Roads

Master Specification

RD-DK-D2 Hydrology

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DEPARTMENT OF PLANNING, TRANSPORT AND INFRASTRUCTURE

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Contents

RD-DK-D2 Hydrology

1 General

1.1 This Design Standard specifies the requirements for undertaking hydrological analysis of stormwater catchments and systems associated with DPTI road, rail and marine infrastructure.

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

1.3 For hydrological analysis guidance, DPTI require the use of the Austroads Guide to Road Design - Drainage Parts 5 as the primary reference. Where DPTI requirements vary from these guides, or where additional information is appropriate, this has been detailed in the following sections of this specification.

2 Standards, Guidelines, Reference Documents and Standard Drawings

2.1 Unless specified otherwise, all stormwater and hydrological assessments shall comply with the most recent revisions (including published amendments) of the following Guidelines and Codes of Practice:

a) Austroads Guide to Road Design – Drainage - Part 5. This is the primary reference / guideline document.

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

c) Austroads Waterway Design Guide (1994).

d) Bureau of Meteorology – Rainfall Data System 2016 - www.bom.gov.au/water/designRainfalls/revised-ifd/.

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

f) DPTI Protecting Waterways Manual.

g) EPA Environment Protection (Water Quality) Policy.

h) Australian Runoff Quality (ARR), A Guide to Water Sensitive Urban Design, Engineers Australia.

2.2 All DPTI publications are available from: https://www.dpti.sa.gov.au/standards.

2.3 Stormwater and hydrological assessments must comply with the following Australian Standards:

a) AS/NZS 3500.3: 2015 Plumbing and Drainage.

b) AS 3735: 2001 Concrete structures retaining liquids.

2.4 Stormwater and hydrology assessment can use the following Reference Documents where relevant for guidance:

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

b) Queensland Urban Drainage Manual.

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

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

e) 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.

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

g) 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).

h) 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).

3 Definitions

Term	Definition
AEP	Average Exceedance Probability
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
AS	Australian Standards
DPTI	Department of Planning, Transport & Infrastructure
DRAINS	Hydrological Modelling Software (Watercom)
EPA	South Australian Environment Protection Authority
FLIKE	Flood Frequency Analysis Software (BMT WBM)
ILSAX	Hydrological Modelling Software (University of NSW)
RORB	Stormwater Runoff Routing Software (Monash University)
RRR	DPTI hydrological modelling software (DPTI)
XP-RAFTS	Hydrological Analysis Software (Innovyze)

4 Safety in Design (Austroads Part 5 Section 2)

Workplace Health and Safety Act and Standards (Austroads Part 5 Section 2.2)

4.1 DPTI require a safety in design assessment to be completed for the stormwater and hydrology assessment. This will need to consider safety in all aspects of existing and proposed stormwater management, including design, construction, operation and decommissioning of associated infrastructure. This analysis can be incorporated into stormwater and hydrology assessment, 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.

5 Climate Change (Austroads Part 5 Section 3)

5.1 Climate Change, resulting in more extreme and frequent rainfall events, will have a significant effect on stormwater and hydrology assessments associated with road, rail and marine infrastructure. Guidance on climate change is outlined in Austroads Part 5 Section 3.2 however specific guidelines on seal level rise, catchment changes and increase in rainfall patterns for South Australia are outlined below.

Sea Level Rise (Austroads Part 5 Section 3.2.2)

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

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

Catchment Changes (Austroads Part 5 Section 3.2.3)

5.4 Allowance should also be made for changes in stormwater catchments due to climate change. South Australian ecology is sensitive to climate change and with South Australia's climate predicted to become warmer (+4 degrees average temperature) and drier (-30% average annual rainfall) by the year 2100, we can expect reduction in vegetation growth, resulting in increased stormwater runoff during extreme events.

Increase in Rainfall Patterns (Austroads Part 5 Section 3.2.4)

5.5 Climate change projections released by the Bureau of Meteorology and CSIRO in 2015 do not include information about changes to rainfall intensity–duration relationships however it is widely accepted that rainfall intensity patterns are sensitive to climate change. Results from climate modelling in various locations in Australia indicate that 1% AEP, 24 hour duration rainfall intensities can increase by up to 20% in some areas and fall in other areas. Given the regional uncertainty in predicting climate change impacts on rainfall intensities, a 5% increase in rainfall intensity per oC of local warming is recommended.

5.6 The IPCC mid-range (most likely) global estimate for average temperature increase to the year 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 in average temperature by the year 2090. Kangaroo Island predicted increase in average temperature by the year 2090 is 3.2 degrees.

5.7 ARR (2016) Book 1, Chapter 6 recognises that failure to account for the impacts of climate change can lead to poor decisions when exposure to climate change is high and outlines a Climate Futures Web Tool for predicting future changes to rainfall intensities. Where the consequence of asset failure is high, a detailed local study should be undertaken. The Climate futures Web Tool features a six step process involving assessment of climate change risks such as geographic location (NRM cluster), design flood standard, effective service life, projected temperature increase, purpose of asset, and assessment of the consequences of climate change projections using the tool. The tool will predict a percentage change in rainfall intensity.

6 Storm Surge (Austroads Part 5 Section 3.7.3)

6.1 Assessment of stormwater catchments and design of infrastructure impacted by sea levels must consider the influence of storm surge on predicted tide levels. Storm surges of 1.4 metres above tide level have been recorded along the metropolitan Adelaide coastline and more than 2 metres above normal tide level at Port Pirie. While there is no specific hydrodynamic modelling for South Australian coastlines, it is expected that more severe weather events due to climate change including higher wind speeds will likely increase storm surge levels over the next 50 years.

7 Hydrology (Austroads Part 5 Section 6)

General

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

7.2 Acceptable predevelopment (i.e. Greenfields) values of paved, supplementary and grassed depression storage (losses) are 1, 1 and 10 mm. Acceptable post development values of paved, supplementary and grassed depression losses are 1, 1 and 5 mm.

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

7.4 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 6 mm/hr and soil type 4 levels off to a continuing loss of 3 mm/hr (see Figure 5.10 of the DRAINS user manual). ARR1987 recommended that initial / continuing loss models in Adelaide use 3 mm/hr continuing loss. Therefore a soil type of 4 would be expected for most clay soils in Adelaide. If justified by the soil type (e.g. sand soils near the coast) lower soil type figures can be used.

7.5 For the proportion of paved, supplementary paved and grassed area determination either the parameters shown on Table RD-DK-D2 7-1 can be used for each land use type, or catchment impervious areas can be measured from aerial photographs and known potential future development in the catchment (refer to Austroads Part 5 Section 6.5.3).

Table RD-DK-D2 7-1 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 300-500 m^2	70	10	20
Residential Allotments 500-700 m^2	60	15	25
Residential Allotments 700-1000 m^2	40	15	45
Residential Allotments 1000-2000 m^2	30	15	55
Rural Allotments 2000-4000 m^2	10	10	85
Rural Allotments > 4000 m^2	0	5	95

7.6 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.

7.7 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 45 mm and continuing loss of 3 mm 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.

7.8 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.

Future Developments (Austroads Part 5 Section 6.5.3)

7.9 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 greenfield 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.

Rural Hydrology (Austroads Part 5 Section 6.6)

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

7.11 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.

7.12 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, FLIKE, RORB or the RRR model must be used.

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

Rational Method (Austroads Part 5 Section 6.6.1)

7.14 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.

7.15 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 1: Location Adjustment Factor (Step 4 of DTPI Rational Method) for small rural catchments less than 5 km^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

7.16 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

7.17 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)

Table RD-DK-D2 7-2 Catchment Terrain Base Coefficients

Type of Catchment Terrain	Base Coefficient
Native Semi-arid Grassland	0.25
Dairy Farming, Orchards / Vineyards, Horticulture	0.20
Cereal cropping, Mixed Farming	0.15

Type of Catchment Terrain	Base Coefficient
Natural Scrub, Forest Plantations	0.10

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

Table RD-DK-D2 7-3 Adjustment Factors

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

7.18 Multiply result of Step 2 by:

a) A = Catchment area in km^2

7.19 If adjusted C after Step 3 > 0.4 use 0.4.

Step 4 – Location Adjustment

7.20 Multiply result of Step 3 by the factor read from the map on Chart No.6 (Appendix 1: Location Adjustment Factor (Step 4 of DTPI Rational Method)).

Step 5 – Average Recurrence Interval (ARI) adjustment

Table RD-DK-D2 7-4 ARI Factors

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

8 Deliverables

8.1 The Contractor shall develop and submit a Hydrological Assessment Report detailing all aspects of the hydrological modelling undertaken including, but not limited to:

a) description of the development of the hydrological model including a discussion on the suitability of modelling software, availability of data and information, management of information gaps, and model limitations;

b) discussion of the source, accuracy and integrity of data used, model parameters, and assumptions made during hydraulic modelling;

c) outcomes of any sensitivity analysis undertaken on parameters used as part of hydrological modelling;

d) a number of predicted flow rates for the various hydrographs used in the hydrological modelling; and

e) discussion on the performance of the model in predicting accurate flow rates and any recommendations to improve future modelling and assessment.

9 Handover

9.1 The Contractor shall handover all hydrological assessment information in accordance with the requirements of the Contract Documents.

10 Records

10.1 The Contractor shall provide the following records to the Principal:

Drawings

10.2 Layout drawings of catchment areas, surface contours, stormwater infrastructure, infrastructure layout, watercourse alignments, land use details, etc., used during the hydrological modelling assessment.

10.3 Drawings of the schematic layout of the hydrological model configuration including nodes, watercourses, conduits, and flow paths.

10.4 Drawings of cross sectional information of watercourses used in the hydrological modelling.

Reports and Hydrological Model

10.5 Preliminary Report detailing hydrological data sets and information to be used in the hydrological modelling assessment including the justification of parameters and assumptions used in the modelling.

10.6 A copy of all electronic files used in the development, calibration and finalisation of the hydrological model including GIS information, topographical surveys, digital elevation terrain models and data from external sources used in the assessment such as streamflow data.

10.7 Final Assessment Report detailing the outcome of hydraulic modelling, predicted flow rates, sensitivity of model parameters, any identified deficiencies in the modelling process and recommendations for any changes that could improve future modelling and assessment.

11 Hold Points

11.1 There are no Hold Points referenced in this Part.

12 Appendix 1: Location Adjustment Factor (Step 4 of DTPI Rational Method)