sewer Connections or adjustments.
- Section 306 Certificate of Compliance Notice of requirements (Water Management Act, 2000).
- Application for Approval of Engineering Plans and Specifications for Water and Sewer Works under Section 306(2)(b)the Water Management Act, 2000.
- Applications for Approval under Sections including 74, 75,115, 122, 138 & 139 Roads Act 1993 to do Work or Control Traffic on a Public Road.
- Works on Council controlled land.
- Approvals under Section 51 of the Road Transport(Safety and Traffic Management) Act 1999.

The requirement to make these applications will usually be contained in the development consent conditions. However the requirement for these applications may not be evident until assessment of civil works designs or the commencement of construction.

4.7 Other Issues relating to a Construction Certificate or Civil Works Design Approval

Applicants are responsible for giving adequate lead time for consideration of an application by Council and any other Authority where applicable.

Construction works cannot commence until a Construction Certificate and/or a Civil Works Design Approval is issued and any other required approval has been obtained.

Further approval will be required to commence works within a public road reserve following the issue of a Civil Works Design Approval. Refer to Volume 2 – Civil Works Construction Specification.

It should be noted that legislation stipulates that a Construction Certificate has no effect and may not be issued retrospectively for works already carried out.

4.8 Application to Modify Construction Certificate or Civil Works Design Approvals

An application may be made for modification of a Construction Certificate as permitted by Regulation 148 of the Environmental Planning and Assessment Regulation 2000.

This application may be made by the applicant for the original Construction Certificate or a person having the benefit of the Construction Certificate.

An application may also be made for modification of a Civil Works Design Approval.

PART 5 – SITE EARTHWORKS DESIGN

5.1 General

The provisions of various chapters of Council's Development Control Plan are a substantial integral part of development works requirements and design guidelines under this manual and shall also be referenced by the Designer where appropriate for the design of site earthworks.

Provisions of this Guideline, the Civil Works Construction Specification and other Council references apply to building development site works involving earthworks or earthen structures as well as subdivision works.

Requirements from any management plans related to the development approval or required by the development approval conditions are to be incorporated in the design of earthworks.

The Developer is to ensure that necessary environmental licences pertaining to site earthworks are obtained and their requirements are incorporated in the Engineering Design and any supplementary specification.

The designer shall consider as a minimum those factors that may affect the earthworks listed in Section 2 of AS3798 "Guidelines on Earthworks for commercial and residential developments" for all types of development.

A geotechnical consultant is to be engaged by the Developer to carry out site investigation and provide site specific recommendations in regards to earthworks design and construction.

5.2 Expansive and Reactive Soils

The use or preservation of expansive and reactive soils shall be in accordance with the recommendations of a Geotechnical Engineer's report obtained in respect of the impact of any reactive soils on:

- The design of road pavements.
- The design of public infrastructure.
- Their behaviour in conjunction with the operation of Water Sensitive Urban Design systems.
- Their suitability for building foundations.

5.3 Urban Salinity

The designer shall seek specialist advice in regards to designing for urban salinity where it has been identified as an issue during the development assessment process or where the site investigation by the Geotechnical Consultant identifies Urban Salinity as an issue.

The designer shall provide measures and specifications to:

- Prevent any impacts of salinity on proposed infrastructure.
- Mitigate the impacts of salinity on proposed private land.
- Prevent any immediate or progressive increase in severity or coverage of areas affected by salinity.

5.4 Minimisation of Soil Surplus

The designer shall endeavour to minimise the amount of surplus material that will be required to be removed from the site. Factors that should be considered in relation to surplus material include the cost to remove and dispose material to an approved waste facility, classification of the material being removed and reuse of the material at an alternate approved site if allowed by the materials waste classification.

5.5 Site Regrading

Site regrading may only be carried out as identified in the Development Consent. The designer shall consider the following points as part of the design:

- Any requirements arising from the Development Consent conditions in particular a Stormwater Management Plan and a Vegetation Management or Tree Protection Plan.
- Cut and filled areas are generally to be shaped and graded at a minimum of 1% to avoid surface ponds and facilitate drainage.
- The fall of the regraded surface shall direct surface flow to generally retain existing runoff conditions beyond the regrade area other than where being collected and conveyed by a designed drainage system such as a roadway. Surface runoff from regrade areas is not to be directed into existing interallotment drainage systems in the general case. Provision is to be made along the toe of the fill batters or base of retaining walls within or adjacent to regrade areas to permit the free passage of stormwater and subsurface water away from adjoining properties.
- Regrading or retaining works at property boundaries are not to cause surface ponding or the reduction in stormwater disbursement from adjoining properties or impact on the amenity of such properties. Catch drains, sub-surface drains and/or interallotment drainage are to be provided to adequately drain such areas. The drainage system shall be designed and have a capacity to ensure that there is no risk to persons, inundation of habitable property or potential for drainage nuisance due to flooding.
- Geotechnical advice is to be obtained in respect of groundwater flows and slope stability (where slopes exceed 1 vertical to 4 horizontal) issues in areas to be affected by regrading.
- The design of works within areas affected by regrading must consider the proposed finished surface levels in addition to the existing surface levels. (Refer to Appendix A – Preparation and Presentation of Design Drawings")

5.6 Retaining Walls and Batters

Retaining walls and batters shall generally be consistent in height and extent as approved in the development consent.

Retaining walls, including the footings (and footing support), and batters, other than road batters shall be wholly located within the lot required to provide support (Note. The common law duty of care for negligence regarding support for land is contained in Section 177 of the Conveyancing Act 1919).

Road batters shall be blended into proposed lots where possible.

The maximum design gradient of batters within lots is to be 1 vertical to 4 horizontal except where written advice is provided by a qualified Geotechnical Engineer which supports steeper batters.

The exact location of retaining walls or batters will depend on:

- The type and design of the wall or batter including surface and subsurface drainage and backfill material.
- Foundation requirements.
- The construction method with provision for support throughout construction activities.
- Locations of existing and proposed services including interallotment drainage and sewers.
- Measures and works designs required for the protection and support of services throughout construction activities and in a permanent manner.
- Any structures on the properties adjacent to a proposed excavation.
- Vegetation to be retained.
- Permission to enter or impacts on adjoining land or structures.

The design of retaining walls associated with site regrading shall as a minimum design standard be carried out in accordance with AS 4678 Earth retaining structures for an absolute minimum design life of 60 years. Where access to the proposed retaining wall will not be practicable in the future for its reconstruction or replacement the design life should be increased to 100 years. The design shall be carried out by a Qualified Certified Structural or Civil Engineer (NPER 3 Registered) using recommendations made by a Geotechnical Engineer.

The design of batters shall be carried out using recommendations made by a Geotechnical Engineer. The Geotechnical Engineer shall also identify any constraints on the use of adjoining areas of land and any ongoing maintenance requirements for particular batters. A batter which imposes or may create in the future onerous constraints and maintenance requirements shall not be acceptable.

5.7 Acoustic Mounds

Acoustic mounds are to be provided in accordance with the approved development layout plan and/or report referred to in the development consent. Attention is to be given to provision for surface drainage flows around mounds in particular the consequences of concentration and diversion of runoff.

5.8 Site Classification in Accordance with AS 2870

Preliminary residential lot "Site Classifications" in accordance with AS 2870 based on anticipated site conditions shall be provided as part of the Geotechnical Engineers site investigation report. This report is to be provided as supporting information for the earthworks design.

Final residential lot "Site Classifications" in accordance with AS 2870, which may be used for footing design purposes, are to be provided to Council prior to the issue of a Subdivision Certificate.

The lot "Site Classification" report (preliminary and final) is to be prepared by a Qualified Practising Geotechnical Engineer.

5.9 Effects on Services

The designer is to include measures to minimise the risk of any adverse effects of earthworks on existing services including but not limited to:

- Obtaining "Dial before you dig" and other services information including Council water and sewer information.
- Showing services locations and descriptions on all Engineering Plans.
- Using specialist Services Locators to confirm locations and depths of services potentially at risk and noting existing and proposed cover or clearances on Engineering Plans.
- Providing details of arrangements and contacts for timely adjustments/relocations by services authorities.
- Noting on Engineering Plans any restrictions on activities near services.
- Noting on Engineering plans the responsibilities and obligations attaching to individuals concerning Services matters.
- Detailing the design of protection works whether temporary or permanent.
- The installation of services in Acid Sulfate Soil(ASS) and Potential Acid Sulfate Soil(PASS) material should be avoided. Where unavoidable ASS and PASS management plans in accordance with the current NSW Acid Sulfate Soil Manuals and Guidelines are required.

PART 6 – DESIGN REQUIREMENTS FOR ROADS AND RELATED CIVIL WORKS

6.1 Scope of Works to be Designed

Detailed design drawings and documentation are to describe the extent of works specified in the development consent.

The designer is to assume that the works will include but not be limited to signage, pavement marking, street lighting, safety barriers, utilities adjustments, transitions and tie in to existing structurally sound road pavements, stormwater drainage, concrete footpaths, cycle ways and remedial works or reconstruction or relocation of adjacent infrastructure necessary for the safe operation and use of the new works.

Design submissions are to be accompanied by a design report which addresses road design issues including provisions for safety, geometric constraints, storm water drainage, public utilities and justification for the design parameters adopted.

The design of storm water drainage and flood ways relating to road design shall be in accordance with the Part 10 "STORMWATER DRAINAGE DESIGN" in this guideline.

6.2 Design Requirements for Road

6.2.1 Road Carriageway and Verge Widths

6.2.1.1 Road Carriageway and Verge Widths for New Roads

Road carriageway (face of kerb to face of kerb) and verge (face of kerb to property boundary) widths for new roads are nominated by Council's DCP as applicable to the subject development.

6.2.1.2 Road Carriageway and Verge Widths on Existing Roads

Road carriageway and verge widths for existing roads shall be determined in consultation with Council's Development Engineering Section. Ordinarily they will match any existing works in the street but consideration needs to be given to future proposals and matters such as:

- Current traffic volume and type of use.
- Proposed road works or traffic management schemes.
- Proposed zoning changes or developments.
- Alignment and condition of constructed road pavement, kerbing etc.
- Drainage (location and adequacy) and topography (for access and footways).
- On street car parking requirements.
- Standard of geometric design.
- Location of existing and proposed services and street trees.
- Requirements of the Roads and Maritime Services (RMS) on Classified Roads.

6.2.2 Road Design Speed

6.2.2.1 Road Design Speeds and Gradients for New Roads

Road design speeds and gradients for new roads are to be in accordance with Council's DCP as applicable to the subject development.

6.2.2.2 Road Design Speeds for Existing Roads

Unless identified in the Development Consent speeds for existing roads are the current signposted speeds. Design criteria will however be based on the 85th percentile speed for existing roads, as identified by Austroads where available or for 50km/hr roads a design speed of 60km/hr shall be adopted and for roads signposted in excess of 50km/hr a design speed of 15km/hr above the signposted speed shall be adopted.

6.2.3 Geometric Design

6.2.3.1 Geometric Design Urban Roads

Geometric Design of Urban Roads shall generally be carried out in accordance with Austroads Guides and Roads and Maritime Services(RMS) Supplements.

The following general design controls shall also be applied in the geometric design of urban roads. However there will be situations where alternate controls may be more desirable. Alternate controls shall be discussed with and accepted by persons within Council's Development Engineering Section.

General Design Controls shall include:

- Desirably, roads should be crowned in the centre.
- A standard 4% crossfall will apply to straight roads.
- The use of superelevation including transitions will only be permitted on major urban and rural roads.
- Subject to the location of an angle within the vertical plane being visually acceptable the minimum deflection for which a horizontal curve is necessary is 0.75 of a degree (45 minutes).
- The minimum centreline radius for a proposed bus route is 60 metres. Depending on the road lane widths, widening may be required.
- In built up areas vertical curves are to be designed for a minimum stopping sight distance for the nominated design speed.
- Where changes of grade less than 1% occur, vertical curve lengths are to satisfy the requirements of appearance criteria.
- Reaction times are to be 2.5 seconds for calculating stopping sight distances.
- In built up areas sag vertical curves are to be of a length to provide adequate riding comfort for the design speed.
- Sag vertical curves will be designed to suit the provision of formal overland flowpaths, determined in conjunction with stormwater drainage design, to cater for storms in excess of the piped system capacity (limiting the depth of ponding to no greater than 0.2 metres).

6.2.3.2 Geometric Design Rural Roads

Rural roads shall be designed generally in accordance with Austroads guides and NSW RMS supplements.

6.2.3.3 Roads in Bush Fire Prone Areas

In Bush Fire Prone Areas, the requirements of the NSW Rural Fire Services, "Planning for Bushfire Protection December 2006, A Guide for Councils, Planners, Fire Authorities and Developers" are to be met in addition to any requirements for private and public roads, driveways and accesses applying from this Manual

6.2.4 Intersection Design

Intersections are to be designed generally in accordance with Austroads guidelines and RMS Supplements to those guidelines.

Safe Intersection Sight Distance is required at all intersections.

6.2.4.1 Intersection Design Minor Intersections

In addition to the general intersection design requirements minor intersections shall adequately cater for the turning paths of the appropriate design vehicle. Desirable minimum kerb return radii will be 7.5 metres for Urban Residential areas and 10.0 metres for Industrial areas.

6.2.4.2 Intersection Design Classified Roads

Intersections or any traffic management proposals on or with Classified Roads are to be designed and constructed in accordance with RMS requirements. RMS input and consent is mandatory for Classified Roads in respect of the creation of any new intersection, the layout of any new or upgraded intersection, the geometric design, drainage design, pavement design and construction matters.

6.2.4.3 Traffic Signal Design

Traffic signals on any road requires the approval of the RMS.

6.2.5 Roundabout Design

Roundabouts are to be designed generally in accordance with Austroad guidelines and Roads and Maritime Services (RMS) Supplements to those guidelines.

Designs adopting alternative criteria will be considered on their merits. Key criteria to be considered shall include:

- Appropriate sight distance for vehicles, pedestrians and cyclists approaching and entering the roundabout. This includes adequate sight distance for pedestrians and cyclists entering the roundabout at design crossing points from the footpath.
- Provisions for Service Authorities future needs.
- Adequate drainage.
- Site specific designed street lighting.
- Signposting and pavement marking.
- The provision for pedestrians and cyclists.

The provision of safety barriers at roundabouts is not favoured. The need for such barriers should be avoided through design. Where barriers must be provided they shall be RMS approved safety barriers.

Minor roundabouts for use as traffic calming devices in local roads shall generally have signage and markings in accordance with AS 1742 and RMS supplements. Preliminary geometric designs and the proposed formation of roundabout islands shall be discussed with Council Development Engineering Section during the initial design stages.

Roundabouts on roads with expected continuing high traffic growth present high cost implications for longer term upgrading. Whilst a rigid pavement roundabout may have a minimum design pavement life of 40 years, the function of the roundabout will extend well beyond that period. Where a road can be predicted to have significant traffic growth beyond forty (40) years there may be a requirement imposed to consider a layout design for a longer term traffic volume. A staged construction option may have to be developed satisfying traffic capacity corresponding to the pavement design life.

As part of the design procedure design vehicle turning paths are to be used to confirm that traffic within the roundabout will travel in compliance with road traffic rules. Council's Development Engineering Section will advise of the design vehicle for each individual site.

The provision of landscaping, when required, shall be designed so as not present any risk to the safe use of the roundabout. The design of landscaping needs to consider such matters as; the creation of hazards to errant vehicles, the loss of sight distance for vehicles and pedestrians throughout the growth cycle of any vegetation, interference to traffic and signage for maintenance, interference with street lighting and any requirement for abnormal road vehicle passage. Measures shall be installed to protect the road pavement and other infrastructure from landscaping related effects such as hard surface runoff, excess irrigation water, tree roots, soft edges. Raised hard landscaping is not to be provided other than in the middle areas of large roundabouts and then by design. Council's Development Engineering Section will advise whether it is appropriate to incorporate raised hard landscaping or other features within a roundabout.

6.2.6 Permanent Cul-de-sacs and Turning Heads

6.2.6.1 Cul-de-sacs

Generally permanent cul-de-sacs and turning heads are not supported by Council and through road networks are preferred. When permitted by the approved development plans cul-de-sac layout criteria is as follows:

- Urban Residential - minimum 8.5m radius to face of kerb. Entry and exit radii as required for the design vehicle turning path but a minimum of 15m will be required.
- Rural Residential - minimum 8.5m radius to lip of dish gutter. Entry and exit radii as required for the design vehicle turning path but a minimum of 15m will be required.
- Urban Industrial - minimum 16m radius to face of kerb. Entry and exit radii as required for the design vehicle turning path. Entry and exit radii as required for the design vehicle turning path but a minimum of 15m will be required and adequate clearance for overhang.
- Rural Industrial - minimum 16m radius to the edge of seal with an additional 1.2m shoulder or concrete gutter. Entry and exit radii as required for the design vehicle turning path but a minimum of 15m will be required and adequate clearance for overhang.
- The following Grades and Crossfalls are to apply to cul-de-sacs.
- Absolute minimum 0.75%.
- Absolute maximum 6%.

6.2.6.2 Turning Heads

Variations of hammer head turning facilities will be permitted where circumstances warrant. Turning heads must adequately cater for design vehicle turning paths.

The following Grades and Crossfalls are to apply to all hammer head turning facilities:

- Absolute minimum 0.75%.
- Absolute maximum 6%.

Where parking facilities are required, they are to be provided outside of the minimum turning path overhang plus 0.6m clearance envelope. These parking facilities are to be designed as an integral part of the public road and streetscape without adversely impacting on footpaths, services installations, opportunities for access to properties, manoeuvring at property accesses, nuisance to and privacy of existing and future homes.

6.2.7 Temporary Turning Facilities

6.2.7.1 Residential Roads

A temporary turning head shall be provide on the design when there is the likelihood of a delay in the construction of a further stage of a subdivision which creates dead ends of longer than 50 metres in length. The temporary turning head pavement shall be the same as the road it serves. Temporary turning heads shall accommodate the turning of a single unit heavy rigid vehicle of 12.5m length.

6.2.7.2 Industrial and Commercial Roads

When there is the likelihood of a delay in the construction of a further stage of a subdivision which creates dead ends of longer than 50 metres in length, a turning facility is to be provided on the design drawings to accommodate an appropriate Design Vehicles. The turning facility shall have pavement construction and sealing as a minimum to the standard of the through road but in any case shall be provided with not less 40mm of asphalt surfacing.

6.2.7.3 Bus Routes

When a proposed road is identified as bus route and is to be constructed in stages and the accumulated or initial length warrants a bus service, a temporary turning facility is to be provided in accordance with this specification. This turning facility may be in the form of a loop road where turning paths permit and likely on street parking will not be an impact.

The turning facility shall have pavement construction and sealing as a minimum to the standard of the through road but in any case shall be provided with not less 40mm of asphalt surfacing.

6.2.8 Half Road / Road Shoulder with Kerb and Gutter, Drainage and Footpath Construction

Development of land, dual occupancies, townhouses, units, subdivisions and large developments fronting existing roads which are not kerbed and guttered but contain a centre sealed portion of the carriageway will be required to provide design and construction of road pavement shoulders and associated works including:

- Road shoulder or half road pavement construction including sealing and asphalt surfacing.
- Subsoil drainage - if required by the pavement design or extension of existing subsoil lines.
- Stormwater drainage within the roadway and footpath including provision for house drainage outlets – where made essential by the works.
- Kerbing and guttering including vehicular gutter crossings and vehicular footpath crossings for the new development.
- Footpath formation –shaping to design standard profiles.
- Foot paving.
- Table drains, tail in and tail out drains.
- Transitions of the new works to existing conditions beyond the site frontage.
- Adjustments of utility poles, mains and installations affected by the works.
- Provision of any signage, pavement marking or other traffic control devices affected by or required by the works.
- Adjustment of fencing or driveways for adjacent properties affected by transitions.
- Restoration of disturbed areas.

Design of such works shall detail the above listed elements as applicable and any other works conditioned or required as a result of the conditioned works.

The design shall detail the ultimate full carriageway formation for the subject length of road plus at least 30m length either side of the subject length. Where the required design length includes intersection or roundabouts details of how the design/construction ties into the intersection or roundabout will be required.

The cross fall of the shoulder pavement construction, in the case that full half road construction is not required, shall not be less than that of the existing adjoining pavement. In any case the design shall show that the edge of bitumen or lip of gutter design level is generally 4% crossfall from the ultimate design centreline levels as determined in the design. Cross falls of the new pavement shoulders in the range of 2% to 6 % will generally be acceptable provided the ultimate half road crossfall of 4 % is achievable in the future. Shoulder cross falls shall not be less then the existing carriageway cross fall.

The extent of new pavement construction and/or reconstruction associated with the shoulder construction will be dependent on the condition of the existing carriageway pavement and the ability to tie proposed design levels to existing pavements with appropriate transition lengths satisfying rate of rotation criteria.

The cost of relocation of utility services can be substantial. Where this becomes evident the designer should discuss preliminary design issues and utility costs with the Council's Development Engineering Section.

6.2.9 Upgrading Rural Public Roads

Where the upgrading of a rural public road is required, the following applies in addition to, but not contrary to any Development Consent condition.

Council's Development Engineering Section shall advise of such matters as:

- The required road cross section.
- The required surfacing and pavement type and required design.
- The design traffic loadings.
- The design recurrence intervals for flooding events for longitudinal and cross drainage.
- Table drain treatments and outlets.
- Effects on farm dams.
- Applicability of street lighting.
- The need to comply with NSW RFS PBP guidelines.

6.2.10 Extension of and Connections to Existing Roads

Where new works are required which extend or connect with an existing road any works at or near the ends of the existing roads which are inconsistent with the through road are to be reconstructed or modified to the through road profile. These works shall be detailed on the design drawings. Such works may include:

- Turning facilities whether provided as temporary measures of a staged development or being long standing cul-de-sac works.
- Retaining walls and batters.
- Pavement cross falls.
- Driveways and foot paving.
- Barriers.
- Drainage and services which do not conform to through road allocations.
- Batters of footpaths and adjacent private property caused by existing turning areas.
- Signage, pavement marking and delineators.
- Guide posts.
- Street lighting.

Transitions of new work to existing formations shall be designed to the standards and requirements included in this manual.

Transitions are to be designed to safely and efficiently merge the new works with existing road pavements, road shoulders, table drains, footpath shape, existing driveways, traffic control devices and other features in the road reserve.

When transition designs cannot avoid the creation or worsening of hazards such as utility poles, driveways, deep edge drains, steep foot paving at the start and end of works, then the hazard is to be removed or works extended to overcome the hazard.

6.2.11 Local Area Traffic Management (LATM)

LATM devices are required to reduce travel speeds to achieve nominated design speeds generally where road geometry cannot satisfy this requirement. LATM devices may also be required by a Development Control Plan or Development Consent.

Control device design should be part of an overall scheme defining specific classes of roads within the local precincts or Local Area Traffic Management Schemes unless required for a specific purpose for a development and address the following:

- Design vehicle turning paths.
- Pedestrians, persons with disabilities and cyclists.
- Bus routes and traffic facilities.
- Drainage.
- Street lighting.
- Sight distance.
- Signage and pavement marking.
- Emergency vehicles.
- Private accesses.
- Car parking.
- Landscaping and streetscape.(Landscaping of LATM facilities will not generally be permitted)
- Crime prevention.
- Noise, vibration or other nuisances.
- Low hazard potential.
- Low demand and cost efficient maintenance requirements.

Local Area Traffic Management devices shall generally be design in accordance with Austroads publications and AS 1742.13

6.2.12 Traffic Facilities

Generally traffic facilities shall be designed in accordance with Austroads publications and RTA supplements to Austroads Publications.

6.2.12.1 Traffic Control Devices

Traffic control devices may incorporate or include signage, pavement marking, delineators, guide posts, traffic signals and traffic islands.

Traffic Control devices shall be detailed in accordance Austroads guidelines, Australian Standards, RMS guides, RMS technical directions and RMS supplements. RMS guides, technical directions and supplements shall take precedence in regards to requirements for traffic control devices.

6.2.12.2 Signage, Pavement Markings and Delineators

Signage and pavement marking should generally be provided to roads, intersections, traffic facilities, cycleways, carparks and other road elements in accordance with RMS requirements. Where not covered by the RMS, acceptable treatment may be determined from Australian Standards and Austroads guides or as agreed with Council's Development Engineering Section

The following specific requirements apply to new roads:

- Roads having carriageways in excess of 6 metres and wider shall have centreline marking for a minimum of 20 metres on approaches to intersections and on horizontal bends. Reflective raised pavement markers (RRPMs) are to be provided the centreline of the curve and for 15m either side of the Tangent Point at 3m centres. Provide white markers on bitumen surfaced roads and yellow on concrete surface roads.
- Roads having carriageways in excess 9 metres shall have centre road line marking with reflective raised pavement markers (RRPMs) or another acceptable form of centre road pavement marking throughout.
- Roads having carriageways of 10 metres and greater shall have centre road line marking with RRPMs and edge lines marking at 3 metres offset from the centre of road.
- Edge lines shall be provided to rural roads irrespective of the width.
- Edge lines where provided shall have RRPMs.

6.2.12.3 Guideposts

Guideposts are to be provided in accordance with RMS requirements as a minimum. Provision of additional guide posts may be required considering local conditions such as the prevalence of fog, use of the road, driver behaviour, likely driver awareness and the adjoining sections of road. Guideposts are to be provided on all rural roads.

6.2.12.4 Street Signs

Street name plates location and type are to be of the standard type throughout Wyong Shire and in accordance with Council's Sign Manual. Reference to the Sign Manual shall be made on the design drawings.

6.2.12.5 "No Through Road" signs

"No Through Road" signs are to be provided and placed in accordance with AS 1742 and as advised by Council's Development Engineering Section. Generally this sign will be required on planned through roads which are temporary dead ends due to subdivision staging. In the instance of staged road extensions the sign is to be relocated or removed as appropriate to suit new works.

6.2.12.6 Safety Barriers

Safety barriers (incl wire rope barriers) are to be provided in accordance with the RMS(former RTA) standards and Austroads warrants, guidelines and RMS supplements and shall be shown on the design drawings.

Elimination of hazards in lieu of installing safety barriers shall be considered prior to detailing any requirement for a safety barrier.

Safety barrier selection type is to be give due consideration to vulnerable road users.

All details of the specified barrier type and any impacts resulting from the proposal are to be addressed in the design documentation.

Delineation of safety barriers is required.

Mowing strips a minimum of 300mm wide (depending on the safety barrier type) and 100mm thick on 100mm compacted gravel with jointing type and locations appropriate for the purpose is required. Rub rails or safety railings are to be provided to the rear of the safety barrier where there is an adjoining pedestrian or shared path system.

6.2.13 Road Batters for Road Formations

6.2.13.1 Rural Roads

Road batters in rural roads may be influenced by matters including:

- Terrain (environmental damage, drainage, benches, earthworks construction cost etc).
- Safety (geometric design, clear zones, traversable slopes, safety barriers etc).
- Sight distance requirements (curve and intersection benching, accesses etc).
- Ground conditions (soil and rock properties, subsurface water, slope stability etc).
- Constraints (existing/planned road boundaries, structures or services).
- Surface stabilisation and maintenance.
- Appearance (constant width batters, batter slope treatments, non-obtrusive etc).

The designer needs to ensure that relevant information is available and that the design addresses pertinent matters. This may involve the preparation of design options to gain an approval.

Batters within the clear zone, particularly those in cutting with a jagged rocky face, are to be either protected from vehicular impact by a safety barrier or be treated to provide a relatively smooth surface to promote sliding when impacted by a vehicle.

6.2.13.2 Urban and Rural Residential Roads

Road batters in this context are those batters extending outside the road boundaries.

Road batters shall extend for as little distance as possible into proposed urban lots, such as to allow free surface runoff and vehicular access gradients to the building line, excepting for minor smoothing out of the alignment of tops and toes or where approved in conjunction with a site regrading plan.

Consideration shall be given to future vehicular access grades particularly where cut /fill building platforms will be utilised.

Permanent cut or fill batter slopes shall nominally comply with six horizontal to one vertical (6H:1V) maximum slope excepting when allowed under the following circumstances.

An increased localised slope of four horizontal to one vertical (4H:1V) maximum slope may be considered where:

- the batter when stabilised can be reasonably maintained, **and**
- due to the terrain, road batters would extend significantly beyond the lot building line over a number of consecutive lots, **or**
- flatter batters would result in the destruction of important stands of trees or individual tree specimens, **or**
- particular environmental or land stability issues are significantly adversely impacted by flatter batters, **or**
- the batter impacts significantly on utility mains.

An increased localised slope of two horizontal to one vertical (2H:1V) maximum slope may be considered where:

- particular environmental or land stability issues are significantly adversely impacted by flatter batters, **and**
- a Geotechnical Engineer's report is provided containing relevant, investigations, site assessment and recommendation, **and**
- the batter is within proposed private property, does not obstruct access onto any lot and when stabilised can be reasonably maintained, **or**
- the batter is within proposed public land or an easement in favour of Council over private land and, is finished in a treatment which does not require routine maintenance and does not obstruct access onto the proposed public land, **or**
- the batter impacts significantly on utility mains.

In rock cuttings faces steeper than 2H to 1V, up to 1H to 4V may be permitted only where:

- particular environmental, land stability or unreasonable construction cost issues are impacted by the alternative use of flatter batters, **and**
- a Geotechnical Engineer's report is provided for consideration initially which identifies an expected long term stability, low potential for weathering and lack of any need for routine maintenance, **and**
- upon completion of the cutting a Geotechnical Engineer's report is provided which confirms the expectations of the initial pre-construction report or provides alternatives in conformance with the as constructed works for consideration.

In any instance the method of stabilising fill batters greater then 6H:1V shall be endorsed by the geotechnical engineering consultant both at the design stage by way of design recommendations and following construction.

6.2.14 Retaining Walls for Road Formations

Retaining walls to support public road formations may be permitted only where:

- particular environmental, land stability or land use issues are significantly adversely impacted by the alternative use of batters, **and**
- the proposed construction materials of the retaining wall are masonry units, durable natural stone or some other masonry components associated with an engineered retaining system, **and**
- retaining walls are designed to accommodate loadings from road plant used to construct and maintain works within the road reservation, **and**
- retaining walls are designed to accommodate loadings and excavations by plant used in the installation and maintenance of utility mains and installations, **and**
- easements for support and maintenance are created in favour of Council over the retaining walls and an adjacent area required for maintenance or rebuilding activities for the retaining wall within any lot affected, **and**
- the retaining wall is constructed in a form which does not require routine maintenance, **and**
- easements for drainage are created in favour of Council over any drainage including sub surface drainage required for any such retaining wall.

Retaining walls to support land above a public road reservation may be permitted only where:

- particular environmental, land stability or land use issues are significantly adversely impacted by the alternative use of batters, **and**
- the proposed materials for construction of the retaining wall are masonry units, durable natural stone or some other masonry components associated with an engineered retaining system, **and**
- retaining walls are designed to accommodate loadings from plant used to perform construction works for the subdivision or lot development, **and**
- retaining walls are set back at least 300mm into lots from the road boundaries and are designed to be stable in the event of excavation of adjacent services to the depth of the original or proposed respective service's trench, **and**
- the extent of the retaining wall shall not unreasonably restrict the future use of a lot, **and**
- the retaining wall is contained wholly within the private land which it supports or within an easement over other private land which allows for the existence, maintenance and rebuilding of the wall, **and**
- all surface or subsurface drainage systems associated with the retaining wall are piped to a Council controlled or interallotment covered drainage system.

In any instance:

- any batter or retaining wall at an intersection or defined point of access shall be of an alignment and profile which provides adequate sight distance for passing and entering vehicular, pedestrian and cycle traffic, **and**
- the extent of any batter or retaining wall fronting a lot, including frontages of public land, shall not obstruct access onto that lot or land.

PART 7 - DESIGN OF PAVEMENTS

7.1 General

This Chapter outlines the minimum requirements for geotechnical investigations and the design of pavements for:

- Public roads (existing and proposed including minor works).
- Footpaths.
- Cycle ways.
- Driveways, accesses.
- Public and private car parks.

7.1.1 Preparation and Council Acceptance of Reports

A Pavement Design Report covering all proposed pavements is to be prepared by a Practising Geotechnical Engineer and submitted to Council for assessment using the application form for Civil Development and Subdivision Works. The report is required to be accepted by Council prior to applying the reports recommendations to any works.

Pavement Investigation and Design shall be addressed with reference to current Austroads Pavement Design Guides and other Austroads Pavement related publications unless otherwise required in this guideline or circumstances warrant otherwise as agreed with Council's Principal Development Construction Engineer.

7.1.2 Council Standard Pavement Designs for Small Projects

A Pavement Design Report may not be required for certain works where Council's Standard Pavement designs may apply. Refer to Volume 2 – Civil Works Construction Specification.

7.1.3 Roads within Floodways and Inundated or Saturated Land

Roads within flood ways that are designed to be inundated more than once every 20 years or as a result of Sea Level Rise and roads over lands which are subject of inundation or saturation are to be constructed of a concrete pavement or other similar rigid pavement not impacted by the effects of moisture.

7.1.4 Pavements that are not Proposed to Become Council's Asset

Other than battle axe driveways for subdivisions and Vehicle Access Crossings (VACs) the information contained in this Chapter in relation to private accesses and car parking is for guidance only unless specified otherwise in the development consent.

Design Consultants should be aware of requirements of the Building Code of Australia, any applicable Australian Standards, documents referred to in Development Approvals and product information when specifying such matters as driveway, parking areas and pathway pavement surface materials or surface finishes which will not become Council's Asset.

7.1.5 Pavement Design Life

The design life of new public road pavements, unless specified otherwise in conditions of development consent, shall be in accordance with "Table 7.1 Public Roads – Design Life for Pavements".

Table 7.1 Public Roads – Design Life for Pavements

Pavement Type	Minimum Design Life
Flexible pavement	30 years
Pavement containing 1 bound layer	30 years
Pavement containing two bound layers **or** full depth bound material	40 years
Rigid Pavement	40 years
Full depth asphalt pavements	40 years

7.2 Pavement Design Life

The pavement design report shall address the following matters as a minimum:

- Projected traffic loadings and vehicle impacts.
- Subgrade and underlying material evaluation including test results from Nata Registered Laboratory.
- Expansive soils and moisture control.
- Subgrade and pavement drainage design concepts.
- Environmental factors found and considered.
- Consideration of consequences of other development works.
- Materials requirements if not in accordance with or specified in Council's Civil Works Construction Specification.
- Construction methods and issues.
- Pavement layer thickness design.

Other geotechnical matters pertinent to the works as a whole may be included in the Pavement Design Report or presented in separate reports. These matters may include:

- Topsoil stripping requirements.
- Slope stability.
- Rock strength and hardness.
- Suitability of materials for fills.
- Potential for subsidence.
- Identification of Unsuitable materials.

- Groundwater issues, cut batters, fill formations (capillary action), fill batters, slope stability, drainage run-on.
- Foundation design criteria for structures include refer to in relevent Chapters.
- Construction vibration damage risk.
- Retaining wall design criteria.
- Actual and potential ASS sampling testing and management plan.
- VENM sampling testing and management plan.
- Testing for Salinity.
- Recommendations concerning road levels and treatments in relation to ground conditions arising from presence of hard rock, unsuitable ground and potential instability.

7.3 Design Traffic Loading

Pavement designs for all proposed public roads are to be based on road categories/street types described in Council's Development Control Plan Chapter 66 "Subdivision". See "Table 7.2 Indicative Minimum Design Traffic Loadings for new Streets and Intersections" for minimum design loadings.

The design traffic loadings will be as nominated, in conditions of the development consent or, by Council's Principal Development Construction Engineer or Development Engineering Team Coordinator in the individual case. Any submission to vary traffic loadings is to include full calculations.

Table 7.2 Indicative Minimum Design Traffic Loadings for New Streets and Intersections

Street Type*	Flexible Pavement Design ESAs	Rigid Pavement Design CVAGs
Urban Residential		
Cul-de-sac and Access Laneway	1.75×10^4	8.75×10^4
Access Street	1.4×10^5	4.6×10^5
Local Street Local Street with Buses	1.9×10^6 3.3×10^6	4.7×10^6 5.5×10^6
Collector Collector with Buses	4.6×10^6 6.1×10^6	7.6×10^6 8.7×10^6
Distributor / Bus Route	2×10^7	2×10^7
Rural		
Local 0-150m	1×10^5	1.7×10^5
Local 150-500m	3.4×10^5	5.6×10^5
>500m	5×10^5	8.4×10^5
Commercial & Industrial		
Minor Local Cul-de-sac / Loop Other	5×10^6 2×10^7	5×10^6 2×10^7
Main / Classified Roads	Refer to Council/RTA	Refer to Council/RTA

Note: Design Traffic Loading (ESA) values for full depth asphalt pavements for roundabouts and other than minor residential intersections are to be factored by 1.2 to allow for torsional effects.

7.4 Evaluation of Subgrade

Investigation by a qualified practicing Geotechnical Engineer and soils testing through a NATA registered laboratory will be required. Testing and test samples are to be undertaken at the approximate design subgrade level where ever practicable.

The design of rigid pavements requires the determination of an "Equivalent Design CBR". This calculation considers subgrade material properties to a depth of 1m. See Austroads Pavement Design Manual.

Investigation of materials below subgrade level is also necessary to assess sub surface moisture and to expose any weak layers below the subgrade. Test pitting, recording of bore logs and materials sampling is to be carried out to include materials to a minimum depth of 1m below design subgrade.

In deep cuttings, deep fills or other instances where testing of subgrade is possible only after bulk earthworks, pavement designs may be assumed for the purpose of submitting the Pavement Design Report for acceptance. In areas where pavement designs have been assumed pavement investigations, sampling and testing are to be carried out in full upon excavations reaching subgrade level and then a pavement design report is to be prepared and submitted for acceptance by Council's Principal Development Construction Engineer.

7.4.1 Determination of Design CBR

Sampling for laboratory CBR testing is to involve the following:

- A minimum of one sample at any sampling location for each subgrade material present to 1m below subgrade.
- A maximum spacing of **60m*** between subgrade sampling locations in residential roads or part thereof.
- A maximum spacing of **120m*** between subgrade sampling locations in rural roads or part thereof.
- A minimum of two subgrade sampling locations in any road.

*Repeated laboratory CBR tests on the same material type sampled throughout a site is not required provided that in-situ testing is undertaken to justify allocating a CBR based on a pair of laboratory results for that material. In-situ testing for determination of the CBR may be carried out using a Cone Penetrometer for fine grained materials. A laboratory CBR test will be required for materials containing larger particles where consistent results are not obtained by a Cone Penetrometer.

7.4.2 Expansive Soils (Reactive)

Sampling and testing of sub grade materials is also to be carried out to determine their "Expansive Nature" classification in accordance with Austroads Pavement Design Guide. Testing is to include the potential swell test in addition to the plasticity index test.

Design measures to control movement of the subgrade are required for pavements over expansive soils classified "high" or "very high". Design measures and subsurface drainage are discussed in Austroads Pavement Design Guide. Preferred measures shall also be discussed with Councils Principal Development Construction Engineer prior to inclusion in any pavement design report.

Pavement subsurface drains generally are not to extend into highly or very highly expansive road subgrade soils.

Drainage lines and utility mains laid in sand or aggregate bedding material are not to be located in or in close proximity to highly or very highly expansive road subgrade soils.

The Geotechnical Engineer is to recommend appropriate treatments to control moisture variations in highly and very highly expansive subgrade soils, subsurface drainage treatments in general and general measures to prevent infiltration of surface water.

7.5 Subsurface Drainage

Subsurface drainage will be required for all new road pavements in order to:

- Prevent groundwater from entering and softening or saturating the subgrade or pavement materials.
- Remove trapped water that enters a pavement either from the side or from beneath the pavement.
- Control moisture levels in subgrade material to prevent reactive soils from damaging pavements.
- Prevent slope instability.
- Achieve consolidation in raised embankments over wet or unstable areas.

The general location for pavement subsurface drainage shall be located as shown on Council's standard drawings. Pavement subsurface drainage shall be required on both side of the roads and across the interface of new construction and existing construction.

Recommendations for subsurface drainage are to be made by the Geotechnical Engineers in the Pavement Design Report where different requirements to those shown on Council's standard drawings are considered necessary by the Geotechnical Engineer.

7.6 Flexible Pavement Design

Bituminous surfacing of 40mm thickness or less thick is not considered to contribute to pavement thickness design.

Notwithstanding other requirements of this chapter the design minimum compacted pavement thickness including bituminous surfacing shall not be less than 300mm on public roads or roads which are to become Council's asset following dedication.

In addition to the requirements of this manual Flexible pavement investigation and design shall generally be carried out in accordance with Austroads Pavement Design Guides.

7.7 Rigid Pavement Design

Rigid pavements on public roads shall be jointed reinforced concrete paving unless advised otherwise by Council's Development Engineering Section or specified in the conditions of development consent.

The minimum requirements for rigid pavements for public roads other than roundabout pavements include a Subbase course of 125mm bound or 150mm unbound material and a Concrete pavement thickness of minimum 165mm 32Mpa (3.5Mpa flexural strength).

Jointing details for rigid pavements shall be detailed on separate design drawings and generally be in accordance Austroad guides, Roads and Maritime Services (RMS) specifications and other Australian design publications on concrete pavement design which may be relevant to the subject pavement. Details of documents referenced in detailing rigid pavement designs shall be provided to Council's Principal Development Construction Engineer with the design drawings.

7.8 Asphalt Pavement Design

The following applications of asphalt for pavements may be acceptable. Details of individual pavement designs including or nominating materials specifications if differing from Councils Civil Works Construction Specification are to be included in the pavement design report:

- Full Depth Asphalt Pavements.
- Modified Full Depth Asphalt Pavements (MFDA).
- Deep Strength Asphalt.
- Wearing Surface Asphalt Containing Plastomer Polymer Modified Binder.
- Composite Pavements – initial Sprayed Seal on Lean Mix Concrete or Bound Subbase.
- Open Graded Asphalt.

7.8.1 Sprayed Primer Seal under Asphalt Surfacing

All asphalt surfacing shall be place on a 7mm primer seal in accordance with the Civil Works Construction Specification.

7.8.2 Edge Drains for Asphalt Pavement Layers

In order to relieve moisture from asphalt pavement layers, effective edge drains are recommended as part of the pavement cross section of Full Depth, Deep Strength, Open Graded and Modified Full Depth Asphalt Pavements.

7.9 Segmental Block Pavement Design

Segmental block pavements are to consist of either concrete or clay pavers overlying as a minimum a base course and a sub-base layer. Details of documents referenced in detailing segmental block pavement designs shall be provided to Council's Principal Development Construction Engineer with the design drawings.

All areas of segmental block paving shall be constrained by some form of approved concrete edge restraint. Edge restraints shall be adequately reinforced. Reinforcement may be required for shrinkage control or for structural purposes in the individual case. The use of standard integral kerbing or other substantial moulded sections as edge restraints will not require the provision of reinforcement.

Adequate consideration is to be given to the provision of surface and subsurface drainage including the sealing and drainage of the surface of the sub base layer.

A header course (soldier course) is to be provided to all paved areas adjacent to edge restraints.

Long paved areas on steep grades shall have transverse modified edge restraints provided at nominal intervals and the bedding and jointing sand shall have provisions for drainage.

Pavers generally shall have a minimum slip resistance surface classification of Class W under AS/NZS 4586 Wet Pendulum Test using Four S Rubber (simulated standard shoe sole rubber). Where pavers are used on sloped surfaces in excess of five percent (5%) the required slip resistance classification shall be increased as determined by HB 197 Appendix A for a Four S rubber notional* BPN test value of 49 for a horizontal surface. *The term 'Notional' is used as in AS/NZS 4663 to 'highlight the need to consider all potential contributing factors to a slip incident'. The adopted horizontal surface BPN value must take into consideration the likely loss in friction during the required life of the pavement attributable to wear, damage and weathering which may be in the order of 10 BPN. This does not consider contamination (where beyond a maintenance matter) or contributing factors which may be peculiar to a site.

7.9.1 Clay Segmental Block Pavers

Clay pavers will be 65mm thick, Class 4 and laid in a herringbone pattern only.

7.9.2 Concrete Segmental Block Pavers

Concrete pavers are to be 80mm thick, shape Type A, and laid in a herringbone pattern only.

7.10 Roundabout Pavement Design

Roundabouts may have pavements constructed in Modified Full Depth Asphalt (MFDA) where the natural subgrade CBR is greater than 10% and the design traffic before factoring for torsion effects does not exceed 5×10^6 ESAs .

Unbound or bound granular materials, other than heavily bound granular materials, are not permitted in roundabout pavements.

7.10.1 Full Depth Asphalt Pavement Design for Roundabout Pavements

The pavement design report shall include justification of the selection of asphalt modulus values used in the design and specify layer thickness and aggregate size.

The following measures are considered appropriate for heavily trafficked pavements, with a large number of commercial vehicles and a likelihood of channelised vehicle movements with slow moving traffic:

- Asphalt should be a dense, continuously graded mix of an intermediate sized stone – x 14mm aggregate for deformation resistance and resistance to plucking.
- For a full depth asphalt or deep lift asphalt pavement, the wearing course should have a Class 320 binder, possibly stiffened with a modifier such as Gilsonite. A Class 600 binder would be appropriate if available. For existing pavements, ensure that the stiffness of any overlay remains compatible with that of the underlying asphalt layer.
- Where roundabouts are constructed on existing pavements crossfall corrections or heavy patching often results in variations in asphalt layer depth. Appropriate mix size should be used in correction layers. The final surfacing layer should have limited variation in depth.

Optimal layering of both Deep Strength and Full Depth Asphalt Pavements is critical to minimise the potential for moisture damage and maximise pavement performance.

Where possible, multiple layers of AC20 or AC14 should be used, preferably in the mid range of the allowable layer thickness.

To increase layer stability in heavy duty situations, on grades or at intersections, combined aggregate grading should comply with the heavy duty grading requirements of RMS Specification 116.

7.10.2 Heavily Bound Pavement

Heavily Bound pavements shall have a minimum surfacing of 100mm thick of asphalt. Heavily bound pavement designs reports shall include references to heavily bound pavement material specification and other construction requirements including individual asphalt layers and asphalt mix type.

7.10.3 Rigid Pavement Design for Roundabouts

Rigid pavements for roundabouts are to be design with reference to the RMS's "Concrete Roundabout Pavements, A guide to their design and construction" and any current information published by the RMS in relation to concrete roundabout pavements.

7.11 Industrial and Commercial Area Road Pavement Design

Pavement designs for roads in industrial and commercial shall consider the possibility of high volume heavy turning movements with resulting surface torsion effects and braking forces. Thin asphalt surfacing which may be suitable for residential subdivision pavements are not considered suitable for industrial and commercial area road pavements.

A heavily bound pavement with a thick asphalt surfacing is one alternative that could be considered when designing pavement for these areas.

7.12 Existing Council Roads – Minor Works – Use of Council Standard Pavement Design

In some cases of minor pavement works on local access roads and minor roads a pavement design report may not be necessary. These cases generally consist of pavement shoulder works of 40m or less length, 3 metres or less in pavement sub base width and where the subgrade CBR is expected to be greater than or equal to 3.

In any case a geotechnical engineer will be required to inspect the subgrade and provide verification that the proposed standard Council design thickness will be suitable for the subgrade exposed on site. Refer to Volume 2 - Civil Works Construction Specification for further details.

7.13 Temporary Roadworks at Temporary Road Ends

The pavement design of temporary turning heads shall be as for the through road pavement. Consideration shall be given to:

- The surface drainage to be provided in the interim.
- The provision of subsurface drainage for the interim and ultimate conditions.

7.14 Temporary Side Tracks and Deviations for Construction Purposes

The design of temporary side tracks and deviation pavements required for construction shall be carried out to ensure that:

- The pavement will withstand the expected traffic loadings without deformation causing interference to traffic flow, speed or safety.
- The surfacing of the pavement will only require minor maintenance during the life of the pavement.
- The effects of surface and subsurface drainage are considered.
- The treatment of the interfaces with existing pavements is considered including subsurface drainage and interlocking of pavement courses.
- Minimum pavement depth requirements also apply.

7.15 Private Driveways, Accesses, Paths And Battle Axe Driveways

Private driveways may range from a single residential access to substantial internal road systems. These may provide access to a range of developments from single residences to major commercial or industrial developments involving high volumes of heavy vehicles. A design standard should be selected which is appropriate for the scale of the development, the anticipated life of the development and traffic type. The standard to be used may also be specified in the conditions of development consent.

Pavements for battle axe lot driveways servicing residential properties within proposed subdivisions are to be constructed in accordance with the requirements of Volume 2 - Civil Works Construction Specification.

7.16 Car Park Pavements

The design of car park pavements is to consider the variations in use and loading throughout the car park, e.g. through routes, locations of high turning movements, heavy vehicle routes. The selected design life of private car parks may give consideration to the life of the development, the practicality of undertaking renewal works and the disruptions associated with periodic maintenance and renewal works. A design life less than 20years will not normally be considered acceptable for permanent construction.

All loading bays and loading zones should be constructed in concrete or concrete segmental block paving to resist damage from diesel and fuel spills. Paving colours should be mottled to mask drip marks.

Car park wearing surfaces are to consist of either asphaltic concrete, rigid pavement or segmental block paving.

Paving surfacing colours which would mask pavement markings should not be selected.

The placement of surface and subsurface drainage can be critical for pavement performance and is to be considered by the pavement designer. The impact of subsurface moisture can be influenced by issues which include steps in subgrades due to pavement depth variations, landscaped and irrigated traffic islands, service trenches, below ground tanks, potential groundwater problems due to boxing and/or filling over broad areas, adjacent water quality systems (rain gardens, bioswales) and the use of pavement surfaces for on-site storm water detention.

The design of porous pavements is to consider subsurface drainage to the extent necessary to ensure subgrade support. This may involve the provision of additional porous pavement courses.

Generally porous pavements are only considered suitable for areas subject to light to medium traffic.

A detailed assessment of the need for surface and subsurface drainage must be made in the individual case.

Design standards applicable to a particular development may also be specified within the conditions of Development Consent.

7.17 Concrete Cycleways

Concrete cycle ways are to generally be constructed in accordance with the requirements of Volume 2- Civil Works Construction Specification and Councils Standard Drawing SD5B except where cycle ways are proposed to be used for vehicle access for maintenance activities or similar. In these cases a specific design of the cycleway pavement shall be detailed on the design drawings.

7.18 Pavement Surfacing

In addition to the requirements of this part of the guidelines, other general requirements for pavement surfacing materials, thickness and finishes are specified in Volume 2 - Civil Works Construction Specification. However, where a particular circumstance is not covered in that specification an appropriate treatment shall be discussed with Council's Development Engineering Section prior to Council's acceptance for the use of the appropriate treatment.

PART 8 – DESIGN OF BRIDGES AND STRUCTURES

The design of structures such as bridges, large drainage structures and retaining walls shall be carried out in accordance with the current relevant Austroad Guides and Australian Standards.

Certification will be required from a Practising Civil/Structural Engineer stating that the design has been prepared in accordance with the required guidelines and standards.

Design certification shall also be provided at construction stage to address the adequacy of the proposed formwork and construction methodology. Refer to Volume 2 - Civil Works Construction Specification for Requirements.

Inspection certification from a Certified Practising Civil/Structural Engineer will be required confirming that construction has been carried out in accordance with the approved design. Refer to Volume 2 - Civil Works Construction Specification for Requirements.

The design and manufacture of all precast structures is to be certified by a Certified Practising Civil/Structural Engineer as being in accordance with relevant standards. Refer to the Civil Works Construction Specification for Requirements. Prior to approval for use of precast products all relevant technical information for installation is to be submitted together with the certification.

PART 9 - DESIGN OF DRIVEWAYS, PROPERTY ACCESS, FIRE TRAILS, CARPARKS, FOOTPATHS AND CYCLEWAYS

9.1 Vehicular Access to Properties

9.1.1 Urban Property Access

Urban property vehicular accesses vary from entrances to major developments, such as regional shopping centres, car parks, entertainment venues to vehicle access for small developments.

The design of the vehicular access needs to consider:

- Type of frontage road.
- Land use of the property.
- Type of vehicle likely to use the access.
- Traffic using the access.
- Street and property drainage.
- The existing and proposed utility services.
- Street trees and street furniture.

Where a minor road type access is required with kerb returns and drainage pits cannot be provided in the public roadway a dish gutter is to be provided in accordance with standard drawing SD 11C Standard Dish Crossing.

The width of the vehicular access or driveway, and the layout should:

- Provide single manoeuvre turns by the design vehicle.
- Provide adequate clearance between the design vehicle's turning path and physical constraints within the property.
- Avoid reversing movement into or out of the development (except in the case of individual residential houses).
- Provide safety for pedestrians by ensuring adequate sight distance.
- Minimise pedestrian / vehicle conflict areas and control vehicle speed across footways.

For local roads low travel speed and driver expectation of interference reduces the likelihood of conflict. Minimum Gap Sight Distance (MGSD) of 4 secs relative to the 85th percentile travel speed should be available for vehicles entering or exiting from a property. This requirement will not generally be applied to individual residential houses in built up areas.

Entrances to major developments such as shopping centres need to be analysed thoroughly to minimise their effect on the through traffic flow. The intersection of such accesses with the frontage road may be required to be treated the same as the intersection of two public roads.

Vehicular access crossings of the road verge for single residences and residential dual occupancy developments shall be in accordance with standard drawing SD2D and SD4D.

9.1.2 Rural Property Access

Treatment of access to rural properties is dependent upon several criteria including through traffic volumes, turning volume, design vehicle type, single or divided carriageway, land use and general topography.

The location for a point of access will be governed by the following:

- Sight distance (particularly at night).
- Median width / storage space (if available).
- Largest design vehicle to utilise the facility.
- Distance to intersection.
- Possible confusion with intersections.
- Deceleration / acceleration movements.
- Drainage.
- The existing and proposed utility services.
- Site restrictions.

There should be adequate sight to and from the access point. Safe Intersection Sight Distance must be provided for the through traffic and 5 seconds Minimum Gap Sight Distance (MGSD) 1.15m to 0.6m height sight line for entering vehicles. Care should be taken to ensure MGSD is not affected by the location and height of roadside furniture, especially for accesses located on the inside of horizontal curves. Roadside landscaping, trees or structures are not to interfere with horizontal and vertical sight lines.

A single unit truck shall be the minimum design vehicle for any rural access.

To enhance safety for the turning vehicle and minimise interference to through traffic a widened shoulder or short auxiliary lane may be required for right turning vehicles on dual carriageways. Similarly on two lane two way roads shoulder widening will be required to enhance safety for all movements.

Sufficient length between the edge of road and any gate is to be available to store the parked design vehicle to allow for the occupants attending a gate. Where the design vehicle is a single unit truck then 15m should be allowed and in the case of an articulated vehicle 22m is the required offset.

At locations where there is high demand for articulated vehicles (eg timber mill, quarry, truck station etc) a road intersection layout shall be required.

9.1.3 Residential Battleaxe Driveways

Designs for battle axe corridors for urban residential developments shall include provisions for the following:

- The driveway is to include gutter and footpath crossings in accordance with WSC standard drawings.
- A pavement design in accordance with Volume 2 - Civil Works Construction Specification or an approved pavement design report.

- The continuation of the driveway into the main body of the lot to allow access to useable land either where the construction of that driveway at a later date would impact on adjoining property or where topography, natural obstructions or poor ground conditions would make the driveway construction expensive.
- Unless a larger design vehicle is intended, the design vehicle for bends in driveway alignment shall be a single unit truck (small commercial removalist vehicle). Pavement widths are to be increased to accommodate tracking of design vehicles.
- In long and multiple user driveways passing bays are to be provided at appropriate intervals and at unavoidable blind crests, side roads and curves.
- The driveway gradient on the approach to the road boundary shall comply with Australian Standards.
- The driveway gradients and surface material specification shall satisfy the relevant Australian Standards and Building Code of Australia requirements including those regarding slip resistance for pedestrian access and mobility.
- The collection and discharge of driveway runoff including runoff from uphill areas. Driveway runoff is not permitted to flow onto the footpath.
- Any batters or retaining structures shall not restrict development over adjoining land or pose risks of instability or erosion.
- Any requirements imposed in relation to fire either through the Building Code of Australia or in Bush Fire Prone Areas, the NSW Rural Fire Services (such requirements may include controls on gradients, driveway widths, clearances and design vehicles for various travel paths).
- Completed works are to satisfy cover and clearance requirements for any utility authority mains and installations.
- Completed works shall allow unobstructed routes for the future provision of private service pipes (where this cannot be achieved those services or appropriate conduits are to be installed in full as part of the works).

9.1.4 Multi-unit Residential, Commercial and Industrial Battleaxe Driveways

Battle axe corridors for large residential, commercial and industrial developments are to be designed with jointed reinforced concrete, concrete pavers or clay pavers. Kerb will be required on both sides of the pavement. The design of the driveway shall include provisions for the following:

- The driveway is to include gutter and footpath crossings in accordance with WSC standard drawings.
- A pavement design, in accordance an approved pavement design and /or report.
- Unless a larger design vehicle is intended, the design vehicle for bends in driveway alignment shall be a single unit truck. Pavement widths are to be increased to accommodate tracking of design vehicles.
- Where a driveway layout is approved as a single lane width, passing bays are to be provided at appropriate intervals and at unavoidable blind crests, side roads and curves.
- The driveway gradient on the approach to the road boundary shall comply with the relevant Australian Standards.
- The driveway gradients and surface material specification shall satisfy the relevant Australian Standards and Building Code of Australia requirements including those regarding slip resistance for pedestrians and access and mobility.
- The collection and discharge of driveway runoff including runoff from uphill areas. Driveway runoff is not permitted to flow onto the footpath.

- The grading of vacant areas within the corridor shall suit adjacent property levels at the boundary.
- Any batters or retaining structures shall not restrict development over adjoining land or pose risks of instability or erosion.
- Any requirements imposed in relation to fire either through the Building Code of Australia or in Bush Fire Prone Areas, the NSW Rural Fire Services (such requirements may include controls on gradients, driveway widths, clearances and design vehicles for various travel paths).
- Completed works are to satisfy cover and clearance requirements for any utility authority mains and installations.
- Completed works shall allow unobstructed routes for the future provision of private service pipes (where this cannot be achieved those services or appropriate conduits are to be installed in full as part of the works).

9.1.5 Rural Residential Battleaxe Driveways and Internal Driveways

Battle axe corridors for rural residential developments are to be constructed as a minimum of asphalt surfaced, flexible road pavement with concrete edging strips. The design of the driveway shall include provisions for the following:

- The driveway is to include, as applicable, table drain, gutter and footpath crossings in accordance with WSC standard drawings.
- A pavement design in accordance with an approved pavement design report.
- The continuation of the driveway into the main body of the lot to allow access to useable land either where the construction of that driveway at a later date would impact on adjoining property or where topography, natural obstructions or poor ground conditions would make the driveway construction expensive.
- The continuation of the driveway into the main body of the lot to the vicinity of any approved building envelope.
- Unless a larger design vehicle is intended, the design vehicle for bends in driveway alignment shall be a single unit truck. Pavement widths are to be increased to accommodate tracking of design vehicles.
- In long and multiple user driveways passing bays are to be provided at appropriate intervals and at unavoidable blind crests, side roads and curves.
- The driveway gradient on the approach to the road boundary shall comply with Australian Standards.
- Where practicable, the design of driveway levels, crossfalls and batters to allow sheet flow to cross the driveway in a manner which does not cause any concentration of flow or erosion potential. Where sheet flow across the driveway may create a nuisance to adjoining properties or cause erosion, the collection and discharge of driveway runoff including runoff from uphill areas is required. Driveway runoff is to be collected and piped to the street drainage.
- Where the collection and discharge of driveway runoff is required, in part or in full, based on hydrologic and hydraulic calculations the driveway will be provided with standard profile gutters and kerbs or formed shot-crete drains
- Any batters or earth retaining structures shall not restrict development over adjoining land or pose risks of instability or erosion.
- Any requirements imposed in relation to fire either through the Building Code of Australia or in Bush Fire Prone Areas, the NSW Rural Fire Services (such requirements may include controls on gradients, driveway widths, clearances and design vehicles for various travel paths).

- Completed works are to satisfy cover and clearance requirements for any utility authority mains and installations.
- The future provision of private service pipes and poles should be considered.

9.1.6 All Weather Access in Private Property

The standard of roads over and within rural properties may vary depending primarily on:

- The intended duration, frequency and type of rural use.
- The route terrain and ground conditions.
- Risks to users. eg provision of safety barriers, type of surfacing for traction, flooding.
- Risks to the Environment. E.g. erosion, pollution, watercourse ecology, flood levels.
- Use for bush fire fighting purposes and as fire escape routes.
- Construction difficulty, particularly achieving compaction and sealing on steep gradients.
- Maintenance considerations including the potential for obstruction of drainage pipes.

As a guide, a road to a rural residence would require:

- A single lane minimum four (4) metre wide flexible road pavement, table drains (pavement courses are extended to free drain into table drains), batters and provision for cross drainage.
- Passing bays provided at appropriate intervals and road widening at any blind crests, side roads and curves.
- Unless a larger design vehicle is intended, the design vehicle for bends in road alignment shall be a light commercial vehicle. Pavement widths are to be increased to accommodate tracking of design vehicles.
- A single coat bitumen seal centrally aligned three (3) metres wide. The pavement seal is to be widened to six (6) metres at sections of road containing passing bays, widening for tracking and through blind crests, side roads junctions and curves.
- A pavement designed in accordance with an approved pavement design report. A pavement report is to include details of any necessary subsoil drainage.
- High side grassed table drain developing into a lined drain where scour may become an issue.
- Low side provision for road runoff to sheet flow away.
- Minor cross drainage shall nominally be 1 in 5 year ARI capacity. Trafficable depths for 1 in 20 year ARI flows. Depth indicators shall be provided.
- Major cross drainage, box culverts and small bridges provided nominally 1:5 ARI. Trafficable depth for 1:20 ARI with depth indicators.
- Cross drainage lines are to extend to the alignment of the table drain invert.
- Headwalls and associated rock protection are to be provided to cross drainage.
- The gradient on the approach to the road boundary shall comply with the Australian Standard for Off Street Parking.
- Cut and fill batters shall be adopted for the ground conditions such as not to pose risks of instability.
- All cut and fill batters (and other remaining disturbed areas) shall be protected from erosion by vegetation.

- Any requirements imposed in relation to NSW Rural Fire Services (such requirements may include controls on gradients, driveway widths, clearances and design vehicles for various travel paths).
- Completed works are to satisfy cover and clearance requirements for any utility authority mains and installations.
- The future provision of any private service pipes and poles should be considered.
- Consider the need or desirability of safety barriers, guide posts, reflectors and warning signs.

9.2 Car Park Design

9.2.1 Non-domestic Parking Areas and Design Standards

Non – domestic parking areas shall be designed applying the requirements of AS 2890 as a minimum. The requirements of other chapters of the Wyong Council DCP shall also be addressed in the design.

The designer shall consider:

- Design vehicles.
- Pedestrian, cyclists and persons with disabilities.
- Driveway widths.
- Parking bays and aisle dimensions.
- Driveway locations.
- Driveway intersections with public roads.
- BCA fire requirements.
- Bush Fire Protection requirements.

9.2.2 Design vehicles

The design shall provide for all design vehicles expected to use the development.

Allowances for manoeuvres of commercial vehicles within the public roadway and in the entry driveway shall be appropriate for the vehicle's turning capabilities and frequency of servicing by those vehicles.

Access by inappropriate vehicles is to be constrained where practicable. Internally vehicles are to be controlled by physical barriers and signage.

9.2.3 Layout Compliance

The layout shall be consistent with the approved development plan particularly in respect of:

- Fixed setbacks.
- Fixed aisle and parking bay geometry.
- The locations and treatment of entries and exits.

The layout shall address detailed building design matters including:

- The intrusion of structural components such as columns.
- The overhead intrusion of ramps, escalators and stairs.
- ground clearance and headroom.

9.2.4 Travel Paths for Pedestrians, Cyclists and Persons with Disabilities

The design of internal driveways, paths and parking areas to be used by pedestrians, cyclists, delivery persons or persons with disabilities shall be appropriate for that usage.

The designer shall consider and make provision for:

- Desirable travel routes.
- Protection measures for travel path users.
- BCA Compliance.
- Facilitating use by persons with disabilities.
- Avoiding conflicts with travel paths of commercial vehicles or concentrations of cars.

9.2.5 Access Driveways

Access driveway layouts shall be appropriate for use by the types of vehicles accessing the development and regarding the traffic and geometric characteristics of the public road.

Adequate sight distance shall be available for drivers leaving the site to vehicular traffic on the road and pedestrians on the footpath having regard as appropriate to the speed of vehicles on the road and the lane configuration of the road.

9.2.6 Vehicular Control Points and Gates

Queuing areas shall be adequate for any vehicular control points having regard to:

- The user class.
- The road traffic volume.
- Entry/exit performance.
- The capacity of the car park.
- Parking turnover patterns.
- Control point operation.
- Providing for persons having disabilities.

9.2.7 Elevated Ramps and Ramps to Basements

The use of ramped sections of internal driveways and parking areas shall incorporate provisions for:

- Meeting acceptable gradients generally, at approaches to boundaries, control points and gates and as appropriate for use by the disabled where relevant.
- Appropriate alignment for the design vehicle usage.
- Achieving adequate sight distance for entering and emerging vehicle drivers.
- Separation of carparking bays from the ramp ends.
- Separation of any pedestrian crossing and informal pedestrian route from the ramp ends.

9.2.8 Vehicular Traffic Control

Road humps shall consider pedestrian and other travel paths and be appropriate for use and in accordance with geometry requirements for:

- AS/NZS 2890.1 Type 1.
- AS/NZS 2890.1 Type 2.
- AS 1742.13 Local area traffic management.

9.2.9 Commercial Vehicle Manoeuvring

The design shall provide for travelling, turning, standing, reversing and other activities associated with the servicing of the development by commercial vehicles in respect of:

- The appropriate classes of design vehicles.
- The frequency of visits made by commercial vehicles.
- The allocation of services bays, service area aprons and the "service area" as a whole (i.e. the area of the development set aside for the manoeuvring, parking and loading or unloading of commercial vehicles for the delivery or removal of goods, freight or waste).
- The suitability of any area of the development in addition to the service area which is to be used by commercial vehicles in common with other vehicles.
- Conflicts with other vehicle travel paths.
- Avoidance of pedestrian travel paths.
- Turning circles including reversing turning, and swept travel paths.
- Loading/unloading operations.
- Roadway widths.
- Overhanging of medians, islands, landscaping.
- Mountable design of kerbing, medians, islands and roundabouts.
- Clearances to adjacent buildings and obstructions, lighting and signposting poles.
- Separation from pedestrians.
- The provision of signs and pavement markings to keep commercial vehicle travel paths separate from car parking.

9.2.10 Protection of Pedestrians

Adequate measures shall be provided to separate vehicular and pedestrian traffic including the use of:

- Kerbs or low barriers.
- Bollards.
- Hand railings or fencing including childproof fencing.
- Pedestrian refuges.
- Kerb blisters in roadways.
- Marked pedestrian crossings.
- Grade separation using footbridges or underpasses.
- Alternate travel paths.
- Ramps in kerbs for prams, trolleys, wheelchairs and scooters.
- Separation of any pedestrian crossing and informal pedestrian route from the ends of vehicle driveway ramps.

9.2.11 Shopping Trolley Bay Locations

The locations of shopping trolley bays shall be considered at the detailed design stage with regard to the following:

- Access to the bays should at all times be clear of commercial vehicle manoeuvring areas and where practicable circulating traffic routes.
- The proximity should be open and well lit for user personal safety and to enhance visibility of trolleys abandoned on the surrounding.
- Surface gradients should be minimal to allow ease of control of the trolleys.
- Surface drainage flows should be minimal so as not to discourage use of the bays in wet weather.

9.2.12 Bicycle Parking Facilities

The design of bicycles parking facilities and their access shall make provision for:

- The class of bicycle parking facility.
- The type and set out of parking rails and racks.
- The need for lighting.
- The need for weather protection.
- Specified clearances to pedestrian and vehicular traffic.
- General avoidance of immediate proximity to pedestrian doorways, attachments for blinds and awnings, pavement service access covers, street furniture, bus stops, loading zones, pedestrian crossings and areas over which car doors may be opened.
- Signage for locating and using the facilities.
- Security, access and ease of use for the relevant class of facility.

9.2.13 Pavement Surfaces

Pavement surface finishes shall be appropriate for roadways, accesses, pathways, ramps including pram ramps, parking area and loading dock pavements in respect of use by:

- Motor vehicles including motor cycles and motorised wheelchairs.
- Bicycles and wheelchairs.
- Pedestrians.
- Persons with disabilities.
- Persons with prams.
- Manual handling of goods.

The design shall provide for:

- Tactile markers.
- Colour contrasting with their surroundings of tripping hazards such as kerbs, wheel stops and low barriers.
- Raised pavement markers specified shall not be greater than 3mm in height.
- Lipless kerb crossings for trolley access on main pedestrian paths.
- Physical controls or traffic management devices shall not obstruct or impede access or create a hazard on travel paths by reducing the available width to less than 1 metre or forcing unsafe manoeuvres.

9.2.14 Gradients for Pavement Areas

The grading of pavement areas shall comply with requirements for:

- Domestic driveways.
- Maximum gradients for vehicular traffic aisles.
- Maximum length wise gradients for car spaces.
- Maximum cross falls for car spaces.
- Minimum gradients for pavement surface drainage.
- Minimum gradients for pavement edge drainage.
- Changes of gradients in driveways.
- Gradients at vehicular control points and associated queuing areas.
- Gradients in access driveways approaching boundaries.
- Gradients across footpaths.
- Where applicable maximum longitudinal gradients for cyclists, pedestrians, persons with disabilities and associated vehicles.
- Where applicable maximum cross falls for cyclists, pedestrians, persons with disabilities and associated vehicles.
- Maximum gradients and cross falls including superelevation for circulation roadways and ramps.
- Containment of shopping trolleys.
- Maximum gradients for special loading/unloading parking spaces.

9.2.15 Signage

Appropriate street signage shall be included for:

- Signifying car park entries.
- Signifying other entries.
- Warning of vehicles entering traffic.
- Warning of aged or disabled pedestrians or schoolchildren.

Appropriate signage shall be included within the site for:

- Controlling traffic movement and driver behaviour.
- Warning of hazards for vehicles or persons.
- Identifying sections or rows of car parking spaces.
- Identifying bus routes and lay-bys.
- Identifying en-route car, motor cycle and bicycle parking and roadway destinations.
- Directing pedestrians to travel paths, stairs, lifts and amenities and showing the layout of the development.
- Assisting people with disabilities.
- Controlling noise, car lights or other environmental nuisances.

9.2.16 Landscaping

The landscaping design shall address:

- Instances where there is a need or likelihood that vehicles will overhang kerbs.
- Avoidance of creating obstructions against parking spaces.
- The performance and sufficiency of street lighting and proposed development lighting.
- The adequacy of sight lines for vehicular traffic entering and exiting the development.
- The adequacy of sight lines for users of all internal travel paths.
- The visibility of signage.

9.2.17 Surface Drainage

The proposed stormwater drainage system and pavement grading shall prevent nuisance flooding of the pavement at:

- Areas of car spaces used to get into or alight from vehicles.
- Main pedestrian and other travel paths.
- Pram ramps.
- Approaches to pedestrian crossings.
- Approaches to intersections.
- Special loading and unloading spaces.
- Disabled car parking spaces.

- Loading docks.
- Bicycle parking facilities.
- Taxi ranks and bus stops.

The proposed stormwater drainage system with the pavement grading shall prevent any flooding of the pavement at:

- Any building doorway or stairway.
- Any pavement or floor drained directly or indirectly to a sewer.
- Any vulnerable surface installation or pit containing machinery, electrical equipment, pipe inlet/outlet fittings or storage tank for the servicing the development.

9.3 Footpaths and Pathways

9.3.1 Design Standards

Footpaths and Pathways shall be designed with reference to Austroads Guides and Australian Standards. Generally the provisions of this guide if different from Austroads Guides and Australian Standards will take precedence in design. However it is noted that some situations may warrant alternative measures to those specified in this guide.

9.3.2 Designing for Pedestrians and Mobility Impaired

Consideration is to be given to designing for pedestrians in applicable aspects of the design of roads and road related areas.

Unless otherwise excluded through the Development Consent, provision shall be made for the use of all public pathways by the Mobility Impaired. In this regard a Development Consent involving roads in excess of appropriate gradients excludes this compliance for footpaths.

Provision for use by mobility scooters shall be made where such use is likely or where required by an approval. Examples include access for aged care facilities, shopping centres and in passive recreation areas.

9.3.3 Footpaths in Public Roads

Foot paving in new public roads shall be provided in accordance with the requirements of other Chapters of Council's DCP or as specified in the development consent.

New foot paving in shall be 1.5m wide, located generally parallel to the adjacent kerb at a distance of 0.6m from the property line.

Foot paving in roads generally has a longitudinal grade the same as the roadway, being an absolute minimum of 0.5% and a desirable maximum of 16%. Where grades exceed 16% special consideration is to be given to alternative access for pedestrians.

A crossfall of 4% applies to footpaving in general. In areas of high pedestrian activity the crossfall is to be reduced to 2.5% provided that the low edge of the paving will drain freely.

In any instance consideration is to be given to the requirements of lot access, the volume and type of pedestrians and Service Authority requirements for existing and proposed utility services.

Kerb ramps shall be provided at road crossing points. Kerb ramps shall be in accordance with Council's standard drawing SD21C.

9.3.4 Public Pathways

Public pathways may be required to be constructed outside a road reserve to:

- Complete a pathway system.
- Be used in conjunction with an overland flow path work.
- Provide access to a specific facility.
- Facilitate a maintenance activity.
- Provide for recreational, scenic or tourist purposes.

Pathways are to be shown on design drawings where:

- The requirement for a pathway is nominated in other Chapters of Council's DCP.
- Nominated by the applicant as part of the development works.
- Required separately by conditions of the Development Consent.

The standard of design may vary depending on the volume and type of pedestrians expected, streetscape, public safety and other considerations. A maximum grade of 8% typically applies to a concrete public pathway not located adjacent to a road. Austroads guides shall be referenced when designing pathways.

Pathways pavements shall be constructed in accordance with standard Council drawings as follows:

- SD 5B Standard Footpath and Cycleway Details
- SD 15B Standard Pathway Barrier
- SD 24B Pathway Steps (permitted only where a ramped alternative cannot be provided)

Alternate details to Council's standard drawings may be required to cater for a particular circumstance. Refer to also to Part 7 Pavement Design.

The design of off-road pathways may require consideration of matters not encountered in providing paving in formed road footpaths including:

- Catch drains to control uphill runoff.
- Protection of batters.
- Provision of handrails, barriers, fences or bollards.
- Cross drainage.
- Additional lighting.
- Public safety.
- Minimisation and facilitation of maintenance activities.

9.3.5 Public Pathways used as Overland Flow Paths

Pathways used as overland flow paths shall generally have:

- A preferred cross fall of 3%.
- An integral 150mm kerb on the low side unless flows are of such a magnitude to warrant special treatment.
- Sufficient capacity to carry the flows with required freeboard.
- Velocity x depth flow criteria for safety to be less then 0.4.

Other forms of pathways for overland flow paths may be considered by Council. Concepts shall be discussed with Council' Development Engineering Section prior to preparation of detailed designs.

9.3.6 Pathways used as Shared Bicycle Facilities

Where a Public Pathway is stipulated as a shared cycleway and bicycle facility the applicable design requirements for cycle ways and bicycle facilities are also to be met.

9.3.7 Ramps and Steps

The provision of steps will only be permitted in steep sections of pathways where no reasonable alternative or ramp arrangement can be provided and the limitation of use of the pathway is accepted as part of the development consent.

Ramps in excess of 8% (other than footpaving in roads) and steps shall be provided with handrails, tactile indicators and lighting.

Specific design details including geometric and structural design shall be provided for ramps and steps.

9.4 Cycle ways and Bicycle Facilities

Consideration is to be given for cyclists in all aspects of road design and roads related areas. Cycleways and other facilities such as cycle parking facilities are to be included in the design where specifically nominated in the development consent, other chapters of Council's DCP or other applicable documents.

Cycle ways and bicycle facilities shall generally be designed in accordance with the requirements of Austroad guides. Issues not covered by Austroad Guides shall be discussed with Council's Development Engineering Section.

Where cycle ways and bicycle facilities are required all related issues including the following shall be considered and detailed on the design drawings:

- Location, horizontal and vertical alignment.
- Width (2.5m minimum) and cross fall.
- Drainage.
- Signage and pavement markings for pedestrians, cyclists and motorists.
- Vertical and lateral clearance to structures, top of embankments, hazards.

- Minimisation of projections into the cycleway (service pits etc).
- Maintenance and access crossings. Thickening, reinforcing and highlighting of such areas.
- The provision of adequate safety railings.
- The provision where warranted of cycleway hand railings at intersections and road crossings.
- The need for the provision of lighting.
- Measures to ensure the distinctiveness of presence and continuity of cycleways, e.g. through changes in pavement types or character of the facility.

PART 10 – STORMWATER DRAINAGE DESIGN

10.1 Introduction

10.1.1 Objectives

The broad objectives seek to achieve an optimum urban environment within the principles of ecologically sustainable development.

Stormwater objectives are seen as being achieved when:

- The planning, design and construction of new facilities is adequate to service new and future developments consistent with both the engineering, environmental and planning best practice.
- There is compatibility with existing facilities, operational methods, and maintenance techniques.
- The facilities provide adequate environmental, community, and asset protection consistent with the accepted design and construction requirements set out in this document and with developments in technology as approved from time to time.

10.1.2 Other Documents

These design guidelines should be read in conjunction with the Civil Works Construction Specification, other chapters of Council's DCP and Council Policies and Plans relating to flooding.

10.2 Design Philosophy

10.2.1 General

Designs for Stormwater Drainage are to be prepared generally adopting the approaches used in "Australian Rainfall and Runoff", Published by Engineers Australia and "Australian Runoff Quality – A guide to Water Sensitive Urban Design", Published by Engineers Australia. Other current Australian published design guides e.g. Austroads and Australian Standards may also be applied to particular design situations. In any case design parameters specified in this document shall be used unless agreement is made with Council's Development Engineering Section to use alternate parameters.

10.2.2 The Major / Minor Stormwater Systems

The provision of stormwater drainage consists basically of a pipe system for controlling nuisance flooding (minor system) combined with a continuous overland flow path or floodway system (major system) to accommodate less frequent flood events and flows in excess of the minor systems. The major/minor concept may be described as a 'system within a system' for it comprises two distinct but conjunctive drainage networks.

All new urban development shall be provided with a major drainage system designed with sufficient capacity and freeboard to ensure that flood flows up to 100 year Average Recurrence Interval(ARI) do not encroach upon private land.

The major drainage system typically consists of the arrangement of pavements, roadway reserves, engineered flow paths and waterways, retarding basins, and major cut-off drains planned to convey a design flow of 100-year ARI in conjunction with the available capacity of the minor drainage system.

10.2.3 Provision for Failure

If failure of stormwater drainage system components occurs during periods of extreme rainfall, the risk to life and property could be significantly increased.

It is important to ensure that the combined major/minor system can safely cope with reasonable surcharge due to blockages and flows in excess of the design ARI.

In establishing the layout of the pipe network, designers shall ensure that surcharge flows will not discharge onto private property during flows up to and including 100 year ARI.

For flows in excess of 100 year ARI, Designers shall ensure that the likelihood of nuisance flooding or damage to private properties is considered and minimised and the likelihood of catastrophic consequences are considered and averted.

All stormwater detention basins and ponds involving dams are to be assessed by the designer under Dams Safety Committee Guidelines, the assessment report submitted to Council for concurrence and referred by the designer to the Committee where required.

10.2.4 Natural Drainage Paths

The minor and major drainage systems shall be planned and designed so as to generally conform to natural drainage patterns and discharge to natural drainage paths in the catchment. If deemed essential these natural drainage paths are to be modified as required to accept the higher peak flows resulting from urban development. The minor drainage system layout may conform to road and lot layouts.

Runoff must be discharged from a development in a manner that will not cause adverse impacts on downstream property, stormwater systems or natural watercourses. In general, runoff from development sites within a catchment shall be discharged at the existing natural drainage outlet or outlets. If the Designer wishes to change discharge points or apportionment of catchment flows between discharge points, they must demonstrate that the change will not have unacceptable adverse impacts on downstream properties or stormwater systems.

10.2.5 Surface Flows

Surface flow safety criteria must be applied to minimise both nuisance flooding and major hazards from flooding of roadways, buildings, and other areas that have regular public access.

10.2.6 Interallotment Drainage

Interallotment Drainage shall be provided for every allotment which does not drain directly to its street frontage and for high side properties fronting roads with either kerbing unable to satisfactorily accommodate kerb outlets or where carriageways have one way crossfall.

10.2.7 Runoff Quantity Control

The level of runoff control required is dependent on the type of development proposed.

Flow control requirements are stipulated for the following:

- new development,
- redevelopment of existing sites,
- augmentation of existing stormwater systems.

10.3 General Requirement for Developments

10.3.1 New Developments

Each new development is to be considered individually with regard to existing and proposed drainage systems, location in the catchment and other matters relating to storm water.

Generally, it can be expected for new development proposals that, the post-development peak flow from the outlet point(s) of the site to the downstream public drainage system or receiving water shall not exceed the pre-development peak flow for both the minor and major system design storm ARI.

Pre-development peak flow shall be the estimated flow from the site based on known or estimated catchment conditions prior to the new development.

To reduce peak outflows, the stormwater system may be provided with flow attenuation measures such as retarding basins, floodway storage, or active storage within urban lakes and water quality control ponds and/or the compensating augmentation of existing drainage systems.

Design storm ARIs for the minor and major drainage systems shall be selected in accordance with Section 10.4.2.

The requirements for the provision of stormwater retarding, detention, storage or other control facilities shall be determined by Council after consideration of relevant stormwater drainage analysis and concepts plans required as part of the development application documentation.

10.3.2 Redevelopment of Existing Developed Sites

Each redevelopment proposal is to be considered individually with regard to existing and proposed drainage systems, alteration or abandonment of existing infrastructure, location in the catchment and other pertinent matters.

Redevelopment includes land redevelopment and subdivision redevelopment.

Land redevelopment is considered to be the redevelopment of single lots or multiple adjacent lots where all of the stormwater system will be privately owned. This includes both Unit and Dual Occupancy developments.

Subdivision redevelopment is considered to be redevelopment where all or parts of the stormwater system will become part of the public drainage system.

Generally, it can be expected for redevelopment sites that, the post-redevelopment peak flow from the outlet point(s) of the redevelopment site to the existing downstream public drainage system or receiving water shall not exceed the pre-redevelopment flow for both the minor and major system ARI.

The pre-redevelopment peak flow shall be the estimated flow from the site based on the development conditions (including any existing flow attenuation facilities) prior to redevelopment.

The degree of runoff control required will depend on the scale of the development and the net change in impervious area. Flow control will be required for any redevelopment where the density (measured as the total equivalent impervious area) of the redevelopment is greater than that of the existing development.

The storm water drainage design for redevelopment site is to ensure that the redevelopment does not create or worsen any capacity problems in the existing public drainage system. This will generally require the construction of on-site and/or off-site public detention/retention systems and/or the compensating augmentation of existing drainage systems.

The minor and major system design storm ARIs referred to shall be those appropriate for the existing development in accordance with Section 10.4.2. Note that these are the ARIs that the existing public drainage system should have been designed for, not the as-constructed capacity of the system.

The requirements for the provision of stormwater retarding, detention, storage or other control facilities shall be determined by Council after consideration of relevant stormwater drainage analysis and concepts plans required as part of the development application documentation.

10.3.3 Stormwater System Augmentation

Stormwater system augmentations are undertaken in existing urban catchments to alleviate flood hazards due to under-capacity minor and/or major drainage systems. The main objectives for such augmentation works are to improve flood protection for land and to increase pedestrian safety and vehicle stability on roadways.

The potential to increase the flow carrying capacity of existing roadways is usually limited.

To achieve the objectives of the stormwater drainage augmentation it may be necessary to increase the ARI capacity of the minor drainage system above that specified in Table 10.1 in order to ensure that:

- The 100 year ARI 'gap' flow on roads (refer to Section 10.4.2) meets the surface flow criteria limits.
- Overland flow from storms up to and including the 100 year ARI is not discharged through easements over private land on the low side of road verges, particularly at steep 'T' intersections and trapped road low points.

10.3.4 Stormwater Inlet and Outlet Discharge

The following requirements shall apply to the design of system inlets and outlets:

- Where no Council piped drainage system exist the maximum permissible site discharge from a development to either the kerb and gutter or table drain shall be up to 25 litres/sec at any one discharge point. Discharge points shall be at least 15m apart.
- For other than single residential or dual occupancy developments, Council's Development Engineering Section shall confirm whether the maximum or any discharge will be allowed to the street surface drainage system in the individual case.
- The design of all inlets and outlets shall ensure that there are no adverse impacts arising from any changes of upstream and downstream water surface levels , flow velocities and flow direction.
- Scour protection at culvert or pipe system inlets and outlets shall be designed in accordance current best industry design guidelines unless outlet conditions dictate the use of more substantial energy dissipation devices for which detailed design is to be carried out with supporting calculations.
- At points of discharge of gutters or stormwater drainage lines or at any concentration of stormwater from or to adjoining properties, Council will require the Developer to enter into a Deed of Agreement with the adjoining owner(s) granting permission to the discharge of stormwater drainage and the creation of any necessary easements with all costs being met by the Developer prior to development approval.
- Where the drainage is to discharge to an area under the control of another statutory authority e.g, the Crown, Public Works, the design requirements of that Statutory Authority are also to be met.
- Piped stormwater drainage discharging to or through recreation reserves, if permitted under the relevant plan of management, is to be taken to a natural water course and discharged through an approved outlet structure or alternatively taken to the nearest stormwater line. All works are to be subject to detailed design. The creation of easements may be required.

10.3.5 Stormwater Quality Control

Urban development will generally result in an increased level of export of a wide range of non-point source pollutants. To protect the quality of local streams, lakes, and river systems, a number of storm water quality control strategies have been adopted by Council. These include:

- the establishment of urban lakes, primarily as biological treatment systems,
- the utilisation of water quality control ponds (WQCP) and constructed wetlands, as physical and biological treatment systems, upstream of urban lakes,
- the incorporation of gross pollutant traps (GPT) on inlets to urban lakes and WQCPs to intercept trash and debris and the coarser fractions of sediment,
- the incorporation of 'off-stream' sediment interception ponds (SIP) in land development works to intercept and chemically treat runoff prior to its discharge to the stormwater system.

The Developer and their consultants should confirm with Council at the stormwater drainage concept plan stage which strategies have been implemented or planned to be implemented for the catchment in which the development is located. In the case that Council has not adopted or implemented a storm water quality control strategy that will cater for the a subject development then the developer will be required to demonstrate by recognised modelling and other calculation that storm water quality treatment objectives quoted in the "Australian Runoff Quality – A guide to Water Sensitive Design" Published by Engineers Australia can be met by implementation of a stormwater quality strategy for the Development.

10.3.5.1 Computer Modelling For Storm Water Quality Concept Design.

Appendix D provides guide lines and tools for the use of the , MUSIC (Model for Urban Stormwater Improvement Conceptualisation) within the Wyong Shire area. Other models may be used for concept plan modelling provided it can be demonstrated that they are suitable for the purpose of concept design.

10.3.5.2 Detail Design of Storm Water Quality Control Measures and Device

Modelling tools such as Music(Model for Urban Stormwater Improvement Conceptualisation) are only for concept design purposes. Detail design shall be based on guideline in publications such as Australian Runoff Quality (ARQ) by Engineers Australia.

10.3.6 Landscaping and Stormwater Infrastructure

The following landscape requirements are intended to ensure that the stormwater drainage system will enhance an area while ensuring that tree planting does not result in flood or tree root intrusion problems.

Tree planting should be restricted within 3 m of a stormwater pipelines except in the case of tree planting in street verges. Vigorous rooting tree species shall not be planted within 10 m of a stormwater pipeline. Where a pipeline passes near or under existing mature trees, consideration shall be given to the use of an alternative alignment.

Allowance shall be made for the effects of landscaping in the hydraulic calculations of floodways and engineered waterways. Approval from the Council is required for the design factors used.

The design of landscaping shall also consider any increased frequency and the facilitation of maintenance of the stormwater system infrastructure.

10.3.7 Maintenance

The stormwater drainage system shall be designed to be readily and economically maintained. Allowances for maintenance including adequate and stable access for maintenance machinery shall be detailed in the design.

Designs incorporating the need for special or unusual equipment should not be prepared without the prior approval of the Council. This approval also extends to the use of special techniques or the hire of special equipment.

The Designer shall refer to the Council for specific maintenance requirements for situations not covered by this document.

10.4 Hydrology

10.4.1 Design Principles

Design methods and data for urban drainage shall be taken from the latest edition of Australian Rainfall and Runoff unless otherwise required by this document.

For catchment areas greater than 50 hectares, two recognised flow estimation methods shall be used for comparative purposes.

Design methods for internal drainage of developments and improvements within a single allotment shall generally be in accordance with the most current version of AS 3500 – Plumbing and Drainage Part 3 Stormwater Drainage.

10.4.2 Design Average Recurrence Intervals

The major/minor drainage system design ARI shall be selected in accordance with Table 10.1.

Table 10.1 Major/Minor System Design ARI

Minor System	ARI
Land Use:	
Urban Residential (single allotments)	5 Year
Urban Residential (medium-high density see below)	20 Year
Commercial	20 Year
Industrial	20 Year
Rural Developments	10 Year
Major System	ARI
Overland Flow Paths and Trunk Drainage	100 Year

The following provisions also apply to adoption of design ARI:

- The design ARI for cycleways and bridges should be consistent with Austroads design guides.
- The analysis carried out by the Designer shall in any instance take into account the possibility of property damage or danger to life that might occur in specific situations outside the recommended design ARI.
- Major overland system flow paths within developments such as pathways or roadways shall cater for the 100 year ARI Event minus 50% of the minor flow (piped system, eg 5 year ARI, see above). This is generally referred to as the "gap-flow". Refer to Austroads Guides to Road Design Part 5: Drainage Design.
- Trunk drainage is excluded from the above "gap-flow" design procedure.

In addition to the above, where a development is designed in such a way that the major system flows involve surcharge across private property, then the underground system (both pipes and inlets with designated blockage factors) shall be designed to capture and contain flows having an ARI of 100 years from the

upstream catchment. An emergency overland flow path shall also be provided for these systems. Easements are to be provided in private property over such pipe systems and overland flow paths. Restrictions shall also be placed on the property so as not to permit changes in surface levels or the construction of certain structures within these easements.

10.4.3 Impervious Area Assumptions

10.4.3.1 Minimum Lot Design Impervious Fraction

The following minimum design impervious percentages shall be used for design purpose unless alternate percentages which are based on site specific details of a proposed development can be determined.

The minimum design impervious percentage for single residential lots shall be:

- 85% for lots 450m^2 and smaller.
- 80% for lots 450m^2 to 700m^2.
- 75% for lots greater than 700m^2.

The minimum design impervious percentage for other lot types shall be:

- 90% for medium and high density residential.
- 95% commercial or industrial developments.

10.4.3.2 Composite Areas

For larger-scale modelling of urban catchments, sub-catchments are typically composite areas that include land, road reserves and open space areas etc.

Table 10.2 Composite Impervious Area Guidelines

Type of Development	Design Impervious Area (%)
Single Residential Lot Subdivisions	80
Multi-Units	90
Commercial and Service Trades	90
Group and Neighbourhood Shopping Centres	90
Town Centres	90
Industrial	90

The Designer shall assess whether the adoption of typical values is accurate enough for the purposes of the drainage analysis. This may be sufficient for preliminary design or master planning, however, a more accurate assessment of total impervious area may be necessary for the investigation of stormwater system failures or detailed design.

10.4.4 Rational Method

The following procedures including Partial area effects shall be adopted when using the Rational Method for drainage design in urban catchments.

10.4.4.1 Catchment Areas

The catchment area of any point is defined in general by the limits from where surface runoff will make its way, either by natural or man made paths, to this point. Consideration shall be given to likely changes to individual catchment areas due to the full development of the catchment.

Where no detailed survey of the catchment is available, 1:4000 ortho photo maps as a minimum are to be used to determine the catchment and to measure areas.

Catchment area land use shall be based on current available zoning information or proposed future zonings, where applicable i.e., the ultimate likely developed state of each catchment including all contributing catchments. Provisions shall be made where the likelihood of higher density developments will take place in the future.

Catchment area details shall be presented as part of the design with sufficient information to enable Council's Development Engineers to be satisfied that the correct catchment allowances have been made in the design.

10.4.4.2 Time of Concentration

The time of concentration of a catchment (tc) is defined as the time required for storm runoff to flow from the most remote point on the catchment to the outlet of the catchment.

The determination of a time of concentration shall be undertaken in accordance with the methods and guidance included in Technical Note 3 Book VIII Urban Stormwater Management Australian Rainfall and Runoff 2001 and the following Council requirements:

- The minimum time of concentration (tc) to be considered shall be 5 minutes.
- The maximum tc in an urban area shall be 20 minutes unless sufficient evidence is provided to justify a substantially greater time.
- The tc in rural areas shall be calculated in accordance with Section 1.4 of Book IV AR&R 2001.
- The tc shall be for the ultimate developed catchment generally catering for the greatest flow.

Consideration shall be given that natural or developed catchments have defined flowpaths and sheet flows generally occur for short distances only. The tc should be calculated using a combination of the Kinematic Wave and Manning's formula to determine as accurately as possible the actual tc. Unless sufficient evidence is provided, the Kinematic Wave equation shall be used for a maximum 50 metre length in determining the tc.
Where the flow path is through areas having different flow characteristics or includes property and roadway, then the flow time of each portion of the flow path shall be calculated separately and added.

Flow paths to pits shall be representative of the fully developed catchment considering such things as fencing and the likely locations of buildings and shall be shown for each collection pit or other device on the catchment area plan.

Consideration shall be given to likely changes to individual flow paths due to the full development of the catchment.

10.4.4.3 Design Rainfall Intensities

The design rainfall intensities given in Appendix B shall be used for the estimation of design flows in all areas. Design rainfall intensities have been determined using the Intensity Frequency Distribution (IFD) data shown in Appendix B.

10.4.4.4 Runoff Coefficient

Coefficients of Run-off shall be calculated in accordance with Section 1.3.2 of Book IV AR&R 2001 and full details of coefficients utilised shall be provided in design calculations.

10.4.5 Rainfall / Runoff Models

The specific parameters recommended for rainfall/runoff computer programs include:

- Design rainfall loss rate estimation parameters.
- Surface runoff routing parameters for pervious and impervious areas.
- Design storm event modelling procedures.

Parameters and procedures as nominated in the following clauses shall be used in lieu of values and procedures recommended in program documentation and related reports.

Where computer analysis programs are used, copies of the final data files of the design shall be provided with the final drawings for approval by the Certifying Authority. Details on the use of specific programs, catchment parameters and any other relevant information shall also be submitted.

10.4.5.1 Drains or Ilsax

The Drains and Ilsax program incorporates the Horton's infiltration equation to determine rainfall losses occurring on pervious surfaces. Drains and Ilsax also requires that a catchment soil type and antecedent moisture condition be specified.

The rainfall loss parameter values to be adopted shall be:

Impervious(paved) depression storage	1mm
Pervious(grassed) depression Storage	5mm
Soil Type	3.0
Antecedent Moisture Condition (AMC)	3.2

The procedure to calculate the time of concentration for sub-catchment pervious runoff shall be that specified for overland flow in Section 10.4.4.2.

The time of concentration for all impervious areas should be set at 6 minutes.

10.4.5.2 Rafts

The Rafts program offers a choice between two approaches to rainfall loss estimation. They are the initial/continuing loss model and the infiltration/water balance procedure which utilises the Australian Representative Basins Model (ARBM). The use of the ARBM loss model shall be used in preference to the initial/continuing loss model due to the ability of ARBM to model a range of ARI events with a single set of model parameters.

The values for the ARBM loss model to be adopted are given in Table 10.3.

The recommended surface runoff routing parameters in Table 10.4 shall be adopted.

Table 10.3 Rafts ARBM Parameters

Parameter	Adopted Values	Initial Values
Storage Capacities		
Impervious (IMP)	0.50	0.0
Interception (ISC)	1.00	0.0
Depression (DSC)	1.00	0.0
Upper soil (USC)	25.00	20.00
Lower soil (LSC)	50.00	40.00
Infiltration		
Dry soil sorptivity (SO)	3.00	
Hydraulic conductivity (KO)	0.33	
Lower soil drainage factor (LDF)	0.05	
Groundwater recession: Constant rate (KG) Variable rate (GN)	 0.94 1.00	
Evapo-Transpiration		
Proportion of rainfall intercepted by vegetation (IAR)	0.70	
Max potential evapo-transpiration: Upper soil (UH) Lower soil (LH)	 10.00 10.00	
Proportion of evapo-transpiration from upper soil zone (ER)	0.70	
Ratio of potential evaporation to A class pan (ECOR)	0.90	

Table 10.4 Rafts Surface Runoff Routing Parameters

Parameter	Value
Impervious surface roughness	0.015
Pervious surface roughness	0.040
Non-linearity coefficient (default)[)]	0.285

10.4.5.3 Rorb

The Rorb model utilises a constant loss rate for impervious areas and an initial loss followed by a runoff coefficient or constant (continuing) proportional loss rate for pervious areas. The rainfall loss parameters in Table 10.5 shall be adopted for pervious areas.

Table 10.5 Rorb Pervious Area Rainfall Loss Parameters

Parameter	Value
Initial loss	10mm
Runoff coefficient	45%

The Rorb runoff routing method is based on the storage-discharge relationship, S = 3600kQm.

The dimensionless coefficient, m, is a measure of catchment non-linearity with a value of 1.0 implying a linear catchment. The dimensionless empirical coefficient, k, is the product of two factors, kc and kr. The factor kr is a dimensionless ratio called the relative delay time applicable to an individual reach storage and kc is an empirical coefficient applicable to the entire catchment and stream network.

The runoff routing parameters in Table 10.6 shall be adopted.

Table 10.6 Rorb Runoff Routing Parameters

Parameter	Value
m (adopt default)	0.8
kc (adopt default equation)	$2.2\ A^{0.5}$

10.4.5.4 Water Bounded Network Model (WBNM)

The WBNM program offers a choice between two approaches to rainfall loss estimation. They are the initial/continuing loss model and the initial/proportional loss model. The initial/continuing loss model shall be used for both urban and rural catchment in the ACT with the recommended values given in Table 10.7.

Table 10.7 WBM Rainfall Loss Values

Catchment	Initial Loss (mm)	ARI				
		2	5	10	20	≥50
		Continuing Loss (mm)				
Rural	0	3.6	3.3	2.8	1.7	1.0
Urban (30% urbanised)	0	2.5	2.3	1.9	1.2	0.7

The values of parameter C in Table 10.9 are recommended for use with the initial/continuing loss model for modelling ungauged catchments.

Table 10.8 WBM Parameter C Values

Number of Sub-catchments	Parameter *C*
1	1.14
≥4	0.90

For non-linear channel routing, the recommended values for the watercourse factor, WCFACT, are given in Table 10.9.

Table 10.9 WBNM WCFACT Values

Watercourse Type	*WCFACT*
Natural channel	0.6
Gravel bed with rip-rap	0.4
Excavated earth	0.3
Concrete lined	0.2

10.4.5.5 Other Methods and Models

The use of other propriety hydrological methods or models will not be permitted without prior approval from Council's Development Engineering Section.

To obtain approval, the Designer must demonstrate, to the satisfaction of the Council's Development Engineering Section, that a particular method or model is appropriate.

10.5 Road Drainage

10.5.1 Road and Street Network

Urban road storm water drainage systems are required to operate in an effective manner with minimal maintenance requirements.

The following provisions shall apply to road drainage design:

- Gutters shall be provided for all kerbs where pavement areas drain to the kerb.
- Adequate pipe and pit inlet capacity shall be provided such that surface flows up to the minor system design ARI are drained from the surface.
- Consideration should be given to the placement and location of pit inlets to minimise driveway conflicts and to adequately intercept surface water from steep grades. This particularly applies where a steep side street intersects a cross street at a 'T' intersection.
- The design of driveways across the verge should take account of water flowing in the street. The verge and driveway profile must maintain a positive grade for sufficient distance behind the kerb to avoid road flows in excess of the pipe system capacity up to the 100 year ARI level from entering adjacent land.
- The use of high inlet capacity pits should be avoided wherever possible and will only be permitted in non-residential areas.
- Grate only inlet pits will not be permitted except in laneways with narrow verges or no verges and where a kerb inlet type sump would conflict with other services.
- A cul-de-sac which falls toward the head shall have an overland flow drainage reserve from the low point in the head to ensure that flows in excess of the capacity of the pipe system, up to 100 year ARI, do not cause flooding within properties. The verge shall be shaped to direct overflows to the drainage reserve.

10.5.2 Surface Flow Criteria

Surface flow criteria must be applied to minimise both nuisance and hazardous flooding conditions on roadways. The criteria shall comprise three basic limits, depending on the road lane configuration and the design storm ARI:

- A flow width limit.
- A pond or flow depth limit.
- A flow velocity x depth limit (for stability of pedestrians and vehicles).

Kerb flow widths may be estimated in accordance with the procedure contained in Australian Rainfall and Runoff.

10.5.3 Surface Flow Criteria for Road with Carriage Way Widths of 11m or Greater

The criteria described in Table 10.10 shall be the design flow criteria used for road drainage where the carriageway width is 11m or greater.

Table 10.10 Surface Flow Criteria for Roads with Carriageway width of 11m or greater (Source: adapted from Queensland Road Drainage Design Manual, 1999)

Criteria	Surface Flow Limit
Minor System Flow	
Two through lanes in the same direction	One full lane clear + minimum 2.5m clear width in the other lane
One lane plus parking lane	One full lane clear
One lane	Minimum 3.0m clear width in the lane
At medians	Minimum 2.5m clear width in the traffic lane
At turn lanes	Minimum clear width of 3.0m in the lane
At pedestrian crossings	$W \leq 0.45$m (1 year ARI flow)
At intersection kerb returns	Clear turning width of 3.0m
50 Year ARI Flow	
Major traffic routes	One full lane clear
Major System Flow	
All locations	$D \leq$ 50mm above top of kerb
Pedestrian safety: (a) no obvious danger (b) obvious danger	 $V.D < 0.6$m^2/s $V.D < 0.4$m^2/s
Vehicular safety	$V.D < 0.6$m^2/s

Notes on Table 10.10:

1 W = flow width on road from kerb gutter invert.

2 Flow limit criteria applies to each direction of traffic flow.

3 D = flow depth on road at kerb gutter invert.

4 V = average longitudinal flow velocity.

5 Lane includes acceleration or deceleration lanes > 60 km/h and any parking lane that has the potential in the future to become used as a through lane for full or part time.

10.5.4 Surface Flow Criteria for Road with Carriage Way Widths of 11m or Less

The following criteria described shall be the design surface flow criteria used for road drainage where the carriageway width is less than 11m:

- Pedestrian safety and vehicular safety shall be the same as that for carriageway widths 11m or greater (see Table 10.10).
- The width of flow depth and ponding depth at sag points shall be no more than 70mm regardless of the pavement crossfall or kerb type.

10.5.5 Major Traffic Routes

Major traffic routes (Arterials and Sub-Arterials) shall remain at least partially operational during major storm events. Where drainage from major traffic routes is connected to urban drainage designed for a lower ARI, consideration shall be given to making the drainage for the two systems compatible.

10.5.6 Protection Drains

Carriageways in cuttings and cut batters should be adequately protected from runoff originating beyond the limits of the road. This protection will generally take the form of cut-off drains or dished gutters.

10.5.7 Cross Drainage

Flows up to and including 100 year ARI shall not be permitted to flow onto major traffic routes from adjacent land.

10.5.8 Major Drainage Crossings

Crossings (eg. bridges, culverts, etc) over major floodways and natural waterways shall be designed with reference to AS 5100 Bridge Design, Austroads Guide to Bridge Technology and Austroads Guide to Road Design Part 5 Road Drainage.

10.5.9 Pedestrian Underpasses

Pedestrian underpasses on roadways shall be provided with sufficient longitudinal grade to facilitate free drainage wherever possible.

Where a self-draining underpass is not possible, the underpass drainage system shall be designed for a 100 year ARI capacity.

Public safety considerations preclude the use of grated sumps or grated strip drains in underpasses.

Where an underpass is part of an engineered waterway, the free draining underpass drainage system shall be designed for a 5 year ARI. The level of footpaths and/or cycleways shall be above the 2 year ARI flood level in the engineered waterway. A floodway advisory sign shall be provided on each approach to the underpass.

10.6 Stormwater Drainage Pipelines

10.6.1 General Pipe Requirements

Stormwater pipeline types shall be in accordance with the requirements of the Civil Works Construction Specification – Part 4.

Alternative pipe materials may be acceptable. Proposals for the use of other materials shall be referred to Council's Development Engineering Section for consideration.

Box culverts may be permitted as part of the minor stormwater system where availability of cover or minimal waterway depths makes the use of pipes unsuitable.

The minimum internal dimensions of any box culvert in a Council drainage system shall be 600mm width and 300mm depth.

The proposed use of box culverts in lieu of standard pipes shall be brought to the attention of the Council's Development Engineering Section for consideration prior to finalising designs.

All pipes proposed for use shall be manufactured, supplied and used in accordance with Australian Standards.

Pipes need to be capable of resisting mines subsidence, root intrusion, hydraulic pressure, soil and construction loading, and have some flexibility at joints.

Pipe jointing types shall be as required by the Civil Works Construction Specification – Part 4.

The maximum allowable pressure head for all pipes shall be in accordance with the appropriate Australian Standard and the manufacturer's specifications for use.

10.6.2 Locations and Alignments

10.6.2.1 Roadway Reserves

The longitudinal alignment of pipes in roads are determined by the set out requirements for Standard grated gully pits with extended kerb inlets as shown on Councils standard drawing SD48E.

The following table reflects those requirements.

Table 10.11 Alignment of Stormwater Pipes in Roads

Diameter (mm)	Alignment (from face of kerb)
<600	95mm
600-750	220mm
825-900	370mm
>900	Half pipe diameter plus 20mm
Multiple pipe groups	Half the sum of (pipe diameters plus 250mm spacings) plus 20mm

Curved pipeline alignments are preferred on curved roadways. However, where there are significant advantages, eg cul-de-sacs or narrow street verges, straight alignments may be permitted (refer to Section 10.9.14 for curved pipelines).

10.6.2.2 Private Land

A stormwater pipeline shall generally not be located within proposed private land except where it is intended solely for the purpose of providing inter-allotment drainage. Stormwater pipelines shall be located such that maintenance access can be readily achieved and restrictions imposed on the use of the land due to the presence of the pipeline are minimised.

Stormwater pipelines should not be constructed through existing private land. However, where such works cannot be avoided, the Designer shall refer the proposed design to Council's Development Engineering Section for consideration.

Wherever stormwater pipelines are required along common boundaries, they should be located along the high side of the downhill property.

Stormwater pipelines proposed to be constructed in parallel to sewers shall generally be shallower then the sewer to facilitate future connections.

Where a proposed development abuts undeveloped land which has the potential to be developed, the possibility of shared stormwater drainage shall be considered as it is undesirable to maintain unnecessary parallel drainage systems. Co-ordination of stormwater drainage to avoid future doubling up of services shall be discussed with Council's Development Engineers.

Alignments shall be offset sufficient distance from building lines to allow working room for excavation equipment.

Stormwater pipelines in easements over residential, commercial, and industrial land shall be laid centrally within the easement.

10.6.2.3 Public Lands

Proposals to locate stormwater pipelines within public land such as open space shall be brought to the attention of the Council's Development Engineers for consideration. Generally, unless directed otherwise, stormwater pipelines shall be located at least 5.5 m off the nearest boundary when proposed to be located on Public Lands.

10.6.2.4 Clearance from Other Services and Utilities

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

Under no circumstances shall stormwater pipelines be:

- Locally deflected from their proposed alignment to avoid other services, utilities or other obstacles.
- Located longitudinally directly above or below other underground services or utilities in the same trench.

Where a stormwater pipeline crosses or is constructed adjacent to an existing service, the design shall be based on the in field physical location and level of that service. Design documentation shall direct the Contractor to confirm the location and level of the existing services prior to constructing the stormwater pipeline in question.

Minimum clearances between stormwater pipelines and other underground services and utilities shall be in accordance with requirements specified by the service or utility asset owner. **It is the designer's responsibility to obtain the current minimum clearances from each service or utility asset owner. The required minimum clearances are to be clearly stated on the design drawings in order for the Contractor to be able to confirm that the required clearances can actually be achieved.**

Where a stormwater pipeline will be located within close proximity to another service, the Designer shall ensure that the requirements of the relevant Authority are met and clearly label on the drawings what the estimated clearance is.

Stormwater pipelines shall be designed such that maintenance activities can be performed without the risk of inadvertent damage to the assets of other Authorities.

10.7 Inter-Allotment Stormwater Drainage

10.7.1 General Inter-Allotment Drainage Requirements

Inter-allotment Drainage shall be provided for every allotment which does not drain directly to its street frontage and for high side properties fronting roads with either kerbing that is unable to satisfactorily accommodate kerb outlets or where the road has a one way crossfall.

The inter-allotment drain shall be designed to accept concentrated drainage from buildings and paved areas on each allotment for flow rates having a design ARI the same as the "minor" street drainage system unless otherwise specified in AS 3500.3.

Inter-allotment drainage shall be contained within easements not less than 1.5m wide. The easements shall be created in favour of the benefiting allotments.

Where detailed site development impervious area cannot be determined, the following areas of impervious surface may be assumed:

Development Type	Minimum % of Lot Area
Residential lots	85
Industrial	90
Commercial	90

Pipes shall be a minimum diameter of 150mm and designed to flow full at the design discharge without surcharging of pits. Hydraulic grade line design is required where connections are made to pressurised systems.

Pipes shall have a minimum cover of 300mm and a minimum grade of 1%.

Where inter-allotment drainage and sewer mains are laid adjacent and parallel to each other they are to be aligned at 0.75 metres between pipe centrelines unless pipelines are greater than 300mm diameter for which the minimum clearance between pipes shall be at least 450mm. The sewer shall be located closest to the dwelling being served.

Stormwater discharge from adjoining existing lots onto proposed development sites shall be catered for by the Developer by the provision of an inter-allotment drainage system providing a point of connection for each existing adjoining lots. This will necessitate the construction of the drainage system and creation of easements in favour of the existing properties.

Inter-allotment drainage pits shall be provided at the low corner of each lot unless otherwise approved and shall comply with the following:

- A minimum internal size of 450mm x 450mm for residential lots increasing to 600mm x 750mm where pits are deeper than 0.7m.
- A minimum internal size of 750mm x 750mm for industrial lots being either cast in-situ or approved precast, with a grated surface inlet.
- Pits of a minimum internal size of 600 x 600mm shall also be provided at changes of pipe size, changes in grade, changes in pipe type or class and changes in direction of 45° or greater. Such pits are to be approved precast or cast insitu.
- Any pit having a depth at or greater than 1.2m shall be a minimum internal size of 750 x 600mm shall be provided with step irons .
- Low corner pits shall be covered by an approved grate, depressed 100mm below surrounding ground level, to provide an adequate surface water inlet. (300mm minimum pipe cover applies below the 100mm depression).
- All pit grates are to be provided with either "J" bolts or secured galvanised chains to prevent removal.
- For single residential dwellings where cast in-situ pits are used, a 150mm diameter stub is to be provided at the pit invert level with a 90° elbow, riser to finished surface with a cap shall be provided.
- For land uses other than residential the stub diameter placed in a cast insitu pit is to be determined by design.
- Precast pits do not require stubs.

The designer is to nominate the inter-allotment drainage pit requirements on the drawings in accordance with the above criteria.

10.7.2 Inter-allotment Drainage Easements

Inter-allotment stormwater drainage easements shall be created in favour of the benefiting properties.
All other stormwater drainage easements shall be in favour of Council.

10.8 Stormwater Drainage Easements and Reserves

10.8.1 General Requirements – Easements

A drainage easement shall be wide enough to contain the pipeline and provide working space on each side of the pipeline for future maintenance activities.

Only pipelines up to and including 675 mm diameter may be located in easements within private properties. Larger diameter pipelines shall be located outside private properties in open space or in separate drainage reserves.

In some developments, direct maintenance access to a stormwater system within a lot may be difficult or prevented entirely. In such cases, easements and inter-allotment pipelines shall not terminate at a dead end but shall be extended to a point where access may be gained from a road reserve or other public area with direct access. A junction box shall be located on both ends of the pipeline to facilitate access.

Easements are to be provided in private property over pipe systems and overland flowpaths. The minimum width of easement will generally be as follows:

Table 10.12 Easement Widths

Pipe Diameter	Easement Width
Interallotment drainage (300mm pipe maximum)	1.5m
Pipes 375mm and 450mm	2.0m
Pipes 525mm and 600mm	2.5m
Pipes 675mm to 1200mm	3.0m
Pipes 1350mm to 2400mm	3.5m

For larger diameter and multiple pipes a minimum clearance of 500mm from each side of the pipes will be required for easements, with the easement width increasing in 500mm intervals.

The above easement widths will require widening where excessive pipe depths occur.

Property restrictions will be required in conjunction with overland flow path drainage easements.

10.8.2 General Requirements Drainage Reserves

Pipelines 750 mm diameter and larger shall not be located within private properties. These pipelines shall be located within public open space or a separate drainage reserve shall be provided.

Consideration should be given to the multi-purpose use of drainage reserves such as open space or pedestrian corridors.

Minimum widths of drainage reserves or pathways and public reserves containing stormwater pipes shall be in accordance with Table 10.13.

Table 10.13 Minimum Drainage Reserve Widths

Diameter (mm)	Reserve Width (m)
0 – 3.0m deep	
225 to 450	2.5
525 to 675	3.0
750 to 900	3.5
1050 to 1200	As directed
3.0 – 6.0m deep	
225 to 450	3.5
525 to 675	4.0
750 to 900	4.5
1050 to 1200	As directed

Note: Where other hydraulic services or electrical services are located within the same reserve, the required reserve width shall be increased to provide adequate clearance between services.

10.9 Hydraulic Design and Pipeline Design

10.9.1 Hydraulic Grade Line (HGL)

Hydraulic calculations shall generally be carried out in accordance with Australian Rainfall and Runoff and shall be undertaken by a qualified person experienced in hydrologic and hydraulic design.

The hydraulic design shall be described in the design drawings and supporting documentation by:

- Hydraulic grade line on pipe profiles with accompanying levels at inlets, pits and outlets.
- Calculations of adopted water level controls, tail water levels and flood levels applying to the site.
- Tabulation of calculations in association with hydrologic calculations.
- Inclusion of listings of all programme input and output.

Downstream hydraulic grade line level requirements for design shall be determined from the worst case produced where:

- A known hydraulic grade line design level from downstream calculations including pit losses at the starting pit for the required design event.
- The downstream starting point is a pit and the hydraulic grade line is unknown, a level of 0.15m below the pit surface inlet in the downstream pit is to be adopted.
- The outlet enters an open channel, the design storm is the minor event and a reasonable assessment of coinciding open channel flow depth does not indicate a higher level, the top of the outlet pipe shall be the downstream control.
- The outlet is an open channel, the design storm is the 100 year ARI event and downstream flood levels are not known and a reasonable assessment of coinciding open channel flow depth does not indicate a higher level, the higher of the top of the outlet pipe and 300mm below the open channel top of bank shall be the downstream control unless Council's Development Engineering Section request that detailed analysis of the open channel flow is required.
- The outlet is an open channel, the design storm is the 100 year ARI event and downstream flood levels are known, the downstream control shall be the 100 year ARI design flood level.
- The future 100 year ARI flood levels are lower than the existing, the higher interim flood level shall be adopted.
- The outlet is at a creek, river or lake the design 100 year ARI flood level shall be the downstream control unless nominated otherwise by Council's Development Engineering Section.
- The outlet is in close proximity to a river or lake Council's Development Engineering Section may nominate a more frequent ARI event for lower parts of the proposed drainage system in conjunction with the adoption of 100 year ARI river or lake levels as downstream controls.

Council's Development Engineering Section can generally provide design flood levels for the Tuggerah Lakes System and most major watercourses in the Wyong Shire.

10.9.2 Design Criteria

Pipes shall be designed by a "hydraulic grade line" (HGL) method using appropriate pipe friction and drainage structure head loss coefficients.

The hydraulic grade line level in drainage pits shall be limited to 0.15m below the gutter invert, 0.15m below surface inlet level and 0.15m below the underside of the lid for junction pits unless otherwise approved by Council's Development Engineering Section.

10.9.3 Hydraulic Losses

Drainage pipe systems shall be designed as an overall system, with due regard to the upstream and downstream system and not as individual pipe lengths. Drainage systems friction losses shall generally be determined as those resulting from pipes flowing full at design discharge.

The pressure change co-efficient "K" shall be generally determined from the "Missouri Charts" and the "Hare Equations". The "Hare Equations" shall only be used as a guide and the "Missouri Charts" shall be used were discrepancies between the two exist.

Computer program default pressure change co-efficient "K" shall not be used unless they are consistent with those derived as described above.

Designs which use larger upstream pipes flowing to into smaller downstream pipes are not permitted without approval of Council's Development Engineering Section .

All private pipe connections to Council's stormwater system, including roof and subsoil pipes, shall enter the main system at pits unless otherwise approved by Council's Development Engineering Section.

Actual pipe diameters, as opposed to nominal pipe diameters, shall be used for hydraulic calculations.

Pipes shall be sized and friction losses determined using the design charts in AS2200 or equivalent calculations. The charts or calculations based on the Colebrook-White equation shall be used for sizing pipes designed to flow full under pressure. The charts based on the Manning's equation shall be used for sizing pipes designed to flow full but not under pressure.

Appropriate pipe roughness values should be selected from Table 10.14.

Table 10.14 Pipe Roughness Values

Pipe Material	*N*	*k*
Precast concrete	0.015	0.6
Spun precast concrete	0.120	0.3
Fibre reinforced cement	0.010	0.06
UPVC	0.009	0.06

10.9.4 Design Principles

The following outlines some HGL design principles that shall be used for all underground stormwater drainage. If conditions occur that fall outside the scope of this document, the Designer shall discuss with Council's Development Engineering Section the appropriate analytical methods to be used in the design.

HGL design requires the prior calculation of catchment hydrology leading to the estimation of flows and a preliminary layout of the pipe network utilising knowledge of HGL techniques and experience of the usual hydraulic controls.

The preferred method of design in all cases is that which starts at the downstream end of the pipe system and proceeds upstream.

The following factors shall be taken into account in the design of the pipe network:

- The downstream Controlling HGL Level (CHGL) shall generally be in accordance with clause 10.9.1.
- The Controlling Surface Level (CSL) at all structures within the pipe system shall be CSL = finished surface level or surface inlet less 150 mm.
- The system shall be deemed to be functional when the HGL is at a level less than the CSL at each structure except where surcharging of the system is intentional within floodways or swales.
- Wherever practical, pipelines at sumps and Junction boxes should be located such that the projected area of the upstream pipe is wholly contained within the area of the downstream pipe.

- The head loss charts in Appendix A are based on pipelines flowing full under pressure with the obverts at structures being covered. Therefore, if the calculated HGL falls below the obvert of the pipeline, the HGL shall be assumed for design purposes to be at the obvert of the pipeline.
- Where multiple parallel pipelines are proposed with equal flow in each pipeline, the pipelines shall be treated as single separate systems.
- HGL methods may be used to design box culvert systems with caution. Friction loss estimates should be made by solution of the Manning's equation.

10.9.5 Grades

The longitudinal grade of a pipeline between drainage structures shall be calculated from midpoint to midpoint of such structures. A minimum of 50mm fall shall be allowed in all drainage structures which shall be shown by the level difference of the inflowing pipe(s) and the out flowing pipes at the mid point.

10.9.6 Design for Mines Subsidence

The design pipe grade shall be adopted as the worst case solution considering the existing ground levels and allowance for the predicted changes in surface slope advised by the Mines Subsidence Board.

The maximum and minimum grades and other grade limits provided in this guideline are to apply to pipes under both existing conditions and post mines subsidence conditions.

10.9.7 Minimum Grades and Velocity

Stormwater pipelines shall be designed and constructed to be self cleansing, eg. free from accumulation of silt. The desirable minimum grade for pipelines is 1.0%. The minimum design velocity shall be 0.6m/s.

An absolute minimum grade of 0.5% may be acceptable where steeper grades are not practical. Such instances shall be brought to the attention of the Council's Development Engineering Section for consideration prior to finalising designs.

10.9.8 Maximum Grades and Velocity

Pipeline grades shall be chosen to limit the pipe full flow velocity to a value less than or equal to 8.0 m/s unless precluded by the manufacturers recommendations. Particular care shall be taken to consider the requirements of high energy flows on pit design and pipeline joint pressure capabilities.

10.9.9 Scour Stops, Trench Stops, Bulkheads

Pipelines laid on steep slopes and in relatively impervious materials such as rock shall be protected from failure due to wash-out of bedding and backfill by the use of scour stops, trench stops or bulkheads. Measures shall be considered by the designer and detailed on the drawings. Details will be required for all pipeline grades are greater than 7%.

10.9.10 Vertical Angles

Stormwater pipelines shall be constructed so that the bore of the pipe has no point where debris can lodge and cause reduction in capacity. The use of vertical angles will not be permitted.

10.9.11 Allowable Pipe Diameters

10.9.11.1 Minimum Diameters

Council Drainage Systems

The minimum diameter for stormwater pipelines generally is 375mm.

Under certain circumstances where downstream system levels are fixed, creating cover or grade design issues and the required pipe capacity permits, 300mm diameter pipes may be used for a short distance.

Inter-allotment Drainage Systems

The minimum diameter for stormwater pipelines is 150mm other than for individual residential stubs and connections which may be 90mm diameter where capacity is sufficient.

Private Drainage Systems

The minimum diameter for stormwater pipelines shall be in accordance with AS 3500.3 National Plumbing and Drainage Code – Stormwater Drainage.

10.9.11.2 Maximum Diameters

The maximum diameter for stormwater pipelines shall be 1200mm unless approved otherwise by Council's Development Engineering Section.

10.9.12 Structural Design of Pipelines

10.9.12.1 Minimum Design Service Life

Pipelines and culverts shall be designed for a minimum effective service life of 50 years.

10.9.12.2 Minimum Depth

Generally the minimum cover over storm water pipe lines that will become Council's Asset shall be 0.7 m from top of pipe to finished surface level or gutter invert level for road drainage.

Pipe depth shall satisfy the cover requirement for the nominated class of pipe, bedding type and construction loadings determined from AS 3725 "Design for Installation of Buried Concrete Pipes".

10.9.12.3 Maximum Depth

The maximum depth of stormwater pipelines to invert level shall be 6 m.

In special cases (eg. for a short length of pipeline through a ridge), approval must be obtained from the Council's Development Engineering Section to exceed this limit.

10.9.12.4 Pipe Class

Pipe class shall be selected to provide adequate strength to meet overburden and traffic loads determined from AS 3725 "Design for Installation of Buried Concrete Pipes". Pipes class shall be calculated assuming a HS3 support condition for pipes under road pavements and HS2 support condition where not under a road pavement.

In calculating pipe class consideration shall be given to design loading and assumed construction loads.

Where load limits are intended to apply, the location and load limitation shall be clearly shown on the drawings along with appropriate signage to be installed identifying the load limit.

10.9.13 Connection to Structures

Where pipes are connected to rigid structures or are embedded in concrete, flexible joints shall be provided to minimise damage caused by differential settlement. Details of required flexible joints and their locations shall be detailed on the drawings.

10.9.14 Curved Pipelines

Curved stormwater pipelines may be utilised wherever there are significant advantages in their use. Ad hoc curving of pipelines to avoid obstacles such as trees, power poles, gas mains etc. is not permitted. Curved pipelines should be positioned to follow easily identifiable surface features, eg. parallel to a kerbline.

Curved pipelines shall have a constant radius.

Curved pipelines are permitted provided they are:

- In the horizontal plane only (no vertical curves).
- In one direction only between successive structures (no reverse curves).

The maximum deflection angle shall be as recommended by the Pipe Manufacturer for a particular pipe.

Splayed pipes may be used to construct a curved pipeline provided that the curve is totally formed by the splays. Splayed pipes shall be factory formed

Design drawings shall show the following curve information:

- Centreline radius.
- Pipe type (normal or splayed).
- Effective length of individual pipes (if other than standard length).
- Type of jointing.

The Designer shall provide documentation to show that the above details are within the Pipe Manufacturer's specifications.

10.9.15 Dead End Pipelines

Dead end pipelines are not be permitted. All Council or proposed Council stormwater pipes shall terminate at pits or inlet/outlet structures. Short lengths of pipe maybe detailed at end pits to facilitate future connection.

10.9.16 Inter-Allotment Drain Connections

Connection of inter-allotment pipe systems to Council's drainage systems shall be made at a Council stormwater pit or by way of an approved discharge structure into an open channel or watercourse.

10.10 Road Culvert Design

10.10.1 General

Box and Pipe culverts shall be design in accordance Austroads Guide to Road Design Part 5 Drainage Design – Section 6.

Design of Pipe or Box culverts shall consider and make provisions acceptable to Council for maintenance of the culvert.

10.10.2 Major System Requirements

Box or pipe culverts may be used as part of the major stormwater system in engineered waterways for road crossings.

Culvert crossings shall be designed for a 100 year ARI flow with an upstream freeboard of at least 0.6 m.

Culvert crossings shall be designed without afflux unless agreed otherwise with Council's Development Engineering Section.

10.11 Stormwater Pits – Inlet and Junction

10.11.1 General

Stormwater pits shall be designed to efficiently conduct storm flows from the design surface to the underground pipe system.

When designing pit locations, consideration shall be given to hydraulic efficiency, vehicle, bicycle and pedestrian safety, debris collection potential, and maintenance.

10.11.2 Council Standard Pit Types

Pits are to conform to Council's current Standard Drawings where applicable. Where Council's standard drawing does describe the pit type required the required pit shall be detailed on the drawings.

Inlet capacities of kerb inlet pit types may be found in the Appendix C.

10.11.3 Design Inlets Sizes

Kerb inlet lengths (lintels) are to be a desirable maximum of 3.0m. With an absolute minimum of 1.2m. Kerb inlet lengths refer to clear opening.

All grates within road reserves and pathways shall be bicycle friendly.

All grate types shall have a load rating suitable for the location of the grate and adjacent areas. Heavy duty grates will be required in most locations. However extra heavy duty grates shall be used where frequent heavy vehicle loading will be encountered. The load rating of the grate shall be specified on the design.

10.11.4 Location

Inlet Pits shall be located to prevent ponding and to limit flow widths and depths to acceptable levels in accordance with these guidelines. Preference shall be given to the location of drainage pits at the upstream side of lots, pedestrian crossing points and kerb returns.

Pits shall be provided:

- To enable access for maintenance.
- At changes in pipeline direction, grade, size, level or class of pipe(if required due to dimensional difference).
- At junctions of pipelines.
- At low points in road gutters, i.e. sag pits.

Kerb inlet pits for all roadways shall be located such that gutter flow widths do not exceed the surface flow limits specified in clause 10.5.3 and 10.5.4.

10.11.5 Maximum Pit Spacing

Maximum spacing of all types of pits shall be in accordance with Table 10.15.

Table 10.15 Maximum Pit Spacing

	Pipe Size (mm)	Spacing (m)
Generally	Less than 1200	80
	1200 or larger	150
In tidal influence	All	80

10.11.6 Junction Pits

Junction pits maybe used where there is no requirement at the pit location to collect surface water. Refer to the Civil Works Construction Specification for surface cover/lid requirement for junction pits.

10.12 Flow Path and Open Channel Design

10.12.1 General Requirements – Flow Paths

Flow path designs shall address the following items as a minimum:

- Velocity depth criteria for safety of vehicles and pedestrians.
- Containment of flows within the designated flow path area.
- Transition of flows between different flow path formations to ensure no inundation of private property.
- Surface treatment of the flow path to ensure ongoing flow path capacity with minimal maintenance.

To ensure public safety within overland flowpaths, the depth of flow should generally be less than 0.2 metres and the product of velocity and depth should not exceed $0.4m^2/sec$ for the major design event flow.

Where public safety is less an issue, higher velocity depth products may be permitted, subject to approval by the Council's Development Engineering Section.

10.12.2 General Requirements – Open Channels

Open channels that form part of the trunk drainage system to cater for major event (100 year ARI) flows shall be designed to have smooth transitions with adequate access provisions for maintenance and cleaning.

Design of open channels shall be generally in accordance with Book 7 AR&R 2001 unless otherwise specified herein, and shall be designed with safety requirements as set out in Section 1.10.4 Safety of Book 8 AR&R 2001 as a primary criterion. Open channel systems shall be designed to contain the major flow with the required freeboard.

The requirement for an engineered open channel shall be approved at the Development Consent stage.

Designs shall be carried out to adequately accommodate the following:

- Hydraulic jumps/supercritical flows.
- Transitions and constrictions of the channel - backwater effect.
- Superelevated flows (around bends).
- Freeboard/provisions for debris under structures, mine subsidence etc.
- Prevention of persons falling or being swept into the open channel.
- Permit easy escape by persons from flood waters.
- Catch rails, side bays or other escape devices as required.
- Minimise velocities or average velocity depth products recognised to safe limits.

Surface treatments of open channels shall be designed to retain channel capacity with minimal maintenance. Due allowance in design capacity shall be made to cater for proposed fully established vegetation treatments. Proposed surface treatments shall be discussed with Council's Development Engineer Section at the preliminary design stage.

Suitable exclusion fencing acceptable to Council's Development Engineering section shall be provided along open channel sections that cannot satisfy safety criteria. Fencing shall make adequate allowance for other safety treatments, maintenance and emergency access.

Calculations supporting the design of all open channels shall be provided as part of the construction certificate / civil works approval application documentation.

10.12.3 Location

Flow paths and open channels shall be located wholly outside private property unless specifically approved in the Development consent.

Open channels shall generally be located along the alignment of existing watercourses and drainage depressions. Diversion of open channels away from natural drainage paths will not generally be permitted.

10.12.4 Freeboard

The minimum freeboard above the "gap flow" for flow paths shall be as shown in Table 10.16. Where Table 10.16 does not address a particular situation free board requirements shall be discussed with Council's Engineering Development section.

Table 10.16 Minimum Freeboard Flow Paths

Flow Path Type	Minimum Freeboard (mm)
Swales and pedestrian pathways adjacent to property boundaries	300
Roadways acting as flow paths to adjacent frontage including driveway level at the boundary*	130

*Note: *Maximum permissible height of flow above top of kerb in roadways subject also to other considerations is 50mm.*

The minimum freeboard above the 100 year ARI design flow level for open channels shall be 300mm to the top of the channel formation. This shall be increased to 600mm in mine subsidence areas.

10.12.5 Grades

10.12.5.1 Minimum Grades

Open Channels and flow paths shall be constructed with sufficient longitudinal grade to ensure that unintentional ponding and/or the accumulation of sediment does not occur, particularly in locations where sediment removal would be difficult.

Flow paths shall generally have a minimum longitudinal grade of 0.5%.

10.12.5.2 Maximum Grades

Open Channels and flow paths shall be designed with longitudinal grades that minimise:

- Hydraulic jumps.
- Dangerous conditions for the public.
- Potential erosion.

Longitudinal grades shall be chosen such that the 100 year ARI flow or "Gap Flow" will not exceed the average velocity limits shown in Table 10.17.

Table 10.17 Maximum Average Flow Velocities

Location	Average Flow Velocity (m/s)
Open channels	2
Swales and flow paths	2
Open channel low flow inverts	4

10.12.5.3 Drop Structures

Drop structures should be provided to reduce waterway longitudinal grades such that 100 year ARI average flow velocities meet the requirements of Table 10.17.

Vertical faced drop structures will not be permitted. The face of the drop structure shall have a maximum slope of 1 horizontal to 1 vertical.

A scour protection apron shall be provided at the upstream edge and downstream toe of the structure.

10.12.6 Advisory Signs

Floodway advisory signs shall be provided adjacent to open channels, natural waterways and flow paths where pedestrian safe velocity depth ratios cannot be achieved. The location of signs shall be shown on the design drawings.

The signs shall be located at points of anticipated pedestrian traffic and generally at about 500 m intervals.

10.12.7 Batter Slope Requirements

Batter side slopes on open channels and flow paths shall generally not exceed 1 in 6 for reasons of public safety. Steeper side slopes up to a maximum of 1 in 4 may be allowed where adequate provision for public safety have been incorporated into the design. The use of steeper batter slopes shall be discussed with Council's Development Engineering Section prior to incorporation into any design.

10.12.8 Low Flow Provision

Low flow provisions in open channels (man-made or altered channels) will require low flows to be contained within an approved treatment generally at the invert of the main channel.

The low flow system shall be designed to covey as a minimum a 1 in 3 month return interval flow. Adequate scour protection shall be provided adjacent to and within the above ground low flow system and any other areas as required.

The low flow system may also incorporate water quality treatment measures.

Subsurface drainage may be required for grass lined low flow channels to prevent water logging of the channel.

10.12.9 Erosion and Scour Protection

The design average flow velocity limits specified have been selected to prevent erosion and scour of surfaces under normal flow conditions. However, waterways may be subject to intense local erosion or scour at obstructions (e.g. bridge piers, pipe headwalls), sudden changes in waterway cross-sections, drops, regions of changes in waterway bed materials and other similar conditions.

Locations were specific erosion and scour prevention measure shall be considered include:

- Transitions - Any changes in cross-section or changes in the channel or flow path surface material. Particular attention should be paid to the region immediately alongside low flow inverts.
- Bends - The outside bank on bends subject to higher flow velocities.
- Pipeline outlets - Flows from pipelines will normally be of relatively high localised velocity.
- Tributaries - Other open channels entering the main channel / natural system may cause turbulence and erosion of the channel invert and banks.
- Energy dissipater structures - Changes in the flow regime will usually occur immediately upstream and downstream of drop structures and energy dissipation basins.
- Culverts - Exit velocities from culvert crossings will normally be supercritical.
- Bridges and under passes - Flow velocities around piers and abutments may be higher than the waterway limit.

Permanent erosion and scour protection must be provided to suit the location soil characteristics. Measures shall be detailed on the design drawings. Advice from a Geotechnical Engineer or soil erosion consultant will be required to identify soil characteristic.

All measures based on the identified soil characteristics shall be detailed on the design drawings.

10.13 Retarding Basins

10.13.1 General

Retarding basins may be provided as an integral part of the major drainage system in new development areas to either:

- Provide a more economic system by reducing downstream flow rates and waterway reserve widths, **or**
- Meet a specific planning requirement that downstream flow rates do not exceed pre-development values for both the minor and major system design ARI.

It should be recognised that the provision of a retarding basin is only one method in a number of techniques available to manage stormwater runoff and therefore should be tested against other drainage strategies to arrive at the optimum solution to meet either of the above objectives.

The provision of retarding basins in the drainage system should be planned and designed as part of an overall catchment drainage strategy.

Submission of design plans and Risk Assessment to the Dam Safety Committee for comment will be required where the Committee's guidelines require it.

Embankments shall be designed and constructed such that they will not breach under any operating conditions for all flows up to and including 100 year ARI. Generally the maximum inundation period during the critical duration 100 year ARI design storm shall be 72 hours to prevent long term damage to surfaces. However this will depend on any secondary usage of the basin.

Retarding basins shall not cause floodwaters up to and including the 100 year ARI event to inundate upstream roads or land.

10.13.2 Analysis

The Designer shall model the performance of the basin using a range of design storms and long term records of rainfall to determine the maximum storage requirements and the size of outlets for the basin.

A hydrograph estimation technique shall be used to estimate appropriate inflow hydrographs to the basin. Inflow hydrographs shall be routed through the basin using full reservoir routing calculations to determine the basin characteristics and resultant outflow hydrographs.

Flood Routing should be modelled by methods outlined in Australian Rainfall and Runoff. Modelling shall demonstrate that the basin does not have an adverse impact on the total catchment main stream flooding.

10.13.3 Outlet Design

10.13.3.1 Bypass Flows

Provision shall be made in a retarding basin design to bypass low flows through or around the basin. This is necessary to ensure that the basin floor, particularly if it is grassed, is not inundated by small storms or continually wetted by dry weather base flow. The minimum amount of bypass shall be the 1 month ARI flow or required environmental flow.

In existing developed areas, it may be desirable to bypass a larger amount than the 1 year ARI flow if a chosen site has insufficient capacity to attenuate both the minor and major system design storms. However, the level of flow bypassed should not exceed the downstream minor system design ARI.

10.13.3.2 Primary Outlet

To achieve the design flow control requirements, the primary outlet configuration will generally consist of a multi-outlet structure or several outlet structures combined to provide multi-stage outlet control.

The outlet hydraulics for multi-outlet structures may be complicated and difficult to analyse. Care must be taken to ensure that the stage-discharge relationship adequately reflects the range of different flow regimes that the structure will operate under. In some cases, particularly if the consequences of failure of the structure are high, the stage-discharge characteristics may need to be verified by physical modelling.

Primary outlets shall be designed to minimise the risk of blocking. The consequences of partial blockage of primary outlets shall be investigated and accounted for in the basin design if found to be significant.

Where a headwall or an open type structure is provided at the entrance to an outlet, an anti-vortex device should be considered to maximise hydraulic efficiency. The need for venting of the outlet should also be investigated.

Pipe systems shall contain the design flow through the Retarding Basin wall and be suitably protected to prevent infiltration of water between the pipe outer surface and the basin wall.

Consideration must be given to the need to protect the toe of the basin embankment and the bed and banks of the downstream waterway from erosion by high velocity outlet discharges.

10.13.3.3 Secondary Outlet

A secondary outlet to allow a non-catastrophic means of failure above the 100 year ARI event shall be provided. The most common outlet is a high-level weir crest and overflow spillway. Spillway design criteria shall be based on the Australian National Committee on Large Dams (ANCOLD) publications and guidelines.

The high level outlet to any retarding basin should have a capacity to contain the 100 year ARI flood event. Additional spillway capacity may be required due to the hazard category of the structure. The hazard category should be determined by reference to ANCOLD publications and guidelines.

Minimum floor levels of dwellings shall be 500mm above the design water level of the emergency spillway when in operation. An additional 300mm freeboard shall be provided in mine subsidence areas.

The surfaces of the embankment and secondary outlet (normally an overflow spillway) must be protected against damage by scour when subject to high velocities. An open stilling basin may be considered at the bottom of the spillway prior to discharge into the downstream waterway.

10.13.4 Embankment and Floor Slopes

Retarding basin embankment slopes shall generally have a maximum batter of 1 vertical to 6 horizontal. Slopes up to 1 vertical to 4 Horizontal may be approved in special circumstances. In any case the design of the basin embankment shall be verified by a suitably qualified engineer.

The floor of the basin shall be designed with a minimum fall of 1 in 50 to minimise the likelihood of ponding.

10.13.5 Safety

It is inevitable that people will have access to a retarding basin, especially if it is designed for multi-purpose usage. A retarding basin must be designed with public safety in mind both when the facility is in operation and also during periods between storms when the facility is empty. Measures to prevent and discourage the public from being exposed to high-hazard areas during these periods shall be incorporated into the design.

The Designer must consider the following safety measures in the basin design:

- Provision of signs that clearly indicate the purpose and potential danger of a basin during storms. Signs should be located such that they are clearly visible at public access points and at entrances and exits to outlet structures.
- Gratings and trash racks at the inlet of a primary outlet structure. These should be inclined at an angle of 60^{o} to the horizontal and placed a sufficient distance upstream of the inlet where the velocity through the rack is low. This should ensure that a person would not become held under the water against the grating or trash rack.
- Safety fencing on steep or vertical drops, such as headwalls and wing walls, at the inlet and outlet to a primary outlet structure to discourage public access. Safety fencing can also prevent a person inadvertently walking into or falling off these structures during periods when the basin is not in operation.
- Screening of outlet structures with bunds or shrubs to reduce their attraction potential to playing children or curious adults during periods that the basin is not in operation.
- Side slopes are to be a maximum of 1 in 6 to allow easy egress.
- Water depths shall be, where possible, less than 1.2m in the 20 year ARI storm event. Where this requirement is not practical or economic, greater depths may be acceptable. In that case the provision of safety refuge mounds should be considered.
- Depth indicators should be provided indicating maximum depth in the basin.

10.13.6 Landscaping

Wherever possible, designs should incorporate naturally shaped basins with landscaped banks, and selective planting of vegetation to help enrich the area and provide a focal point for surrounding development.

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

10.13.7 Maintenance

Retarding basins shall be provided with adequate access for maintenance machinery to remove silt or debris from the floor of the basin. Access for maintenance shall also be provided to the primary and secondary outlets.

10.14 On Site Stormwater Detention

On-site stormwater detention may be required for individual building developments and on redevelopment sites to attenuate the runoff to discharge levels expected from the pre-developed site for the minor and major storm events.

Calculations are to include any upstream catchments which contribute to the runoff.

Various storm durations are to be modelled to determine the critical duration both pre and post development.

The temporary storage of water is to be contained within the site, and is not to encroach onto adjacent properties or public and road reserves. Pedestrian access is not to be included within the storage area unless readily available alternative routes are provided.

Enclosed structures are not recommended due to maintenance problems and possible health problems.

The maximum water depth for the 100 year ARI event is 200mm for car parks, and 600mm for gardens.

An overland flow path (or spillway) must be provided for the on-site detention area. A minimum freeboard of 300mm must be provided to floor levels (including adjacent properties) for the 100 year ARI event, assuming 100% blockage of the piped discharge.

The piped discharge from the detention area is to connect directly to the street drainage system where possible. However other discharge locations may be considered.

PART 11 – STREET AND PUBLIC PLACE LIGHTING GENERAL REQUIREMENTS

Lighting shall be designed and constructed for:

- Subdivision or development roads.
- Intersections, roundabouts and traffic control devices.
- Public areas where nominated in the development consent.
- Pedestrian underpasses, overpasses, bridges and ramps.
- Bicycle parking facilities.
- Car parks.
- Cul-de-sacs, permanent turning heads and temporary turning facilities.

Lighting shall be designed in accordance with AS1158 and AS4282 allowing for:

- The lighting category nominated in other chapters of Council's DCP.
- A minimum of 20 year design life for all lighting components and structures.
- Best practice energy efficient lighting.

Only galvanised finished light poles and associated fittings will be accepted by Council unless otherwise negotiated with Council's Development Engineering Section.

Where other chapters of Council's DCP does not describe a lighting category Council's requirement shall be obtained from Council's Development Engineering Section.

Street Lighting requirements on rural roads shall be discussed with Council's Development Engineering Section.

It is the Developer's responsibility to meet all costs associated with the design, supply and installation of street lighting where required by the Development Consent, this guide and other chapters of Council's DCP.

PART 12 – UTILITY SERVICES DESIGN AND INSTALLATION

It is advisable that the Developer liaise with Service Authorities at any early stage of the development process to resolve servicing issues such as proposed services layouts, future services, the locations of Substations and Telecommunications installations and planning regarding existing services alterations or amplifications.

It is advisable that the Designer liaise with Service Authorities at any early stage of the design process to prepare engineering designs which are compatible with Service Authority's requirements.

The Developer must provide all Service Authorities with finished surface levels and/or up and down measurements from the top of kerb at the proposed property boundary and/or the proposed location of the Service Authorities pit, marker, etc, to ensure that:

- All Service Authority conduits etc have correct cover.
- All Service Authority pits, markers etc do not require future adjustments to suit driveways, footpaths or similar.

The arrangement of services within new roads shall generally be in accordance with the NSW Streets Opening Conference current edition of "Guide to Codes and Practices for Street Opening" and any specific site requirements imposed by Council.

Any area to be disturbed by the provision of services shall be restored to design levels either to new surface treatments when within the site or by reinstatement of existing surface treatments within existing roads and properties.

Refer to Volume 2 – Civil Works Construction Specification for requirements in regards to installation of road crossings in new road pavements and reinstatement of approved road crossings in existing road pavements. Engineering drawings shall be notated accordingly with details to specify remedial works where not adequately covered by the Volume 2 Civil Works Construction Specification.

PART 13 – CIVIL WORKS AND LANDSCAPING

Landscaping may be required by conditions of development consent approvals and/or other chapters of Council's DCP. Landscaping including estate entry features, fencing, mounding or site regrading not shown on the approved Landscaping plans shall not otherwise to be undertaken.

Landscaping Plans shall be prepared in conjunction with civil works design plans and shall generally be approved by Council prior to the release of a subdivision construction certificate or Civil Works Design Approval.

The design of landscaping shall be carried out by appropriately qualified persons capable of providing site assessment in accordance with Council's Landscape Policy, providing for any impacts on civil works and designing landscaping which is practical in terms of maintenance.

In particular vegetation and hard landscaping should not cause impacts as follows:

- Root intrusion into road pavements and sub soil drainage.
- Uplifting of paving, damage to structures or creating of hazards to pedestrians by tree roots.
- Restricting access or altering cover to buried services and stormwater lines particularly at Fittings, connections and inspection points.
- Unsafe or nuisance surface flooding or pavement damaging subsurface flooding by irrigation systems or associated water quality measures.
- Restrictions on view and sight lines which have implications for public safety and crime prevention.
- Hazardous maintenance practices.
- Maintenance practices requiring disruptions to traffic.
- The creation of unsound or hazardous structures.

Enquiries in regards to Landscape Design and approval shall be directed to Councils Principal Landscape Architect.

APPENDIX A – PREPARATION AND PRESENTATION OF DESIGN DRAWINGS

A.1 Plans

A.1.1 Size

All plans submitted for assessment shall be drawn on standard A1 (full size metric) sheets, regardless of the extent of the work. A set of A3 reductions shall also be submitted.

A.1.2 Scales

1 Plan

- Road & Drainage: 1:500 minimum or as required for clarity. 1:100 or 1:200 for detailed road intersection plans.
- Sewer & Water: Refer to Water Authority Requirements and adopted WSAA Code.

2 Detail

- As required for clarity.

3 Long Sections

- Generally, 1:500 Horizontal, 1:100 Vertical.
- Vertical scale may vary in very flat or steep grades.

4 Cross Sections

- 1:100 or 1:200 Natural.

5 Kerb Returns

- See kerb return profiles section (A.1.8).

6 Catchment Areas

- As required to suitably denote new and existing contributing catchments in accordance with Australian Standard 1100.

A.1.3 Drawing Title

All sheets must show the following information in the title block:

1 Development Consent Number.

2 Property Description.

3 Owner/Developer.

4 Surveyor/Engineer.

5 Scale, bar scale and survey datum.

6 Plan number, sheet number and amendment number/letter.

7 Description of Work on Sheets.

A.1.4 Standard Notes to be Shown on Drawings

The following general notes shall be shown on the first or cover sheet of all design drawings:

1 All works to be constructed out in accordance with the requirements of Wyong Shire Councils "Civil Works Construction Specification".

2 If the standard or requirements for works shown on the drawings differ from that required by Council's "Civil Works Construction Specification' then the requirements of the "Civil Works Construction Specification" will generally prevail. Clarification shall be obtained from Council's Principal Development Construction Engineer if there is concern that the requirements of Council's "Civil Works Construction Specification" may not be appropriate for a specific circumstance.

3 The Developer, the Developer's Project Manager and the Developers Contractor shall address all pre construction requirements of Council's "Civil Works Construction Specification" prior to commencement of any works.

4 The Developer, The Developer's Project Manager or the Developer's Contractor shall contact Council's Principal Development Construction Engineer on Phone (02)43505479 to arrange a preconstruction site meeting at least 5 days prior to the planned commencement of construction.

5 The Contractor is to prepare and implement a Traffic Control Plan (TCP) for any works that are within an existing Council road reserve regardless of the nature and extent of the works and/or if the works will disrupt the normal path of vehicles and pedestrians. Traffic Control Plans shall be prepared only by persons that hold current RTA/RMS accreditation. Traffic controls plans shall be implemented on site only by persons with RTA/RMS accreditation. The Contractor shall provide to Council a copy of the initial Traffic Control Plan prepared for the works and any other records related to traffic control when requested by Council.

A.1.5 Road and Stormwater Drainage Design Plans

Road and stormwater drainage design plans as a minimum shall detail:

1 Site Location.

2 Centre Line chainages as pegged.

3 The chainage shall be aligned with the longitudinal section and generally run left to right across the plan.

4 North point to define orientation.

5 The centre line bearing of straight sections and the radii of curves.

6 Location, description and RL of bench marks, to AHD.

7 Position of proposed sub-surface drainage lines. (May be covered by note or shown on typical cross sections).

8 Existing road names and proposed road number/names, property boundaries(existing and proposed) and lot numbers.

9 Proposed type and alignment of kerbs including road and lane widths.

10 Proposed dimensions, locations and types of all pavement marking (including raised pavement markers) and signage.

11 The location and level of all existing services with construction notes relating to any necessary alterations or protection treatments.

12 The location of proposed drainage structures with pits and headwalls numbered to correspond with drainage calculations and longitudinal section. For clarity drainage details may be shown on a separate drainage plan.

13 The face of kerb radius of all kerbs.

14 Existing drainage structures and conduits including size, type and invert levels.

15 Existing road feature level and location either side of the new road location sufficient to determine design grades and cross falls to the new work.

16 Show proposed and existing contours at 0.5m intervals, together with any relevant topographical features over the whole site.

17 The limits of cut and fill batters of significance.

18 Existing and proposed road reserve boundaries.

19 Major trees - 0.3m diameter and greater measured 1.0m above the ground or the extent of canopy of group plantings.

20 Co-ordinated set out points for all design centrelines, stormwater structures and any other design feature requiring accurate set out information.

21 Details of intersections showing kerb return chainages, kerb radii, road design centrelines, finished surface contours at 0.1m intervals or 0.2m intervals if required for clarity and coordinated set out points.

22 The location and details of permanent and temporary survey marks required for set out purposes.

A.1.6 Longitudinal Sections for Roads

Longitudinal Section shall have chainages running left to right across the page. Other information to be shown shall include:

1 Chainages.

2 Natural surface levels on the pegged or design control line.

3 Design surface level on the pegged or design control line.

4 Details of the vertical alignment.

5 Grades, size of vertical curves and chainage, and chainage and RL of intersection points.

6 Datum RL of longitudinal section.

7 The Chainage, size and level of Public Utility mains and services.

8 In rural or other areas as required, a horizontal alignment line incorporating guide post locations and line marking details unless adequately detailed on the plan sheets.

A.1.7 Cross Sections

1 Cross Sections should be generally shown at no more than 20 metre intervals and at key points for design purposes, e.g where access require special design, where cover requirements over services are critical or where superelevation is required at the relevant transition chainages. Where appropriate for level control designs may require cross sections at 5 metre intervals.

2 They should be placed such that the lowest chainage occupies the bottom left corner of the sheet and run sequentially up the sheet in progressive columns towards the right.

3 Cross Sections should extend for the full road reserve width or for a sufficient distance to detail the proposed method of satisfactorily matching the design and existing surfaces.

4 Provide sufficient existing cross section profiles and cross falls to show transitions to proposed work where required.

5 The details to be shown should include:

- The road centreline chainage in bold print below each section.
- The offset chainage from the pegged or design control line.
- The existing surface RL.
- The design surface RL.
- The design crossfall (%).
- The batter slopes (Ratio).
- Access grades (%).
- The design centreline shift, offset crown or transitions where applicable.
- The position, size and level of any public utility, mains and services affecting the work.
- Existing and proposed road reserve boundaries and levels within properties or regrading levels where required.

A.1.8 Kerb Return Profiles

1 Each profile should have a kerb return number (eg KR2) corresponding with a number shown on the plan view. The profile should represent the view as looking from the road to the face of the kerb.

2 The details to be shown include:

- The horizontal and vertical scale. This scale should be selected to clearly show the convexity of the kerb profile.
- Chainage. The running face of kerb chainage related to the profile together with the chainage related to the road centrelines.
- Design level, specifying either top of kerb or lip of gutter.
- Existing kerb levels.
- The applicable road/street names/numbers leading into the profile.
- An extension of a minimum of 15 metres beyond the tangent points to ensure a smooth profile is achieved.
- Show location and number of proposed drainage structures.
- Datum RL of kerb return.

3 Kerb or pavement profiles shall be provided for all traffic islands.

A.1.9 Stormwater Design

1 Catchment calculations.

2 Full catchment details are to be provided for checking with all stormwater drainage design. The extent of the catchment including that outside the development must be shown and accounted for in the calculations.

3 Each pit sub-catchment shall have a reference number/letter which must be consistently used on the catchment plan, drainage calculations sheet, drainage longitudinal sections and kerb returns.

4 The major event (100 year ARI) overland flowpaths shall be shown on the catchment plan. Flowpath capacity calculations shall be shown on the drawings.

A.1.10 Stormwater

1 Plan.

2 The stormwater plan may be incorporated on the road plan if space permits otherwise shown on a separate sheet orientated the same as the road plan sheet.

3 Details to be shown shall include:

- North point.
- The pit/structure reference number/letter.
- The location of any public utility mains/services crossing influenced by the work.
- The location and centreline chainage of any applicable drainage structure.
- Note referring to type of bedding/backfill condition required in accordance with AS3725.
- Location and width of existing or proposed drainage easements.
- Overland flowpaths, typical sections and capacities.

6 Longitudinal Section - The longitudinal section shall be plotted on the sheet so that the chainages run left to right across the sheet starting at the downstream end of the system. Details to be shown shall include:

- Running chainage along the line together with road centreline chainage where applicable.
- Pipe design invert level.
- Pipe grade.
- Existing surface level.
- Existing invert of drainage where applicable (ie, pipes, creeks, drains etc).
- Finished surface levels. Refer Clause A.3.4.
- Pipe size, class and type.
- The location, size and level of any public utility main or service that may be affected by the work and proposed treatment.
- The pit/structure reference number and type (to be shown above the section together with details of kerb inlet extensions).
- Datum RL of the longitudinal section to AHD.
- The hydraulic grade line and levels including the receiving waters design level.
- Capacity and design flow.
- Trench stop or bulkhead locations and spacing required.
- Special bedding requirements.

7 All relevant references to standard drawings and structural details for non-standard drainage structures.

A.2 Engineering Survey

A.2.1 General

The engineering survey shall accurately show the landforms to facilitate the best possible design and construction of road works, drainage and services.

A.2.2 Site Detail

Prior to any layout design, all physical features that may affect construction are to be located, levelled and plotted on the design plans. These include but shall not be limited to:

- Rock outcrops (including cliffs, caves etc).
- The canopy spread of individual trees 0.3m dia and larger measured 1.0m above the ground unless the tree forms part of a group planting, in which case show the group canopy spread.
- Watercourses, ponds, springs etc.
- Man made structures (including existing road formation, kerb and gutter, fences, buildings and vehicle entrances).
- Existing drainage structures.
- Existing utilities and services.
- Contours generally at 0.5m intervals or as the terrain dictates.
- Top and bottom of banks.

A.2.3 Datum

Bench marks are to be established clear of any works with a maximum of 200 metres spacing and clearly shown on all working drawings.

They should be a conventional type and constructed according to good survey practice.

A.2.4 Roadworks Pegging

The centreline start chainage shall be the intersection of the centrelines of the new road and the road which it intersects.

Where an existing road is to be extended, the start chainage should be the intersection of the subject road the last cross or side road.

If this is not practical, the start chainage should be squared off to a suitable property boundary (min 60m).

The centreline should be marked and the chainage indicated at each cross section according to good survey practice.

A.2.5 Cross Sections

Cross Sections are to be provided at 20 metre maximum spacing on straight sections and 15 metre maximum on curves.

A cross section is also to be provided at the tangent points of curves. If superelevation is required, cross sections are to be provided to the superelevation/widening transition development design standards.

The above spacings are a minimum and extra cross sections may be required for the proper design of difficult accesses, for the accurate calculation of earthworks where accurate level control and details are required or at severe crossfall transitions (ie, roundabouts, intersections, etc).

The cross section is to be extended for the full width of the road reserve or further in cases where extra information is necessary.

Cross sections shall be provided for a minimum of 60 metres along existing intersecting roads (in each direction of the intersection).

A.2.6 Longitudinal Section

As for cross sections, the longitudinal section is to be extended for a minimum of 60 metres along existing intersecting roads to enable proper design tie ins.

The longitudinal section of cul-de-sacs shall be carried to the recovery peg on the prolongation of the centreline.

The longitudinal section of an offset cul-de-sac shall be curved to the centre of the turning circle and not in a straight line with an offset to the centre.

Hammerhead turning facilities shall have the long section continued along the main line of the facility. Where a cross section does not show the design centreline of the other turning arm a long section shall be provided in accordance with the previous guidelines.

A.3 Environmental Management Plan

A.3.1 Environment/Vegetation Protection Plans

These plans shall show kerb lines, drainage, sewer and any other civil infrastructure that will require disturbance to the natural environment. These plans shall show "NO GO AREAS" and proposed fencelines and types to ensure there is no disturbance outside the construction corridors.

A.3.2 Erosion and Sediment Control Plans / Soil and Water Management Plans

These plans shall show the location, type and specific details of all sediment and erosion control devices. Refer Appendix "A" of the "Civil Works Construction Specification.

Details of sediment basins shall show the capacity, batter slopes, maintenance access, fencing, spillway, pumping requirements, dosing/flocculation requirements and stabilisation of the basin as a minimum. Details shall also show proposed staging of works, requirements for revegetation or progressive revegetation. Stockpile sites and source control measures for the stockpiles shall also be detailed.

APPENDIX B – RAINFALL DESIGN INTENSITIES

METEOROLOGY INTENSITY COEFFICIENTS (for equation 2.1 in AR & R)

THE ENTRANCE 33° 22'S / 151° 30'E

Period	A	B	C	D	E	F	G
1	3.4254	-.6022	-.0472	.00718	.002261	-.0001434	-.0000744
2	3.6806	-.5994	-.0495	.00699	.002551	-.0001230	-.0000852
5	3.9393	-.5919	-.0555	.00646	.003326	-.0000676	-.0001143
10	4.0641	-.5879	-.0587	.00618	.003730	-.0000387	-.0001295
20	4.2075	-.5847	-.0613	.00596	.004065	-.0000148	-.0001420
50	4.3688	-.5811	-.0643	.00570	.004441	.0000121	-.0001561
100	4.4763	-.5786	-.0662	.00553	.004692	.0000300	-.0001655

JILLIBY 33° 15'S / 151° 23'E

Period	A	B	C	D	E	F	G
1	3.3076	-.5550	-.0113	.00805	-.001518	-.0002765	.0000506
2	3.5599	-.5522	-.0106	.00802	-.001574	-.0002749	.0000520
5	3.8098	-.5445	-.0087	.00793	-.001723	-.0002703	.0000558
10	3.9304	-.5405	-.0078	.00788	-.001801	-.0002679	.0000577
20	4.0705	-.5371	-.0070	.00785	-.001866	-.0002659	.0000593
50	4.2283	-.5334	-.0061	.00780	-.001938	-.0002636	.0000611
100	4.3337	-.5309	-.0054	.00777	-.007987	-.0002621	.0000623

OURIMBAH 33° 21'S 30"S / 151° 22' 30" E

Period	A	B	C	D	E	F	G
1	3.4425	-.5685	-.0229	.00765	-.000254	-.0002172	.0000066
2	3.6965	-.5660	-.0252	.00753	.000012	-.0002086	-.0000017
5	3.9516	-.5593	-.0314	.00720	.000719	-.0001855	-.0000239
10	4.0746	-.5559	-.0347	.00703	.001089	-.0001734	-.0000355
20	4.2165	-.5530	-.0374	.00689	.001394	-.0001634	-.0000451
50	4.3760	-.5498	-.0404	.00673	.001737	-.0001522	-.0000558
100	4.4825	-.5477	-.0424	.00663	.001966	-.0001447	-.0000630

MANNERING PARK 33° 11'S / 151° 32' 30" E

Period	A	B	C	D	E	F	G
1	3.2979	-.5730	-.0219	.00813	-000535	-0002848	.0000246
2	3.5557	-.5717	-.0236	.00792	-.000294	-.0002581	.0000140
5	3.8211	-.5682	-.0281	.00737	.000349	-.0001860	-.0000145
10	3.9495	-.5664	-.0304	.00708	.000686	-.0001483	-.0000294
20	4.0958	-.5649	-.0323	.00684	.000964	-.0001172	-.0000416
50	4.2604	-.5633	-.0345	.00657	.001276	-.0000822	-.0000555
100	4.3701	-.5621	-.0360	.00639	.001485	-.0000589	-.0000647

NORAH HEAD 33° 16'S / 151° 34'E

Period	A	B	C	D	E	F	G
1	3.3030	-.5881	-.0317	.00820	.000373	-.0002944	.0000009
2	3.5656	-.5871	-.0347	.00792	.000762	-.0002587	-.0000151
5	3.8438	-.5845	-.0426	.00717	.001807	-.0001625	-0000582
10	3.9788	-.5831	-.0467	.00678	.002353	-.0001122	-.0000807
20	4.1306	-.5820	-.0501	.00645	.002805	-.0000707	-.0000993
50	4.3015	-.5807	-.0539	.00609	.003312	-.0000240	-.0001202
100	4.4154	-.5798	-.0565	.00585	.003651	.0000072	-.0001341

METEOROLOGY INTENSITY COEFFICIENTS (for equation 2.1 in AR & R)

GOROKAN 33° 16'S / 151° 30'E

Period	A	B	C	D	E	F	G
1	3.3275	-.5792	-.0262	.00871	-.000368	-.0003809	.0000350
2	3.5814	-.5766	-.0271	.00846	-.000187	-.0003472	.0000250
5	3.8364	-.5699	-.0294	.00779	.000300	-.0002558	-.0000021
10	3.9593	-.5664	-.0306	.00744	.000554	-.0002080	-.0000163
20	4.1010	-.5635	-.0316	.00715	.000765	-.0001686	-.0000281
50	4.2605	-.5603	-.0327	.00682	.001001	-.0001242	-.0000412
100	4.3669	-.5581	-.0335	.00660	.001159	-.0000946	-.0000500

WARNERVALE 33° 15'S / 151° 27'E

Period	A	B	C	D	E	F	G
1	3.2901	-.5628	-.0049	.01165	-.003605	-.0008369	.0001951
2	3.5476	-.5611	-.0072	.01107	-.003155	-.0007507	.0001695
5	3.8121	-.5567	-.0132	.00949	-.001936	-.0005160	0000998
10	3.9400	-.5544	-.0164	.00866	-.001298	-.0003933	0000634
20	4.0858	-.5524	-.0190	.00798	-.000772	-.0002920	.0000333
50	4.2500	-.5503	-.0220	.00721	-.000180	-.0001780	-.0000005
100	4.3594	-.5488	-.0240	.00670	.000215	-.0001020	-.0000231

YARRAMALONG 33° 13' 30" S / 151° 16' 30" E

Period	A	B	C	D	E	F	G
1	3.2962	-.5474	-.0068	.00768	-.001796	-.0002191	.0000494
2	3.5429	-.5441	-.0053	.00745	-.001844	-.0001821	.0000450
5	3.7783	-.5354	-.0013	.00680	-.001961	-.0000816	.0000326
10	3.8914	-.5308	.0008	.00646	-.002022	-.0000290	.0000262
20	4.0251	-.5270	.0025	.00618	-.002073	.0000145	.0000208
50	4.1759	-.5227	.0045	.00587	-.002130	.0000636	.0000148
100	4.2765	-.5199	.0058	.00566	-.022169	.0000963	.0000108

GWANDALAN 33° 8' 30" S / 151° 35' E

Period	A	B	C	D	E	F	G
1	3.2994	-.5842	-.0309	.00776	.000477	-.0002269	-.0000123
2	3.5560	-.5821	-.0319	.00756	.000646	-.0002012	-.0000208
5	3.8181	-.5766	-.0345	.00703	.001100	-.0001315	-.0000437
10	3.9447	-.5737	-.0358	.00675	.001337	-.0000951	-.0000557
20	4.0896	-.5713	-.0369	.00652	.001533	-0000650	-.0000656
50	4.2525	-.5686	-.0382	.00626	.001754	-.0000311	-.0000767
100	4.3612	-.5668	-.0390	.00609	.001901	-.0000086	-.0000841

SAN REMO 33° 12' 30" S / 151° 31' 30" E

Period	A	B	C	D	E	F	G
1	3.3008	-.5744	-.0233	.00803	-.000363	-.0002692	.0000174
2	3.5584	-.5722	-.0241	.00791	-.000247	-.0002568	.0000125
5	3.8231	-.5662	-.0261	.00760	.000063	-.0002231	-.0000008
10	3.9512	-.5631	-.0272	.00744	.000225	-.0002054	-.0000078
20	4.0971	-.5606	-.0280	.00731	.000359	-.0001908	-.0000135
50	4.2614	-.5577	-.0290	.00716	.000509	-.0001745	-.0000199
100	4.3710	-.5557	-.0297	.00706	.000610	-.0001635	-.0000243

METEOROLOGY INTENSITY COEFFICIENTS (for equation 2.1 in AR & R)

KANWAL 33° 16' 30" S / 151° 29' E

Period	A	B	C	D	E	F	G
1	3.2988	-.5742	-.0228	.00807	-.000431	-.0002758	.0000203
2	3.5584	-.5722	-.0241	.00791	-.000247	-.0002568	.0000125
5	3.8285	-.5667	-.0275	.00748	.000247	-.0002054	-.0000086
10	3.9593	-.5638	-.0293	.00725	.000505	-.0001785	-.0000196
20	4.1077	-.5615	-.0308	.00706	.000718	-.0001562	-.0000286
50	4.2745	-.5588	-.0324	.00685	.000958	-.0001313	-.0000389
100	4.3858	-.5570	-.0335	.00671	.001117	-.0001146	-.0000457

LAKE MUNMORAH 33° 12'S / 151° 34' 30" E

Period	A	B	C	D	E	F	G
1	3.3093	-.5839	-.0303	.00789	.000367	-.0002472	-.0000062
2	3.5671	-.5817	-.0314	.00777	.000508	-.0002353	-.0000117
5	3.8327	-.5759	-.0341	.00746	.000885	-.0002030	-.0000266
10	3.9611	-.5729	-.0355	.00730	.001083	-.0001861	-.0000343
20	4.1074	-.5705	-.0367	.00716	.001245	-.0001721	-.0000408
50	4.2720	-.5677	-.0381	.00701	.001429	-.0001564	-.0000480
100	4.3818	-.5658	-.0389	.00691	.001551	-.0001460	-.0000528

WYONG 33° 18'S / 151° 25' 30" E

Period	A	B	C	D	E	F	G
1	3.3425	-.5708	-.0218	.00798	-.000487	-.0002649	.0000203
2	3.5981	-.5679	-.0224	.00790	-.000406	-.0002579	.0000172
5	3.8577	-.5600	-.0237	.00766	-.000191	-.0002387	.0000089
10	3.9830	-.5560	-.0245	.00754	-.000079	-.0002286	.0000045
20	4.1268	-.5526	-.0251	.00744	.000014	-.0002203	.0000009
50	4.2885	-.5488	-.0257	.00733	.000118	-.0002110	-.0000031
100	4.3964	-.5462	-.0262	.00725	.000188	-.0002047	-.0000058

THE ENTRANCE

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	99.7	127.2	159.9	178.2	203.0	235.1	259.2
0 6	93.3	119.1	149.8	167.2	190.6	220.8	243.6
0 7	88.0	112.4	141.6	158.1	180.4	209.1	230.8
0 8	83.5	106.8	134.7	150.5	171.7	199.2	220.0
0 9	79.7	101.9	128.7	143.9	164.3	190.7	210.7
0 10	76.3	97.6	123.5	138.2	157.8	183.3	202.6
0 11	73.3	93.9	118.8	133.1	152.1	176.7	195.4
0 12	70.6	90.5	114.7	128.5	146.9	170.8	188.9
0 13	68.2	87.4	110.9	124.3	142.2	165.5	183.1
0 14	66.0	84.6	107.5	120.6	138.0	160.6	177.8
0 15	64.0	82.0	104.3	117.1	134.1	156.2	172.9
0 16	62.1	79.7	101.4	113.9	130.5	152.0	168.3
0 17	60.4	77.5	98.7	110.9	127.1	148.2	164.2
0 18	58.8	75.5	96.2	108.2	124.0	144.6	160.2
0 19	57.3	73.6	93.9	105.6	121.1	141.3	156.6
0 20	55.9	71.8	91.7	103.2	118.3	138.1	153.1
0 21	54.6	70.1	89.7	100.9	115.8	135.2	149.9
0 22	53.4	68.6	87.7	98.7	113.3	132.4	146.8
0 23	52.2	67.1	85.9	96.7	111.0	129.7	143.9
0 24	51.1	65.7	84.1	94.8	108.8	127.2	141.2
0 25	50.0	64.3	82.5	92.9	106.8	124.8	138.5
0 26	49.1	63.1	80.9	91.2	104.8	122.6	136.0
0 27	48.1	61.9	79.4	89.5	102.9	120.4	133.6
0 28	47.2	60.7	78.0	87.9	101.1	118.3	131.4
0 29	46.3	59.6	76.6	86.4	99.4	116.3	129.2
0 30	45.5	58.6	75.3	85.0	97.7	114.4	127.1
0 31	44.7	57.6	74.0	83.6	96.1	112.6	125.1
0 32	44.0	46.6	72.8	82.2	94.6	110.8	123.1
0 33	43.3	55.7	71.7	80.9	93.2	109.1	121.3
0 34	42.6	54.8	70.6	79.7	91.8	107.5	119.5
0 35	41.9	54.0	69.5	78.5	90.4	105.9	117.7
0 36	41.3	53.2	68.5	77.4	89.1	104.4	116.1
0 37	40.6	52.4	67.5	76.3	87.8	103.0	114.5
0 38	40.0	51.6	66.5	75.2	86.6	101.5	112.9
0 39	39.5	50.9	65.6	74.2	85.4	100.2	111.4
0 40	38.9	50.2	64.7	73.2	84.3	98.8	109.9
0 41	38.4	49.5	63.8	72.2	83.2	97.6	108.5
0 42	37.9	48.8	63.0	71.2	82.1	96.3	107.1
0 43	37.4	48.2	62.2	70.3	81.1	95.1	105.8
0 44	36.9	47.5	61.4	69.5	80.1	93.9	104.5
0 45	36.4	46.9	60.6	68.6	79.1	92.8	103.3
0 46	35.9	46.4	59.9	67.8	78.1	91.7	102.0
0 47	35.5	45.8	59.2	67.0	77.2	90.6	100.8
0 48	35.1	45.2	58.5	66.2	76.3	89.6	99.7
0 49	34.7	44.7	57.8	65.4	75.4	88.6	98.6
0 50	34.2	44.2	57.1	64.7	74.6	87.6	97.5
0 51	33.9	43.7	56.5	63.9	73.8	86.6	96.4
0 52	33.5	43.2	55.9	63.2	73.0	85.7	95.4
0 53	33.1	42.7	55.2	62.6	72.2	84.8	94.4
0 54	32.7	42.2	54.7	61.9	71.4	83.9	93.4
0 55	32.4	41.8	54.1	61.2	70.7	83.0	92.4
0 56	32.9	41.3	53.5	60.6	69.9	82.2	91.5
0 57	31.7	40.9	53.0	60.0	69.2	81.3	90.5
0 58	31.4	40.5	52.4	59.4	68.5	80.5	89.6
0 59	31.0	40.1	51.9	58.8	67.8	79.7	88.8
1 0	30.7	39.7	51.4	58.2	67.2	78.9	87.9

JILLIBY

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	87.7	112.4	142.6	159.9	183.1	213.2	236.0
0 6	82.3	105.5	134.0	150.3	172.1	200.5	222.0
0 7	77.7	99.7	126.7	142.2	162.8	189.8	210.2
0 8	73.8	94.7	120.4	135.2	154.8	180.5	199.9
0 9	70.4	90.3	114.9	129.0	147.8	172.3	190.9
0 10	67.4	86.5	110.0	123.6	141.6	165.1	182.9
0 11	64.7	83.0	105.7	118.7	136.1	158.7	175.8
0 12	62.3	79.9	101.8	114.3	131.1	152.9	169.4
0 13	60.1	77.1	98.2	110.4	126.5	147.6	163.6
0 14	58.1	74.5	95.0	106.7	122.4	142.8	158.2
0 15	56.3	72.2	92.0	103.4	118.6	138.4	153.4
0 16	54.6	70.1	89.3	100.4	115.1	134.3	148.9
0 17	53.0	68.1	86.8	97.6	111.9	130.6	144.7
0 18	51.6	66.2	84.4	94.9	108.9	127.1	140.9
0 19	50.2	64.5	82.3	92.5	106.1	123.9	137.3
0 20	49.0	62.9	80.2	90.2	103.5	120.8	134.0
0 21	47.8	61.4	78.3	88.1	101.1	118.0	130.8
0 22	46.7	60.0	76.5	86.1	98.8	115.3	127.9
0 23	45.7	58.6	74.9	84.2	96.6	112.8	125.1
0 24	44.7	57.4	73.3	82.4	94.6	110.5	122.5
0 25	43.8	56.2	71.8	80.8	92.7	108.2	120.1
0 26	42.9	55.1	70.4	79.2	90.9	106.1	117.7
0 27	42.1	54.0	69.0	77.7	89.1	104.1	115.5
0 28	41.3	53.0	67.7	76.2	87.5	102.2	113.4
0 29	40.5	52.1	66.5	74.9	86.0	100.4	111.4
0 30	39.8	51.1	65.4	73.6	84.5	98.7	109.5
0 31	39.1	50.3	64.3	72.3	83.1	97.1	107.7
0 32	38.5	49.4	63.2	71.2	81.7	95.5	106.0
0 33	37.8	48.6	62.2	70.0	80.4	94.0	104.3
0 34	37.2	47.9	61.2	68.9	79.2	92.5	102.7
0 35	36.7	47.1	60.3	67.9	78.0	91.2	101.2
0 36	36.1	46.4	59.4	66.9	76.9	89.8	99.7
0 37	35.6	45.8	58.6	66.0	75.8	88.6	98.3
0 38	35.1	45.1	57.7	65.0	74.7	87.3	96.9
0 39	34.6	44.5	56.9	64.1	73.7	86.2	96.6
0 40	34.1	43.9	56.2	63.3	72.7	85.0	94.4
0 41	33.7	43.3	55.4	62.5	71.8	83.9	93.2
0 42	32.2	42.7	54.7	61.7	70.9	82.9	92.0
0 43	32.8	42.2	54.0	60.9	70.0	81.9	90.9
0 44	32.4	41.7	53.4	60.2	69.1	80.9	89.8
0 45	32.0	41.2	52.7	59.4	68.3	79.9	88.7
0 46	31.6	40.7	52.1	58.8	67.5	79.0	87.7
0 47	31.3	40.2	51.5	58.1	66.8	78.1	86.7
0 48	30.9	39.7	50.9	57.4	66.0	77.2	85.8
0 49	30.6	39.3	50.4	56.8	65.3	76.4	84.9
0 50	30.2	38.9	49.8	56.2	64.6	75.6	84.0
0 51	29.9	38.4	49.3	55.6	63.9	74.8	83.1
0 52	29.6	38.0	48.8	55.0	63.3	74.0	82.2
0 53	29.3	37.6	48.3	54.5	62.6	73.3	81.4
0 54	29.0	37.3	47.8	53.9	62.0	72.6	80.6
0 55	28.7	36.9	47.3	53.4	61.4	71.9	79.8
0 56	28.4	36.5	46.9	52.9	60.8	71.2	79.1
0 57	28.1	36.2	46.4	52.4	60.2	70.5	78.3
0 58	27.8	35.8	46.0	51.9	59.7	69.9	77.6
0 59	27.6	35.5	45.6	51.4	59.1	69.2	76.9
1 0	27.3	35.2	45.1	50.9	58.6	68.6	76.2

OURIMBAH

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	100.4	127.9	160.2	178.3	202.8	234.4	258.2
0 6	94.1	120.0	150.5	167.6	190.7	220.5	243.0
0 7	88.9	113.4	142.4	158.6	180.6	209.0	230.4
0 8	84.4	107.8	135.4	151.1	172.1	199.3	219.8
0 9	80.5	102.9	129.4	144.5	164.7	190.8	210.5
0 10	77.1	98.5	124.2	138.7	158.2	183.4	202.4
0 11	74.1	94.7	119.5	133.5	152.4	176.8	195.2
0 12	71.3	91.2	115.2	128.9	147.1	170.8	188.7
0 13	68.8	88.1	111.4	124.6	142.4	165.4	182.8
0 14	66.6	85.2	107.9	120.8	138.1	160.5	177.4
0 15	64.5	82.6	104.7	117.3	134.1	155.9	172.4
0 16	62.6	80.2	101.7	114.0	130.4	151.8	167.9
0 17	60.8	77.9	99.0	111.0	127.0	147.9	163.6
0 18	59.2	75.9	96.4	108.2	123.9	144.3	159.7
0 19	57.6	73.9	94.1	105.6	120.9	140,9	156.0
0 20	56.2	72.1	91.8	103.1	118.2	137.7	152.5
0 21	54.9	70.4	89.7	100.8	115.6	134.7	149.2
0 22	53.6	68.8	87.8	98.6	113.1	131.9	146.1
0 23	52.4	67.3	85.9	96.6	110.8	129.2	143.2
0 24	51.3	65.9	84.3	94.7	108.6	126.7	140.5
0 25	50.3	64.6	82.5	92.8	106.5	124.3	137.9
0 26	49.3	63.3	80.9	91.1	104.5	122.1	135.4
0 27	48.3	62.1	79.4	89.4	102.6	119.9	133.0
0 28	47.4	60.9	78.0	87.8	100.9	117.8	130.7
0 29	46.6	59.8	76.6	86.3	99.1	115.9	128.5
0 30	45.7	58.8	75.3	84.9	97.5	114.0	126.5
0 31	45.0	57.8	74.1	83.5	95.9	112.2	124.5
0 32	44.2	56.9	72.9	82.2	94.4	110.4	122.6
0 33	43.5	55.9	71.8	80.9	93.0	108.8	120.7
0 34	42.8	55.1	70.7	79.7	91.6	107.2	119.0
0 35	42.1	54.2	69.6	78.5	90.3	105.6	117.3
0 36	41.5	53.4	68.6	77.4	89.0	104.1	115.6
0 37	40.9	52.6	67.6	76.3	87.7	102.7	114.1
0 38	40.3	51.9	66.7	75.2	86.5	101.3	112.5
0 39	39.7	51.2	65.8	74.2	85.4	100.0	111.1
0 40	39.2	50.5	64.9	73.2	84.3	98.7	109.6
0 41	38.7	49.8	64.1	72.3	83.2	97.4	108.3
0 42	38.2	49.1	63.2	71.4	82.2	96.2	106.9
0 43	37.7	48.5	62.4	70.5	81.2	95.1	105.6
0 44	37.2	47.9	61.7	69.7	80.2	93.9	104.4
0 45	36.7	47.3	60.9	68.8	79.2	92.8	103.2
0 46	36.3	46.8	60.2	68.0	78.3	91.8	102.0
0 47	35.9	46.2	59.5	67.2	77.4	90.7	100.8
0 48	35.5	45.7	58.8	66.5	76.5	89.7	99.7
0 49	35.0	45.2	58.2	65.7	75.7	88.7	98.7
0 50	34.7	44.6	57.5	65.0	74.9	87.8	97.6
0 51	34.3	44.2	56.9	64.3	74.1	86.9	96.6
0 52	33.9	43.7	56.3	63.7	73.3	86.0	95.6
0 53	33.5	43.2	55.7	63.0	72.6	85.1	94.6
0 54	33.2	42.8	55.2	62.4	71.8	84.2	93.7
0 55	32.8	42.3	54.6	61.7	71.1	83.4	92.7
0 56	32.5	41.9	54.1	61.1	70.4	82.6	91.8
0 57	32.2	41.5	53.5	60.5	69.7	81.8	91.0
0 58	31.9	41.1	53.0	59.9	69.1	81.0	90.1
0 59	31.6	40.7	52.5	59.4	68.4	80.3	89.3
1 0	31.3	40.3	52.0	58.8	67.8	79.5	88.5

MANNERING PARK

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	87.7	112.8	144.6	163.0	187.3	219.1	243.2
0 6	82.2	105.7	135.7	153.0	175.9	205.8	228.5
0 7	77.6	99.8	128.2	144.7	166.4	194.7	216.3
0 8	73.6	94.8	121.8	137.5	158.2	185.2	205.7
0 9	70.2	90.4	116.3	131.3	151.1	176.9	196.6
0 10	67.2	86.6	111.4	125.8	144.8	169.7	188.6
0 11	64.5	83.1	107.1	121.0	139.3	163.2	181.4
0 12	62.1	80.1	103.2	116.6	134.3	157.4	175.0
0 13	60.0	77.3	99.6	112.6	129.7	152.1	169.1
0 14	58.0	74.7	96.4	109.0	125.6	147.3	163.8
0 15	56.2	74.2	93.4	105.7	121.8	142.9	159.0
0 16	54.5	70.2	90.7	102.6	118.3	138.8	154.5
0 17	52.9	68.3	88.2	99.8	115.1	135.1	150.3
0 18	51.5	66.4	85.9	97.2	112.1	131.6	146.5
0 19	50.2	64.7	83.7	94.8	109.3	128.3	142.9
0 20	48.9	63.1	81.7	92.5	106.7	125.3	139.5
0 21	47.7	61.6	79.7	90.3	104.2	122.4	136.3
0 22	46.6	60.2	78.0	88.3	101.9	119.8	133.3
0 23	45.6	58.9	76.3	86.4	99.7	117.3	130.5
0 24	44.6	57.6	74.7	84.6	97.7	114.8	127.9
0 25	43.7	56.4	73.1	82.9	95.7	112.6	125.4
0 26	42.8	55.3	71.7	81.3	93.9	110.4	123.0
0 27	42.0	54.2	70.3	79.8	92.1	108.3	120.7
0 28	41.2	53.2	69.0	78.3	90.5	106.4	118.6
0 29	40.4	52.2	67.8	76.9	88.9	104.5	116.5
0 30	39.7	51.3	66.6	75.6	87.3	102.8	114.5
0 31	39.0	50.4	65.5	74.3	85.9	101.1	112.6
0 32	38.4	49.6	64.4	73.1	84.5	99.4	110.8
0 33	33.7	48.8	63.4	71.9	83.1	97.9	109.1
0 34	37.1	48.0	62.4	70.8	81.9	96.4	107.4
0 35	36.6	47.3	61.4	69.8	80.6	94.9	105.8
0 36	36.0	46.5	60.5	68.7	79.4	93.5	104.3
0 37	35.5	45.9	59.6	67.7	78.3	92.2	102.8
0 38	35.0	45.2	58.8	66.8	77.2	90.9	101.4
0 39	34.5	44.6	58.0	65.8	76.1	89.7	100.0
0 40	34.0	44.0	57.2	65.0	75.1	88.5	98.7
0 41	33.5	43.4	56.4	64.1	74.1	87.3	97.4
0 42	33.1	42.8	55.7	63.3	73.2	86.2	96.1
0 43	32.7	42.2	55.0	62.5	72.3	85.1	94.9
0 44	32.2	41.7	54.3	61.7	71.4	84.1	93.8
0 45	31.8	41.2	53.6	60.9	70.5	83.0	92.6
0 46	31.5	40.7	53.0	60.2	69.6	82.1	91.5
0 47	31.1	40.2	52.4	59.5	68.8	81.1	90.5
0 48	30.7	39.7	51.8	58.8	68.0	80.2	89.5
0 49	30.4	39.3	51.2	58.1	67.3	79.3	88.5
0 50	30.0	38.8	50.6	57.5	66.5	78.4	87.5
0 51	29.7	38.4	50.0	56.9	65.8	77.6	86.5
0 52	29.4	38.0	49.5	56.3	65.1	76.7	85.6
0 53	29.0	37.6	49.0	55.7	64.4	75.9	84.7
0 54	28.7	37.2	48.5	55.1	63.7	75.1	83.8
0 55	28.4	36.8	48.0	54.5	63.1	74.4	83.0
0 56	28.1	36.4	47.5	54.0	62.5	73.6	82.2
0 57	27.9	36.1	47.0	53.4	61.8	72.9	81.4
0 58	27.6	35.7	46.5	52.9	61.2	72.2	80.6
0 59	27.3	35.3	46.1	52.4	60.7	71.5	79.8
1 0	27.1	35.0	45.7	51.9	60.1	70.8	79.1

NORAH HEAD

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	88.7	114.3	147.5	166.8	192.2	225.5	250.8
0 6	83.0	107.0	138.2	156.4	180.4	211.7	235.5
0 7	78.3	101.0	130.6	147.9	170.5	200.2	222.9
0 8	74.3	95.9	124.1	140.6	162.2	190.6	212.2
0 9	70.9	91.5	118.5	134.3	155.1	182.2	203.0
0 10	67.8	87.6	113.6	128.8	148.8	174.9	194.9
0 11	65.1	84.2	109.3	123.9	143.2	168.4	187.7
0 12	62.7	81.1	105.3	119.5	138.2	162.6	181.3
0 13	60.5	78.3	101.8	115.6	133.6	157.3	175.4
0 14	58.6	75.7	98.6	112.0	129.5	152.5	170.1
0 15	56.7	73.4	95.6	108.6	125.7	148.1	165.3
0 16	55.1	71.2	92.9	105.6	122.2	144.1	160.8
0 17	53.5	69.2	90.3	102.8	119.0	140.3	156.6
0 18	52.1	67.4	88.0	100.1	116.0	136.8	152.7
0 19	50.7	65.7	85.8	97.7	113.1	133.5	149.1
0 20	49.4	64.1	83.7	95.4	110.5	130.4	145.7
0 21	48.3	62.5	81.8	93.2	108.0	127.5	142.5
0 22	47.2	61.1	80.0	91.1	105.7	124.8	139.5
0 23	46.1	59.8	78.3	89.2	103.5	122.2	136.6
0 24	45.1	58.5	76.7	87.4	101.4	119.8	133.9
0 25	44.2	57.3	75.1	85.7	99.4	117.5	131.3
0 26	43.3	56.2	73.7	84.0	97.5	115.3	128.9
0 27	42.5	55.1	72.3	82.5	95.7	113.2	126.6
0 28	41.7	54.0	71.0	81.0	94.0	111.2	124.3
0 29	40.9	53.1	69.7	79.5	92.3	109.3	122.2
0 30	40.2	52.1	68.5	78.2	90.8	107.4	120.2
0 31	39.5	51.2	67.3	76.9	89.3	105.7	118.2
0 32	38.8	50.4	66.2	75.6	87.8	104.0	116.4
0 33	38.1	49.5	65.2	74.4	86.5	102.4	114.6
0 34	37.5	48.7	64.1	73.3	85.1	100.8	112.8
0 35	36.9	48.0	63.1	72.1	83.8	99.3	111.1
0 36	36.4	47.2	62.2	71.1	82.6	97.8	109.5
0 37	35.8	46.5	61.3	70.0	81.4	96.5	108.0
0 38	35.3	45.9	60.4	69.1	80.3	95.1	106.5
0 39	34.8	45.2	59.6	68.1	79.2	93.8	105.0
0 40	34.3	44.6	58.8	67.2	78.1	92.5	103.6
0 41	33.8	44.0	58.0	66.3	77.1	91.3	102.3
0 42	33.4	43.4	57.2	65.4	76.1	90.2	101.0
0 43	33.0	42.8	56.5	64.6	75.1	89.0	99.7
0 44	32.5	42.3	55.7	63.8	74.2	87.9	98.5
0 45	32.1	41.7	55.1	63.0	73.2	86.8	97.3
0 46	31.7	41.2	54.4	62.2	72.4	85.8	96.1
0 47	31.3	40.7	53.7	61.5	71.5	84.8	95.0
0 48	31.0	40.2	53.1	60.7	70.7	83.8	93.9
0 49	30.6	39.8	52.5	60.0	69.9	82.8	92.8
0 50	30.2	39.3	51.9	59.4	69.1	81.9	91.8
0 51	29.9	38.9	51.3	58.7	68.3	81.0	90.7
0 52	29.6	38.4	50.7	58.1	67.6	80.1	89.8
0 53	29.2	38.0	50.2	57.4	66.8	79.3	88.8
0 54	28.9	37.6	49.6	56.8	66.1	78.4	87.9
0 55	28.6	37.2	49.1	56.2	65.4	77.6	87.0
0 56	28.3	36.8	48.6	55.6	64.8	76.8	86.1
0 57	28.0	36.4	48.1	55.1	64.1	76.0	85.2
0 58	27.7	36.1	47.6	54.5	63.5	75.3	84.3
0 59	27.5	35.7	47.2	54.0	62.8	74.5	83.5
0 1	27.2	35.4	46.7	53.5	62.2	73.8	82.7

GOROKAN

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	90.1	115.4	146.4	164.1	187.7	218.4	241.5
0 6	84.4	108.1	137.3	154.0	176.3	205.2	227.0
0 7	79.6	102.1	129.8	145.6	166.7	194.1	214.9
0 8	75.6	96.9	123.3	138.4	158.5	184.7	204.5
0 9	72.1	92.5	117.8	132.2	151.5	176.5	195.4
0 10	69.1	88.6	112.9	126.7	145.2	169.2	187.4
0 11	66.4	85.1	108.5	121.9	139.7	162.8	180.3
0 12	63.9	82.0	104.6	117.5	134.7	157.0	174.0
0 13	61.7	79.2	101.0	113.5	130.1	151.8	168.2
0 14	59.7	76.6	97.8	109.9	126.0	147.0	162.9
0 15	57.8	74.2	94.8	106.6	122.2	142.6	158.1
0 16	56.1	72.1	92.0	103.5	118.7	138.6	153.6
0 17	54.5	70.1	89.5	100.7	115.5	134.8	149.5
0 18	53.1	68.2	87.1	98.1	112.5	131.4	145.7
0 19	51.7	66.4	84.9	95.6	109.7	128.1	142.1
0 20	50.4	64.8	82.9	93.3	107.1	125.1	138.7
0 21	49.2	63.3	81.0	91.1	104.6	122.2	135.6
0 22	48.1	61.8	79.1	89.1	102.3	119.6	132.6
0 23	47.0	60.5	77.4	87.2	100.2	117.0	129.9
0 24	46.0	59.2	75.8	85.4	98.1	114.7	127.2
0 25	45.1	58.0	74.3	83.7	96.1	112.4	124.7
0 26	44.2	56.8	72.8	82.1	94.3	110.2	122.4
0 27	43.3	55.7	71.4	80.5	92.5	108.2	120.1
0 28	42.5	54.7	70.1	79.1	90.9	106.3	118.0
0 29	41.7	53.7	68.9	77.7	89.3	104.4	115.9
0 30	41.0	52.7	67.7	76.3	87.7	102.6	113.9
0 31	40.3	51.8	66.5	75.0	86.3	100.9	112.1
0 32	39.6	51.0	65.4	73.8	84.9	99.3	110.3
0 33	39.0	50.1	64.4	72.6	83.5	97.8	108.6
0 34	38.3	49.3	63.4	71.5	82.2	96.3	106.9
0 35	37.7	48.6	62.4	70.4	81.0	94.8	105.3
0 36	37.2	47.8	61.5	69.4	79.8	93.4	103.8
0 37	36.6	47.1	60.6	68.4	78.7	92.1	102.3
0 38	36.1	46.4	59.7	67.4	77.6	90.8	100.9
0 39	35.6	45.8	58.9	66.5	76.5	89.6	99.5
0 40	35.1	45.2	58.1	65.6	75.5	88.4	98.2
0 41	34.6	44.5	57.3	64.7	74.5	87.2	97.0
0 42	34.1	44.0	56.6	63.9	73.5	86.1	95.7
0 43	33.7	43.4	55.9	63.1	72.6	85.1	94.5
0 44	33.3	42.8	55.2	62.3	71.7	84.0	93.4
0 45	32.8	42.3	54.5	61.5	70.8	83.0	92.3
0 46	32.4	41.8	53.8	60.8	70.0	82.0	91.2
0 47	32.0	41.3	53.2	60.1	69.2	81.1	90.1
0 48	31.7	40.8	52.8	59.4	68.4	80.1	89.1
0 49	31.3	40.3	52.0	58.7	67.6	79.3	88.1
0 50	30.9	39.9	51.4	58.1	66.9	78.4	87.1
0 51	30.6	39.4	50.8	57.4	66.1	77.5	86.2
0 52	30.3	39.0	50.3	56.8	65.4	76.7	85.3
0 53	29.9	38.6	49.7	56.2	64.7	75.9	84.4
0 54	29.6	38.2	49.2	55.6	64.1	75.1	83.5
0 55	29.3	37.8	48.7	55.1	63.4	74.4	82.7
0 56	29.0	37.4	48.2	54.5	62.8	73.6	81.9
0 57	28.7	37.0	47.7	54.0	62.2	72.9	81.1
0 58	28.4	36.6	47.3	53.4	61.6	72.2	80.3
0 59	28.1	36.3	46.8	52.9	61.0	71.5	79.5
0 1	27.9	35.9	46.4	52.4	60.4	70.8	78.8

WARNERVALE

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	87.1	112.0	143.5	161.7	185.8	217.2	241.0
0 6	81.4	104.8	134.5	151.7	174.5	204.1	226.7
0 7	76.8	98.9	127.1	143.4	165.0	193.2	214.6
0 8	73.0	94.0	120.8	136.4	156.9	183.7	204.1
0 9	69.7	89.7	115.4	130.2	149.8	175.5	195.0
0 10	66.7	85.9	110.5	124.8	143.6	168.2	186.9
0 11	64.1	82.5	106.2	120.0	138.1	161.7	179.7
0 12	61.7	79.5	102.4	115.6	133.1	155.9	173.3
0 13	59.6	76.8	98.8	111.7	128.5	150.6	167.4
0 14	57.6	74.2	95.6	108.1	124.4	145.8	162.1
0 15	55.8	71.9	92.7	104.7	120.6	141.4	157.2
0 16	54.2	69.8	90.0	101.7	117.1	137.3	152.7
0 17	52.6	67.8	87.5	98.9	113.9	133.6	148.5
0 18	51.2	66.0	85.1	96.3	110.9	130.1	144.7
0 19	49.8	64.3	82.9	93.8	108.1	126.8	141.1
0 20	48.6	62.7	80.9	91.5	105.5	123.8	137.7
0 21	47.4	61.1	79.0	89.4	103.0	120.9	134.5
0 22	46.3	59.7	77.2	87.4	100.7	118.2	131.6
0 23	45.3	58.4	75.5	85.5	98.6	115.7	128.8
0 24	44.3	57.1	73.9	83.7	96.5	113.3	126.1
0 25	43.4	56.0	72.4	82.0	94.6	111.1	123.6
0 26	42.5	54.8	71.0	80.4	92.7	108.9	121.3
0 27	41.7	53.8	69.6	78.8	91.0	106.9	119.0
0 28	40.9	52.7	68.3	77.4	89.3	104.9	116.9
0 29	40.1	51.8	67.1	76.0	87.7	103.1	114.8
0 30	39.4	50.8	65.9	74.7	86.2	101.3	112.9
0 31	38.7	50.0	64.8	73.4	84.8	99.7	111.0
0 32	38.0	49.1	63.7	72.2	83.4	98.0	109.2
0 33	37.4	48.3	62.7	71.1	82.1	96.5	107.5
0 34	36.8	47.5	61.7	70.0	80.8	95.0	105.9
0 35	36.2	46.8	60.7	68.9	79.6	93.6	104.3
0 36	35.7	46.1	59.8	67.9	78.4	92.2	102.8
0 37	35.1	45.4	59.0	66.9	77.3	90.9	101.3
0 38	34.6	44.8	58.1	65.9	76.2	89.7	99.9
0 39	34.1	44.1	57.3	65.0	75.2	88.4	98.6
0 40	33.7	43.5	56.5	64.2	74.2	87.3	97.3
0 41	33.2	42.9	55.8	63.3	73.2	86.1	96.0
0 42	32.8	42.4	55.1	62.5	72.2	85.0	94.8
0 43	32.3	41.8	54.4	61.7	71.3	84.0	93.6
0 44	31.9	41.3	53.7	60.9	70.5	83.0	92.5
0 45	31.5	40.8	53.0	60.2	69.6	82.0	91.4
0 46	31.2	40.3	52.4	59.5	68.8	81.0	90.3
0 47	30.8	39.8	51.8	58.8	68.0	80.1	89.3
0 48	30.4	39.3	51.2	58.1	67.2	79.2	88.3
0 49	30.1	38.9	50.6	57.5	66.5	78.3	87.3
0 50	29.7	38.5	50.1	56.9	65.8	77.4	86.4
0 51	29.4	38.0	49.5	56.2	65.0	76.6	85.5
0 52	29.1	37.6	49.0	55.6	64.4	75.8	84.6
0 53	28.8	37.2	48.5	55.1	63.7	75.0	83.7
0 54	28.5	36.8	48.0	54.5	63.0	74.3	82.8
0 55	28.2	36.5	47.5	54.0	62.4	73.5	82.0
0 56	27.9	36.1	47.0	53.4	61.8	72.8	81.2
0 57	27.6	35.7	46.6	52.9	61.2	72.1	80.4
0 58	27.4	35.4	46.1	52.4	60.6	71.4	79.7
0 59	27.1	35.1	45.7	51.9	60.0	70.8	78.9
1 0	26.8	34.7	45.2	51.4	59.5	70.1	78.2

YARRAMALONG

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	86.5	110.5	139.3	155.7	177.6	206.1	227.7
0 6	81.3	103.9	131.1	146.6	167.4	194.4	214.7
0 7	76.8	98.2	124.0	138.7	158.4	183.9	203.2
0 8	72.9	93.3	117.8	131.7	150.4	174.7	193.0
0 9	69.5	88.9	112.3	125.6	143.4	166.5	184.0
0 10	66.6	85.1	107.4	120.1	137.1	159.2	175.9
0 11	63.9	81.7	103.1	115.2	131.5	152.7	168.7
0 12	61.5	78.6	99.1	110.8	126.5	146.9	162.3
0 13	59.3	75.8	95.6	106.8	122.0	141.6	156.4
0 14	57.3	73.2	92.4	103.2	117.8	136.7	151.0
0 15	55.5	70.9	89.4	99.9	114.0	132.3	146.2
0 16	53.8	68.8	86.7	96.9	110.6	128.3	141.7
0 17	52.3	66.8	84.2	94.1	107.4	124.6	137.6
0 18	50.8	65.0	81.9	91.5	104.4	121.1	133.8
0 19	49.5	63.3	79.7	89.1	101.6	117.9	130.2
0 20	48.3	61.7	77.7	86.8	99.1	115.0	127.0
0 21	47.1	60.2	75.9	84.7	96.7	112.2	123.9
0 22	46.0	58.8	74.1	82.8	94.4	109.6	121.0
0 23	45.0	57.5	72.4	80.9	92.3	107.1	118.3
0 24	44.0	56.3	70.9	79.2	90.4	104.9	115.8
0 25	43.1	55.1	69.4	77.6	88.5	102.7	113.4
0 26	42.3	54.0	68.0	76.0	86.7	100.6	111.2
0 27	41.4	53.0	66.7	74.6	85.1	98.7	109.0
0 28	40.7	52.0	65.5	73.2	83.5	96.9	107.0
0 29	39.9	51.0	64.3	71.9	82.0	95.1	105.1
0 30	39.2	50.1	63.2	70.6	80.6	93.5	103.3
0 31	38.6	49.3	62.1	69.4	79.2	91.9	101.5
0 32	37.9	48.5	61.1	68.3	77.9	90.4	99.9
0 33	37.3	47.7	60.1	67.2	76.7	89.0	98.3
0 34	36.7	46.9	59.2	66.1	75.5	87.6	96.8
0 35	36.2	46.2	58.3	65.1	74.3	86.3	95.3
0 36	35.6	45.5	57.4	64.2	73.3	85.0	93.9
0 37	35.1	44.9	56.6	63.3	72.2	83.8	92.6
0 38	34.6	44.2	55.8	62.4	71.2	82.7	91.3
0 39	34.1	43.6	55.0	61.5	70.3	81.6	90.1
0 40	33.7	43.0	54.3	60.7	69.3	80.5	88.9
0 41	33.2	42.5	53.6	59.9	68.4	79.5	87.8
0 42	32.8	41.9	52.9	59.2	67.6	78.5	86.7
0 43	32.4	41.4	52.3	58.4	66.7	77.5	85.6
0 44	32.0	40.9	51.6	57.7	65.9	76.6	84.6
0 45	31.6	40.4	51.0	57.1	65.2	75.7	83.6
0 46	31.2	39.9	50.4	56.4	64.4	74.8	82.7
0 47	30.9	39.5	49.8	55.8	63.7	74.0	81.8
0 48	30.5	39.0	49.3	55.1	63.0	73.2	80.9
0 49	30.2	38.6	48.7	54.5	62.3	72.4	80.0
0 50	29.8	38.2	48.2	54.0	61.6	71.6	79.2
0 51	29.5	37.8	47.7	53.4	61.0	70.9	78.3
0 52	29.2	37.4	47.2	52.8	60.4	70.2	77.6
0 53	28.9	37.0	46.7	52.3	59.8	69.5	76.8
0 54	28.6	36.6	46.3	51.8	59.2	68.8	76.0
0 55	28.3	36.2	45.8	51.3	58.6	68.1	75.3
0 56	28.0	35.9	45.4	50.8	58.1	67.5	74.6
0 57	27.8	35.5	45.0	50.3	57.5	66.9	73.9
0 58	27.5	35.2	44.5	49.9	57.0	66.3	73.3
0 59	27.3	34.9	44.1	49.4	56.5	65.7	72.6
1 0	27.0	34.6	43.7	49.0	56.0	65.1	72.0

GWANDALAN

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	88.0	113.1	144.6	162.8	186.9	218.2	242.0
0 6	82.4	106.0	135.7	152.8	175.4	205.0	227.4
0 7	77.8	100.0	128.1	144.4	165.8	193.8	215.1
0 8	73.9	95.0	121.8	137.2	157.7	184.3	204.6
0 9	70.4	90.6	116.2	131.0	150.6	176.1	195.5
0 10	67.4	86.7	111.3	125.5	144.3	168.8	187.4
0 11	64.7	83.3	107.0	120.7	138.7	162.4	180.3
0 12	62.3	80.2	103.1	116.3	133.8	156.6	173.9
0 13	60.2	77.4	99.6	112.3	129.2	151.3	168.1
0 14	58.2	74.9	96.3	108.7	125.1	146.5	162.8
0 15	56.4	72.6	93.4	105.4	121.4	142.1	157.9
0 16	54.7	70.5	90.7	102.4	117.9	138.1	153.5
0 17	53.2	68.5	88.2	99.6	114.7	134.4	149.3
0 18	51.7	66.6	85.8	97.0	111.7	130.9	145.5
0 19	50.4	64.9	83.7	94.6	108.9	127.7	141.9
0 20	49.1	63.3	81.6	92.3	106.3	124.6	138.6
0 21	48.0	61.8	79.7	90.1	103.8	121.8	135.4
0 22	46.9	60.4	77.9	88.1	101.5	119.1	132.5
0 23	45.8	59.1	76.3	86.2	99.4	116.6	129.7
0 24	44.8	57.8	74.7	84.4	97.3	114.2	127.0
0 25	53.9	56.6	73.1	82.7	95.4	111.9	124.5
0 26	43.0	55.5	71.7	81.1	93.5	109.8	122.2
0 27	42.2	54.4	70.3	79.6	91.8	107.7	119.9
0 28	41.4	53.4	69.0	78.1	90.1	105.8	117.7
0 29	40.7	52.4	67.8	76.8	88.5	103.9	115.7
0 30	39.9	51.5	66.6	75.4	87.0	102.2	113.7
0 31	39.2	50.6	65.5	74.2	85.6	100.5	111.8
0 32	38.6	49.8	64.4	72.9	84.2	98.8	110.0
0 33	37.9	49.0	63.4	71.8	82.8	97.3	108.3
0 34	37.3	48.2	62.4	70.7	81.5	95.8	106.7
0 35	36.8	47.4	61.4	69.6	80.3	94.4	105.1
0 36	36.2	46.7	60.5	68.5	79.1	93.0	103.5
0 37	35.7	46.0	59.6	67.6	78.0	91.6	102.1
0 38	35.1	45.4	58.8	66.6	76.9	90.4	100.6
0 39	34.6	44.7	57.9	65.7	75.8	89.1	99.3
0 40	34.1	44.1	57.2	64.8	74.8	87.9	97.9
0 41	33.7	43.5	56.4	63.9	73.8	86.8	96.6
0 42	33.2	42.9	55.6	63.1	72.8	85.6	95.4
0 43	32.8	42.8	54.9	62.3	71.9	84.6	94.2
0 44	32.4	41.8	54.2	61.5	71.0	83.5	93.0
0 45	32.0	41.3	53.6	60.7	70.2	82.5	91.9
0 46	31.6	40.8	52.9	60.0	69.3	81.5	90.8
0 47	31.2	40.3	52.3	59.3	68.5	80.6	89.8
0 48	30.8	39.8	51.7	58.6	67.7	79.6	88.7
0 49	30.5	39.4	51.1	57.9	66.9	78.7	87.7
0 50	30.1	38.9	50.5	57.3	66.2	77.9	86.8
0 51	29.8	38.5	49.9	56.7	65.5	77.0	85.8
0 52	29.4	38.0	49.4	56.0	64.8	76.2	84.9
0 53	29.1	37.6	48.9	55.4	64.1	75.4	84.0
0 54	28.8	37.2	48.3	54.9	63.4	74.6	83.1
0 55	28.5	36.8	47.8	54.3	62.7	73.8	82.3
0 56	28.2	36.5	47.4	53.7	62.1	73.1	81.5
0 57	27.9	36.1	46.9	53.2	61.5	72.4	80.7
0 58	27.6	35.7	46.4	52.7	60.9	71.6	79.9
0 59	27.4	35.4	46.0	52.2	60.3	71.0	79.1
1 0	27.1	35.0	45.5	51.7	59.7	70.3	78.4

SAN REMO

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	88.0	113.1	144.9	163.2	187.4	219.1	243.1
0 6	82.4	106.0	135.9	153.2	176.0	205.8	228.4
0 7	77.8	100.1	128.4	144.8	166.5	194.7	216.2
0 8	73.9	95.0	122.0	137.7	158.3	185.2	205.7
0 9	70.4	90.6	116.5	131.4	151.2	177.0	196.6
0 10	67.4	86.8	111.6	126.0	144.9	169.7	188.6
0 11	64.7	83.3	107.3	121.1	139.4	163.2	181.4
0 12	62.3	80.3	103.3	116.7	134.4	157.4	175.0
0 13	60.1	77.5	99.8	112.7	129.8	152.1	169.1
0 14	58.1	74.9	96.6	109.1	125.7	147.3	163.8
0 15	56.3	72.6	93.6	105.8	121.9	142.9	158.9
0 16	54.6	70.4	90.9	102.8	118.4	138.9	154.4
0 17	53.1	68.4	88.4	99.9	115.2	135.1	150.3
0 18	51.7	66.6	86.0	97.3	112.2	131.6	146.4
0 19	50.3	64.9	83.8	94.8	109.3	128.3	142.8
0 20	49.1	63.3	81.8	92.6	106.7	125.3	139.4
0 21	47.9	61.8	79.9	90.4	104.3	122.4	136.2
0 22	46.8	60.4	78.1	88.4	102.0	119.7	133.3
0 23	45.7	59.0	76.4	86.5	99.8	117.2	130.4
0 24	44.8	57.8	74.8	84.7	97.7	114.8	127.8
0 25	43.8	56.6	73.3	83.0	95.8	112.5	125.3
0 26	43.0	55.4	71.8	81.4	93.9	110.3	122.9
0 27	42.1	54.4	70.4	79.8	92.1	108.3	120.6
0 28	41.3	53.4	69.1	78.4	90.5	106.3	118.4
0 29	40.6	52.4	67.9	77.0	88.9	104.5	116.4
0 30	39.8	51.5	66.7	75.6	87.3	102.7	114.4
0 31	39.2	50.6	65.6	74.4	85.9	101.0	112.5
0 32	38.5	49.7	64.5	73.2	84.5	99.4	110.7
0 33	37.9	48.9	63.5	72.0	83.2	97.8	109.0
0 34	37.3	48.1	62.5	70.9	81.9	96.3	107.3
0 35	36.7	47.4	61.5	69.8	80.6	94.9	105.7
0 36	36.1	46.7	60.6	68.8	79.5	93.5	104.2
0 37	35.6	46.0	59.7	67.8	78.3	92.2	102.7
0 38	35.1	45.3	58.9	66.8	77.2	90.9	101.3
0 39	34.6	44.7	58.1	65.9	76.2	89.6	99.9
0 40	34.1	44.1	57.3	65.0	75.1	88.4	98.6
0 41	33.6	43.5	56.5	64.2	74.2	87.3	97.3
0 42	33.2	42.9	55.8	63.3	73.2	86.2	96.1
0 43	32.8	42.4	55.1	62.5	72.3	85.1	94.9
0 44	32.3	41.8	54.4	61.7	71.4	84.0	93.7
0 45	31.9	41.3	53.7	61.0	70.5	83.0	92.6
0 46	31.6	40.8	53.1	60.3	69.7	82.1	91.5
0 47	31.2	40.3	52.4	59.6	68.9	81.1	90.5
0 48	30.8	39.8	51.8	58.9	68.1	80.2	89.4
0 49	30.5	39.4	51.2	58.2	67.3	79.3	88.4
0 50	30.1	38.9	50.7	57.6	66.6	78.4	87.5
0 51	29.8	38.5	50.1	56.9	65.9	77.6	86.5
0 52	29.4	38.1	49.6	56.3	65.2	76.8	85.6
0 53	29.1	37.7	49.1	55.7	64.5	76.0	84.7
0 54	28.8	37.3	48.5	55.2	63.8	75.2	83.9
0 55	28.5	36.9	48.0	54.6	63.2	74.4	83.0
0 56	28.2	36.5	47.6	54.0	62.5	73.7	82.2
0 57	27.9	36.1	47.1	53.5	61.9	73.0	81.4
0 58	27.7	35.8	46.6	53.0	61.3	72.3	80.6
0 59	27.4	35.4	46.2	52.5	60.7	71.6	79.9
1 0	27.1	35.1	45.7	52.0	60.2	70.9	79.1

KANWAL

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	87.9	113.1	145.3	164.0	188.7	220.9	245.4
0 6	82.3	106.0	136.4	154.0	177.2	207.5	230.6
0 7	77.7	100.1	128.9	145.6	167.6	196.4	218.3
0 8	73.8	95.0	122.5	138.4	159.4	186.9	207.7
0 9	70.3	90.6	116.9	132.2	152.3	178.6	198.6
0 10	67.3	86.8	112.0	126.7	146.0	171.3	190.5
0 11	64.6	83.3	107.7	121.8	140.4	164.8	183.3
0 12	62.2	80.3	103.7	117.4	135.4	158.9	176.9
0 13	60.0	77.5	100.2	113.4	130.8	153.6	171.0
0 14	58.1	74.9	97.0	109.8	126.7	148.8	165.7
0 15	56.2	72.6	94.0	106.5	122.9	144.4	160.8
0 16	54.6	70.4	91.3	103.4	119.4	140.3	156.3
0 17	53.0	68.4	88.7	100.6	116.1	136.5	152.1
0 18	51.6	66.6	86.4	98.0	113.1	133.0	148.2
0 19	50.2	64.9	84.2	95.5	110.3	129.8	144.6
0 20	49.0	63.3	82.2	93.2	107.7	126.7	141.2
0 21	47.8	61.8	80.2	91.1	105.2	123.8	138.0
0 22	46.7	60.4	78.4	89.0	102.9	121.1	135.0
0 23	45.7	59.0	76.7	87.1	100.7	118.6	132.2
0 24	44.7	57.8	75.1	85.3	98.6	116.1	129.5
0 25	43.8	56.6	73.6	83.6	96.7	113.9	127.0
0 26	42.9	55.4	72.2	82.0	94.8	111.7	124.6
0 27	42.0	54.4	70.8	80.4	93.0	109.6	122.3
0 28	41.2	53.4	69.5	79.0	91.4	107.7	120.1
0 29	40.5	52.4	68.3	77.6	89.8	105.8	118.0
0 30	39.8	51.5	67.1	76.2	88.2	104.0	116.0
0 31	39.1	50.6	65.9	75.0	86.8	102.3	114.1
0 32	38.4	49.7	64.9	73.7	85.4	100.6	112.3
0 33	37.8	48.9	63.8	72.6	84.0	99.1	110.6
0 34	37.2	48.1	62.8	71.4	82.7	97.5	108.9
0 35	36.6	47.4	61.9	70.4	81.5	96.1	107.3
0 36	36.1	46.7	60.9	69.3	80.3	94.7	105.7
0 37	35.5	46.0	60.1	68.3	79.1	93.4	104.2
0 38	35.0	45.3	59.2	67.4	78.0	92.1	102.8
0 39	34.5	44.7	58.4	66.4	77.0	90.8	101.4
0 40	34.0	44.1	57.6	65.5	75.9	89.6	100.1
0 41	33.6	43.5	56.8	64.7	74.9	88.4	98.8
0 42	33.1	42.9	56.1	63.8	74.0	87.3	97.5
0 43	32.7	42.4	55.4	63.0	73.0	86.2	96.3
0 44	32.3	41.8	54.7	62.3	72.1	85.2	95.1
0 45	31.9	41.3	54.0	61.5	71.3	84.1	94.0
0 46	31.5	40.8	53.4	60.8	70.4	83.1	92.9
0 47	31.1	40.3	52.7	60.1	69.6	82.2	91.8
0 48	30.7	39.8	52.1	59.4	68.8	81.3	90.8
0 49	30.4	39.4	51.5	58.7	68.0	80.3	89.8
0 50	30.0	38.9	51.0	58.0	67.3	79.5	88.8
0 51	29.7	38.5	50.4	57.4	66.6	78.6	87.8
0 52	29.4	38.1	49.9	56.8	65.8	77.8	86.9
0 53	29.1	37.7	49.3	56.2	65.2	77.0	86.0
0 54	28.8	37.3	48.8	55.6	64.5	76.2	85.1
0 55	28.5	36.9	48.3	55.0	63.8	75.4	84.3
0 56	28.2	36.5	47.8	54.5	63.2	74.7	83.4
0 57	27.9	36.1	47.3	54.0	62.6	73.9	82.6
0 58	27.6	35.8	46.9	53.4	62.0	73.2	81.8
0 59	27.3	35.4	46.4	52.9	61.4	72.5	81.1
1 0	27.1	35.1	46.0	52.4	60.8	71.8	80.3

LAKE MUNMORAH

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	88.9	114.3	146.3	164.7	189.1	221.0	245.1
0 6	83.3	107.0	137.1	154.5	177.5	207.4	230.2
0 7	78.6	101.0	129.6	146.0	167.8	196.2	217.8
0 8	74.6	95.9	123.1	138.8	159.6	186.7	207.3
0 9	71.1	91.5	117.5	132.6	152.5	178.4	198.2
0 10	68.1	87.6	112.6	127.1	146.2	171.2	190.1
0 11	65.4	84.2	108.3	122.2	140.6	164.7	183.0
0 12	63.0	81.1	104.4	117.8	135.6	158.9	176.6
0 13	60.8	78.3	100.8	113.9	131.1	153.6	170.8
0 14	58.8	75.7	97.6	110.3	127.0	148.8	165.5
0 15	56.9	73.4	94.6	106.9	123.2	144.4	160.6
0 16	55.2	71.2	91.9	103.9	119.7	140.4	156.1
0 17	53.7	69.2	89.4	101.1	116.5	136.6	152.0
0 18	52.2	67.4	87.0	98.4	113.5	133.1	148.1
0 19	50.9	65.6	84.8	96.0	110.6	129.9	144.5
0 20	49.6	64.0	82.8	93.7	108.0	126.8	141.1
0 21	48.4	62.5	80.8	91.5	105.6	123.9	138.0
0 22	47.3	61.1	79.0	89.5	103.2	121.2	135.0
0 23	46.3	59.7	77.3	87.6	101.0	118.7	132.1
0 24	45.3	58.5	75.7	85.8	99.0	116.3	129.5
0 25	44.4	57.3	74.2	84.0	97.0	114.0	126.9
0 26	43.5	56.1	72.7	82.4	95.1	111.8	124.5
0 27	42.6	55.0	71.3	80.9	93.4	109.7	122.2
0 28	41.8	54.0	70.0	79.4	91.7	107.8	120.1
0 29	41.1	53.0	68.8	78.0	90.0	105.9	118.0
0 30	40.3	52.1	67.6	76.6	88.5	104.1	116.0
0 31	39.6	51.2	66.4	75.3	87.0	102.4	114.1
0 32	39.0	50.3	65.3	74.1	85.6	100.7	112.2
0 33	38.3	49.5	64.3	72.9	84.3	99.1	110.5
0 34	37.7	48.7	63.3	71.8	83.0	97.6	108.8
0 35	37.1	48.0	62.3	70.7	81.7	96.2	107.2
0 36	36.5	47.2	61.4	69.7	80.5	94.8	105.6
0 37	36.0	46.5	60.5	68.6	79.3	93.4	104.1
0 38	35.5	45.9	59.6	67.7	78.2	92.1	102.7
0 39	35.0	45.2	58.8	66.7	77.2	90.8	101.3
0 40	34.5	44.6	58.0	65.8	76.1	89.6	99.9
0 41	34.0	44.0	57.2	65.0	75.1	88.4	98.6
0 42	33.6	43.4	56.5	64.1	74.1	87.3	97.4
0 43	33.1	42.8	55.7	63.3	73.2	86.2	96.1
0 44	32.7	42.3	55.0	62.5	72.3	85.1	95.0
0 45	32.3	41.7	54.3	61.7	71.4	84.1	93.8
0 46	31.9	41.2	53.7	61.0	70.5	83.1	92.7
0 47	31.5	40.7	53.0	60.3	69.7	82.1	91.6
0 48	31.1	40.3	52.4	59.6	68.9	81.2	90.6
0 49	30.8	39.8	51.8	58.9	68.1	80.3	89.5
0 50	30.4	39.3	51.2	58.2	67.4	79.4	88.6
0 51	30.1	38.9	50.7	57.6	66.6	78.5	87.6
0 52	29.7	38.5	50.1	57.0	65.9	77.7	86.7
0 53	29.4	38.0	49.6	56.4	65.2	76.9	85.7
0 54	29.1	37.6	49.1	55.8	64.5	76.1	84.9
0 55	28.8	37.2	48.5	55.2	63.9	75.3	84.0
0 56	28.5	36.9	48.0	54.6	63.2	74.5	83.2
0 57	28.2	36.5	47.6	54.1	62.6	73.8	82.3
0 58	27.9	36.1	47.7	53.5	62.0	73.1	81.5
0 59	27.6	35.8	46.6	53.0	61.4	72.4	80.7
1 0	27.4	35.4	46.2	52.5	60.8	71.7	80.0

WYONG

RETURN PERIOD (YEARS)

Time Hr Min	1	2	5	10	20	50	100
0 5	91.4	117.1	148.8	166.9	191.1	222.4	246.2
0 6	85.6	109.8	139.7	156.7	179.5	209.1	231.5
0 7	80.8	103.7	132.0	148.3	169.9	197.9	219.2
0 8	76.8	98.5	125.5	141.0	161.6	188.4	208.7
0 9	73.2	94.0	119.8	134.7	154.4	180.1	199.6
0 10	70.1	90.0	114.8	129.1	148.1	172.8	191.5
0 11	67.3	86.4	110.4	124.2	142.5	166.3	184.3
0 12	64.8	83.2	106.4	119.7	137.4	160.4	177.8
0 13	62.5	80.3	102.8	115.7	132.8	155.1	172.0
0 14	60.5	77.7	99.4	112.0	128.6	150.2	166.6
0 15	58.6	75.3	96.4	108.6	124.7	145.7	161.7
0 16	56.8	73.1	93.6	105.5	121.2	141.6	157.2
0 17	55.2	71.0	91.0	102.6	117.9	137.8	153.0
0 18	53.7	69.1	88.6	99.9	114.8	134.3	149.1
0 19	52.3	67.3	86.4	97.4	112.0	131.0	145.4
0 20	51.0	65.7	84.3	95.1	109.3	127.9	142.0
0 21	49.8	64.1	82.3	92.9	106.8	125.0	138.8
0 22	48.7	62.6	80.5	90.8	104.4	122.3	135.8
0 23	47.6	61.2	78.7	88.9	102.2	119.7	133.0
0 24	46.6	59.9	77.1	87.0	100.1	117.3	130.3
0 25	45.6	58.7	75.5	85.3	98.1	115.0	127.7
0 26	44.7	57.5	74.1	83.6	96.3	112.8	125.3
0 27	43.8	56.4	72.7	82.1	94.5	110.7	123.0
0 28	43.0	55.4	71.3	80.6	92.8	108.7	120.8
0 29	42.2	54.4	70.1	79.2	91.1	106.8	118.8
0 30	41.5	53.4	68.8	77.8	89.6	105.0	116.8
0 31	40.8	52.5	67.7	76.5	88.1	103.3	114.9
0 32	40.1	51.6	66.6	75.3	86.7	101.7	113.0
0 33	39.4	50.8	65.5	74.1	85.3	100.1	111.3
0 34	38.8	50.0	64.5	72.9	84.0	98.6	109.6
0 35	38.2	49.2	63.5	71.8	82.8	97.1	108.0
0 36	37.6	48.5	62.6	70.8	81.6	95.7	106.5
0 37	37.1	47.8	61.7	69.8	80.4	94.4	105.0
0 38	36.5	47.1	60.8	68.8	79.3	93.1	103.5
0 39	36.0	46.4	60.0	67.9	78.2	91.8	102.1
0 40	35.5	45.8	59.2	66.9	77.2	90.6	100.8
0 41	35.0	45.2	58.4	66.1	76.2	89.4	99.5
0 42	34.6	44.6	57.6	65.2	75.2	88.3	98.3
0 43	34.1	44.0	56.9	64.4	74.3	87.2	97.0
0 44	33.7	43.5	56.2	63.6	73.4	86.1	95.9
0 45	33.3	42.9	55.5	62.9	72.5	85.1	94.7
0 46	32.9	42.4	54.9	62.1	71.6	84.1	93.7
0 47	32.5	41.9	54.2	61.4	70.8	83.2	92.6
0 48	32.1	41.4	53.6	60.7	70.0	82.2	91.6
0 49	31.7	40.9	53.0	60.0	69.2	81.3	90.6
0 50	31.4	40.5	52.4	59.4	68.5	80.5	89.6
0 51	31.0	40.0	51.8	58.7	67.8	79.6	88.6
0 52	30.7	39.6	51.3	58.1	67.0	78.8	87.7
0 53	30.4	39.2	50.7	57.5	66.3	78.0	86.8
0 54	30.0	38.8	50.2	56.9	65.7	77.2	85.9
0 55	29.7	38.4	49.7	56.3	65.0	76.4	85.1
0 56	29.4	38.0	49.2	55.8	64.4	75.7	84.3
0 57	29.1	37.6	48.7	55.2	63.8	74.9	83.5
0 58	28.8	37.2	48.3	54.7	63.1	74.2	82.7
0 59	28.6	36.9	47.8	54.2	62.6	73.5	81.9
1 0	28.3	36.5	47.4	53.7	62.0	72.9	81.2

APPENDIX C – STORMWATER PIT INLET CAPACITIES

C.1.1 General

The following pit inlet graphs should be used as a guide only, specifically for on-grade applications. Minor changes to inlet characteristics generally outside the designer's control such as parked vehicles, variations in kerb type (roll or integral), debris, alterations in pit depressions, etc may considerably affect inlet capacity.

C.1.2 Graph Notes

1 Lintel sizes refer to clear openings.

2 Grate inlet capacity based on "Weldlok Gully Grate GG78-50" or the current equivalent.

3 Changes in road cross fall shall have an assumed variation to on grade inlet capacities of 0.005m3/s per 1% changes in grade.

4 Sag pit inlet capacities shall be determined from the addition of values obtained from graphs of sag lintel inlets and sag grate inlets.

5 Pit intake capacities shown in graphs incorporate the following blockage factors:

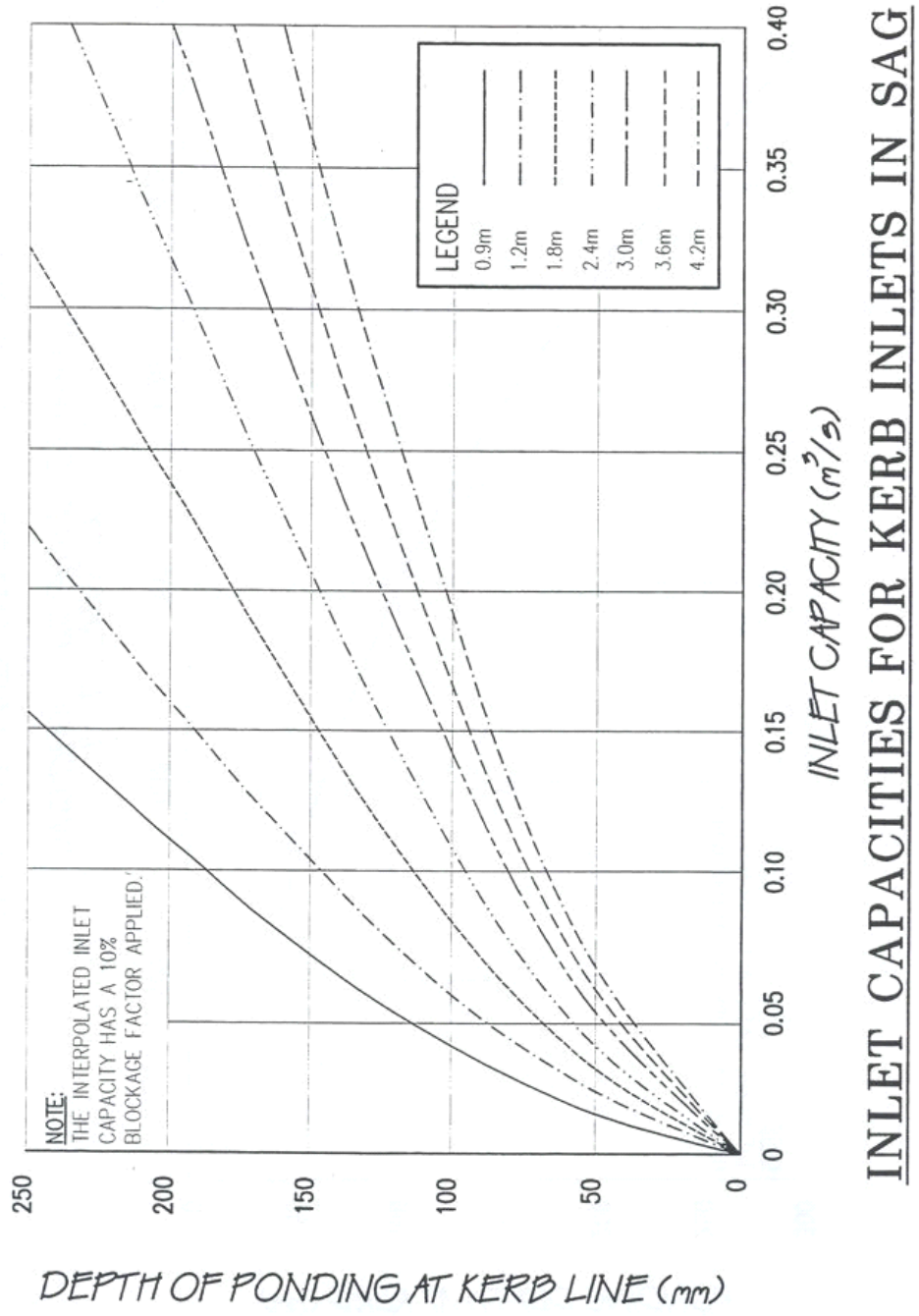
6 A 10% blockage factor applies to all lintel openings irrespective of being in sags or on grade.

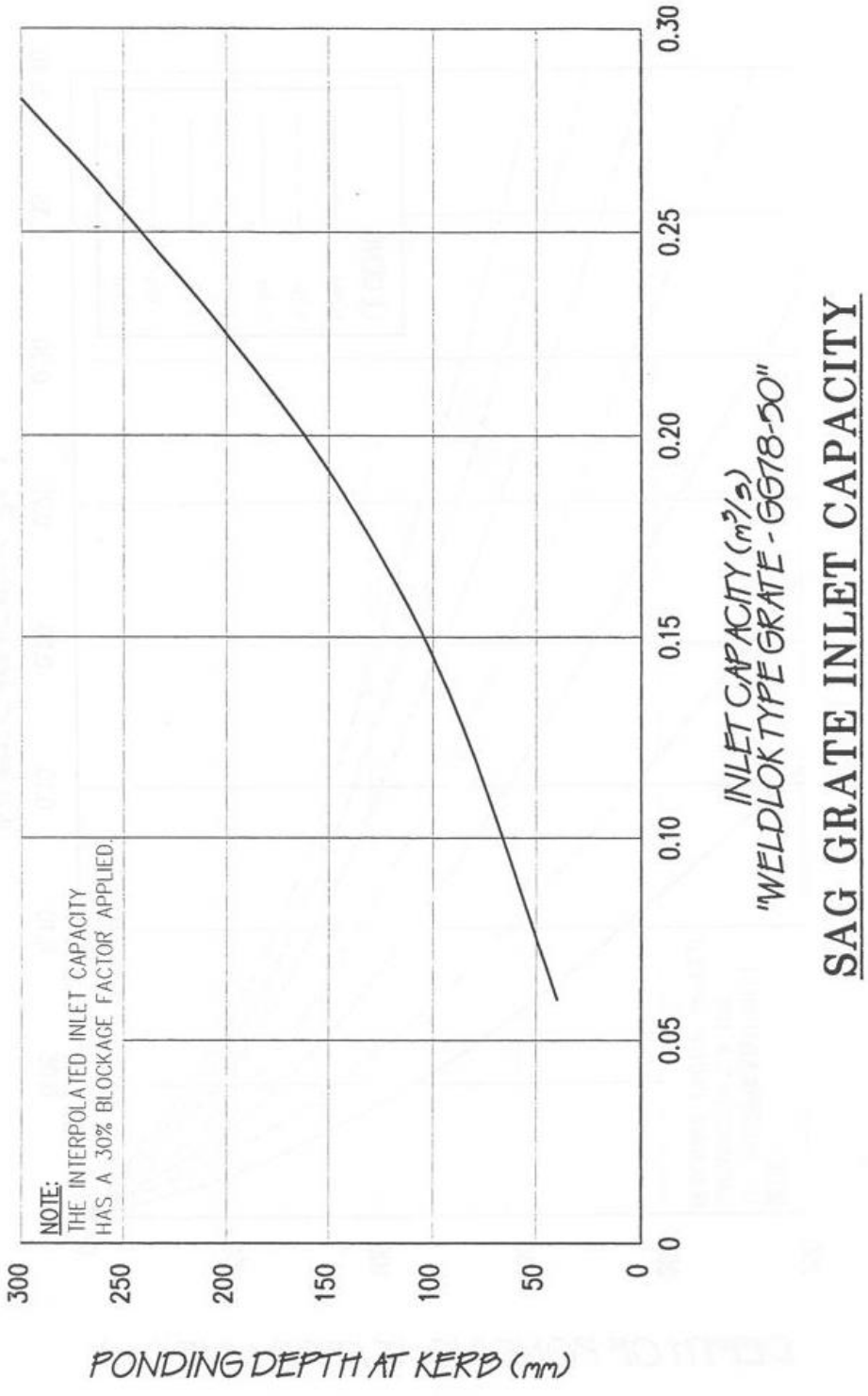
7 A 30% blockage factor applies to sag pit grates in kerb and guttering.

8 On-grade grates incorporated in sumps are assumed to capture minimal flows.

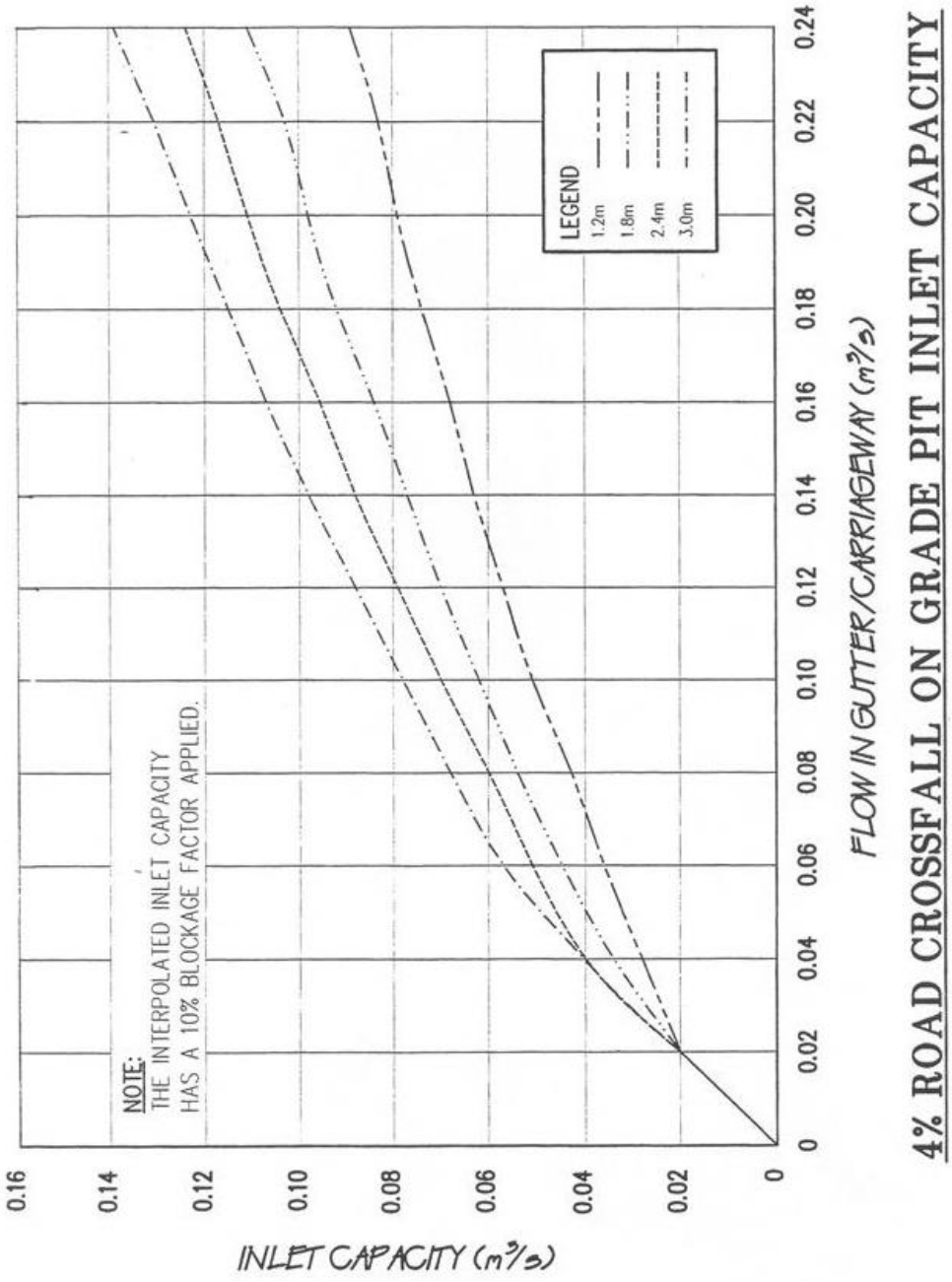
9 Generally the maximum depth of ponding permitted shall be 200mm unless otherwise approved by the Engineer.

10 Median kerb, letterbox, grated surface inlet and specifically designed pits shall have suitable blockage factors applied for the inlet type, location and catchment characteristics. Inlet capacities to be calculated generally in accordance with Australian Rainfall and Runoff and shall be accepted by Council's Development Engineering Section.


INLET CAPACITIES FOR KERB INLETS IN SAG
INLET CAPACITY (m³/s)
0
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
DEPTH OF PONDING AT KERB LINE (mm)
250
200
150
100
50
0
LEGEND
0.9m
1.2m
1.8m
2.4m
3.0m
3.6m
4.2m
NOTE:
THE INTERPOLATED INLET CAPACITY HAS A 10% BLOCKAGE FACTOR APPLIED.



SAG GRATE INLET CAPACITY



4% ROAD CROSSFALL ON GRADE PIT INLET CAPACITY

APPENDIX D – WATER SENSITIVE URBAN DESIGN – CONCEPT DESIGN TOOLS

WYONG SHIRE COUNCIL

WATER SENSITIVE URBAN DESIGN TECHNICAL GUIDELINE

CONCEPT DESIGN TOOLS

November 2010

Document Control Sheet		
DRAFT	April 2008	For Exhibition
DRAFT	April 2009	Remove MUSIC help menus and other minor amendments.
DRAFT	Nov 2010	Amend for revised IWCM Strategy, NSW MUSIC Modelling Guidelines & WSC Deemed to Comply Provisions. For Exhibition.
FINAL	July 2012	Amended for inclusion as an appendix to the "Civil Works Design Guidelines.

Table of Contents

1.0 INTRODUCTION

This document contains the following three tools:

- Stormwater quality (MUSIC) modelling guidelines (Section 2);
- Stormwater storage design curves (Section 3);
- Stormwater storage modelling tool (Section 4).

These tools are relevant to the Development Application stage of the design and approval process. Other useful tools, relevant to the detailed design stage of the process, can be found in the Australian Runoff Quality (ARQ) by Engineers Australia.

This document expects a certain level of knowledge of the MUSIC program. Information and training is available on MUSIC. Go to www.ewater.com.au for further information.

Water quality modelling is required to demonstrate compliance with the stormwater quality objectives.

Section 2 details the stormwater quality modelling guidelines and includes the following sections:

- Sections 2.3 to 2.6 cover key inputs to the MUSIC model, including meteorological data, catchment details, rainfall runoff parameters and pollutant generation parameters. These sections guide the setup of the MUSIC model.
- Section 2.8 describes how to model stormwater treatment elements in MUSIC, including wetlands, sedimentation basins, infiltration basins, gross pollutant traps, buffer strips, bioretention systems, swales, bioretention swales and rainwater tanks.

Section 3 details the stormwater storage design curves for standard development applications. The stormwater storage design curves and associated modelling tool are designed to assist in demonstrating compliance with the wetland hydrology objectives and/or waterway stability objectives for broad, undefined drainage depressions. The stormwater storage design curves can be used for standard applications (e.g. typical detached dwellings, attached dwellings, multi-storey residential, commercial and industrial land uses) or for an initial estimate of stormwater storage requirements.

Section 4 details the stormwater storage design tool for non-standard development applications. Non-standard applications are when the design principles specified in Section 3 are not adhered to or site conditions and WSUD designs are non standard regional IWCM design parameters are not adhered to. It includes the following sections:

- Sections 4.1 describes how to use MUSIC to produce flow time series data for the pre- and post-development scenarios.
- Section 4.2 also describes how to model different types of stormwater storages, including: active storages, storages for reuse, detention storages.
- Section 4.3 describes the use of the post processing tool, which translates time series flow data into low and high flow duration frequency curves and low flow spells frequency curves.
- Section 4.4 describes how to check compliance with the wetland hydrology and waterway stability objectives.

THE GUIDELINES AND TOOLS WITHIN THIS DOCUMENT PROVIDE INFORMATION IN RELATION TO THE *MUSIC* MODELLING TOOL KIT. OTHER MODELLING TOOLS ARE ON THE MARKET AND CAN BE USED WITH PRIOR APPROVAL FROM COUNCIL.

2.0 STORMWATER QUALITY (MUSIC) MODELLING GUIDELINES

2.1 Introduction

Recent developments in urban stormwater quality modelling software have resulted in a significant advancement in the ability to simulate the pollutant removal efficiency of a range of stormwater treatment devices. Specifically, MUSIC (Model for Urban Stormwater Improvement Conceptualisation) developed by the Cooperative Research Centre for Catchment Hydrology (CRC-CH) now provides stormwater practitioners with a conceptual design tool that estimates stormwater pollutant generation and the performance of stormwater treatment measures. MUSIC is designed for use by a range of stormwater professionals who require a good understanding and knowledge of stormwater management principles. MUSIC can be used to:

- Undertake conceptual design of stormwater treatment elements;
- Undertake stormwater storage modelling to establish the size of stormwater storages. This is required if stormwater storage curves provided in Section 4 do not adequately represent the proposed harvesting strategy in a particular catchment.

These guidelines are provided to ensure consultants, developers and Council have a consistent and uniform approach to stormwater quality and harvesting modelling within the Wyong Shire region. The guidelines provide specific guidance on rainfall and evaporation inputs, source node selection, rainfall runoff parameters, pollutant generation parameters, stormwater treatment nodes and stormwater storage nodes. The use of parameters different to those listed in this document must be justified.

These guidelines should be read in combination with the *NSW MUSIC Modelling Guideline*[1] *s (BMT WBM 2010)* and the MUSIC User Guide, which outlines all the definitions, assumptions and methodologies provided within the MUSIC tool.

2.2 MUSIC Model Setup

A MUSIC model requires a significant amount of information during the model set-up stage. These steps include the selection and input of the following information:

- Appropriate meteorological data (rainfall and evaporation inputs);
- Defining catchment areas (source nodes) to be incorporated into the model;
- Appropriate soil properties (rainfall runoff properties); and
- Pollutant generation characteristics for selected source nodes.

These are discussed in further detail in sections 2.2 – 2.7.

[1] Guidelines are available for download from the *eWater* Toolkit – see http://www.ewatercrc.com.au/index.html

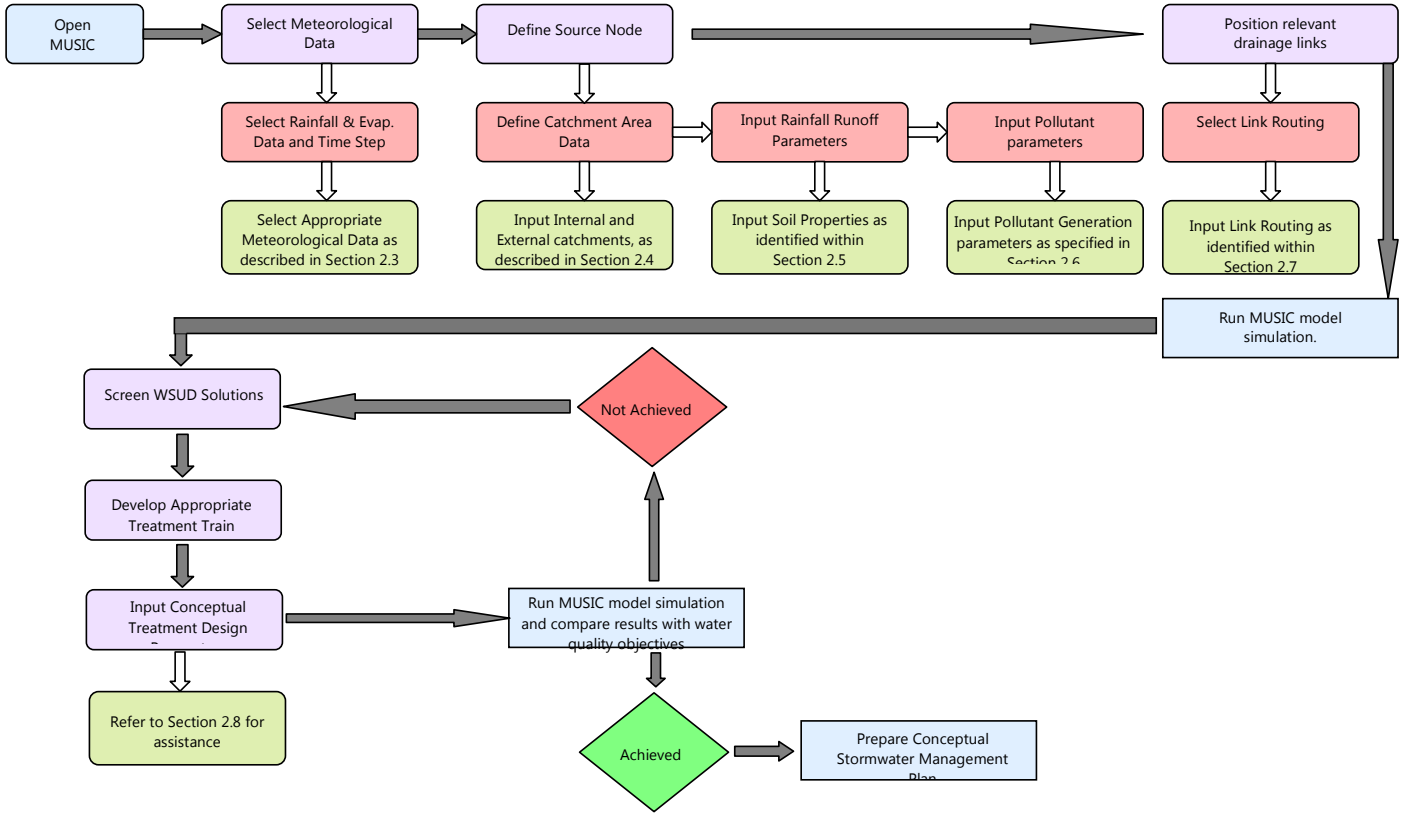


Figure 1 Schematic of MUSIC modelling process (as adapted from the Gold Coast City Council MUSIC Guidelines)

2.3 Rainfall and Evaporation Inputs

Stormwater runoff is represented as both surface runoff and baseflow in the MUSIC model. It is generated in MUSIC through the interaction of rainfall, evapotranspiration and the MUSIC Rainfall-Runoff Model (see MUSIC User Manual for full description of Rainfall-Runoff Model). The following sections outline Council's preferred rainfall and evapotranspiration datasets to be used when undertaking stormwater quality designs and hydrologic investigations for stormwater harvesting.

2.3.1 Rainfall Data for Water Quality Modelling

Council requires the following approach to rainfall simulation be adopted for stormwater quality modelling:

- Continuous simulation of a minimum of 10 years; and
- A six (6) minute time step is to be utilised as this allows for the appropriate definition of storm hydrograph movement through small-scale stormwater treatment processes such as vegetated swales and bioretention systems.

To provide a consistent approach to stormwater modelling, Council has identified an appropriate rainfall station for the Shire, and periods of modelling to be utilised within the MUSIC model. Three 6 minute data stations were investigated for their suitability. These included rainfall stations at:

- Kulnurra (William Road), approximately 25km west of Wyong;
- Peats Ridge approximately 20 km west-southwest of Wyong;
- Sydney Observatory Hill, approximately 70-75 km south-southwest of Wyong.

Comparison of rainfall at various stations in Wyong Shire and Sydney Observatory Hill are shown below in Figure 2.

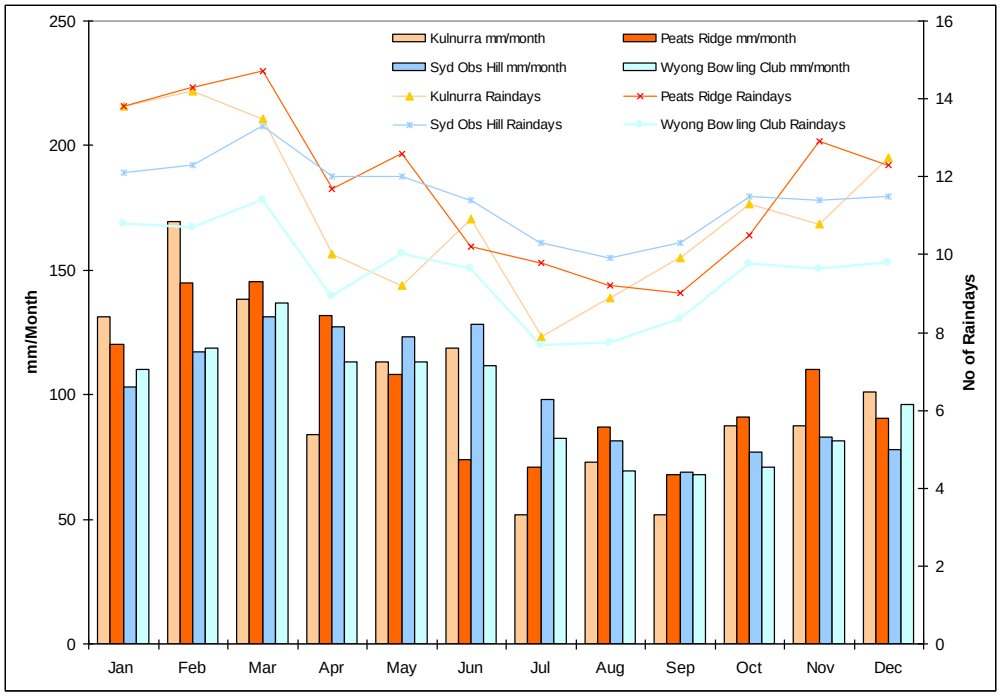


Figure 2 Minute Rainfall Station Comparison

Wyong Shire Council has identified that the 6 minute rainfall data at Sydney Observatory Hill is comparable to the rainfall experienced in the Wyong Shire, with the rainfall and number of raindays per month, when compared to Wyong Bowling Club rainfall records. It consistently has about one more rain day a month than Wyong, suggesting that rainfall at Wyong Bowling Club is more intense than at Sydney.

Given the above, Council requires all stormwater quality modelling in MUSIC to be undertaken using the Sydney Observatory Hill rainfall data and the modelling period between 1973-1993 (refer Table 1).

Table 1: Recommended 6 Minute Rainfall Station

Rainfall Station	Modelling Period	Annual Rainfall (mm)
Sydney Observatory Hill (station 066062)	1973-1993	1273

2.3.2 Rainfall Data for Hydrologic Modelling

The following approach is to be undertaken for hydrologic assessment modelling. That is, modelling required for stormwater harvesting and stormwater storage design in response to wetland hydrology and waterway stability objectives.

Continuous simulation of a minimum of 20 years should be used, including:

- Daily time step is to be utilised for simulating stormwater storage sizes where the pump rate drains the storage over three days or greater;
- minute to hourly time step is to be utilised for storages where the pump rate drains the storage in less than three days;
- The rainfall data contains a wet, dry and average rainfall year.

Wyong Shire Council has identified two appropriate daily rainfall stations to be utilised within the MUSIC model for hydrologic modelling. Sydney Observatory Hill is the preferred rainfall station (refer section 2.3.1). However, if daily rainfall data is required, then the Wyong Bowling Club rainfall records can be used.

Table 2: Recommended Daily Rainfall Station

Rainfall Station	Modelling Period [2]	Mean Annual Rainfall (mm)
Sydney Observatory Hill **(preferred)**	1963-1993	1222
Wyong Bowling Club	1918-1965	1184

2.3.4 Evapotranspiration Data

Wyong Shire Council found that Sydney evaporation data closely matches that from the Wyong Shire region (although slightly higher) and is therefore suitable for use in MUSIC modelling for water quality and hydrology. The monthly evapotranspiration values for Sydney are shown in Table 3and the comparison with Peats Ridge and Kulnura is illustrated in Figure 3.

[2] Select a period that has minimal gaps in the data

Table 3: Evapotranspiration Values

Month	J	F	M	A	M	J	J	A	S	O	N	D
Evapotranspiration(mm)	180	135	128	85	58	43	43	58	88	127	152	163

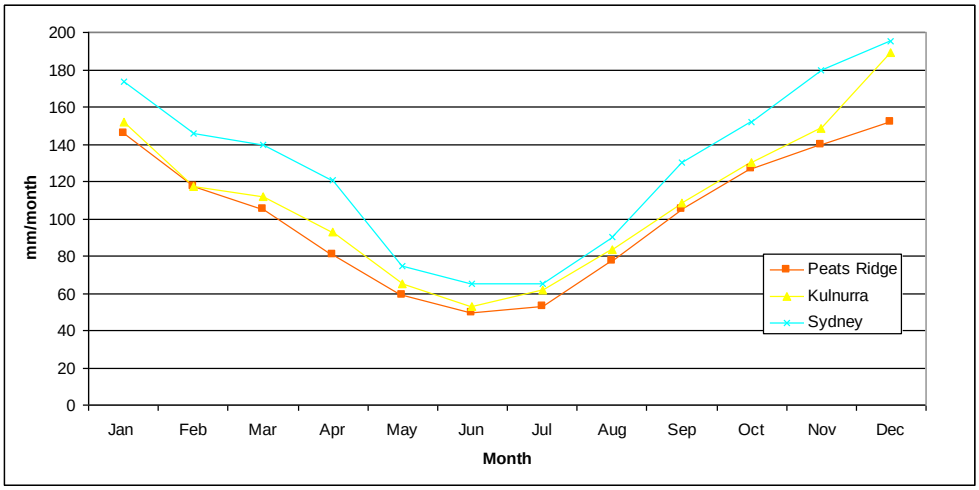


Figure 3 Comparison of evaporation data for Sydney and Wyong regions

2.4 MUSIC Source Nodes

The source nodes must be defined to reflect the details of the contributing catchments of the development. Source Nodes for Wyong Shire catchments are defined below:

- The Urban Source Node in MUSIC is used to describe low to high density residential, commercial and industrial areas. These land uses include lots with all associated facilities, such as roads and parks;
- The Agricultural Source Node refers to areas of large scale cropping or grazing. This node should be only be used for low density rural areas situated in predominantly agricultural settings;
- The Forested Source Node is to be used for natural bushland areas. This node is to be utilised in areas where canopy densities are greater than 50%;
- The Imported Data Source Node is to be utilised in the regional storage and harvesting scenario modelling. This setup is explained in further detail in Section 0.

Each individual Source Node, with the exception of the Imported Data Node, requires the total area and impervious percentage of the site to be defined.

An initial estimate of percentage impervious for each particular land use should be based on the ultimate zoning of the area, reflecting the ultimate land use of the catchment. Building density controls for urban areas must also be considered, including elements such as minimum soft landscaping area, maximum building envelopes, floor space ratios and road design guidelines. These estimates should also be compared to aerial photos of similar recent housing developments in the vicinity of the proposed development.Where differences between the estimates and the on ground impervious area are significant then estimates should be revised or the differences justified. Consult Part 10 – STORMWATER DRAINAGE DESIGN of the Civil Works Design Guideline for further information on determining development impervious areas.

2.4.1 Urban Land Use Split

The urban node must be split into the various land use types (i.e. road reserve, roof, ground level pervious and impervious) when the following proposed developments are modelled:

- a single lot (including commercial and industrial);
- a single street (including multiple lots);
- the influence of rainwater tanks within a development (regardless of the size of development).

When utilising this approach:

- Roof areas are to be modelled as 100% impervious;
- Road reserve areas include the road and adjacent landscaping and footpaths contained within the road reserve. Imperviousness of this node should be approximately 70%; and
- Remaining ground areas can be further split into pervious and impervious areas when required.

An example of an urban land-use split in MUSIC is shown below:

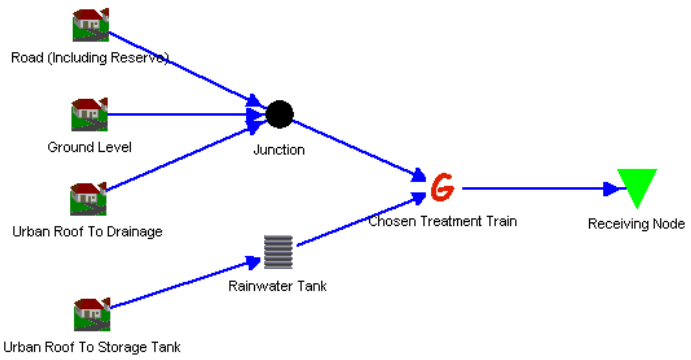


Figure 4 Example MUSIC model setup including a rainwater tank

2.5 Rainfall Runoff Parameters

Stormwater runoff (represented as storm flow and baseflow) is generated in MUSIC through the interaction of rainfall, evapotranspiration and the MUSIC Rainfall-Runoff Model[3].

MUSIC rainfall-runoff parameters were derived for the Wyong Shire region through a calibration process to stream information for Jilliby - Jilliby Creek (upstream tributary of Wyong River). Details of this calibration process is provided in the *DRAFT Discussion Paper Modelling Rationale for the Porters Creek Stormwater Harvesting Strategy (Ecological Engineering 2006)*.

Based on the calibration to stream flow data at Jilliby - Jilliby Creek two general pervious source nodes were developed, an 'upland' and 'lowland' node, based on the following catchment geography:

- Upland nodes are areas within the catchment where slopes are generally greater than 5%., and are typically found in the headwaters of the catchments;

[3] A full description of the MUSIC Rainfall-Runoff Model is provided in the MUSIC User Manual.

- Lowland nodes are areas with slopes generally less than 5% and are typically found in the floodplain zone of unconfined valleys of a higher order creek.

Pervious areas must be modelled as upland or lowland area depending on the location of the development within Wyong Shire.

Section 2.5.1 outlines the way to determine whether a development is in an upland or lowland catchment. Section 2.5.2 outlines the steps to inputting this data into the MUSIC Source Node Parameters.

2.5.1 Defining Upland and Lowland Areas

To delineate between upland and lowland areas, the following steps should be undertaken:

a Obtain the best available contour data for the catchments of interest.

b Make an initial visual assessment of the contour information based on obvious changes in slope and topography for a rough estimation of upland and lowland areas.

c Calculate ground slopes (%) for the area of interest. A Digital Elevation Model may be of assistance in delineating upland and lowland areas for larger catchments.

d Analyse slope data to identify areas greater than and less than approximately 5% slope. **Slopes <5% are considered lowland and slopes >5% are considered upland.** Note: It may be necessary to repeat this step with slopes of 2-6% in order to achieve a reasonable delineation between upland and lowland areas.

e Perform a manual check and edit anomalies. Common anomalies include relatively flat areas in the upper part of the catchment (e.g. gently sloping hill tops). These areas should be modelled as upland to reflect the likely soil properties.

A site-specific assessment should be performed for most developments, to generate more detailed information at a scale appropriate to the individual development.

2.5.2 Rainfall – Runoff Parameters for Upland and Lowland Areas

The following soil characteristics are to be used in the rainfall-runoff parameters of upland and lowland areas:

Table 4: Soil Characteristics

Parameter	Upland	Lowland
Rainfall Threshold (mm)	1	1
Soil Capacity (mm)	200	250
Initial Storage (%)	30	30
Field Capacity	80	100
Infiltration Capacity Coefficient a	200	200
Infiltration Capacity Coefficient b	1	1
Initial Depth (mm)	10	10
Daily Recharge Rate (%)	0.5	4
Daily Baseflow Rate (%)	0.16	2
Deep Seepage (%)	2	0.4

Note: The above rainfall threshold values are an average value for the various land-use types. Refer to the NSW MUSIC Modelling Guidelines [4] for specific threshold values relating to roofs, roads etc.

2.6 Pollutant Generation

The recommended model defaults for various land use categories is based on research by Fletcher et al. (2004). These are to be as per the guidelines listed in *NSW MUSIC Modelling Guidelines.*

Note: For all simulations the MUSIC model must be run with pollutant export estimation method set to "stochastic generated".

2.7 Link Routing

Routing may be used to reflect the travel time for flood wave propagation through the catchment. For all MUSIC model simulations it is recommended that the channel routing option in MUSIC be set to "No Routing" as this is the most conservative modelling scenario.

If the routing option is used in the model, suitable justification is required to be submitted with the concept design. Translation only method or Muskingham-Cunge method are to be used if the routing option is chosen. The user is referred to the MUSIC User Manual for further details.

[4] Guidelines are available for download from the *eWater* Toolkit – see http://www.ewatercrc.com.au/index.html

2.8 Stormwater Quality Treatment Nodes

Several stormwater treatment elements are available in MUSIC as shown adjacent. Once the WSUD objectives have been determined for a site, an appropriate treatment train can be modelled in MUSIC.

***Note 1**: The following devices are not to be modelled within the MUSIC program: natural waterways, natural wetlands, naturalised channel systems, environmental buffers and natural lake/pond systems. The following Sections 2.8.1 to 2.8.10 briefly outline each treatment element available in MUSIC, and parameters to be used, if applicable. Further reference should be made to the MUSIC user manual.*

***Note 2**: MUSIC is a conceptual comparison tool only, not a design tool. It is essential that devices included in a model are achievable within the modelled catchment. The designer should carry out preliminary calculations to ensure that devices included can be drained and adequate allowance had been made for batters in restricted areas.*

A summary of modelling guidelines is provided below.For further details and modelling requirements for rainwater reuse, pervious pavements and other treatment measures refer to the *NSW MUSIC Modelling Guidelines*.

2.8.1 Wetland 

Constructed wetland systems use enhanced sedimentation, fine filtration and pollutant uptake processes to remove pollutants from stormwater. Constructed wetland systems consist of:

- an inlet zone (sediment basin to remove coarse sediments);
- a macrophyte zone (a shallow heavily vegetated area to remove fine particulates and uptake of soluble pollutants); and
- a high flow bypass channel (to protect the macrophyte zone).

The following parameters are to be included when modelling a wetland:

- Extended detention depth of between 0.25 - 0.75m;
- Seepage losses set to zero unless geotechnical soil testing indicates otherwise;
- Adjust the pipe diameter or orifice size to ensure the device has adequate detention time (a notional detention time of 48 hours to 72 hrs is required) . Sizes less than 100mm diameter are to consider appropriate screening to prevent blockage.

2.8.2 Sedimentation Basin 

Sediment basins are used to retain coarse sediments from runoff. They operate by reducing flow velocities and encouraging sediments to settle out of the water column.

They are frequently used for trapping sediment in runoff during construction activities and for pre-treatment to measures such as wetlands and are sized according to the design storm discharge and the target particle size for trapping (generally 0.125 mm). These devices can be utilised as pre-treatment devices upstream of bioretention devices to allow for a diversion of flows above recommended scour velocities.

The following parameters are to be included when modelling a sedimentation basin:

- Seepage losses set to zero unless soil testing indicates otherwise;
- Adjust the pipe diameter to ensure the device has a detention time of approximately 48 - 72 hours.

2.8.3 Infiltration Basin 

Infiltration measures encourage stormwater to infiltrate into surrounding soils. Infiltration measures are highly dependent on local soil characteristics and are best suited to sandy and sandy clay soils with deep groundwater. Generally geotechnical assessment is to be undertaken before infiltration is considered at a particular site.

Note: Infliltration measures are not treatment systems and suitable pre-treatment of stormwater is required prior to entering the infiltration measure. When assessing pollutant removal performance in MUSIC, the water quality objectives should be met upstream of any infiltration system.

The following parameters are to be included when modelling an infiltration basin:

- Establish the infiltration rate based on findings from a geotechnical engineering report or soil percolation test to determine the likely infiltration rate from the device to the surrounding soils.

2.8.4 Gross Pollutant Trap 

Gross Pollutant Traps (GPT's) typically remove rubbish, sediment and hydrocarbons from stormwater runoff. GPT's can be very effective at removal of solids conveyed within stormwater which are typically larger than 5mm in size.

There are no specific input parameters for GPT's.

Pollutant removal efficiency of gross pollutant devices will have to be adequately demonstrated by independent testing. Pollutant removal efficiencies claimed by manufacturers of proprietary devices are not considered sufficient. Manufacturer's claims must be supported by independent testing comprising continuous monitoring of the product for a time frame of three months after an initial storm event. [5].

[5] Typically independent testing would be carried out over a minimum three month period. The test results should include various documented design events (and include typical stormwater runoff from the chosen land use). No pollutants are to be removed from the device during the assessment of the device to mimic the actual maintenance regime of GPT's within the Wyong Shire.

2.8.5 Buffer 

Buffer or filter strips, in the context of urban stormwater, are grassed or vegetated areas over which stormwater runoff from adjoining impervious catchments traverses enroute to the stormwater drainage system or receiving environment. Buffer strips are intended to provide discontinuity between impervious surfaces and the drainage system. Buffer strips receive water from impervious surfaces in a distributed manner, promoting uniform flows while enabling minor filtration of sediments and coarse pollutants. The most important component of a buffer strip is its ability to distribute flows over a wide vegetated area. They also provide a minor detention role to slow flows down. The buffer design in MUSIC must be a realistic representation of the post-construction scenario for incoming flow discharge points.

The following parameters are to be included when modelling a buffer area:

- The seepage losses set to zero.

***Note**: Utilise buffer devices upstream of other treatment devices to assist in sediment drop out prior to stormwater entering secondary treatment devices i.e. swales.*

2.8.6 Bioretention 

Bioretention systems (also known as biofiltration trenches) are a combination of vegetation and filter substrate that provides treatment of stormwater through filtration, extended detention and some biological uptake.

The following parameters are to be included when modelling a bioretention area:

- Ponding depths of 0.1 to 0.30 metres are recommended for plant sustainability and adequate draining times. Depths greater than 0.40 metres not recommended;
- Minimum depth within the device: > 0.5 m for rushes and shrubs and > 0.8 m for tree species;
- The seepage losses set to zero.

a Provide the proposed depth of filter media within the device. The following depths are recommended as a minimum within the device: > 0.5 m for rushes and shrubs and > 0.8 m for tree species proposed to ensure adequate area for root growth are provided within the device. This depth does not include the drainage layer;

b Identify the type of filter media proposed based upon particle size and hydraulic conductivity. A sandy-loam mixture is recommended to provide adequate organic material for vegetation/root yet still has sufficient drainage characteristics;

c The depth below underdrain pipe is the percentage of filter below the slotted drainage pipe;

d The default k-c* values for the bioretention system must not be adjusted without appropriate confirmation from Council.

***Note**: When locating bioretention devices ensure the ability of the devices to drain adequately has been assessed. Also ensure the device has sufficient pre treatment bypass flows or contains structures to ensure flows within the device are kept below the scour velocity of the chosen filter media.*

2.8.7 Swale 

Vegetated swales are open vegetated channels that can be used as an alternative stormwater conveyance system to pipes or can be used in conjunction with a pipe system. The interaction of surface flows with the vegetation in a swale facilitates an even distribution and slowing of flows thus encouraging particulate pollutant settlement. Swales can be incorporated into streetscape designs and can add to the aesthetic character of an area.

The following parameters are to be included when modelling a swale area:

- The seepage set to zero;
- Swales with a bed slope greater than 5% and less than 2% are not recommended;
- Swales with bed slopes less than 2% must incorporate a low-flow drainage line;
- Ensure side batters are a minimum of 1 (vertical) : 4 (horizontal).

2.8.8 Bioretention Swales

In order to model the proposed treatment efficiency of a bioretention swale within a treatment train, the bioretention swale should be split into its various components. These are the bioretention filter surface and battered slopes of the grassed channel. The image above depicts a standard layout for incorporating a bioretention swale within a treatment train.

The following parameters are to be included when modelling a bioretention swale:

Bioretention Component:

- The device should have no extended detention depth as runoff is anticipated to be conveyed through the device and not ponded to a design depth;
- Seepage set to zero;
- The filter media used is to be a sandy-loam material to ensure vegetation can establish on the surface of the filter media.

Swale Component:

- Ensure that the bed slope of the swale is not less than 2% and does not exceed 5%.
- Seepage set to zero.

2.8.9 Rainwater Tank 

In order to appropriately model the treatment efficiency of a rainwater tank within an urban development, the rainwater tank that is entered into MUSIC must comply with any BASIX certificate for that residential site.

The following parameters are to be included when modelling rainwater tanks:

- Relatively constant demands such as toilet flushing should be entered as a daily demand in kL/day;

- Seasonal demands such as irrigation should be entered as an annual demand in ML/year, and should be scaled according to 5 inSection 4.2.3;
- End Use demands should be verified with demands from BASIX calculated water demands.

Where rainwater tanks are included in a particular stormwater strategy the various "land types" need to be delineated in the MUSIC model to ensure the pollutant export and treatment processes are appropriately considered (i.e. less TSS and TP is exported from roof areas so rainwater tanks play only a small role in the management of these pollutants).

A generic node is also provided at the end this Section (Section 2.8.11) which models Council's Deemed to Comply Provisions for small scale residential development – this makes allowance for an average size rainwater tank.

2.8.10 Generic Node

This node allows the user to simulate the treatment performance of devices not listed within the default parameters. This use of this device is similar to the processes identified for a Gross Pollutant Trap with the exception of a Flow transfer function to replicate any flow attenuation produced by the proposed device.
The Generic Node is also to be used to represent application of Deemed to Comply Provisions on individual allotments in a residential subdivision as described in Section 2.4.1

***Note 1**: This node is used to model Wyong Council's Deemed to Comply Provisions. See Section 2.8.11 for further details.*

***Note 2**: Not withstanding the above the use of the Generic Node shall only be permitted if sufficient justification can be provided and where Council support this information. Typically Wyong Shire Council discourage the use of this node, and if this node is utilised the user is to justify the treatment efficiency along with any additional supporting information to Councils requirements.*

2.8.11 Modelling for Deemed To Comply Provisions

For the purpose of devising a WSUD Strategy for subdivisions or similar then certain assumptions are needed in relation to expected treatment measures and this is outlined below.

Residential single allotments should be modelled as an urban node with 70 % impervious area . Figure 5 shows a simplified subdivision model which should be amended to suit each project. Road reserves, community facilities and open space should be provided with separate nodes reflecting each of these uses.

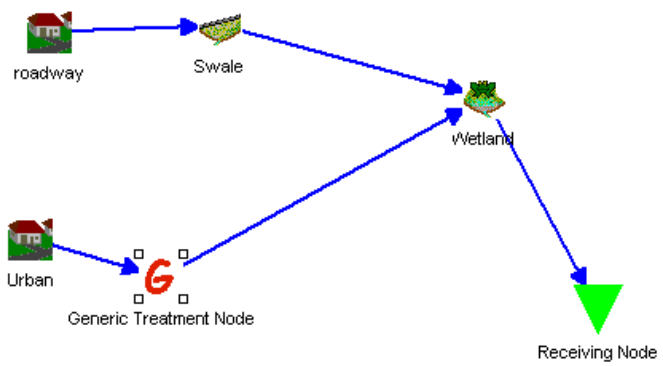


Figure: 5 Example of a simplified MUSIC model for subdivision using single node for allotments and generic node for Deemed to Comply Provisions

The WSUD Deemed to Comply Provision for treatment on individual allotments is to be modelled using a generic treatment node with the following parameters:

- Flow Reduction 25%[6];
- TSS reduction 50%;
- Phosphorus reduction 40%;
- Nitrogen reduction 40%;
- Gross Pollutants reduction 80%.

These parameters take into account a combination of treatment and flow reduction measures including rainwater tanks, rain gardens and pervious pavement or reduced hardstand. No further credit may be claimed for allotment treatment where the deemed to comply solution is adopted.

A screen capture from the MUSIC program is illustrated in Figure 5b over the page. This shows the input parameters for the generic treatment node. The high flow bypass for the generic node should be set at 0.01 per allotment and scaled for the total number of allotments in the subdivision. The generic nodes shown are for 10 allotments.

[6] The flow reduction is intended for use in the water quality MUSIC model. However it can also be used in the Hydrological modelling which is used to assess performance of the wetland hydrology

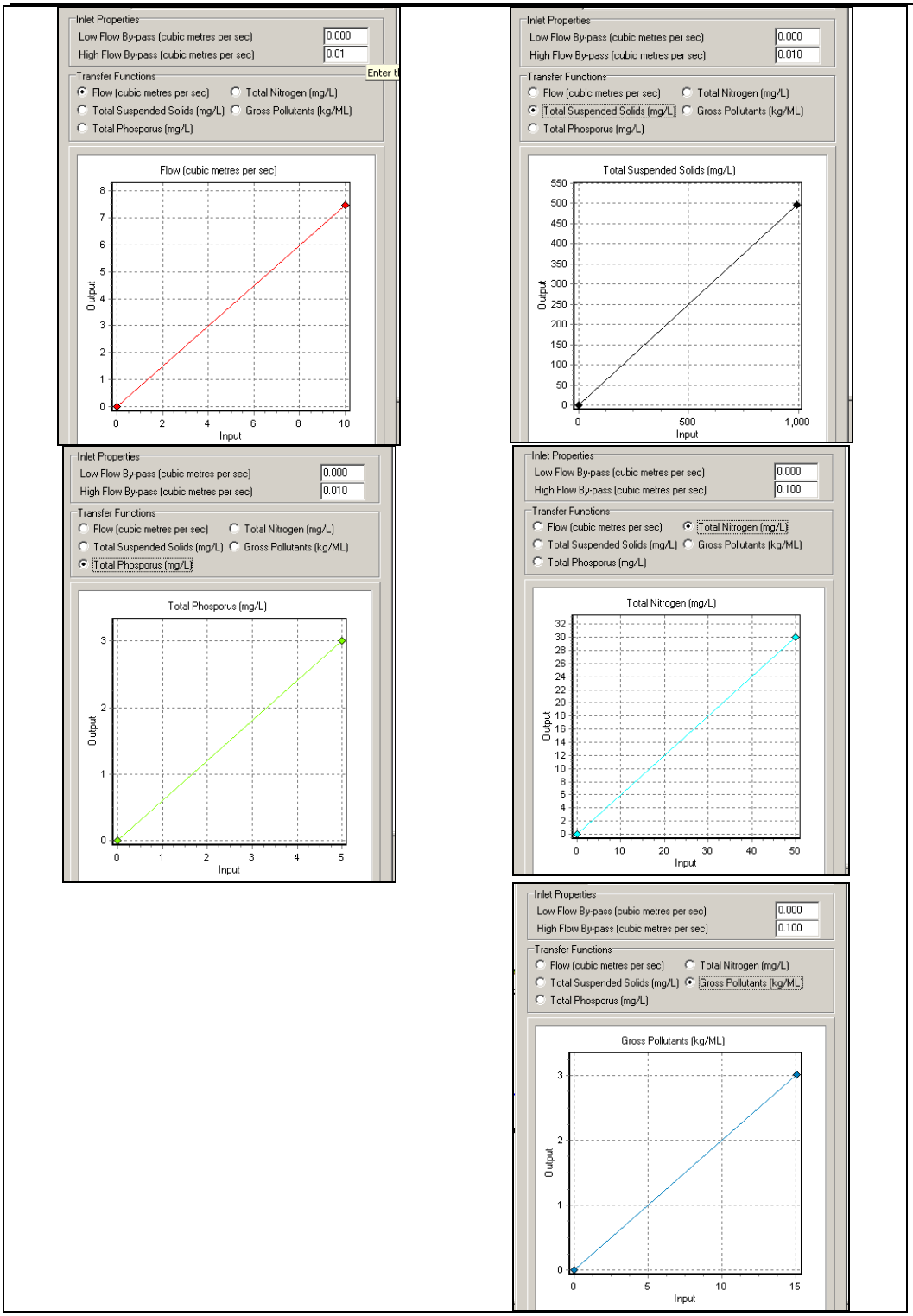


Figure 6 **Deemed to Comply Node – input parameters for Flow, TSS, TP, TN and Gross pollutants**

2.8.12 Modelling for Regional Wetlands

For areas where there is an IWCM Scheme the development will drain to a regional wetland/storage basin which is generally identified in the relevant Contributions Plan. . It is proposed that the WSUD Strategy will include stormwater treatment in the street-scape via buffer strips, raingardens or grass swales. The contribution of the regional wetland may be modelled using the music parameters detailed in Figure 6. The parameters shown in the table below are for a 1 hectare site, areas and volumes should be scaled to suit. Note: the extended detention depth is not to be scaled.

Outlet pipe size should be adjusted to achieve approximately 48 hours – 72 hours detention time to reflect detention times achieved in the regional wetland..

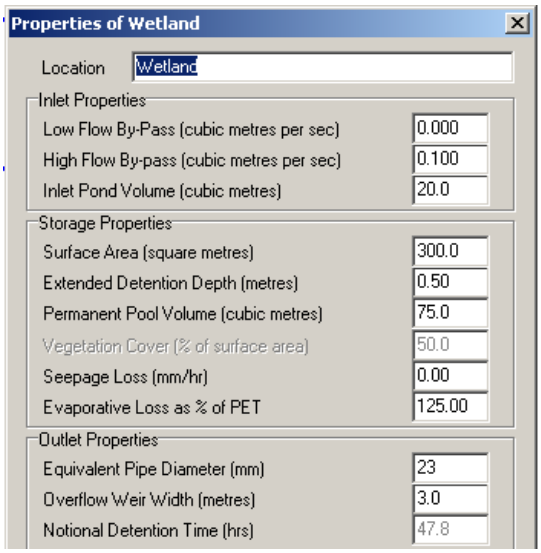


Figure 7 Wetland treatment node input parameters (for 1 hectare size wetland)

3.0 STORMWATER STORAGE DESIGN CURVES (STANDARD APPLICATIONS)

Urban development increases the volume and frequency of runoff, which changes the natural hydrology of an area. These changes can have a major impact on natural wetlands, lakes and salt marshes. There are a number of management measures to mitigate these impacts on wetlands including using stormwater storages with associated re-use.

In order to assess the effectiveness a detention and/or harvesting and reuse strategy for its effectiveness in meeting the wetland hydrology and waterway stability objectives, the stormwater storage modelling tool can be used.

The stormwater storage design curves can be used:

- to size active stormwater storages for standard applications (including typical detached dwellings, attached dwellings, multi-storey residential, commercial and industrial development).

The hydrologic modelling tools described in Section 2 have been used to derive a standard set of 'stormwater storage design curves'. The curves allow initial sizing of the stormwater storage designs , once the final landuse is established, without the need to undertake detailed hydrology modelling.

Stormwater storage design curves have been generated for two wetland hydrologic objectives:

- Freshwater wetlands;
- Undefined drainage depressions;
- Standard design curves have not been produced to meet the objectives for estuarine lakes (7-day high flow duration frequency curve). This objective is generally easier to meet than the above two.

A set of standard design curves have been produced for typical developments, including:

- detached and attached dwellings;
- multi-storey residential;
- commercial and industrial land uses.

The stormwater storage modelling tool of Section 4 should only be used in non-standard situations where:

a The landuse and percentage impervious assumptions vary significantly from those presented in the standard application Stormwater Storage Design Curves (standard applications) Tool; AND

b The Stormwater Storage Design Curves do not adequately represent the proposed WSUD and stormwater harvesting solution. It is anticipated the stormwater storage design curves will apply to most WSUD and stormwater harvesting solutions in Wyong Shire.

The following sections include:

- Section 3.1 discusses the development of the curves;
- Section 3.2 presents the curves themselves;
- Section 3.3 provides an illustrative application of the curves.

3.1 Development of the Stormwater Storage Design Curves

Numerous scenarios were assessed to define the stormwater storage design curves, utilising the modelling tool detailed in Section 4. A range of development types were considered, including detached dwellings, multi-storey residential and commercial development. Each development type was modelled with and without rainwater tanks and with a range of percentage impervious areas, as currently found throughout Wyong Shire. The optimal stormwater storage size for each land use percentage impervious was established by comparing the pre and post development low flow durations, high flow durations and low flow spells.

Importantly, modelling determined that stormwater storage requirements were not reduced enough with the inclusion of a rainwater tank, as required by BASIX. The demand on rainwater tanks under a typical BASIX scenario is more than an order of magnitude smaller than a pump rate of 50 kL/day/ha applied to the active stormwater storage. As such, rainwater tanks under a typical BASIX scenario play only a very minor role in achieving the wetland hydrology and waterway stability objectives.

It should be noted that rainwater tanks may be more effective in reducing overall stormwater storage sizes if developments include rainwater tanks larger than those typically required for BASIX and if they are plumbed into additional constant daily uses these required by BASIX, such as washing machines and hot water systems.

3.2 Stormwater Storage Design Curves

This section presents standard stormwater storage design curves for typical development in Wyong Shire. Note that in producing these curves, a pump rate of 38 kL/day/ha has been assumed. This is the pump rate adopted in the Porters Creek IWCM Strategy area in order to satisfy the objectives that serve to protect Porters Creek wetland. If a different pump rate is used, the Stormwater Storage Modelling Tool should be used instead of the standard design curves .

It can be concluded that active stormwater storage size is directly related to the impervious fraction of the catchment and that rainwater harvesting under a typical BASIX scenario within the development does not have great impact in reducing stormwater runoff in a volume sense.

Figure 8indicates the derived stormwater storage design curves, from modelling numerous scenarios across the full range of impervious fractions, for both 30 day and 14 day reference durations. The curves define the volume of “active storage” required to deliver the relevant hydrologic objectives across a range of catchment impervious fractions. These curves are to be used by designers, developers and Council to define the size of the active stormwater storage volume once the final landuse (and associated impervious fraction) is established.

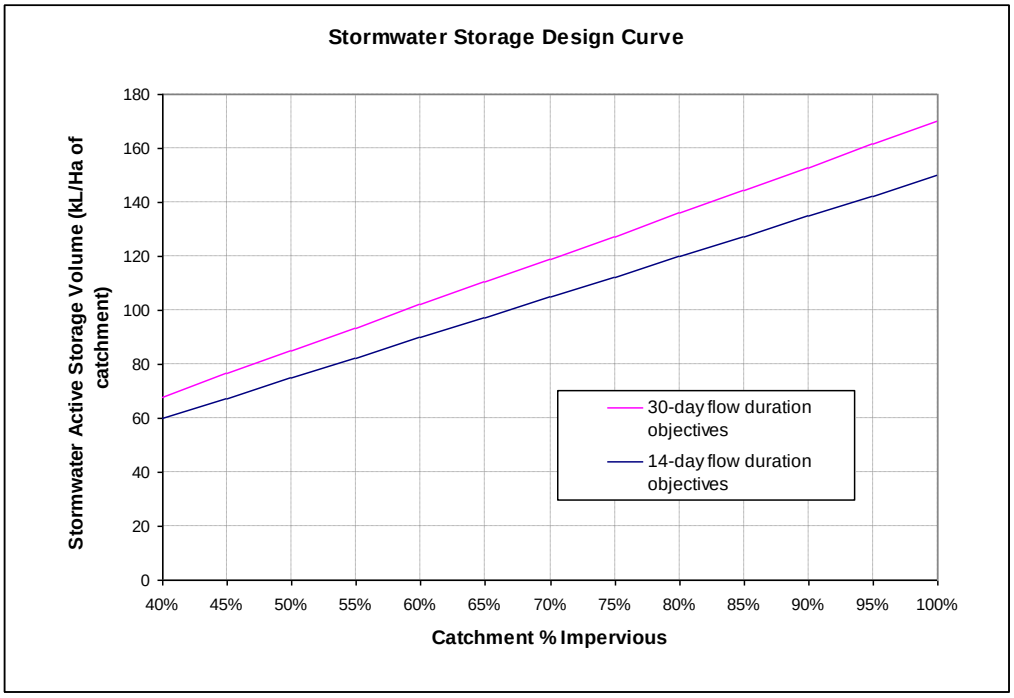


Figure 8 Storage design curves (sizing the active storage volume)

Interpretation of the curves provided in Figure 5indicates that for the protection of downstream freshwater wetlands (30-day reference duration) the following design principles apply:

- **Standard active storage pump rate = 38kL/day/ha;**
- **Active stormwater storage volume = Impervious Area (ha) x 170 (kL/ha);**
- To satisfy the Waterway stability targets for undefined drainage depressions, **active stormwater storage volume = Impervious Area (ha) x 150 (kL/ha).**

3.3 Stormwater Storage Example

A catchment within Warnervale Town Centre is 15.5Ha and is to be developed as a residential estate with an estimated 65% impervious fraction. This area naturally drains to Porters Creek Wetland and therefore the following objectives apply:

- Preserve the pre-development 30 day low flow duration frequency curve for the dry season (October to January);
- Preserve the low flow spells frequency curve for the dry season;
- Preserve the pre-development 30 day high flow duration frequency curve for all months.

To achieve these hydrologic objectives, the following active storage parameters would apply:

- Active storage volume = 110 kL/ha (8). Total volume required = 110 kL/ha x 15.5 ha = 1,710 kL
- Pump rate = 38 kL/day/ha x 15.5 ha = 598 kL/day.

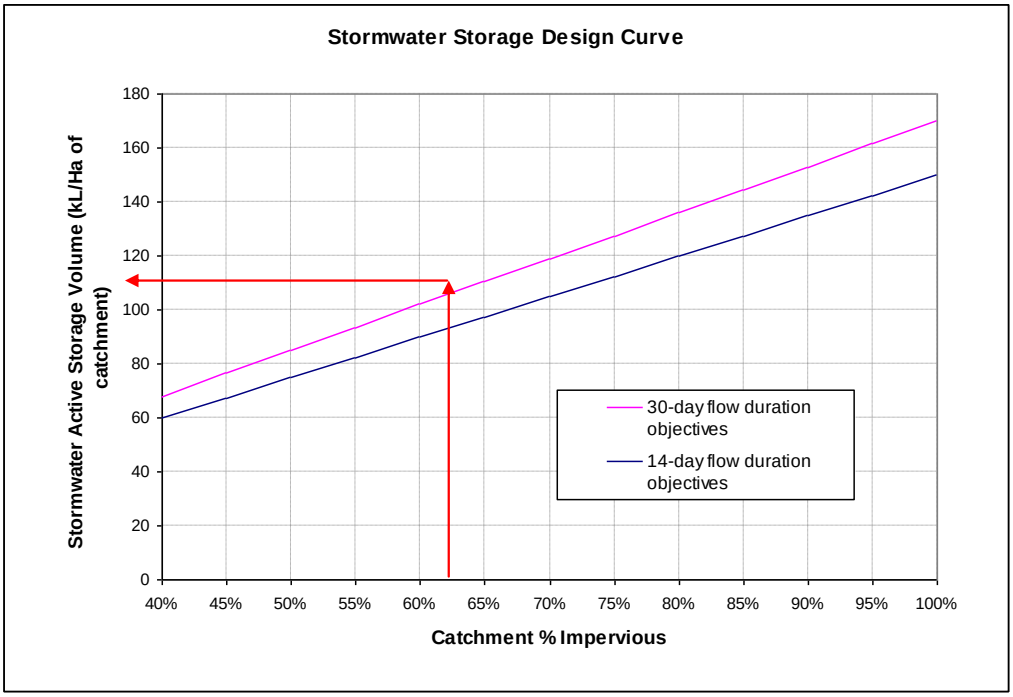


Figure 9 **Example use of the storage curves**

4.0 STORMWATER STORAGE MODELLING TOOL (NON-STANDARD APPLICATIONS)

Non-standard applications are when the design principles specified in Section 3 are not adhered to or when other issues complicate the analysis e.g. development crosses separate catchment boundaries etc.

To size stormwater storages and demonstrate compliance with the hydrologic objectives for non-standard developments, the following section details the methodology to comply with the following objectives:

- Low flow duration frequency curve for the dry season (October to January);
- High flow duration frequency curve for the whole year (July to June);
- Low flow spells frequency curve for the dry season (October to January).

There are four main steps in applying the non-standard *Stormwater Storage Modelling Tool*:

- Section 4.1 - Using MUSIC, produce a time series of pre-development flows;
- Section 4.2 - Using MUSIC, produce a time series of post-development flows, including mitigation measures;
- Section 4.3 - Analyse each time series to produce the three hydrologic indices – the low and high flow duration frequency curves and the low flow spells frequency curve. MUSIC does not have the capability to generate these hydrologic indices; therefore a specific post processing tool has been developed for this task. Results from the MUSIC model are inputted into the post-processing tool, which then produces the appropriate hydrologic objective indices;
- Section 4.4 - Compare the pre- and post-developed hydrologic indices' to ensure compliance with their respective objectives.

The post processing tool is available from Council and comprises an excel spread sheet with in-built macros that permit the imported MUSIC model data files to be processed and presented as frequency duration curves.

Comment [SC1]: Who in Council w have this?

Council staff can provide examples of such analysis if required. This is helpful to familiarise the user with the methods and ensure the correct steps and procedures are included in the modelling.

Comment [SC2]: Who in Council?

4.1 Pre-Development

To establish the hydrology of the site prior to development (i.e. no impervious areas) a pre-development MUSIC model must be created. The simulated flows are then exported from the MUSIC model and analysed using the post processing tool.

Set-up an existing MUSIC model for the site, as indicated in Section 2;

Place a flux file on the outlet node, and run the model;

Export the results files.

4.2 Post-Development with WSUD Strategy

Following the simulation of pre-development hydrologic conditions, MUSIC is used to simulate post-development conditions and configure the WSUD treatment train. The key features of a MUSIC model used for post-development hydrology assessment are:

- The setup of imported nodes to separate baseflows and surface flows from pervious areas;
- The inclusion of stormwater storages to represent the stormwater detention, harvesting and reuse and/or diversion scheme.

The recommended model setup for the post development hydrology regime is described in Sections 4.2.1 to 4.2.6.

Rainwater tanks to harvest roof runoff may be included in this *hydrologic* MUSIC model however tanks of the size required to satisfy BASIX requirements have been found to have minimal impact on post development hydrology. Where rainwater tanks are used in the model their size and reuse characteristics must be demonstrated to be applicable to the development under consideration. Generally most water quality WSUD elements have negligible effect on the hydrologic objectives. As such, they do not have to be included in the *hydrologic* MUSIC model.

4.2.1 Baseflow Separation Using Imported Data Nodes

The post-development MUSIC model should be set up in accordance with Section 2, ensuring appropriate delineation of nodes and impervious areas.

Pervious areas generate both surface runoff and baseflow. To assess the impact of the post development scenario on stormwater flow regimes, it is necessary to separate surface flows that would flow into treatment and storage systems, from baseflow, which would not enter treatment or storage systems at all.

Baseflow can be separated from the stormwater storage catchment by use of an imported "base flow only" node. An example of a MUSIC model setup including baseflow is indicated in Figure . Note that the use of imported data nodes is only required for the modelling of the post development model hydrologic regime.

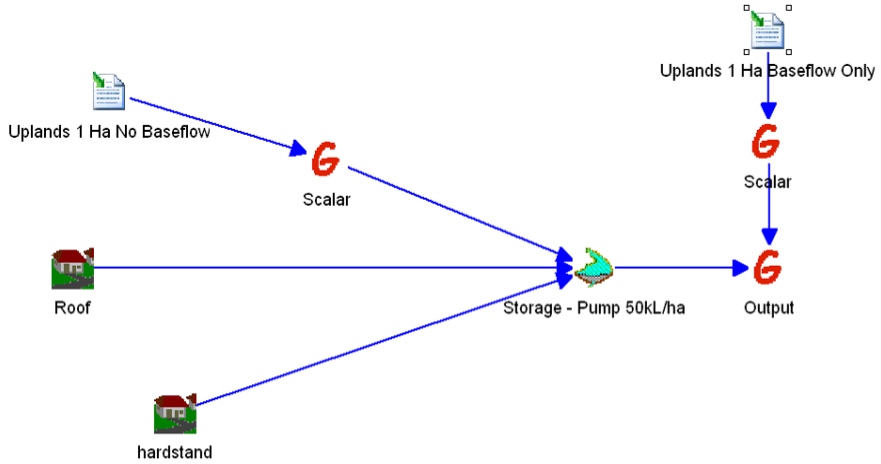
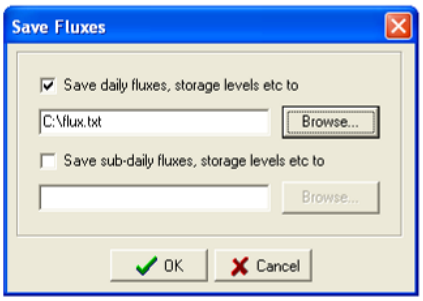


Figure 10 Recommended MUSIC model setup for post-development hydrology modelling

The imported nodes need to be created for a specific pervious catchment (upland or lowland) and for specific rainfall conditions. Standard pervious nodes have been developed for the Wyong Shire so that they can be automatically imported, for the following specific conditions:

- upland pervious areas;
- Sydney Observatory Hill rainfall for 70 years of daily data from 1921 to 1990;
- general urban water quality pollutant generation parameters – specified in Section 2.0.

If different rainfall data, different time step, or pervious node runoff or pollutant parameters are required the imported nodes will need to be created. The creation of these nodes requires the following:



Step 1: Run a 1 hectare 100% pervious upland or lowland node, as appropriate for the catchment and selected rainfall data, with a daily flux file on the source node (not the node downstream), as shown on the right. For sub-daily time steps the second box will need to be selected as the flux file.

Step 2: Open the flux file in a spreadsheet package and convert the "Pervious area surface runoff (mm)" and "baseflow (mm)" outputs into m^3/s (for daily time steps this requires dividing the value in the flux file by 8640).

Step 3: Using the spreadsheet package, set up a new file for the baseflow. Column 1 should contain exactly the same dates (and timesteps if sub-daily) as the selected rainfall file. Column 2 should contain the baseflows in m^3/s (as calculated in Step 2).

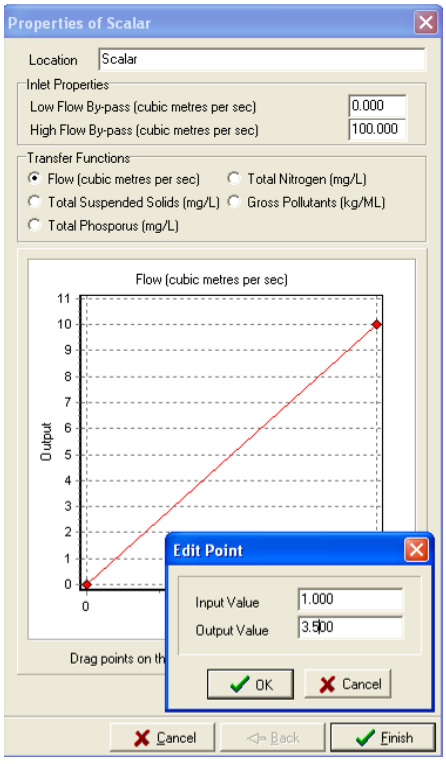
Step 4: In the same file as Step 3, Columns 3-5 should contain the TSS, TP and TN concentrations in mg/L. Copy the baseflow concentrations in mg/L from the flux file into the new baseflow file for TSS, TP and TN. Create a Column 6 for Gross Pollutants and set to 0 for all timesteps. Save the file as a text file (tab or comma delimited recommended).

Step 5: Select an imported data node in MUSIC and "Import" the text file that was created in Steps 3-4.

Step 6: Repeat steps 3 to 5 for pervious surface runoff, using the surface runoff flow values in m^3/s, and concentrations for pollutants including gross pollutants.

Step 7: Run the MUSIC file with the two imported nodes and confirm that the sum of the baseflow and surface runoff nodes is equal to the original 1 hectare node for runoff volumes and pollutant loads.

Step 8: Steps 1-7 created two imported nodes representing pervious area baseflow and surface runoff. The imported nodes are generic 1 hectare upland or lowland nodes. The final step involves scaling flows from the 1 ha catchment to the size of the actual pervious area. This is done using a Generic Node, as shown on the right.



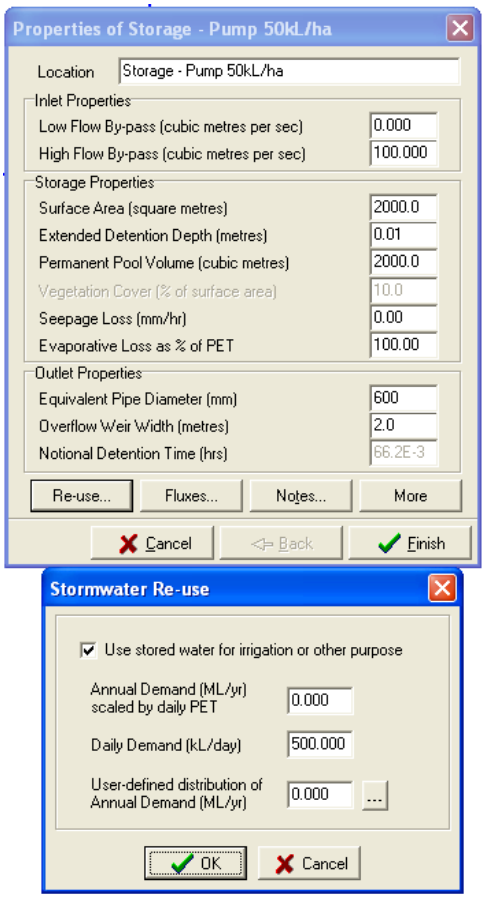
Step 9: Run the MUSIC file with the two scaled nodes and confirm that the sum of the pre and post developed base flow is equal (see example below).

For example, if there was 3.5 hectares of pervious area in the development then the generic scalar would be 3.5. In the Generic Node, only the flows should be scaled; not any of the pollutant concentrations. This is done by editing the point on the flow curve to an output value of 3.5 for an input value of 1 (as shown above). Note that this MUST be done for both baseflow AND surface flow by the same scalar factor. It is recommended that the scalar be clearly labelled to identify this.

These imported (baseflow and surface runoff nodes) and the associated scalars are combined with the 100% impervious nodes (roof, hardstand, road) to create the source nodes for the post development model, as indicted on Figure 10.

4.2.2 Modelling Active Stormwater Storages

The active stormwater storage node is the key element of the post-development hydrology model. The active stormwater storage requires a specific treatment node in MUSIC due to its specific design requirements. The node is shown on the right. The "pond" treatment node in MUSIC is used to model the storage.



The key feature is that only the active storage zone is modelled and this is represented by the permanent pool volume in the MUSIC model. There is no extended detention. Evaporative loss should only be included if the storage is open.

The active stormwater storage and re-use is modelled this way in MUSIC due to the constant draw-down the re-use demand generates. If the "extended detention depth" option is chosen, then the rate of outflow will vary with the depth of the detention volume. The constant draw-down the pump generates will remove the stormwater from the system and it will not contribute to downstream flows.

This is achieved in MUSIC by specifying a "re-use" demand on the permanent pool. In MUSIC the re-use demand is set to equal the proposed pump rate. Reuse demands only applies to the permanent pool and not the extended detention, thus the active storage zone is modelled as the permanent pool volume in MUSIC.

Where rainwater tanks are used to harvest roof runoff, these can be included in the post-development hydrology model downstream of the roof areas where the hydrology objectives are based on a 7-day reference duration. Where the hydrology objectives are based on a 30 day or 14 day reference duration, rainwater tanks have negligible impact on the hydrologic indices.

Active Volume Storage and Area

The key parameter that is used to alleviate the impact of the post development hydrologic regime on Wyong Shires sensitive freshwater wetlands, estuarine lakes and undefined drainage depressions is the volume of the active storage (permanent pool volume in MUSIC). This parameter is varied until the post-developed dry season low flow duration and low flow spells frequency curves and the annual high flow duration frequency curve match the pre-development curves (see Section 0 and 0 for details). The storage area will also change accordingly, and the final storage volume must be aware of the actual area and topography available for the storage. It is recommended to use a standard 0.75 m depth for the active storage zone. If the storage is to be vegetated, 0.75m is a reasonable inundation depth for a variety of wetland plants.

Pump Rate

The pump rate (stormwater re-use demand in MUSIC) is the rate at which water is extracted from the active storage zone (permanent pool volume in MUSIC) and either diverted from the catchment or directed to secondary storages for beneficial reuse. A pump rate should be selected so that the active storage will be drawn down completely in no more than four days. For example, as part of the Porters Creek Wetland Stormwater Harvesting Strategy, a pump rate has been set at 38kL/day/ha. Hence for a 10 hectare catchment the pump rate (reuse demand) is set to 380 kL/day. The pump rate has been set based on a number of different factors including the rate required to effectively draw down the storage, pumping costs, yield from the storages and regional infrastructure provision. For more information on the setting of this pump rate refer to the Porters Creek Regional IWCM Technical Paper (Wyong Shire Council, 2010).

Other Parameters

While the storage volume and area are varied to determine the optimum storage size, all other parameters, including extended detention, equivalent pipe diameter and overflow weir must not be changed from the settings in the model.

4.2.3 Modelling Stormwater Storages for Harvesting and Reuse

Stormwater storages can also be designed to retain water for reuse. These types of stormwater storages will not be as effective at meeting the hydrology objectives; however they may still contribute as part of an overall scheme.

In order to model a storage designed for reuse, the principles are similar to the active storage modelling described above, where there is no extended detention and the permanent pool is the storage volume. Evaporative loss should only be included if the storage is open. However in this case the demand should be the total water demands (e.g. irrigation, toilet flushing) and should be specified as follows:

- Relatively constant demands such as toilet flushing should be entered as a daily demand in kL/day;
- Seasonal demands such as irrigation should be entered as an annual demand in ML/year, and should be scaled according to Table 5 below.

Table 5: Typical annual distribution of irrigation demand for Wyong Shire

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17%	9%	6%	1%	0%	0%	0%	5%	11%	14%	16%	21%

It is typical to size stormwater storages for harvesting and reuse on the basis of a storage reliability curve. An example is shown inFigure 11. For a given demand, a range of storage sizes are modelled in MUSIC and their ability to meet the reuse demand is expressed as a percentage of demand met.

To determine how much of the demand is met by stormwater re-use, the following steps can be taken:

- Set up a MUSIC model to represent the catchment, storage and demand;
- Run the MUSIC model at a daily time step;
- Query the Mean Annual Loads for the storage pond, and compare Inflow to Outflow. The difference is the total annual volume extracted from the storage pond;
- Divide this volume by the total annual demand and convert to a percentage.

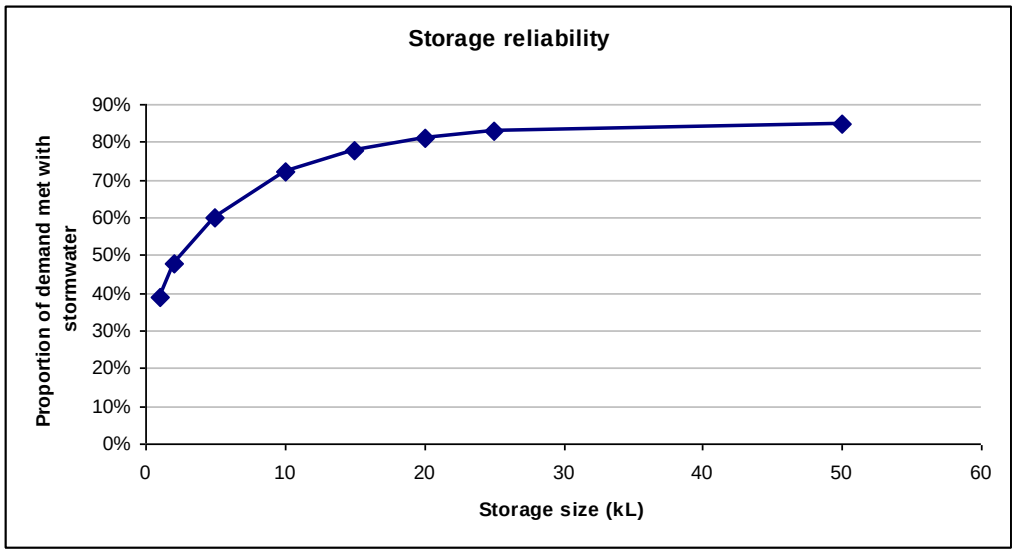


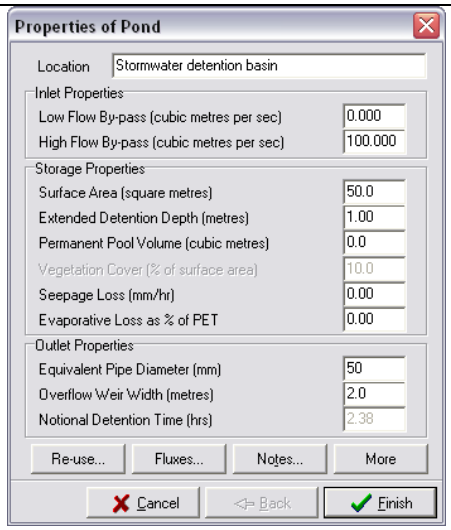
Figure 11 Example storage reliability curve

4.2.4 Modelling Stormwater Storages for Detention

Detention reduces high flows by capturing stormwater, storing it temporarily and releasing it slowly at a controlled rate. In some cases it may be feasible to meet the hydrology objective for estuarine lakes (preservation of the pre-development 7 day high flow duration frequency curve) with the use of stormwater detention. Stormwater detention designed to meet the 2 year ARI flow objective for waterways may also contribute to meeting the hydrology objectives and could be included in the MUSIC model for the post-development case.

When stormwater detention is included in the MUSIC model, the model should be set up as per 10 so that pervious area surface runoff enters the detention system, while baseflows bypass the detention system. Stormwater detention can be modelled as a pond with the following parameters:

- No permanent pool.
- The total detention volume should be entered as the extended detention surface area and depth in MUSIC.
- Evaporative losses set to zero unless the detention system is an open basin.
- The equivalent pipe diameter is set to achieve the desired outflow rate.
- Where detention times are small the detention basin should be modelled at a 6 minute time step, as it will often fill and empty again within one day.



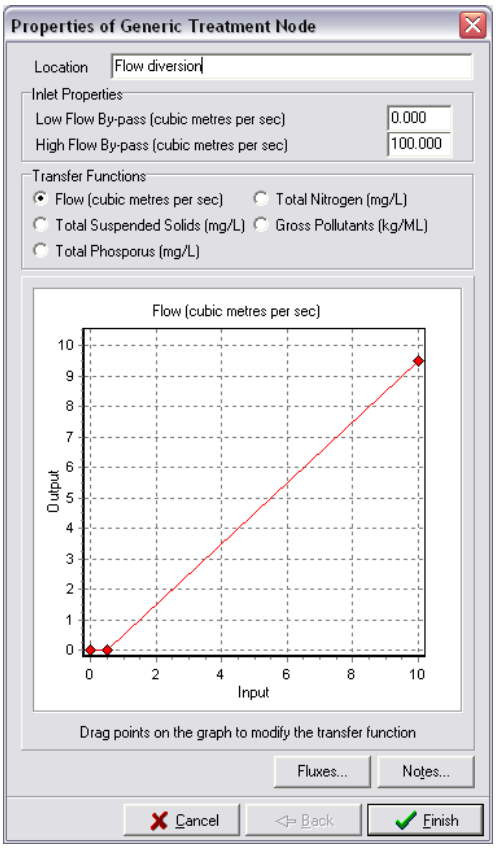
4.2.5 Modelling a Bypass Scheme (e.g. for salt marsh protection)

The most straightforward way to meet the hydrology objectives for salt marshes is to bypass excess stormwater flows around the salt marsh area. Salt marshes often occur in a narrow zone around the foreshore of the estuarine lakes, and in these situations it should be relatively straightforward to divert flows up to a certain rate in a defined open channel or pipe through the foreshore area.

Note: The music modelling must be a true representation of what is achievable on the site.

A bypass system can be represented in MUSIC using a generic node. The example to the right shows a generic node for diversion of all flows up to 0.5 m^3/s. Flows up to this value are stripped in the generic node. Pollutant concentrations should not be modified.

The stormwater diversion generic node should be located as per the stormwater storage inFigure 10, so that pervious area baseflows would bypass such a system.



4.2.6 Summary of Post Development Model Setup

The following is the summary of the steps involved in setting up the post development MUSIC model:

Step 1: Set up the imported nodes as described in Section 4.2.1. If upland areas are to be used, with the recommended Wyong Bowls Club or Sydney daily rainfall period of 1920 to 1990, then the 'template' post development MUSIC model imported source nodes can be used.

Step 2: Determine the area of impervious and pervious surfaces in the development.

Step 3: Enter the impervious area values directly into the impervious source nodes, as 100% impervious.

Step 4: Enter the pervious area values using the generic scalar nodes. It is important that the generic same value scalar node is used for both the baseflow and pervious surface runoff.

Step 5: Add treatment measures to the model, including stormwater storage and reuse systems (Section 0), stormwater detention systems (Section 3.2.4) and/or stormwater diversion systems (Section 4.2.5). Rainwater tanks and other stormwater treatment, harvesting and reuse measures can also be included in the model at this stage if desired.

Step 6: For all daily time step models place a flux file on the output generic node and run the model. For sub-daily time steps run the model and export the flow data at a daily timestep.

4.3 Post processing tool

MUSIC does not have the capability to generate flow duration curves and low flow spells curves. To overcome this gap a specific post processing tool was developed for this task. The tool automates the process of accessing MUSIC model results and developing the respective hydrologic indices, thus ensuring efficient and accurate post processing of model results.

The post processing tool utilises an Excel macro to generate low flow duration frequency curves, high flow duration frequency curves and low flow spells frequency curves. The use of this tool ensures that the post processing can be automated and also that there is a consistent post processing analysis procedure.
The basic steps included in the post processing tool are shown in the flow charts inFigure 11.

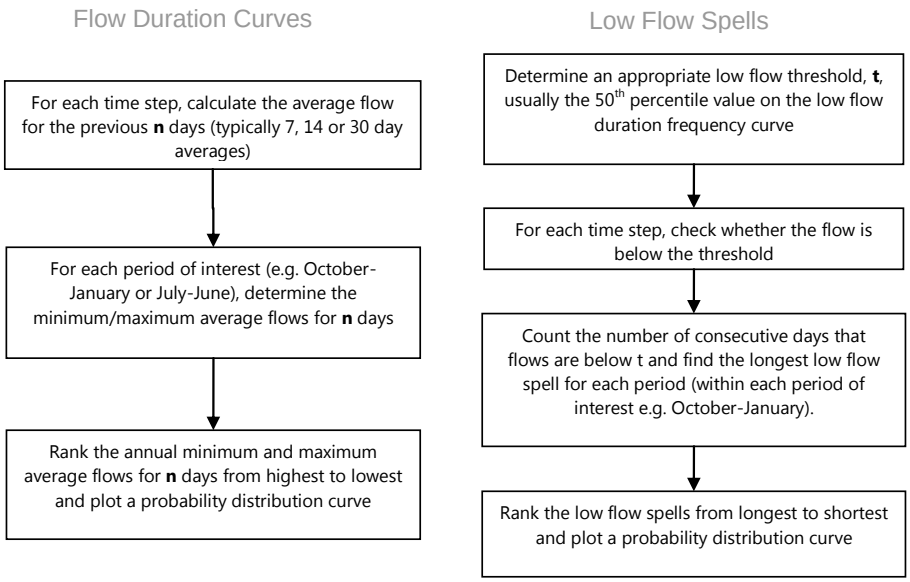


Figure 11 Steps included in the post-processing tool

The tool has two main sections, pre and post development. The only difference between the two sections is where the final data is copied to. This is important to ensure that the pre-development curve is represented separately from the post development curve on the Excel chart.

This section focuses on how to use the post processing tool and outlines the steps that are required to take the outputs from MUSIC and generate the relevant curves to analyse pre and post development hydrology.

Note: The post-processing tool (Excel file) that reflects the WSUD Strategy needs to be submitted to Council.

4.3.1 Definition of Terms

The key parameters for the user to select are the rainfall year, the critical drying period, the reference duration (n), and the low flow threshold (t). These are defined as follows:

Rainfall Year: The rainfall year is a continuous period of 12 months from a selected reference point (for Wyong - 1st July). The designation of a rainfall year is to ensure that critical periods, such as the summer drying period from October to January, are considered in the hydrologic assessment.

Critical Drying Period: The critical drying period is the period of interest for low flow analysis, for both low flow duration and low flow spells. The critical drying period is important for many key biological and chemical processes in natural wetlands. The critical drying period is determined by the period when the wetland is most likely to dry out and can be determined by analysing the evapotranspiration compared to rainfall. When evapotranspiration is higher than rainfall the wetland is likely to dry out. This period has been determined for wetlands in the Wyong Shire as October to January (refer to Figure 1 in WSUD Technical Guideline No1).

Reference Duration, (n): The number of days over which to average the flows for low and high flow duration analysis is directly related to the hydrologic regime of the downstream aquatic environment. Different natural wetlands and aquatic environments are sensitive to different lengths of wetting and drying periods. Freshwater wetlands are sensitive to wetting and drying periods of months in duration, and a reference duration of 30 days is used. Ecosystems in the estuarine lakes are sensitive to shorter periods of high freshwater inflows and reference duration of 7 days is used.

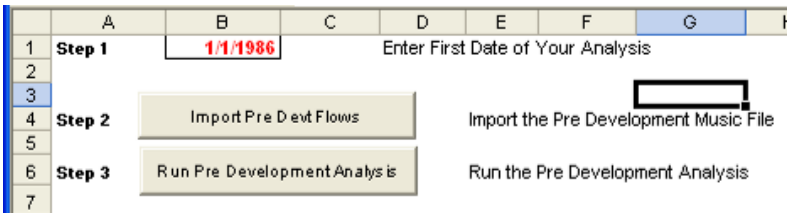
Low Flow Threshold, (t): Low flow spells are another hydrologic indicator available to determine hydrologic changes as a result of development. Low flow spells indicate drying processes within a wetland (i.e. drying out of a wetland is expected to occur during low flow periods). A measure of these low flow periods is to determine the number of consecutive days the flows into the wetland are below a daily flow threshold. As the drying period is concerned primarily with low flows the threshold is determined by taking the 50^{th} percentile daily flow rate from the low flow duration curve. Thus the low flow threshold is defined as the median low flow during the critical drying period.

For more information on these terms, definitions and the importance of these to the hydrology of natural wetlands, see the *DRAFT Discussion Paper Modelling Rationale for the Porters Creek Stormwater Harvesting Strategy* (Ecological Engineering, 2006) and *Water Sensitive Urban Design Solutions for Catchments above Wetlands* (Ecological Engineering, 2005) reports prepared for Wyong Shire Council.

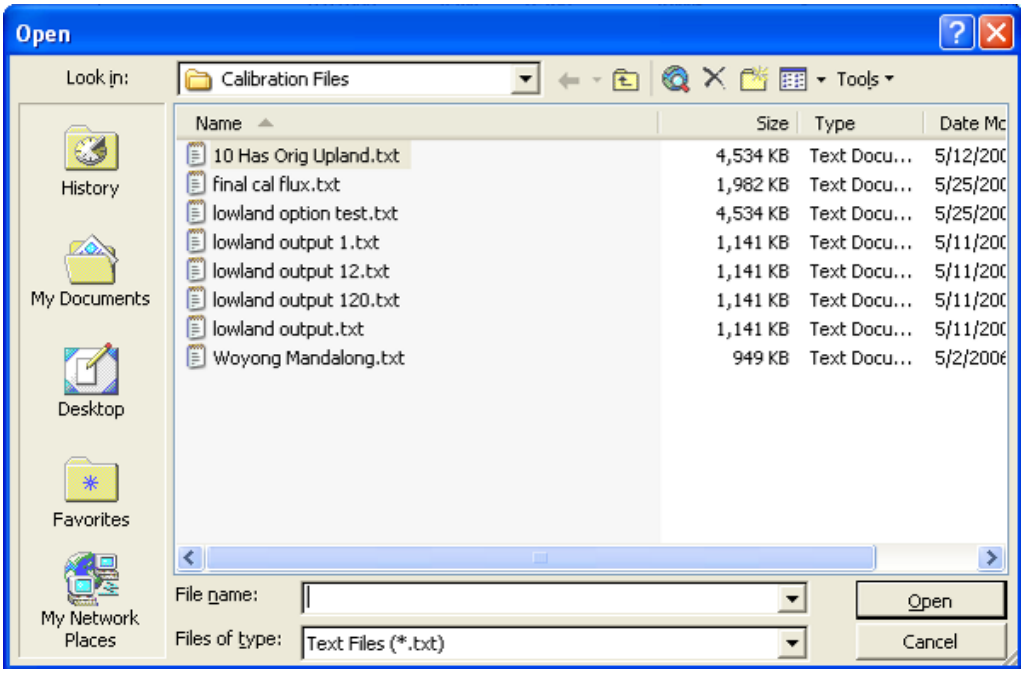
4.3.2 Using the Post Processing Tool

The use of the post processing tool is described in the following five steps. (NOTE: post processing tools only work with daily rainfall data.)

Step 1: In the top row enter the date that your analysis starts. This step is necessary as MUSIC does not save the date in the flux file. This can be determined by opening the MUSIC file and selecting Edit , then selecting Rainfall Data.



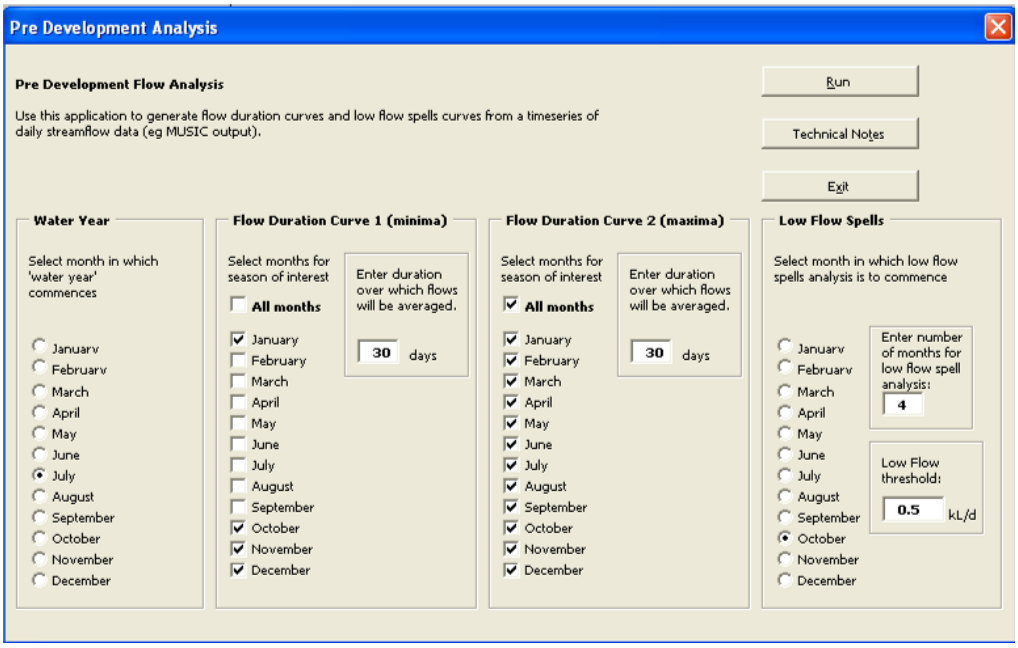
Step 2: Import the pre-development flux file, or exported daily flow file, using the command button "Import Pre Devt Flows". The "Open" dialogue box will appear and you can navigate to the appropriate file.



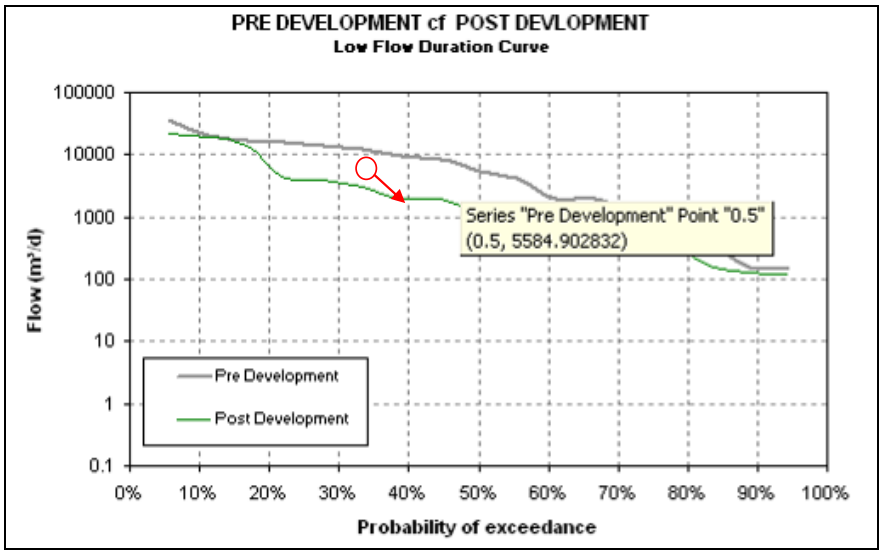
Step 3: Run the pre-development analysis by selecting the "Run Pre Development Analysis" button. A dialogue box will appear where you should enter the following parameters:

- Water year (July-June in Wyong);
- Critical drying period (October-January in Wyong);
- Reference duration (7, 14 or 30 days depending on the objectives that apply).

At this point it is not possible to determine the low flow threshold. Note that for Wyong Shire the high flow duration frequency curve should be produced for the whole water year, while the low flow duration frequency curve should be produced for the critical drying period.

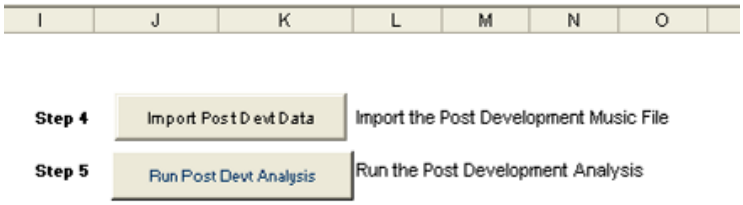


When the analysis is complete, the charts within the spreadsheet should be updated with the pre-development data. Read the 50th percentile value off the pre development low flow duration curve. In the example below this value is 5,585 kL/d.

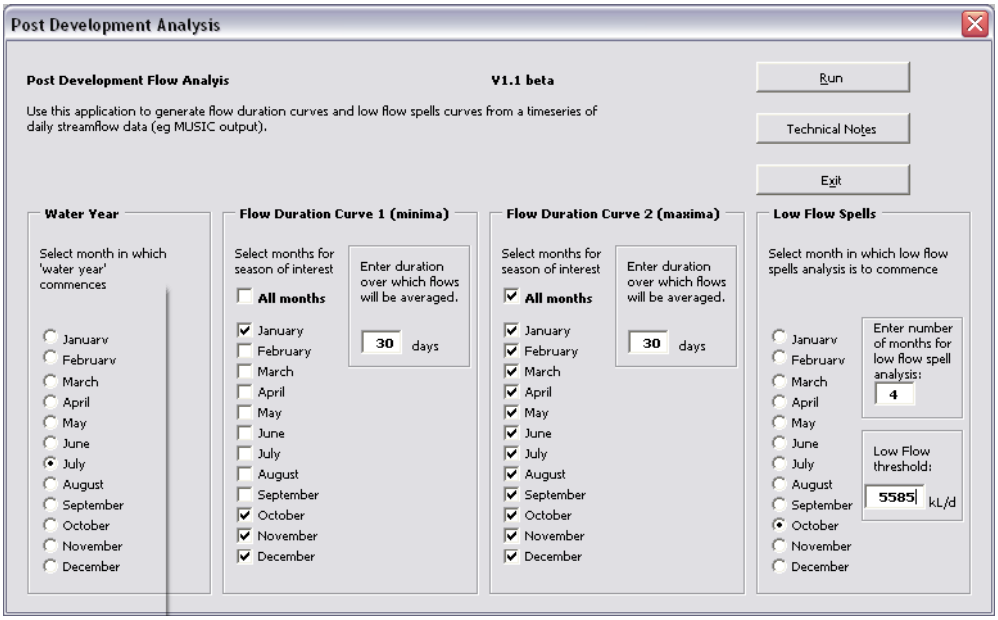


Re-run the pre-development analysis with the 50th percentile low flow value entered as the low flow spells threshold value. Keep all the other parameters the same as above.

Step 4: Import the post-development flows using the "Import Post Devt Data" command button.



Step 5: Run the post-development analysis by selecting the "Run Post Devt Analysis" button. Use the same values as in Step 3 for the water year, critical drying period, reference duration and low flow threshold.



At the completion of Step 5, the charts within the spreadsheet should be updated with the post-development data. It is now possible to compare the results for the pre and post development scenarios. Check the frequency curves for the low flow duration, high flow duration and low flow spells that have been generated in Excel.

4.4 Checking Compliance with the Objectives

Where the post development curves generally match the pre development curves, in particular between the probability exceedance of 20% and 80%, and achieve an R^2 greater than 0.8, the stormwater management strategy is considered appropriate. Where the post development curves do not match the pre development curves, in particular between the AEP of 20% and 80%, the stormwater management strategy will need to be adjusted. In particular, storage sizes may need to be adjusted in MUSIC and the above steps 1-5 repeated.

In some cases, it may be difficult to achieve simultaneous compliance with the low flow duration, high flow duration and low flow spells objectives, as there is effectively a trade off between meeting the low flow and high flow objectives. In these cases, discussion with Council is recommended in order to achieve a solution that balances the objectives.

REFERENCES

CRC for Catchment Hydrology 2005 *MUSIC User Guide* (Manual for MUSIC Version 3, April 2005).

Ecological Engineering 2005 "Water Sensitive Urban Design Solutions for Catchments above Wetlands" prepared for Wyong Shire Council. Available online: http://www.huntercouncils.com.au/environment/products/publications.html

Ecological Engineering 2006 "DRAFT Discussion Paper Modelling Rationale for the Porters Creek Stormwater Harvesting Strategy" prepared for Wyong Shire Council.

Ecological Engineering 2006 "Integrated Water Cycle Management Strategy – Wyong Employment Zone (WEZ)" prepared for Wyong Shire Council, November 2006.

Ecological Engineering 2006 "Integrated Water Cycle Management Strategy – Warnervale Town Centre" prepared for Wyong Shire Council, November 2006.

Moreton Bay Waterways and Catchments Partnership 2006 *WSUD Technical Design Guidelines for South East Queensland*.

BMT WBM 2010 "NSW MUSIC Modelling Guidelines" Prepared for the Sydney Metropolitan Catchment Management Authority. Available for download from *eWater* website (www.ewatercrc.com.au)

Wyong Shire Council ,2010. "Porters Creek Regional IWCM Technical Paper" (YET TO BE PRODUCED)

Comment [SC3]: Is this correct? Is this available?

APPENDIX E – REVISION TABLE

Revision 1 – August 2013

Part / Section / Clause	**Description of Amendment**
Various	Typographical errors amended
3.10	Requirements for Road Safety Audits amended
7.1.1	Reference to other Austroads Pavement related publications added
10.3.5.1	Clause added on computer modelling for storm water quality concept plans
10.3.5.2	Clause added on detail design of storm water quality control measures and devices
10.7.1	Reference to SD 49A deleted
Appendix D	Appendix added for WSUD Concept Design Tools
Appendix E	Appendix added to document amendments