ROAD DESIGN
Standards & Guidelines

STORMWATER DESIGN - DD 300

Contents

DD 300 Revision Register

Date-Revision	Details of Revision	Authorised By
24/10/14 – Rev 0	DD 300 released	Bill Lipp PSE
24/6/2015 – Rev1	Partial revision to address blockage, climate change and clarifying ARI standards for different roads.	Bill Lipp PSE

1 INTRODUCTION

This Design Standard specifies the requirements for undertaking the design and documentation of stormwater systems associated with DPTI road infrastructure.

The key standards and guidelines that are required for stormwater design are listed, as well as the key design requirements and documentation deliverables.

For road stormwater design guidance, DPTI require the use of the Austroads Guide to Road Design - Drainage Parts 5, 5A and 5B as the primary reference. Where DPTI requirements vary from these guides, or where additional information is appropriate this has been detailed in a DPTI Supplement in the final section of this design standard.

This design standard does not cover the design of stormwater systems for railways. (refer http://www.dpti.sa.gov.au/contractor_documents/public_transport_technical_standards)

2 DESIGN STANDARDS, GUIDELINES, REFERENCE DOCUMENTS AND STANDARD DRAWINGS

2.1 Guideline Documents

The design must comply with the following guideline documents.

a) Austroads Guide to Road Design – Drainage - Parts 5, 5A and 5B.. This is the primary reference / guideline document.

b) Australian Rainfall and Runoff (ARR), various editions as quoted.

c) Austroads Waterway Design Guide (1994).

d) Austroads Guide to Pavement Technology Part 10: Subsurface Drainage.

e) Environmental Protection Authority "Stormwater Pollution Prevention – Code of Practice for Local, State and Federal Government".

f) DPTI Protecting Waterways Manual.

g) DPTI Stormwater Treatment Infrastructure Manual.

h) EPA Environment Protection Water Quality Policy.

i) Australian Runoff Quality, A Guide to Water Sensitive Urban Design, Engineers Australia.

j) DPTI - Easements Across Departmental Land Instructions to Engineers – Amendment No. 13

k) DPTI – Care, Control and Management of Roads (Highways) by the Commissioner of Highways (Section 26 of the Highways Act) – Operational Instruction 20.1.

l) DPTI – Instruction to Engineers SAI 24 – DD302 (DPTI Policies on Assistance to Councils for Stormwater Drainage).

DPTI publications are available from: http://www.dpti.sa.gov.au/standards.

2.2 Australian Standards

Material s specified in the design must comply with the following standards:

a) AS/NZS 3725:2007 Design for installation of buried concrete pipes.

b) AS 1597.1 - 2010 Precast reinforced concrete box culverts – Small culverts (up to 1200 x 1200 RCBC).

c) AS 1597.2 – 2013 Precast reinforced concrete box culverts – Large culverts (exceeding 1200 x 1200 RCBC). To be used in conjunction with DPTI Design Standard: Structural (refer to DPTI Structures Group Standards and Guidelines).

d) AS 4139 – 2013 Fibre reinforced concrete pipes and fittings.

e) AS 2566.1 – 1998 Buried flexible pipelines – Structural design.

f) AS 3996 – 2006 Access covers and grates.

g) AS 3735 – 2001 Concrete structures retaining liquids.

2.3 Reference documents

The design can use the following reference documents where relevant for design guidance:

a) Storm drainage design in small urban catchments, John Argue, 1986.

b) Queensland Urban Drainage Manual.

c) Hydraulic Design of Highway Culverts (HDS 5), U.S. Department of Transportation Federal Highway Administration.

d) Hydraulic Design of Energy Dissipators for Culverts and Channels (HEC-14), U.S. Department of Transportation Federal Highway Administration.

e) Design of Roadside Channels with Flexible Linings (HEC-15), U.S. Department of Transportation Federal Highway Administration.

f) Urban Drainage Design Manual (HEC-22), U.S. Department of Transportation Federal Highway Administration.

g) CPAA Design Manual – Hydraulics of Precast Concrete Conduits, Concrete Pipe Association of Australasia.

h) Best Practice Erosion and Sediment Control, International Erosion Control Association (Australasia) (IECA 2008).

i) Austroads Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure

j) Water Sensitive Urban Design Technical Manual, Greater Adelaide Region (Department of Planning and Local Government, 2010). Available (as at October 2014) at: http://www.sa.gov.au/topics/housing-property-and-land/building-and-development/land-supply-and-planning-system/water-sensitive-urban-design

k) WSUD: Basic Procedures for 'Source Control' of Stormwater, John Argue.

l) Services in Streets - a code for the placement of infrastructure services in new and existing streets (1997 edition), South Australian Public Utilities Advisory Coordinating Committee (PUACC)

m) Land subsidence and sea level rise in the Port Adelaide estuary: Implications for monitoring the greenhouse effect (paper by Belperio AP in Australian Journal of Earth Sciences Volume 4, Issue 4,1993)

n) Predicting Storm Runoff in Adelaide – How much do we know (Paper by Kemp DJ & Lipp WR in seminar proceedings, Living with Water, Hydrological Society of SA, October 1999)

2.4 DPTI Standard Drawings

Culvert Headwall and Endwall Drawings

S-4002, Sheet 17 Driveable Culvert Endwall Type 1

S-4002, Sheet 18 Driveable Culvert Endwall Type 2

S-4002, Sheet 19 Box Culvert Skew Angle 0 - 20 degrees

S-4002, Sheet 20 Box Culvert Skew Angle 21 – 45 degrees

S-4002, Sheet 21 Reinforced Concrete Pipe 450mm – 900mm Angle 0-20 degrees

S-4002, Sheet 22 Reinforced Concrete Pipe 1050mm – 1800mm Angle 0-20 degrees

S-4002, Sheet 23 Reinforced Concrete Pipe 450mm – 900mm Angle 21 - 45 degrees

S-4002, Sheet 24 Reinforced Concrete Pipe 1050mm – 1800mm Angle 21 - 45 degrees

<u>Stormwater Inlets and Junction Boxes</u>

S-4065, Sheet 1 Concrete Channels and Grates

S-4080, Sheet 1 Single Pipe Junction Box Types A, B and C

S-4080, Sheet 2 Side Entry Gullies

S-4080, Sheet 3 Combined Junction Boxes and Side Entry Gully

S-4080, Sheet 6 Grated Field Pit

S-4080, Sheet 7 Grated Inlet Pit for Concrete Side Drain (V-Shaped grate)

S-4080, Sheet 13 Special Combined Junction Boxes with Side Entry Gullies or Grated Inlet Pit

<u>Kerbing</u>

S-4070, Sheet 6 Median and Traffic Island Kerbing

S-4070, Sheet 7 Kerb and Gutter

<u>Floodways</u>

S-4002, Sheet 25 Batter Protection – Floodway Road Crossing

3 DESIGN REQUIREMENTS

3.1 <u>Design Life</u>

Unless specified otherwise, the various components of the design must be designed for the following minimum design life (ie before replacement of that component is required):

COMPONENT	DESIGN LIFE (YEARS)
Scour protection	50
Inaccessible stormwater components	100
Stormwater components that are easily accessible for refurbishment or replacement, except for water quality components	50
Water quality components	20

“Water quality components” includes sedimentation / retention / detention basins and ponds.

3.2 <u>Design Standard (ARI)</u>

Unless specified otherwise, the following minimum design average recurrence intervals (ARIs) must be applied in the design of DPTI maintained stormwater infrastructure. Where the stormwater infrastructure is intended to be maintained by the Local Council, the particular Council(s) involved may have design standards that differ from those listed below. These different standards would then apply.

Bike Lanes

COMPONENT	DESIGN STANDARD (ARI - YEARS)
0.5m of lane clear of gutter flow	1 (where practicable – may not be achievable on very flat grades)

Unsealed Roads in remote areas

COMPONENT	DESIGN STANDARD (ARI - YEARS)
Longitudinal swales	5 – may need to calculate two flows, one from the road pavement and one from surrounding land depending on location.
Catch drains (designed to exclude external flows from the road corridor)	10 – see also comments on Part 5 Section 3.6.1in supplementary section.
Transverse road culverts where the vertical alignment requires a culvert	20
Bridge crossings on major or named watercourses where the vertical alignment requires a bridge	50
New channels or watercourses associated with a major culvert/bridge crossing	50
Floodways	50
Scour Protection in channels etc	The greater of 50 years or the ARI of the channel design or channel capacity.

Sealed Unkerbed Roads (normally located in rural areas)

COMPONENT	DESIGN STANDARD (ARI - YEARS)
Longitudinal swales	5 – may need to calculate two flows one from the road pavement and one

	from surrounding land depending on location.
Capture of concentrated flow across traffic lane(s)	5
Catch drains (designed to exclude external flows from the road corridor)	10 – see also comments on Part 5 Section 3.6.1in supplementary section.
Sheet drainage down fill batters greater than 1.5m high and steeper than 1:4. from more than one traffic lane	10
Transverse road culverts	20
Bridge crossings on major or named watercourses	50
New channels or watercourses associated with a major culvert/bridge crossing	50
Floodways	50
Scour Protection in channels etc	The greater of 50 years or the ARI of the channel design or channel capacity

Kerbed Roads (normally located in urban areas)

COMPONENT	DESIGN STANDARD (ARI - YEARS)
Longitudinal and minor network stormwater systems (urban road drainage) (gutter flow widths not exceeding criteria also apply to guide kerb inlet spacing)	5
Capture of concentrated flow across traffic lane(s)	5
Longitudinal drainage for elevated roadways or long bridge structures	10
Catch drains (designed to exclude external flows from the road corridor)	10 – see also comments on Part 5 Section 3.6.1in supplementary section.
Landlocked road sag points / underpasses / depressed roadways	20
Transverse road culverts	50 or the Council required standard
Bridge crossings on major or named watercourses	50 or the Council required standard
Major storm for the purpose of checking the effect of the project on major (overflow) flow paths ie not exacerbating flooding of downstream properties due to runoff from the project itself or by the project redirecting major flow paths that originate from further upstream	100
Measures to ensure that external surface flows do not enter depressed (below natural surface) sections of roadways	100

New channels or watercourses associated with a major culvert/bridge crossing	Match culvert/bridge ARI
Scour Protection in channels etc	The greater of 50 or the channel design capacity

National highways

COMPONENT	DESIGN STANDARD (ARI - YEARS)
Longitudinal and minor network stormwater (Urban road drainage) (gutter flow widths not exceeding criteria also apply to guide kerb inlet spacing)	5
Capture of concentrated flows across traffic lanes	5
Longitudinal drainage for elevated roadways or long bridge structures	10
Catch drains (designed to exclude external flows from the road corridor)	20 – see also comments on Part 5 Section 3.6.1in supplementary section.
Landlocked road sag points / underpasses / depressed roadways	20
One lane each direction free of inundation in underpasses / depressed roadways	100
Transverse road culvert and bridge crossings	100 or the Council required standard
Major storm for the purpose of checking the effect of the project on major (overflow) flow paths ie not exacerbating flooding of downstream properties due to runoff from the project itself or by the project redirecting major flow paths that originate from further upstream	100
Measures to ensure that external surface flows do not enter depressed (below natural surface) sections of roadways	100
New channels or watercourses associated with a major culvert/bridge crossing	Match culvert/bridge ARI
Scour Protection in channels etc	The greater of 50 or the channel design capacity

Freeways / expressways / motorways

COMPONENT	DESIGN STANDARD (ARI - YEARS)
Longitudinal and minor network stormwater (Urban road drainage) (gutter flow widths not exceeding criteria also apply to guide kerb inlet spacing)	10
Capture of concentrated flows across traffic lanes	10
Longitudinal drainage for elevated roadways or long bridge structures	20
Catch drains (designed to exclude external flows from the road corridor)	20 – see also comments on Part 5

	Section 3.6.1in supplementary section.
Landlocked road sag points / underpasses / depressed roadways	20
Transverse road culvert and bridge crossings	100 or the Council required standard
Major storm for the purpose of checking the effect of the project on major (overflow) flow paths ie not exacerbating flooding of downstream properties due to runoff from the project itself or by the project redirecting major flow paths that originate from further upstream	100
Minor storm event have all lanes in each direction free of inundation	10
Major storm event have a minimum of one lane in each direction clear of inundation	100
Measures to ensure that external surface flows do not enter depressed (below natural surface) sections of roadways	100
New channels or watercourses associated with a major culvert/bridge crossing	Match culvert/bridge ARI
Scour Protection in channels etc	100

Note: where there are two different design standards for a component, the higher standard applies.

4 STORMWATER DOCUMENTATION DELIVERABLES

The following records must be provided to the DPTI Stormwater Group:

<u>Drawings</u>

- The drawings described in the DPTI: Road Design Standards and Guidelines and Part D010. In particular a drainage longitudinal section/s, catchment/sand detail/s drawing (if relevant) are to be provided in conjunction with the main drainage layout drawing which is to be shown on the general construction drawing or a dedicated drainage layout drawing.
- As constructed drawings (if required).
- Drawing of any temporary stormwater and/or sedimentation control devices required to comply with the SEDMP.

<u>Reports/Stormwater Models</u>

A stormwater design report is to be provided detailing all aspects of the stormwater design, including all relevant calculations and design considerations. This report is to be provided to the DPTI Stormwater Group upon completion of the stormwater design and in draft form at relevant stages of the design to allow for review and feedback.

In conjunction with the design report all relevant stormwater models are to be provided upon completion of the design and at relevant review periods.

<u>As constructed GIS Stormwater Data</u>

The Designer and / or constructor must submit to the DPTI Stormwater Group the final as constructed stormwater system details in shapefile format suitable for use in ESRI ArcGIS. This information must consist of a separate "Pits" shapefile detailing the location of all new stormwater pits, junction boxes and headwalls including attribute information that lists as a minimum:

- Pit type (eg. Double Side Entry Pit)
- Pit invert level (metres AHD)
- Design pit surface level (i.e. gutter invert for SEP, surface level for JB) (metres AHD)
- Year of construction

In conjunction with the "Pits" shapefile, a "Pipes" shapefile is also to be provided detailing the location of all new stormwater and modified stormwater pipes/culverts, including the following minimum attribute information:

- Pipe material and type (RCP, FRC, RCBC, etc)
- Pipe diameter, length and Pipe Class
- Width/height (for RCBC) (in millimetres)
- Upstream and Downstream pipe invert levels (m AHD)
- Year of construction

These two shapefiles are to be provided in MGA coordinates suitable to be overlaid with aerial imagery and other state government data.

Stormwater Treatment Infrastructure (STI)

The Designer and / or constructor must submit information, in the form of proformas as detailed below, which record physical details and maintenance requirements for any stormwater treatment devices (including detention basins) that are associated with the works.

The Designer and / or constructor must update the Stormwater Treatment Infrastructure (STI) manual by completing a "New STI (Location) Proforma" (Refer to http://www.dpti.sa.gov.au/standards) and a "New STI (Type) Proforma" if not already included in the manual (http://www.dpti.sa.gov.au/standards).

Approvals from relevant Councils

The relevant Council(s) must be consulted during the progress of the design and written approval from the Council(s) must be obtained and submitted to the relevant DPTI Project Manager at the conclusion of the stormwater design, if the design involves discharge into any Council controlled fixed capacity downstream stormwater infrastructure.

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5 DPTI SUPPLEMENT TO THE AUSTROADS GUIDE TO ROAD DESIGN - DRAINAGE

This section is a supplement to the following Austroads Guide to Road Design drainage guides:

- Part 5 – Drainage: General and Hydrology Considerations
- Part 5A – Drainage: Road Surface, Networks, Basins and Subsurface
- Part 5B – Drainage: Open Channels, Culverts and Floodways

This supplement lists SA Government and DPTI requirements that clarify, modify or add to the direction provided in the guides. The supplementary comments are listed in line with the relevant section in the Austroads drainage guides. If further clarification is required this can be obtained from the DPTI Stormwater Group.

Austroads Guide to Road Design Part 5: Drainage- General and Hydrology Considerations

Part 5 Section 2.0 Safety in Design

2.2 Workplace Health and Safety Act and Standards

DPTI require a safety in design assessment to be completed for the stormwater design. This will need to consider safety in all aspects of the proposed stormwater infrastructure, including design, construction, operation and decommissioning. This assessment can be incorporated into the stormwater design, road design or standalone Safety in Design reports. The appropriate report to be used for a particular project is to be confirmed with the relevant DPTI Project Manager.

Part 5 Section 3.0 Environment

3.2 Climate Change

3.2.2 Sea Level Rise

Climate change projection recommendations from the SA Coast Protection Board (2012) are to allow for 0.3m of sea level rise by 2050 and for 0.7m by 2100. International Panel on Climate Change (IPCC) Report 5 (2014) predictions is for 1m sea level rise to 2100 and for this rate of level increase to continue. The design of stormwater systems that discharge at or close to sea levels should make allowance for these predictions.

Allowance should also be made for land subsidence in some areas of Adelaide, particularly Port Adelaide - see Belperio AP in reference document list.

3.2.4 Increase in Rainfall Patterns

The draft advice from ARR (2014) on climate change is for a 5% increase in rainfall intensity for every degree of global warming.

IPCC mid range (most likely) global estimate for 2100 is 4 degrees. The Goyder Institute climate downscaling modelling for each Natural Resource Management region in SA identified a 3.2 to 4 degree increase for 2090. Kangaroo Island was 3.2 degrees.

Therefore a 15% to 20% design rainfall intensity increase by 2090 is possible across South Australia due to climate change. This increase applies to all ARIs and storm durations. Conversely a generally dryer climate is also expected due to climate change. These two changes may offset each other to some degree due to higher rainfall losses on pervious surfaces. Due to the ARR advice still being draft and the unknown effect on rainfall losses of climate change, at this stage DPTI does not require that rainfall intensities be increased for design purposes. However a sensitivity test should be carried out with higher rainfall intensities, especially in urban areas where the runoff is dominated by flow from impervious surfaces and consideration be given to increasing pipe sizes etc where the required design standards are appreciably degraded.

3.3 Fauna Passage/Crossings

Refer to DPTI Environment Standards and Guidelines for more guidance, in particular the Protecting Waterways Manual. The requirement for these crossings shall be determined in conjunction with the DPTI Environment Group and the DPTI Stormwater Group prior to their design.

3.4 Pollution Control and Water Quality

3.4.3 Spill Management

Where there are sensitive downstream ecosystems (as identified by the Water Quality Risk Assessment process), road design elements that do not meet Austroads Guidelines that are likely to increase the likelihood of collisions (such as shortened acceleration lanes or merging lanes at intersections) and high traffic volumes, accidental spill retention is required.

Where deemed required, DPTI require the provision of a minimum of 50m^3 of accidental spill volume to be provided. The location and functionality of this volume is to be detailed in a STI location proforma for inclusion in the DPTI Stormwater Treatment Infrastructure (STI) manual (refer to Section 4 – Stormwater Documentation Deliverables). The stormwater design report (in an Appendix) must also include an Emergency Response Plan detailing the measures to be undertaken in the event of an accidental spill to ensure spills are contained and no sensitive downstream environments are impacted. This is to be provided to the DPTI Stormwater Group who will ensure that it is conveyed to DPTI's Traffic Management Centre.

3.5 Water Sensitive Design

3.5.4 Performance Objectives

The SA Government WSUD Policy sets guidelines for water quality improvement that apply to road projects. These are:

- 80% reduction in average annual load of Total Suspended Solids (TSS)
- 45% reduction in average annual load of Total Nitrogen (TN)
- 60% reduction in average annual load of Total Phosphorus (TP)
- 90% reduction in average annual load of Gross Pollutants (GP)

- Runoff from the project does not exceed the pre-urban development 1yr ARI peak flow rate where the project drains to an unlined watercourse.

- No increase in 5yr ARI peak flow or 100yr ARI flood risk.

In addition the Protecting Waterways manual sets the following targets:

- Retention of litter greater than 50mm for flows up to the 3 months ARI peak flow; and
- No visible oils/hydrocarbons for flows up to the 3 months ARI peak flow.

In addition it should be noted where road projects are upstream of stormwater reuse infrastructure such as wetland systems, any decrease in water quality can impact on the ability of the operator to recharge water in addition to increasing their operating costs.

The application of these targets and the general requirement for permanent water quality (WSUD/WSRD) treatment devices varies for each DPTI project, depending on the findings of a Water Quality Risk Assessment process which is completed by DPTI personnel prior to the writing of the CSTR document. DPTI will state the level of water quality treatment required for a given project in "Part D022 – Roadworks Stormwater" of the CSTR document.

If water quality measures are not specified for a particular project (such as for a developer funded project), the contractor may need to undertake, as part of the design, a Water Quality Risk Assessment in accordance with the DPTI Protecting Waterways manual in consultation with the DPTI Environmental Officers, DPTI Stormwater Group, DPTI regional officers, EPA, regional NRM Boardand local council.

The design of water quality treatment needs to demonstrate that all practical and reasonable steps have been taken to mitigate water quality impacts and that reasonable attempt has been made to meet water quality targets.

3.5.5 MUSIC Model

DPTI require the completion of a MUSIC model when designing WSRD elements. This is to be provided to the DPTI Stormwater Group for review and acceptance during the design phase. DPTI may consider alternative design methodologies, however prior approval is required from the DPTI Stormwater Group before these are used.

3.5.6 Key Design References

A key South Australian based WSUD reference is the SA Government Water Sensitive Urban Design Technical Manual, Greater Adelaide Region (Department of Planning and Local Government, 2010). This is currently available at the following website:

http://www.sa.gov.au/topics/housing-property-and-land/building-and-development/land-supply-and-planning-system/water-sensitive-urban-design

3.5.8 Bio-retention systems

Design should be undertaken in accordance with the *Adoption Guidelines for Stormwater Biofiltration Systems 2015* by the CRC for Water Sensitive Cities. For bio-retention systems the overflow must be designed assuming 75% blockage of the filter area. Consideration of bio retention systems is encouraged where there is space allowed to provide separation between traffic lanes and pedestrians.

3.5.9 Wetlands

In South Australia, appropriate plants are critical to the success of wetland systems as they are likely to be ephemeral. They will need to survive inundation and dry periods. Plant selection will need to be approved by the Landscape Group. With appropriate plant selection for these conditions, contrary to the Austroads guide, wetlands are considered suitable for the treatment of flows from catchments consisting of predominantly road or road surfaces.

3.5.11 Maintenance and Disposal

The DPTI Stormwater Treatment Infrastructure (STI) manual details all existing DPTI Water Sensitive Road Design (WSRD) devices. When designing new WSRD infrastructure, documentation needs to be provided to detail this infrastructure in the STI manual (refer to Section 4 – Project Stormwater Documentation Deliverables).

Maintenance of any WSRD infrastructure is key to its treatment effectiveness. It must be considered, designed and detailed appropriately. Key maintenance activities must be detailed in the STI manual documentation.

3.6 Erosion and Sediment

3.6.1 General

Concentrated surface runoff must not be designed to discharge down any fill batter with slope exceeding 1:6, unless contained within an enclosed conduit (pipe or box culvert) system. Where the batter is flatter than 1:6, an appropriately stabilised batter chute (open channel) may be used to transfer such flows down the batter.

Where a catch drain is used at the top of a cut face (i.e. kerbing or swales), the effect of a major event (100 year ARI) shall be considered and the stormwater infrastructure sized so that significant damage to the road formation is avoided in this event. This is to avoid situations where substantial catchments areas are being diverted via catch drains and the kerbing or swales have inadequate capacity.

3.6.4 Erosion and Scour Protection Measures

Sheet runoff from more than one sealed traffic lane shall not be allowed to discharge down any fill batter greater than 1m in height and steeper than 1:4 in slope unless collected and contained within a formal drainage system, or the surface has been appropriately designed or protected to cater for the expected flow rate and velocity.

Where dispersive soils (Soils having Emerson Class 1 or 2 in accordance with AS 1289.3.8.1-2006) are exposed in any cuts, a minimum of 150mm of non-dispersive topsoil shall be placed before revegetation to protect the cut face from erosion from local runoff. Longitudinal stormwater infrastructure shall also be used at the top of such cut faces to prevent external water from flowing down the cut face.

Scour protection, as deemed necessary, shall be provided at any other area susceptible to scouring, such as bridge piers and abutments, verge drains, culvert inlets and outlets, longitudinal drain outlets and cross-sectional changes along constructed or natural watercourses where there may be a risk of erosion. Scour protection shall prevent scour for the design flow. Techniques shall be appropriately selected and designed to suit the application and performance requirements.

Where dispersive soils (Soils having Emerson Class 1 or 2 in accordance with AS 1289.3.8.1-2006) are exposed in areas where scour protection measures are required to be constructed, in addition to any other requirements, a minimum of 200mm of non-dispersive topsoil or other cohesive material (depending on location and circumstances) shall be placed before vegetation is planted or other scour protection measures are constructed.

Permanent (expected design life of at least 50 years) scour protection measures must be provided in areas of concentrated flow (such as swales and channels) where the maximum allowable flow velocity of the insitu soil type has been exceeded as defined in Table 3.5 (or Table 2.5 in Part 5B: Drainage – Open Channels, Culverts and Floodways). This requires that 50yr ARI flows and velocities must be used to design the scour protection measures.

Native grassed lined swales are the preferred scour protection solution followed by non native grassed lined swales followed by rip rap lined channels before more engineered channel s can be considered. Each of the preferred scour protection solutions must be demonstrated to be unsuitable before moving onto the next.

Grassed linings need to be designed having regard to the grass species to be used, the average annual rainfall, summer dry periods between rainfall events and the expected high flow duration in the swale / channel. Table 2.6 of the Austroads Guide Part 5B can be used as a guide for determining if grass is a suitable treatment option once flow velocities have been determined. All native grassed swales must be designed on the basis of a maximum cover of 50% and non native grassed swales on the basis of a maximum cover of 70%. The project landscape architect must also be consulted during the design phase to ensure that all scour protection objectives are achieved. The maximum side slope for grassed channels is 1 in 6.

Where rip rap is to be used this must be designed and specified in accordance with the Austroads guide. Rip rap channels must include an underlying geotextile fabric appropriate to the rock size with an appropriate freeboard to ensure flows are restricted to the rip rap lined area. The maximum side slope for rip rap lined channel is 1 in 3.

Drop structures may be included to reduce flow velocity. The design must demonstrate that the risk of downstream scour has been adequately mitigated.

Reno mattresses and other synthetic channel protection linings must be used in accordance with manufacturer’s recommendations. Refer to Tables A23 – A27 in Appendix A of IECA 2008 (listed in Section 2.3 - Reference Documents above) for guideline allowable flow velocities for various channel linings. Such linings must be demonstrated to be vandal and fire resistant.

3.6.5 Rock Protection

SA experience has been that where rock is machine placed on 1 in 1.5 slopes recommended in Austroads, the placed rocks have not been stable. Therefore the maximum allowable bank/cross slope for machine placed rock protection is 1 in 3. Designs that specify steeper slopes will need to identify the source of rock, dimensionsand demonstrate that it can be effectively laid. Eg where rock used will have parallel faces. Such designs will need approval of the Geotechnical and Stormwater Groups.

3.6.9 Ground Cover

Ground cover must be self-sustaining ie not contain solely sterile species.

Part 5 Section 4.0 Drainage Considerations

4.6 Selection of ARI

Refer to Section 3 of this document “Design requirements” as the prime point of reference for selection of the design ARI for a given project and its required stormwater design standard.

4.7 Freeboard

4.7.6 Culvert Design

Culvert obverts must NOT be designed higher than the subgrade level (ie intruding into the pavement layers) without prior approval from both the DPTI Pavements Unit and the DPTI Project Manager.

4.8 Other Considerations

4.8.1 Drainage Construction Materials

Unless approved otherwise by the DPTI Stormwater Group stormwater infrastructure and materials must comply with the following requirements.

Culverts must comply with the following:

(a) Box culverts must be reinforced concrete (RCBC);

(b) When box culverts (RCBC) are required, a minimum 450 x 300 RCBC must be used in rural/unkerbed areas and 375 x 225mm in urban/kerbed areas;

(c) Pipe culverts must be either concrete (RCP), fibre cement (FRC) or Black Max. Where Black Max is used, a length of RCP (i.e. 2.44m) must be used to connect it to an inlet or outlet headwall. Where there are disparities in the internal diameters of RCP and Black Max pipes, the internal diameter must increase from the inlet to outlet to reduce the risk of blockage;

(d) The diameter of pipes used in drainage networks or as cross culverts must not be less than 375 mm in urban/kerbed areas and 450mm in rural/unkerbed areas;

(e) Rubber ring jointed pipes (RRJ) must be used where:

   a. Pipes are required to permanently hold water;

   b. A change of direction is being made by deflecting pipe joints;

   c. Below the measured maximum groundwater level;

   d. Pipe movement is expected during operation such as within a fill formation; and

   e. The pipe is closer to a tree than three times its mature canopy radius.

(f) Pipe loadings for pipe class selection must be the more critical of expected construction equipment loading or traffic loading;

(g) Prior to the use of jacking pipes the designer must gain prior approval from the DPTI Structures Unit;

(h) Culvert classifications and installations must be as required by the Australian Standard relevant to the culvert material used;

The following materials must not be used for stormwater purposes:

(a) Metal culverts to AS 2041; and

(b) Plastic pipes (except Black Max).

Part 5 Section 6.0 Hydrology

In general DPTI require the completion of a DRAINS model for road stormwater designs in urban areas. The ILSAX hydrology option should be used.

Acceptable predevelopment (ie greenfields) values of paved, supplementary and grassed depression storage (losses) are 1, 1and 10mm. Acceptable post development values of paved, supplementary and grassed depression losses are 1, 1 and 5mm.

If using the default Antecedent Moisture Conditions (AMC) and Horton Soil Type, the following guidance on model parameters is provided:

The US Soil Conservation Service infiltration curves are used in DRAINS. After about 100 minutes after the start of the storm soil type 3 levels off to a continuing loss of 6mm/hr and soil type 4 levels off to a continuing loss of 3mm/hr (see Figure 5.10 DRAINS user manual). ARR1987 recommended that initial / continuing loss models in Adelaide use 3mm/hr continuing loss. Therefore a soil type of 4 would be expected for most clay soils in Adelaide. If justified by the soil type (eg sand soils near the coast) lower soil type figures can be used.

For the proportion of paved, supplementary paved and grassed area determination either the parameters shown on the table below can be used for each landuse type, or catchment impervious areas can be measured from aerial photographs and known potential future development in the catchment factored in (refer to section 6.5 below).

Acceptable DRAINS paved, supplementary paved and grassed parameters by percentage impervious			
Land Use	Paved	Supplementary	Grassed
commercial/industrial	90	0	10
Residential Allotments < 300 m^2	80	10	10
Residential Allotments 300-500m^2	70	10	20
Residential Allotments 500-700m^2	60	15	25
Residential Allotments 700-1000m^2	40	15	45
Residential Allotments 1000-2000m^2	30	15	55
Rural Allotments 2000-4000m^2	10	10	85
Rural Allotments > 4000m^2	0	5	95

In the absence of an analysis of antecedent moisture conditions an Antecedent Moisture Condition (AMC) of 2.5 should be used in the DRAINS model. An analysis of antecedent moisture conditions is recommended, as daily rainfall data is readily available over the internet from the Bureau of Meteorology. The DRAINS user manual should be consulted on guidance on how to undertake this analysis.

As urban runoff in SA is dominated by the impervious area response, a simple initial continuing loss model can also be used for the grassed (pervious) area. Following an analysis of urban streamflow gauging records, the pervious area initial loss was found to be at least 45 mm in Adelaide with a continuing loss of 3 mm / h – see Kemp DJ et al in the reference document list. Based on this an initial loss of 45mm and continuing loss of 3mm can be used.. These can be entered under the “you specify” section under soil type. No depression storage should be allowed for in the grassed area as this is accounted for in the loss model, but the 1 mm for depression storage for the paved and supplementary areas should still be used.

The 2013/14 revision of Australian Rainfall and Runoff has developed an online regional regression tool to determine flows from rural catchments. If this tool is used the shape of the catchment, slope, soil type and depth, the average rainfall and vegetation type and cover need to be considered in estimating design flood flows.

6.5 Catchments

6.5.3 Future Developments

Future increased impervious area and reduced time of concentration for a minimum 50 year future timeframe must be allowed for in the stormwater design hydrology. If moving from less intensive to more intensive built development, the percentage of existing buildings replaced by more intensive urban development should be set at 70% in a 50 year future timeframe . If moving from a greenfields site, the site can be expected to be fully developed in the 50 year future timeframe. Appropriate reference documents must be used to determine the extent of known future allowable development (including density) such as Council Development Plans or other relevant planning documents such as the 30 Year Plan for Greater Adelaide.

6.6 Rural Hydrology

For catchments larger than 5km[2] the proposed hydrological approach must be agreed with the DPTI Stormwater Group prior to the commencement of the design.

Stormwater Management Plans and many older flood / drainage studies have been undertaken over many parts of metropolitan Adelaide and many country towns. Where a road project is within the area of one of these plans or studies, they should be referred to and can be a source of design flow information. Use of such information for design purposes requires the prior approval of the DPTI Stormwater Group.

If measured flow data is available in the same hydrological catchment or in a hydrologically similar adjacent catchment this data should be used for hydrological model calibration and flood frequency analysis and the results considered as part of the design flow selection process. Where a design hydrograph is required (such as for designing detention storage) a computer hydrological model such as XP-RAFTS, RORB or the RRR model must be used.

RORB is not a preferred rural hydrology modeland where it is proposed to be used, the DPTI Stormwater Group must approve the subcatchment layout and parameters. For example where rural catchments are being urbanised RORB models must be set up so that this area is a separate subcatchment and parameters are adjusted accordingly.

6.6.1 Rational Method

For further clarification of the two suggested rational methods for rural areas in South Australia shown in Table 6.1 and additional methods, refer to Book 4, Section 1.4.6 – South Australia, Australian Rainfall and Runoff, 2001 (revised 1987) Edition.

The DPTI Rational Method, discussed below, is preferred to the other rational method approaches to estimate peak catchment flows for the area shown in Appendix A for small rural catchments less than 5km[2]. . However, this estimate should be compared to at least one other method (such as regional regression formulas or hydrological model results) and then engineering judgement used in selecting a design flow.

DPTI Rational Method

Use the rational method formula as detailed in Section 6.6.1 of the Austroads Part 5 Drainage Guide. The catchment area should be calculated from topographic mapping or other survey or contour information, then the time of concentration and runoff coefficient can be determined as defined below and the rainfall intensity derived from ARR 2013 IFD data for the geographic location of the catchment.

Time of concentration:

For rural catchments with a defined watercourse use the Bransby-Williams formula as defined in Section 6.6.2 – Time of concentration of this Austroads Drainage guide.

Runoff Coefficient, C:

Step 1 – Base Coefficient (10 year ARI level)

Type of Catchment Terrain	Base Coeffcient
Native Semi-arid Grassland	0.25
Dairy Farming, Orchards/Vineyards, Horticulture	0.20
Cereal cropping, Mixed Farming	0.15
Natural Scrub, Forest Plantations	0.10

Step 2 – Slope Adjustment (add/subtract to base coefficient in Step 1)

Se (Equal Area Slope) as used in the Bransby-Williams formula	Adjustment Factor

<2 m/km	-0.08
<5 m/km	-0.05
>50 m/km	+0.03

Step 3 – Catchment Area Adjustment

Multiply result of Step 2 by:

$(100/A)^{0.10}$ (A = Catchment area in km2)

If adjusted C after Step 3 > 0.4 use 0.4.

Step 4 – Location Adjustment

Multiply result of Step 3 by the factor read from the map on Chart No.6 (attached in Appendix A).

Step 5 – Average Recurrence Interval (ARI) adjustment

ARI	Factor (to multiply result of Step 4 by)
5	0.7
10	1.0
20	1.15
50	1.4
100	1.6

Austroads Guide to Road Design Part 5A – Drainage: Road Surface, Networks, Basins and Subsurface

Part 5A Section 4.0 Aquaplanning

An aquaplaning assessment must be completed as part of the stormwater design in accordance with the methodology in this section and evidence of this assessment must be provided in the stormwater design report (refer to Section 4 - Stormwater Documentation Deliverables). The full road design surface must be examined, but evidence of the assessment is only expected at critical locations where the water film depth is close to or exceeds the criteria in Section 4.10. Where the allowable water film depth is exceeded, the road or stormwater design shall be altered to reduce or eliminate this depth.

In addition, road crossfalls shall be an absolute minimum of 2.5%, with a desirable minimum of 3.0%. Crossfall in excess of 3.0% will need to be considered where high longitudinal grades reduce the effectiveness of the crossfall to remove surface sheet runoff from the pavement.

All concentrated flows across the road pavement must be avoided for the relevant design ARI event (minimum of the 5 year ARI event) to avoid the risk of aquaplaning. Locations that need to be checked include median or kerb terminations and at crossfall transition points.

Part 5A Section 5.0 Kerbed Drainage

In general, DPTI require the completion of a DRAINS model to undertake the required hydraulic calculations for stormwater infrastructure in DPTI roads.

5.3 Kerbed Drainage Elements

5.3.1 Kerbing

In general only DPTI Standard kerbing must be used as detailed on the DPTI Standard Drawings listed in Section 2.4 – DPTI Standard Drawings.

5.3.2 Inlets

In general only DPTI Standard stormwater inlets must be used as detailed on the DPTI Standard Drawings listed in Section 2.4 – DPTI Standard Drawings. DPTI also allow the use of the Rocla Drainway Kerb Inlet System (to be used in conjunction with a DPTI standard pit base) in narrow medians. Grated inlets are only to be used after prior approval from DPTI's Stormwater Group due to the risk of blockage.

The use of any other manufacturer's alternative stormwater inlets can only be used after prior approval from both DPTI's Stormwater Group and Structures Unit.

Where concentrated flows are collected by a kerbline (including medians or islands) stormwater inlet pits should be provided in the design to collect this flow. However, where it is impractical to provided underground stormwater infrastructure, kerb openings/gaps may be considered. These kerb openings are usually a minimum of 300mm in width and spaced evenly along the kerb to ensure concentrated flow discharges do not exceed the recommended flow depths defined in Section 4.0 Aquaplaning in this Austroads guide. Kerb openings should not be used where design speeds exceed 80km/hr.

5.3.4 Inlet Locations

At landlocked sag points extra stormwater inlets must be provided up to 10 metres either side such that their gutter levels are 50mm higher than the sag point level. This is to provide inlet redundancy in the event of inlet blockage. Ideally a second outlet pipe will also be provided to a separate outfall to cater for pipe redundancy in the event of pipe blockage, however it is recognised that this is not always practical.

To allow for stormwater pipe access locations for maintenance purposes, DPTI require a maximum pit spacing of 100 metres in general or 200 metres for outlet pipes greater than 1800mm in diameter

5.4 Design Criteria

5.4.2 Pavement Spread and Gutter Flow Limits

DPTI only require that flow widths be minimised for the relevant ARI event (generally 5 year or 20 year at landlocked sag points) so that a 2.2 metre width is provided clear of water in the outside travel lane. For the 100 year ARI event on national highways or freeways / expressways / motorways one lane in each direction is to be provided clear of water (This is most likely to be a design constraint where either a New Jersey barrier is used or in sections of cut that prevent stormwater escaping elsewhere).

Where a new road design (including scope for a new or upgraded drainage system) is to include bicycle lanes on the road adjacent the kerb, 0.5m of the cycle lane must be maintained clear of water in a 1 year ARI event where practical. It is recognised that this requirement may not be achievable in areas with very flat grades. In addition the stormwater design should aim to eliminate 1 year ARI kerbside flow widths prior to pedestrian crossings or other high usage points such as bus stops.

5.4.5 Gradient

DPTI require a minimum longitudinal kerb gradient of 0.3%. The road designer shall aim to maximise gradient to reduce the extent of required drainage infrastructure without significantly increasing the cost of earthworks.

5.5 Design Theory

5.5.2 Inlet Capture Rates

The full sized University of SA test rig inlet capture test results (both on-grade and sag) must be used for the DPTI Standard Side Entry Pit and Grated Inlet Pit for Concrete Side Drain. For other types of inlets (approved for use by the DPTI Stormwater Group) it is acceptable to use the HEC-22 Wizard in DRAINS to estimate inlet capacity where test results are not available.

5.5.3 Blockage

Blockage factors should also be applied to the design event not just when analysing the major event.

In a sag, the percentage of full theoretical capacity allowed should be 60% for kerb inlets and 30% for grates.

In industrial or commercial areas which generate a lot of litter; eg timber dunnage / fast food outlet packaging or where deciduous street trees are present, an additional 5% reduction should be applied to the capacity of kerb inlets and 15% to grates for each of the above factors. This should be applied to both on grade (Table 5.4 figures) and sag inlets (above figures).

Part 5A Section 6.0 Underground Piped Networks

6.2 Design Considerations

If there are no other service constraints, longitudinal stormwater drains are to be located as detailed in the South Australian Public Utilities Advisory Coordinating Committee (PUACC) publication "Services in Streets - a code for the placement of infrastructure services in new and existing streets (1997 edition). Where stormwater must be located within close proximity to existing services, the relevant service authority guidelines must be used to determine required horizontal and vertical clearances.

6.4.2 Bedding and Haunch Support

Assume that HS2 bedding and haunch support will be provided in construction.

6.5 Design Criteria

A minimum of 150mm freeboard is required between design water levels and gutter inverts at all kerb inlet pits. Note that the gutter invert at a properly constructed kerb inlet pit should be 50mm lower than the gutter invert adjacent to the pit. The 150mm requirement applied to the gutter invert level adjacent to the pit.

A minimum 20mm difference in level is required between all inlet pipes and the outlet pipe from a junction box. The base of all junction boxes must be mortared with a semi-circular shape up to 1/3 the height of the main inlet and the outlet pipe to minimise hydraulic losses through the junction box. The mortar must be properly keyed to the sides and base of the pit.

6.5.2 Size

DPTI require a minimum 450x 300mm RCBC in rural areas and 375 x 225mmfor RCBC in urban areas. For pipes the minimum required diameters are 375mm in urban/kerbed and 450mm in rural/unkerbed environments for pipes.

Part 5A Section 7.0 Basins

7.1.4 Basin Construction

All basins must contain an impervious lining. Prior approval is required from the DPTI Stormwater Group before a basin is designed without an impervious liner, if for example higher infiltration rates are required for the basin functionality. For sedimentation basins or where removal of accumulated pollutants is expected than a minimum 150mm rock lining or alternative approved by DPTI Stormwater Group shall be provided to delineate the basin design invert.

7.2 Detention Basins

Where used, DPTI require that detention basins be configured such that outflows for all rainfall events up to a 100 year ARI event do not exceed existing peak outflows. Multi-stage outlets may be required to achieve this. DPTI require all detention basins to be sized using a runoff routing model such as DRAINS. The basin must be assessed for multiple storm durations for the design ARI to ensure the highest storm volume is detained.

Triangular hydrograph methods are only acceptable to obtain preliminary design sizes for feasibility estimates.

Where the basin includes a bank above natural surface, which may overtop in a rarer storm event, provision must be made for safe overflow by a formalised spillway to ensure that the banks do not scour and fail.

7.2.9 Other Design Considerations

For all basin designs, maintenance requirements are to be considered, designed and detailed including the following:

- All weather access needs to be provided to the basin (from the nearest public road) for maintenance vehicles including room for a vacuum truck to park within 10 metres of all basin inlet and outlet structures;
- Access to the basin invert for a maintenance vehicle appropriate to the size and layout of the basin (eg front end loader or excavator) if maintenance is expected to be required in the future (i.e. sedimentation basins, detention basins, ponds and wetlands). Ramps must be provided with a 1:10 or flatter gradient;
- Where the basin is to become a DPTI asset all maintenance requirements need to be detailed in the appropriate format for entry into the DPTI Stormwater Treatment Infrastructure (STI) Manual (refer to Section 4 – Project Stormwater Documentation Deliverables).

Part 5A Section 8.0 Subsurface Drainage

Subsurface drainage is rarely required on DPTI roads. The requirement and scope for subsurface drainage must be decided after consultation between the project designers, DPTI's Geotechnical Group and Pavement Unit, including consideration of the particular geotechnical and groundwater conditions and the overall proposed stormwater system extent. Either the stormwater or pavement designers may complete the subsurface drainage design, but this must be completed in accordance with this section of the Austroads Guide and the more comprehensive Austroads Guide to Pavement Technology Part 10: Subsurface Drainage.

Subsurface drainage must be connected to drainage pits within the drainage network at intervals of no more than 250m and must include flush out points with appropriate covers at intervals of no more than 100m.

Austroads Guide to Road Design Part 5B – Drainage: Open Channels, Culverts and Floodways

Part 5B Section 2.0 Open Drains and Channels

All open channels must be trapezoidal or an alternative shape that does not have an invert of limited width (i.e. v-shaped). If dispersive soils (soils having Emerson Class 1 or 2 in accordance with AS1289.3.8.1 – 2006) are be exposed by an open channel excavation then a minimum of 200mm of non-dispersive topsoil or other cohesive material must be provided underneath any proposed vegetation or other erosion control layers. These protective layers must be detailed on the design to ensure that the construction contractor over-excavates the channel to allow for backfilling with the non-dispersive material to ensure the channel design cross-section is achieved.

2.14 Batter Drains and Chutes

Fill batter chutes (open channels) must not be used unless the fill batter slope is flatter than 1:6 . For slopes of 1:6 and steeper all stormwater drains down batter slopes shall be piped to the toe of batter.

Part 5B Section 3.0 Culverts

3.4 Culvert Type and 3.5 Culvert Size

Refer to previously listed allowable materials and minimum pipe / box /culvert sizes to be used under DPTI roads. These are summarised under the supplementary comments shown for Part 5, Section 4.8.1 above.

3.6 Structural Design requirements

Where box culverts are to be used with a clear span greater than 1.2 metres, a structural design is required in accordance with the requirements in the DPTI Structural Design Standard available on the DPTI webpage (design to be approved by the DPTI Structures Unit):

http://www.dpti.sa.gov.au/standards

For box culverts with clear span equal to or less than 1.2 metres, DPTI will accept structural designs completed by box culvert manufacturers as long as they are designed and manufactured in accordance with AS1597.1 and AS1597.2.

3.6.4 Cover over pipes

Pipes require a minimum of 600mm of cover to the road surface. Where there is insufficient cover for all or some of the pipes under the road surface, box culverts should be used.

3.7.2 Outlet Velocity

The Department of Transport and Main Roads (Qld) s reviewed it's scour and erosion protection guidance since Table 3.1 (2010) was published as a result of significant scour during flood events. Their updated guidance should be used.

3.7.3 Culverts in Flat Terrain

In certain situations levee banks should also be constructed to guide water to the intended culvert and to ensure that water does not travel along the road embankment to the next culvert, potentially exceeding its capacity.

3.11 Blockage of Culverts

Flood debris is significant in South Australia in rare flood events. Blockage of multiple pipe and culvert runs by floating debris including branches and other vegetation is common. Often there is preferential flow in one cell, with sedimentation occurring in others. Culverts and pipes are put on a maintenance schedule to be cleared when they are identified in periodic inspections as being greater than 50% blocked.

To minimise the risk of blockage, single pipes, single span culverts, or single span wider structures should be used. Where multiple spans are proposed, blockage factors must be applied to the design according to the following table:

Number of spans/culverts	1	2	3	4	5	6 or more
Blockage factor (%)	0	10	15	20	25	30

Where the spans or pipe diameters are less than 2m an additional 10% blockage factor should be applied.
Where the spans or pipe diameters are less than 1.5m an additional 15% blockage factor should be applied.
Where the spans or pipe diameters are less than 1m an additional 25% blockage factor should be applied.

3.14 Culvert End Treatments

3.14.3 Traversable Endwalls

DPTI allow the use of driveable endwalls (headwalls) for culverts up to 600mm in diameter or span (refer to Section 2.4 – DPTI Standard Drawings). These drivable endwalls are normally used face on to traffic, typically under driveways and side roads. The potential for blockage is significantly increased with these structures, so a blockage factor of 50% must be used in the design.

For all road cross culverts above 600mm in diameter or span the headwalls should all be located outside the clear zone if practical. Otherwise, an assessment should be done of the relative hazard of the culvert vs alternative physical protection such as guardrail to determine whether any treatment is required.

Traversable endwalls are not required where there is another obstacle such as an embankment, or tree that will prevent an errant vehicle from reaching the endwall..

Part 5B Section 4.0 Floodways

4.2.2 Geometric

Floodways should be designed to cross at right angles in straight sections of the watercourse wherever possible. The road longitudinal profile should follow the bed of the watercourse as closely as possible while meeting sight distance requirements. This will minimise the effect on the hydraulics of the watercourse and hence scour on the floodway.

4.5.3 Other Floodways

Many floodway structures have been constructed in the semi-arid areas of SA. The most cost effective have been 400mm cement treated pavement with spray sealand concrete cutoff walls to reduce the risk of undermining of the pavement. The downstream cutoff wall is more critical, typically 900-1200mm deepand the upstream 600-900mm. The nominal width of concrete cutoff walls is 300mm, however creek bed material is frequently loose and as a result walls are often far from vertical. This generally requires a significant increase in the volume of concrete for the cutoff walls, typically double what would be indicated by the design. The floodways are built with one way crossfall in the direction of flow, generally 1%, but this will vary with the bed slope of the creek. In most situations the cutoff walls should extend only across the main channel where the water depth and velocity will be higher. Cement treated pavement should extend to the apparent width of the floodplain.

Where larger and steeper watercourse are involved, typically in the Flinders Ranges, more elaborate floodways along the lines described in Section 4.5.3 will need to be considered..

Appendix A – Location Adjustment Factor (to be used in Step 4 of DTPI Rational Method)