Department of Transport and Main Roads

Road Planning and Design Manual
Edition 2: Volume 3

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

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Relationship with Austroads Guide to Road Design – Part 5 (2023)

The Department of Transport and Main Roads has, in principle, agreed to adopt the standards published in the Austroads *Guide to Road Design* (2023) *Part 5: Drainage – General and Hydrology Considerations*.

When reference is made to other parts of the Austroads *Guide to Road Design*, Austroads *Guide to Traffic Management* or the Austroads *Guide to Road Safety*, the reader should also refer to Transport and Main Roads related manuals:

- *Road Planning and Design Manual* (RPDM)
- *Traffic and Road Use Management Manual* (TRUM).

Where a section does not appear in the body of this supplement, the Austroads *Guide to Road Design – Part 5* criteria is accepted unamended.

This supplement:

1. has precedence over the Austroads *Guide to Road Design – Part 5* when applied in Queensland
2. details additional requirements, including *accepted with amendments* (additions or differences), *new* or *not accepted*, and
3. has the same structure (section numbering, headings and contents) as Austroads *Guide to Road Design – Part 5*.

The following table summarises the relationship between the Austroads *Guide to Road Design – Part 5* and this supplement using the following criteria:

Accepted	Where a section does not appear in the body of this supplement, the Austroads *Guide to Road Design – Part 5* is accepted.
Accepted with amendments	Part or all of the section has been accepted with additions and/or differences.
New	There is no equivalent section in the Austroads Guide.
Not Accepted	The section of the Austroads Guide is not accepted.

Austroads Guide to Road Design – Part 5		RPDM relationship
1 Introduction		
1.1	Purpose	Accepted
1.2	Scope and Definitions	Accepted
1.3	Jurisdictional Considerations	Accepted with amendments
1.4	Inter-agency Relations	Accepted
1.5	Management and Planning Framework	Accepted with amendments
1.6	Principles and Objectives of Drainage	Accepted with amendments
1.7	Geometry and Drainage Relationship	Accepted with amendments
1.8	Use of Software	Accepted with amendments
1.9	Non-standard and structural design of drainage elements	New

Austroads Guide to Road Design – Part 5		RPDM relationship
2 Safety in Design		
2.1	Safe System	Accepted
2.2	Workplace Health and Safety Act and Standards	Accepted
2.3	Life and Property	Accepted
2.4	Road Safety	Accepted
2.5	On-road Safety	Accepted
2.6	Off-road Safety	Accepted
2.7	Protection of General Public	Accepted
3 Environment		
3.1	General	Accepted with amendments
3.2	Climate Change	Accepted with amendments
3.2.4	ARR Data Hub Output for Climate Change Factor	Not accepted
3.2.5	Change in Sea Level	Not accepted
3.3	Fauna Passage/Crossings	Accepted with amendments
3.4	Pollution Control and Water Quality	Accepted with amendments
3.5	Water Sensitive Design	Accepted with amendments
3.6	Erosion and Sediment	Accepted with amendments
3.7	Blockage	Accepted with amendments
3.8	Miscellaneous	Accepted with amendments
4 Drainage Considerations		
4.1	General Considerations	Accepted
4.2	Road User Considerations	Accepted
4.3	Design Considerations	Accepted with amendments
4.4	Selection of Recurrence Interval and Flood Immunity	Accepted
4.5	Defining Immunity	Accepted with amendments
4.6	Freeboard	Accepted with amendments
4.7	Other Considerations	Accepted with amendments
4.8	Extreme Events	Accepted with amendments
4.9	Waterway Structures	Accepted with amendments
5 Operations and Maintenance		
5.1	Maintenance Access and Location	Accepted
5.2	Operation	Accepted
5.3	Maintenance	Accepted with amendments
5.4	Drainage Failures	Accepted
5.5	Remediation	Accepted with amendments
6 Hydrology		
6.1	Introduction	Accepted
6.2	Terminology	Accepted
6.3	Catchment Hydrology	Accepted
6.4	Probability and Risk	Accepted with amendments
6.5	Data for Drainage Design	Accepted with amendments

Austroads Guide to Road Design – Part 5		RPDM relationship
6.6	Hydrology Methods for Road Drainage and Flood Design	Accepted with amendments
6.7	Design Inputs	Accepted with amendments
6.8	Design Software	Accepted
6.9	Very Rare and Extreme Events	Accepted
6.10	Specific Design Issues	Accepted with amendments
6.11	Safety in Design	Accepted
6.12	Joint Probability	Accepted
6.13	Uncertainty	Accepted
References		
References		Accepted with amendments
Appendices		
Appendix A	Design of an Infiltration Basin	Accepted
Appendix B	Drainage Construction Material Considerations	Accepted with amendments
Appendix C	Summary of Erosion and Sedimentation Control Techniques	Accepted
Appendix D	Rational Method Background and Application	Accepted with amendments
Appendix E	Estimation of Coefficient of Run-off – Queensland Application	Accepted
Appendix F	Estimation of Discharge from Rural Catchments in Victoria – Use of Area Size Factor	Not Accepted
Appendix G	Blockage Form	Accepted

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- Structures, Transport and Main Roads email: roaddesignstandards@tmr.qld.gov.au. Road Design Standards will direct this email to the correct area for reply.
- Director (Geospatial Technologies), Geospatial Technologies, Engineering and Technology Transport and Main Roads email: TMR_Spatial_Enquiry@tmr.qld.gov.au
- Director (Environment and Cultural Heritage), Program Management and Delivery, Transport and Main Roads email: environment@tmr.qld.gov.au (environmental process inquiries only). For inquiries about delivery of environmental work contact should directly be made with the district environmental officers.
- General enquiries or feedback email roaddesignstandards@tmr.qld.gov.au

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1 Introduction

1.3 Jurisdictional Considerations

1.3.2 Road Agency Policies and Guidelines

Addition

In using this supplement, reference will need to be made to other departmental documents developed to assist in the planning, design, construction, and maintenance of drainage infrastructure on state-controlled roads in Queensland.

These reference documents include:

- RPDM (2nd edition)
- *Environmental Processes Manual*
- *Environmental Legislation Register*
- *Road Landscape Manual*
- *Roads in the Wet Tropics Manual*
- Engineering Policy EP170 *Climate Change Risk Assessment Methodology*
- *Climate Change Risk and Adaptation Assessments Framework for Infrastructure Projects*, and
- Technical Guideline *Hydrologic and Hydraulic Modelling*.

1.5 Management and Planning Framework

Addition

It is recognised that a road requires a drainage system to deal with stormwater runoff; therefore, the drainage system becomes an important and integral consideration in the planning and design of road infrastructure.

To provide an appropriate and economic drainage system, all road projects (irrespective of location, size, cost, or complexity) must consider and address:

- provision of an acceptable level of flood immunity and accessibility
- effects of flooding of public and private property
- conveyance of stormwater through the road reserve at a developmental and environmental cost that is acceptable to the community as a whole
- protection of the roadway asset
- safety of all road users
- pollutant discharge from the road reserve to receiving waters
- land degradation caused by erosion and sedimentation during road construction, operation and maintenance
- any effect on habitats for terrestrial and aquatic flora and fauna, and
- any effect on the movement of terrestrial and aquatic fauna.

This requirement particularly applies to projects where it is proposed to keep the existing drainage infrastructure. The original design intent must be reviewed and understood, and the existing system needs to be assessed against the aspects listed previously for performance, adequacy and continued durability. Design must ensure that the original intent is restored, deficiencies corrected and modifications / changes appropriately considered and detailed.

1.6 Principles and Objectives of Drainage

1.6.1 Principles

Addition

There are various design considerations, controls, criteria and standards that apply when planning a drainage system.

The design considerations for the strategic planning of drainage include flood immunity, no worsening to the downstream, community impacts, safety, and environmental impacts.

Departures and Relaxations

While the drainage design for state-controlled roads and roads within Auslink should provide for the general required level of flood immunity, there are situations where this standard is impossible to meet. In this case, and after careful consideration of the issues presented here, a lower standard of flood immunity may be approved. However, if this is the case, the following process shall be followed.

Where drainage parameters do not meet departmental criterion and a drainage departure is proposed, Transport and Main Roads are to be notified without delay and the following information shall be provided:

- detailed documented evidence to demonstrate why the design parameter cannot be met
- an assessment of impact of the departure from the allowable design range on all applicable design considerations including safety, performance, efficiency, reliability, maintenance, design life / residual life, and sustainability
- details of alternative options considered
- an assessment of residual risks, value for money or cost effectiveness of the proposal to be considered, and
- evidence that granting the requested departure will not create the need for further, subsequent departures which would compound the design issue.

Wherever required by the department, it is the responsibility of the concerned party to ensure that the departure is undertaken by a suitably qualified Register Professional Engineer of Queensland (RPEQ).

1.6.2 Objectives

Addition

There are two aspects of development control related to drainage that the department must consider.

Firstly, the department could be regarded as a developer because it controls and directs the construction of road infrastructure and this development may have an impact on the surrounding environment, both natural and built. Road planning, therefore, must determine, assess, and mitigate any impacts to an acceptable level.

Secondly, the department needs to be aware of development near roads and/or in a catchment that may impact on existing departmental drainage infrastructure. This impact could be a change in flood levels or flows or a diversion of runoff. The department is consulted on development approvals when the proposed development is within 25 m of an existing state-controlled road or for parcels of land that lie directly (wholly or partly) under a future planned state-controlled road declaration. This criterion provides for a number of developments, but there are occasions where the proposed development is in the catchment draining to the road crossing, but further away. Development anywhere in the catchment may have an adverse impact on the road drainage, even if it is remote from the road. In this case, the department must maintain surveillance of development and make appropriate allowances or provide advice to developers or a council. Consultation with local authorities assists in this provision.

Both of these aspects must be analysed to ensure that the department's road infrastructure is and/or remains acceptable from the point of view of drainage considerations. To enable analysis of these aspects, the department must firstly determine or establish the hydrologic / hydraulic conditions of the site including the capacities (and immunity level) of any existing drainage infrastructure.

This is a complex area, and it is difficult to provide any clear-cut criteria, but there are some general principles that should be considered in assessment of development and this section has some comments on relevant issues.

A. Departmental impacts

When the department builds a new road or rebuilds / upgrades an existing road, the drainage impacts of this road must be considered. There are three main aspects, namely afflux, the concentration of flow and flow diversions.

Afflux is a critical consideration / criterion as it is often the controlling factor in drainage designs. New road embankments and changes to existing embankments (even by small amounts) will create or change water levels both upstream and downstream of the crossing. These impacts need to be determined and mitigated.

Generally, floodplain flow will tend to be concentrated when directed through culverts under the road. This concentration of flow provides a higher risk of scour at the culvert outlet. The design, therefore, must consider this risk and make appropriate allowances.

Roads may actually change the direction of flow in some circumstances, and this diversion could have serious adverse impacts on the environment and neighbouring property owners. The design must carefully review the possible flow redirection and generally minimise any diversions.

The impact of road drainage on flooding is usually analysed for the range of floods down to an Annual Exceedance Probability (AEP) of 1%, the most commonly used flood criterion for floodplain management in local authorities.

However, in some circumstances, it may be appropriate to consider larger floods, even extreme events. This situation usually arises in urban areas, or where there are particularly sensitive locations. It is also only relevant where the road construction may cause obstruction to flow for larger floods, while allowing the smaller floods up to 1% AEP to pass through the drainage structures. Occasions where this may be important is where there is a high embankment, where there may be safety or noise barriers on the road or where overpasses cause obstructions.

The road design should be reviewed in all cases, and specific analysis should be conducted in cases where this is considered necessary. A risk assessment should be carried out in each case and if necessary, modifications should be made to the design.

B. Development impacts

The most important development issue of concern for the department is urbanisation (including residential and commercial development). Urbanisation increases stormwater runoff from a catchment. However, while urbanisation may be the most significant development that may affect road drainage, there are other forms of development that may also have an impact. These include:

- levees and other farm works – these may divert flows across the floodplain and may, therefore, change the point where flow must cross the road, and/or
- Dams, detention basins and other water storages may affect flood levels and discharges. Refer to Figure 1.6.2.

Figure 1.6.2 – Detention basin in a residential subdivision

Urbanisation increases stormwater discharge by increasing the impervious area in a catchment and by improving the channel conditions. The combination of these two factors increases the volume of runoff and the peak discharge, and changes the time the peak discharge occurs, both of which may affect the existing road drainage. Furthermore, urbanisation generally provides artificial flow paths and can reduce the floodplain storage by the filling of depressions and so on. These aspects also increase the flood discharge. Any increase in discharge will most likely affect the flood immunity of the road as it would have been designed for less runoff. The impacts to departmental drainage structures (located downstream of development) can be the increased chance of overtopping the road and/or increased outlet velocities. These factors, in turn, increase the risk of scour, water quality problems and safety concerns. Also, the increased discharge will most likely increase the peak water levels at that location, increasing the level of flooding.

Urbanisation or development downstream of departmental drainage structures may change the condition of the outlet channel (in the external environment). Change or improvement in the channel will most likely change the tailwater level at the structure. If the channel can drain the stormwater away more quickly than before the changes were made, the tailwater at the structure will drop. This can change the operation of the culvert and, in turn, could mean increased outlet velocities. If the channel capacity is reduced or restricted, the tailwater at the structure will increase which will reduce the capability of the culvert which will typically increase flooding on the upstream side of the structure.

Where development is planned that may affect the department’s drainage systems, the development should be reviewed to ensure that the existing operation and conditions of departmental owned / controlled drainage structures is not adversely affected.

These reviews should not be limited to cross-drainage infrastructure and must include the following departmental drainage infrastructure:

- longitudinal drainage (table drains, kerb and channel and so on)
- diversion channels
- energy dissipation measures
- retention / detention basins
- levees
- catch banks / drains
- underground systems (pits and pipes) and subsoil drains
- water treatment / quality devices (including sediment basins), and/or
- any other environmental protection device / measure related to drainage.

The department should check for:

- worsening of flood levels (afflux) upstream and downstream of the road
- any increase in the risk of water occurring on / overtopping the road
- any change in the risk of scour because of larger flows / higher velocities, and/or
- any increased risk of environmental harm or change in water quality.

As well as individual impacts, cumulative impacts should also be considered. These impacts are where the development currently being proposed is one of several (or many) that may occur. One individual development may not have an adverse impact, but further similar developments may be unacceptable when they are all combined.

Stormwater management reports should be received from developers, or consultants for developers, for all proposed developments where the runoff or flooding may affect a state-controlled road. These reports should be reviewed to assess the potential impacts and, if there are impacts, acceptable mitigation measures should be proposed.

Key requirements of these reports are:

- The flood report should be prepared by a suitably qualified and experienced consultant.
- The hydrologic and hydraulic modelling should be appropriate for the required assessment and should be described fully in the report.
- The analysis should calculate the flood discharges and flood levels for a range of AEPs.
- The base case should calculate the flood discharges and levels for the existing conditions, and clearly show the results where the flow crosses the state-controlled road. It is possible that the base case shows that the road has a flood immunity that does not meet the departmental criterion, but the objective of this analysis is to show no worsening of drainage performance when compared to the base case.

- The developed case should include the proposed development and should calculate the flood discharges and levels at the state-controlled road.
- If there is an adverse impact, mitigation measures must be provided. Adverse impacts include an increase in flood discharge or flood level at the road. If there is an increase in flood level or discharge, but the road still maintains the required flood immunity, this may still be regarded as adverse, since other similar developments could make conditions worse. The flood discharges and levels for the mitigated case should be shown at the state-controlled road crossing and these must be no worse than for the base case.
- Mitigation measures may include detention basins, channel works, diversions or other works that ensure that the flood conditions are not worsened. It is important that mitigation measures at one crossing should not worsen conditions at other locations.
- The study should be supported by a comprehensive report that describes the analysis undertaken and presents assumptions with the results.

C. System augmentation

As stated, the department must first determine or establish the hydrologic / hydraulic conditions at the site including the capacities (and immunity level) of any existing drainage infrastructure. When these existing conditions are compared to the drainage outcomes of any proposed development, the differences and potential impacts can be determined and understood.

In the event that the department believes that a proposed development will have adverse effects on its existing drainage infrastructure, a financial contribution from developers can be requested to allow the department to undertake appropriate work to augment or upgrade the existing drainage infrastructure in order to handle the changed conditions (hydrologic and/or hydraulic) caused by the development.

To allow discussion and negotiation regarding any financial contribution from a developer, a reasonable basis for negotiation needs to be established. The following cases outline different situations that can, in turn, form the basis of discussion / negotiation with developers.

Case 1

If it is determined that the existing departmental drainage infrastructure meets current and planned (immunity and environmental) requirements and currently performs / operates satisfactorily, then any change required to the existing drainage infrastructure to enable it to adequately handle the changed hydrologic, hydraulic and/or environmental conditions caused by the development should be met by the developer.

Case 2

If it is determined that the existing departmental drainage infrastructure meets current and planned (immunity and environmental) requirements, but does not currently perform or operate satisfactorily, then the department would be responsible to undertake remedial work to enable the infrastructure to adequately perform / operate while any change required to the existing drainage infrastructure to enable it to adequately handle the changed hydrologic, hydraulic and/or environmental conditions caused by the development should be met by the developer.

Case 3

If it is determined that the existing departmental drainage infrastructure does not meet current or planned (immunity and environmental) requirements, the changes required to the existing drainage infrastructure to meet current or planned (immunity and environmental) requirements is the responsibility of the department, while any additional augmentation to the infrastructure required to adequately handle any additional hydrologic, hydraulic and/or environmental conditions caused by the development should be met by the developer.

1.7 Geometry and Drainage Relationship

Addition

Establishing the geometry of a drainage site is an initial part of the design process. Early sizing of drainage in the planning phase requires some assumption of the road alignments and cross-sections to provide dimensional inputs (height and width) to calculations of possible drainage solutions.

Site-specific geometry is also necessary for the calculation of quantities for use in estimates of cost for:

- Comparison of drainage alternatives, and
- Stages of the planning and design process.

As the planning and design process progresses with the selected infrastructure, geometric design of the proposal is developed by:

- Locating and aligning the structure with the watercourse or drainage path and any identified fauna passage requirements.
- Determining the length of the structure and setting invert levels using hydraulic slope requirements.
- Checking maximum allowable afflux related to neighbouring properties and design culvert appropriately.
- Determining and designing any mitigation works required to address unacceptable afflux levels.
- Checking appropriate distribution of culverts to maintain existing flow patterns.
- Checking maximum allowable outlet flow velocity and sizing culvert appropriately or designing suitable outlet scour protection measures.
- Checking both culvert inlet and outlet control conditions with proposed design levels – maximum outlet velocities can be determined and compared against maximum allowable outlet flow velocities.
- Determining tailwater level based on hydraulic gradient of existing channel flow for a design event, including a check for backwater effect.
- Reviewing surface water flow paths to ensure water is quickly shed from the road surface (within allowable depths of flow) to reduce potential for aquaplaning.
- Ensuring table drains slopes are equal to or greater than the minimum allowable.
- Ensuring diversion drains (outlets to table drains) are available, preferably within the existing road reserve, or beyond, by agreement with the affected property owner.
- Checking cover, backfilling and structural requirements for culverts, including laying method and class of culvert (where applicable).

- Checking consistency of longitudinal and cross-drainage.
- Checking for any bypass flows to adjoining culverts / catchments and mitigate as necessary.
- Checking for the risk of blockage of culverts and designing the works suitably.
- Locating and sizing necessary environmental drainage works, and
- Selecting headwalls, wingwalls, aprons, cut-off walls and erosion protection works as applicable.

1.8 Use of Software

Addition

The department may require the use of specific software on projects. This requirement will be specified either within this manual and/or the relevant project documentation.

All departmental designers and prequalified consultants are required to undertake 3D modelling and quantity calculation of cross-drainage (culvert) infrastructure using the department's CULVERT software. Using this program ensures departmental processes and practices are followed for:

- Drawing drainage cross-sections (such as location, skew, invert heights, culvert component details, bedding and backfill material quantities, and so on) when used within 12d Model™, and
- Producing a culvert electronic model that allows splicing into and storage with the project electronic model when used within 12d Model™.

Software packages approved for use on departmental projects by prequalified consultants are:

- Hydrology (hydrologic analysis shall be undertaken in accordance with the latest version of the Transport and Main Roads *Hydrologic and Hydraulic Modelling* Technical Guideline, available on the department's website):
  - RORB
  - XP-RAFTS™
  - URBS™
  - WBNM, and
  - Bureau of Meteorology (BoM) website
- Hydraulic design:
  - Drainage, Drainage analysis and Drainage dynamic modules within 12d Model™ (for longitudinal drainage, this software is preferred by the department)
  - HEC RAS
  - MIKE 11™
  - DRAINS™
  - SWMM™, XPSTORM™
  - HY-8, and
  - CulvertMaster and FlowMaster®

- 3D modelling and quantity calculation:
  - CULVERT (departmental software)
- Hydraulic design – 2D Modelling:
  - MIKE FLOOD™, MIKE 21™, and
  - TUFLOW™
- Water quality:
  - MUSIC™, and
  - AQUALM™.

Use of any other software package must be approved in writing by Director (Road Design) and/or Director (Hydraulics and Flooding), Transport and Main Roads, Engineering and Technology Branch. Engineering consultants must be prequalified with the department in the prequalification category of hydraulic design before providing any drainage advice or undertaking any drainage design or review on behalf of the department.

1.8.1 Validation of Software and Predetermined Criteria

Addition

Any spreadsheet or computer-based tool developed and then used to assist with drainage design must be checked and tested for applicability, accuracy of results and compliance to current standards and methodologies as prescribed in this supplement / Transport and Main Roads Technical Specifications and Standard Drawings. Certification of design is deemed to cover use of these spreadsheets / tools.

While it is desirable that all software packages used, as listed in Section 1.8, be the latest version, it is not a requirement; however, it is a requirement that project workings must clearly state the software package and version being used.

It is also a requirement that users check / test software to be used for compliance with current standards and methodologies as prescribed in RPDM Volume 3, Part 5, Part 5A and Part 5B / Transport and Main Roads Technical Specifications and Standard Drawings. There is often a time lag between the release of updated departmental Standards Drawings / Technical Specifications and updates to software packages. Where software is not compliant and difference is minor (major differences would prohibit use), any output must be adjusted accordingly, and adjustments recorded and checked. Again, certification of design is deemed to cover this requirement.

1.9 Non-standard and structural design of drainage elements

New

Non-standard drainage elements and structures must be referred to the Transport and Main Roads Structures Section located within the Engineering and Technology Branch or suitably prequalified consultants. Where design is conducted by a suitably prequalified consultant, design must be approved by the Transport and Main Roads, Engineering and Technology, Structures Section.

Examples of these non-standard structural drainage elements include:

- all bridges
- any proposal to replace an existing bridge with a culvert, and/or
- any culvert installation using non-standard components.

2 Safety in Design

Addition

- Reference should also be made to Chapter 12 of *Queensland Urban Drainage Manual* (QUDM).
- Maintenance access – safe access needs to be provided to all drainage structures that require either ongoing (that is, mowing of drains) or occasional (being removal of debris) maintenance. This access is required for vehicles and maintenance crews, depending on the type of maintenance that will be undertaken. Safe access to erosion and sediment control devices during the construction phase should also be allowed.
- Traffic safety – projecting culvert ends have the potential to act as obstructions to 'out of control' vehicles. Where there are no safety barriers, culvert ends should be designed to not present an obstruction. If obstructions from projecting culverts or head walls are unavoidable then safety barriers should be considered.
- Energy dissipators – reference should also be made to Chapter 12 of QUDM. Energy dissipators are very costly to build and maintain, and changes to the design, such as flattening of channel gradient to reduce high velocities, is preferred.

3 Environment

3.1 General

Addition

Road infrastructure environmental issues should be identified and assessed throughout the road planning and design process. Project-specific environmental assessment provides information about the condition of the existing environment, the proposed project area, associated environmental impacts of the proposal and the identification of any opportunities for environmental management.

The *Environmental Protection Act* 1994 (Qld) (EP Act) places an obligation upon all persons in Queensland who are carrying out activities which may cause environmental harm. Under the EP Act, the department and all persons working for the department must adopt all reasonable and practical measures to prevent or minimise environmental harm. This is called the general environmental duty.

Depending on the location and scope of work, there may also be project-specific legislative requirements. Project-specific legislative requirements regarding design requirements will be outlined in the project environmental assessment.

For up-to-date information on general legislative requirements, contact your local departmental environmental officer and/or refer to the department's *Environmental Legislation Register*.

The Queensland Government, through the *Environmental Protection (Water) Policy* 2009, details environmental values that it is seeking to protect and enhance for the majority of waterbodies within Queensland. Specific water quality objectives are then set for these values.

The environmental values and the water quality objectives for waterbodies that the road is draining into can, therefore, provide an indication of the level of treatment that should be incorporated into road drainage design.

3.2 Climate Change

3.2.1 Introduction and Overview

Addition

The department needs to consider the possible effects of climate change on a number of aspects in the design, planning and operation process and part of this consideration is for road drainage.

Allowance for climate change is important since transport infrastructure has a long design life and the infrastructure is critical and needs to operate to design standards for this design life. There may be changes in design parameters for flood estimates during the design life and these should be incorporated into the planning and design process. Transport and Main Roads' Engineering Policy EP170 *Climate Change Risk Assessments* provides guidance on the climate change projections and appropriate assessment timeframes.

Australian Rainfall and Runoff (ARR) is the standard guideline for flood estimation in Australia, and the department takes guidance from this publication.

There are two aspects for drainage design that need to consider climate change. These are changes in rainfall intensity (including the catchment conditions that are relevant to convert this rainfall into floods) and possible sea level changes, including average sea levels, as well as tidal ranges and storm tides.

a) Rainfall and floods

   Chapter 6 of ARR Book 1 is accepted in regard to estimated increases in rainfall intensities, subject to the following amendments:

   - At least two RCP scenarios be included for assessment, being RCP 6.0 and RCP 8.5. Predicted increases in rainfall intensity for RCP 6.0 shall be taken to be the mean of the values based on RCP 4.5 and RCP 8.5.

b) Sea level

   The 2014 edition of the withdrawn *Road Drainage Manual* recommended an allowance of 0.6 m for sea level rise, with no comment on various tidal levels or storm tides. It was assumed that all parameters increased by the same 0.6 m. There are a number of different recommended changes in sea level provided in guidelines elsewhere in Queensland, as well as throughout Australia.

   The 2019 edition of the withdrawn *Road Drainage Manual* recommended an allowance of 0.8 m by 2100 for sea level rise, which was consistent with the Department of Environment and Science (DES) advice at the time and was the figure used for mapping of coastal erosion prone areas.

The most recent 6th assessment report (AR6) from the Intergovernmental Panel on Climate Change (IPCC) included the following information based on projections of future sea levels:

- A likely range of 28 to 55 cm by 2100 under a low emissions scenario, and about 60 cm to 1 m by 2100 under a high emissions scenario.
- A plausible range approaching 2m by 2100 and 5 m by 2150 under a very high emissions scenario.
- Even if warming is limited to 2°C, we are likely to see 2-6 m of sea level rise over the next few hundred years (because of system inertia and the long time for the surface temperature increase to be reflected in thermal expansion of the deep ocean).

The global emissions trajectory is currently tracking the IPCC high emissions scenario fairly closely and is likely to continue that pattern until at least the middle of the century. There are, of course, uncertainties regarding the realised emissions trajectory, the response of ice sheets, and so on.

The level of 0.8 m by 2100 specified in the *State Planning Policy* (SPP) is based on the midpoint of the likely range in an earlier assessment report. However, this only applies to the relatively narrow purposes of the SPP and doesn't limit options for climate risk assessments.

It is now considered prudent to consider multiple levels in a risk assessment or other analyses. Reasonable options at this stage include:

- 0.8 m by 2100 (to align with previous advice and the current level specified in the SPP)
- 1 m (the top of the likely range for 2100), and
- 2 m (the top of the plausible range for 2100).

It is likely that considering sea level rise levels to 2 m may have significant implications for the costs of some projects. However, if this value is considered in the context of a risk range / envelope – other factors in decision-making, such as the department's risk appetite; avoided costs over the lifetime of long-lived infrastructure; level of vulnerability; required level of service; consequence of failure and tolerance for residual risk will, and be part of, the final decision.

c) Conclusion and recommendations

The allowance for climate change for departmental drainage designs should be:

- At least two RCP scenarios be included for assessment, being RCP 6.0 and RCP 8.5. Predicted increases in rainfall intensity for RCP 6.0 shall be taken to be the mean of the values based on RCP 4.5 and RCP 8, as defined in Chapter 6 of ARR, and
- An adjustment for sea level rise should be made for mean sea level, as well as for all tidal levels, considering a range from 0.8 m to 2.0 m, to allow for the projection of sea level increase to 2100.

3.2.4 ARR Data Hub Output for Climate Change Factor

Not accepted

Refer to Transport and Main Roads Engineering Policy EP170 *Climate Change Risk Assessment Methodology*.

3.2.5 Changes in Sea Level

Not accepted

Refer to Section 3.2.1 of this supplement.

3.3 Fauna Passage / Crossings

3.3.1 General

Addition

Further reading on this topic is available in Transport and Main Roads *Fauna Sensitive Road Design*: Volume 1 and Transport and Main Roads *Fauna Sensitive Road Design*: Volume 2. Specifically, for fish passage requirements, all works shall comply with the Department of Agriculture and Fisheries (DAF) *Accepted development requirements for operational work that is constructing or raising waterway barrier works*.

3.3.3 Identify Terrestrial and Aquatic Fauna Pathways

Addition

Specifically, for fish passage requirements, DAF has mapping of fish passage waterways throughout Queensland. The mapping characterises waterways as low (green), moderate (amber), high (red) or major (purple) value for the assessment of proposed waterway barrier works. If the project involves drainage structure works on any DAF-mapped waterways, design for fish passage is required. Details are provided in the DAF *Accepted development requirements for operational work that is constructing or raising waterway barrier works*.

3.3.4 Identify the Species Group

Addition

It is also important to identify the actual animal species that are using the area. This information will be required for legislative approvals associated with construction of the infrastructure as different species. Knowledge of the specific animal will also assist during design of infrastructure. For example, some species of frog prefer trees and leaf litter habitat while others prefer denser understorey of shrubs.

3.3.5 Consult with the Relevant Authority

Addition

It is critical early in the process to identify the legislation that applies to infrastructure being designed including any exemptions or self-assessments available for appropriate design.

This will be available within the environmental assessment for the project. In some cases, additional onsite surveys will be required to submit permit application and/or obtain the necessary approvals. The most triggered pieces of legislation are provided in Table 3.3.5.

Table 3.3.5 – Commonly triggered legislation for the protection of fauna

Species	Relevant legislation
Fish and other aquatic fauna	*Fisheries Act* 1994 (Qld) Fisheries Regulation 2008 (Qld)
Species and communities of national significance*	*Environmental Protection and Biodiversity Conservation Act* 1999 (Cth) Environmental Protection and Biodiversity Conservation Regulations 2000 (Cth)
Other fauna	*Nature Conservation Act* 1992 (Qld) Nature Conservation (Wildlife management) Regulation 2006 (Qld) Nature Conservation (Wildlife) Regulation 2006 (Qld) *Queensland Government Environmental Offsets Policy*

For project specific requirements, consult the project environmental assessment and project environmental officer.

3.3.6 Identify Criteria Affecting Drainage Design

Addition

For fish passage requirements, design criteria to be adopted are provided in the DAF *Accepted development requirements for operational work that is constructing or raising waterway barrier works*. These conditions and requirements take precedence over the Austroads *Guide to Road Design – Part 5*.

Design of fauna passage is a relatively young field. Design criteria is being improved continuously based on investigations and trials. Consult an environmental officer for the most recent information and design criteria.

3.3.7 Fish Passage

Addition

For fish passage requirements, design criteria to be adopted are provided in the DAF *Accepted development requirements for operational work that is constructing or raising waterway barrier works*. These conditions and requirements take precedence over the Austroads *Guide to Road Design*.

Design of fauna passage is a relatively young field. Design criteria is being improved continuously based on investigations and trials. Consult an environmental officer for the most recent information and design criteria.

3.3.8 Fauna Crossings – Design Criteria

Addition

For fish passage requirements, design criteria to be adopted are provided in the DAF *Accepted development requirements for operational work that is constructing or raising waterway barrier works*. These conditions and requirements take precedence over the Austroads *Guide to Road Design*.

Design of fauna passage is a relatively young field. Design criteria is being improved continuously based on investigations and trials. Consult an environmental officer for the most recent information and design criteria.

3.3.9 Riparian and Wildlife Corridors

Addition

For fish passage requirements, design criteria to be adopted are provided in the DAF *Accepted development requirements for operational work that is constructing or raising waterway barrier works*. These conditions and requirements take precedence over the Austroads *Guide to Road Design*.

Design of fauna passage is a relatively young field. Design criteria is being improved continuously based on investigations and trials. Consult an environmental officer for the most recent information and design criteria.

3.4 Pollution Control and Water Quality

3.4.1 General

Addition

The Queensland Government, through the *Environmental Protection (Water) Policy* 2009, details environmental values that it is seeking to protect and enhance for the majority of waterbodies within Queensland. Specific water quality objectives are then set for these values.

The environmental values and the water quality objectives for waterbodies that the road is draining into can, therefore, provide an indication of the level of treatment that should be incorporated into road drainage design.

- Performance criteria: Departmental projects shall endeavour to meet the intent of Queensland's SPP. These objectives are:
  - 75–85% minimum reduction in total suspended solids from unmitigated development
  - ~60% reduction in total phosphorus
  - 40–45% reduction in total nitrogen, and
  - 90% reduction in gross pollutants (> 5mm).
- For further advice on the water quality design criteria for a specific project, refer to the environmental assessment for that project.
- In urban catchments, reference should also be made to *Australian Runoff Quality – A Guide to Water Sensitive Urban Design* (Engineers Australia) and QUDM.

3.4.2 Sources of Pollution from Roads

Addition

Section 3.4.2 of Austroads *Guide to Road Design – Part 5* provides an overview of potential pollutants within road runoff. Increased alkalinity of stormwater from concrete systems is a relatively new issue with potential impact on biodiversity being investigated.

3.4.4 Typical Steps for Pollution Control and Treatment

Addition

When identifying the need for pollution control, the following steps should be completed:

- Determine management objective (Section 3.4.4.1)
- Determine water quality design criteria (Section 3.4.4.2)

- Identify pollutant sources and estimation of pollutant loads (Section 3.4.4.3)
- Identify pollutant transport processes (Section 3.4.4.4)
- Identify pollutant removal processes (Section 3.4.4.5)
- Assess potential pollutant control devices (Section 3.4.4.6)
- Calculate potential pollutant removal (Section 3.4.4.7)
- Implement treatments (Section 3.4.4.8), and
- Evaluate the working efficacy of pollutant removal processes and review if necessary (Section 3.4.4.9).

3.4.4.1 Determine Management Objective

New

Water quality objectives for a section of the asset are to be determined based on:

- Existing ecological values of receiving waterbodies and broader environment
- Existing water quality of receiving waterbodies
- Current and potential future users of receiving waterbodies and the suitable water quality for those uses, and
- Risk posed by the asset to the receiving waterbodies during operation phase. Considering AADT, % heavy vehicles, crash (spill) risk, traffic flow patterns (areas of heavy breaking can increase road runoff pollution). The management objective should also consider the scale and scope of project:
  - Low: minimal drainage works involved in scope of works, gravel roads
  - Medium: projects involve some drainage design, drainage already existing, some ability to make minor amendments to existing drainage and/or retrofit water quality measures, and
  - High: greenfield projects, major opportunities to optimise drainage design and achieve water quality objectives.

The environmental assessment shall consider these factors and provide advice on the most appropriate water quality objectives for the asset in the study area.

3.4.4.2 Determine Water Quality Design Criteria

New

Design criteria for water quality may be set as:

- reduction in mean annual load compared to unmitigated development (%), and/or
- concentration of various pollutants in runoff.

Reduction in Mean Annual Load

Stormwater policies and guidelines for water sensitive urban design are increasingly using reduction in annual pollutant load as the design criteria.

In Queensland, the design objectives in Table 3.4.4.2 have been set for all low erosion risk Environmentally Relevant Activities (through *Stormwater Guideline – Environmentally Relevant*

Activities, Department of Environment and Science, 2014) and for development in urban areas subject to local planning schemes (through the SPP).

This approach is recommended to be adopted for road design in locations of high risk for water quality.

Table 3.4.4.2 – Design objectives for management of stormwater quality

Climatic Region	**Minimum reductions in mean annual loads from unmitigated development (%)**				**Notes**
	Total suspended solids (TSS)	**Total phosphorus (TP)**	**Total nitrogen (TN)**	**Gross pollutants**	
Cape York / Far North Queensland	80	60	45	90	TSS – DES has 75% for Eastern and Northern Cape York TP – DES has 65% for SW and Central South Cape York TN – DES has 35% reduction for (Eastern Cape York) and 40% elsewhere
Wet Tropics	80	60 (DSDILGP) 65 (DES)	40	90	
Dry Tropics	80	60 (DSDILGP) 65 (DES)	40	90	TP – Townsville City Council has 65%
Central Queensland (north)	75	60	35 (DES) 40 (DSDILGP)	90	
Central Queensland (south)	85	60 (DSDILGP) 70 (DES)	45	90	
South East Queensland	80	60	45	90	
Western Queensland	85	60 (DSDILGP) 70 (DES)	45	90	

From:

- *Stormwater Guideline – Environmentally Relevant Activities* (Department of Environment and Science)
- SPP (Department of State Development, Infrastructure, Local Government and Planning (DSDILGP) 2017)

Note: Within the SPP, these stormwater management design objectives relate only to urban centres.

Runoff Pollutant Concentration

Chapter 7 of *Australian Runoff Quality – A Guide to Water Sensitive Urban Design* (Engineers Australia) outlines a methodology for estimating permissible concentrations of runoff to meet receiving water quality guideline levels such as those within the *Environmental Protection (Water) Policy* 2009. This methodology involves the development of models that include equations for water body hydrodynamics and associated physico-chemical and biological processes.

3.4.4.3 Identify Pollutant Sources and Estimation of Pollutant Loads

New

Section 3.4.2 of Austroads *Guide to Road Design – Part 5* provides an overview of potential pollutants within road runoff. Increased alkalinity of stormwater from concrete systems is a relatively new issue with potential impact on biodiversity being investigated (Wright et al).

The pollutant loads associated with corridor drainage will be a sum of the direct pollutant concentrates from the road (such as heavy metals from brakes, oils from vehicles) and indirect impacts from catchment areas draining to corridor (such as nutrient runoff from agriculture or litter from urban areas).

Road runoff pollutant loads can be estimated by:

- analysis of data from a representative storm-event monitoring program combined with simple computations, and/or
- an appropriate water quality model.

The method selected will depend on the management objective, water quality criteria chosen and data availability. Average long-term pollutant loads can be estimated from historic rainfall data, baseline monitoring and from simple information about the catchment and road corridor, or qualitative understandings of catchment and management techniques.

Event Mean Concentrations

Event Mean Concentration (EMC) can be estimated by monitoring mean pollutant concentration and discharge over a storm event. The EMC within one catchment can, however, differ significantly from storm to storm. The EMC depends on many catchment and climate characteristics and can vary in magnitude between catchments.

Therefore, a good event monitoring program is essential where accurate estimates of pollutant loads are required. Significant errors in estimating long-term pollutant loads can result without monitoring programs. Typical errors in estimating long-term pollutant loads are as follows:

- no monitoring – 100 to more than 1000%
- some periodic monitoring – 50 to more than 500%, and/or
- detailed event monitoring – 20 to 100%.

Pollutant loads

Simple computations can be used as a guide to calculate approximate estimates of pollutant loads. This can be useful when assessing potential pollutant loads in rainfall volumes.

The average long-term pollutant load of an area can be estimated using the following formula:

Pollutant load = runoff x EMC where EMC = Event Mean Concentration

Water Quality Modelling

Computer models may be used to estimate runoff quantity and quality from a road corridor to provide estimates for:

- characterising peak, mean and average annual pollutant loads, and/or
- determining seasonal and spatial characteristics.

A number of water quality and stormwater system models exist, which are designed for use by engineers, managers, planners and other staff from private to public organisations.

A commonly used catchment model used to assist water quality management is the Model for Urban Stormwater Improvement Conceptualisation or 'MUSIC' (Wong et al). MUSIC modelling is a decision support tool that can assist in the planning of stormwater quality management strategies.

MUSIC allows the user to determine the likely stormwater quality resulting from specific catchments, predict specific stormwater treatment device performance and create subsequent management plans and evaluate their success.

MUSIC can operate over a range of spatial and temporal scales. It can be used with several other models, such as models used for soils, hydrology, rainfall, operation of culverts, and so on (Wong et al and eWater).

3.4.4.4 Identify Pollutant Transport Processes

New

The determination of additional design criteria to enhance or maintain the downstream water quality will require the knowledge of relevant pollutant transport mechanisms.

Pollutant runoff from a roadway will be generally transported by the roadway drainage infrastructure and will concentrate in gutters, pipes and channels. The pollutants associated with the stormwater runoff will be transported as coarse or bottom sediments, suspended (fine) particles or in solution. The rate of pollutant transport is dependent on pollutant size, water velocity, depth and the degree of turbulence.

Fine particulates and dissolved pollutants (such as heavy metals) can become attached to sediments or flocculate to form larger particles. Most of the pollutants in sediments are found attached to smaller particles owing to their greater surface area relative to larger particles. Pollutants attached to fine particles are easily transported because small flows (and hence low velocities) are sufficient to mobilise and keep them in suspension.

Heavy metals from motor vehicles and atmospheric fallout may deposit directly onto road surfaces or become entrained in air flows and deposited some distance away depending on their particle size. Particulate material on the road surface, such as sediment, bituminous products, rubber from tyre wear and particles coated with oils, actively adsorb heavy metals. The particulates and associated heavy metals temporarily bind themselves to the road surface and particulate material until they are dislodged and transported by rainfall events.

Heavy metals contained in road runoff will be distributed in either bound or soluble forms. Chromium, iron, nickel, lead and hydrocarbons are predominantly adsorbed to sediments and particulate matter. This provides an opportunity for heavy metal removal by targeting the removal of sediments from runoff.

Cadmium, copper and zinc appear at higher percentages in the soluble phase and, thus, are required to be removed by storage and/or uptake by aquatic biota (such as insects, aquatic plants, and so on) (Peterson and Batley).

3.4.4.5 Identify Pollutant Removal Processes

New

Stormwater quality improvement measures rely on a variety of mechanisms for reducing pollutant levels within stormwater. The mechanisms employed may be either or a combination of physical (such as stormwater grate, continuous deflection systems), or biological (such as macrophytes) processes and their effectiveness may be dependent on the site conditions and stormwater characteristics. Stormwater pollution removal devices can be grouped into three categories based on their dominant treatment processes:

- primary treatment – physical screening or rapid sedimentation techniques (for example, typically retained contaminants include gross pollutants and course sediments)
- secondary treatment – sedimentation of finer particles and filtration / chemical techniques (for example, typically retained contaminants consist of fine particles and attached pollutants), and
- tertiary treatment – enhanced sedimentation and filtration, biological uptake, adsorption onto sediments (for example, typically retained contaminants are nutrients and heavy metals).

There is general industry recognition to, where possible, incorporate a combination of treatment mechanisms in one location, to optimise the amount and range of pollutants removed from stormwater runoff. In other circumstances where space limitations and certain practicalities impose, single treatment measures are used to achieve prescribed regional Water Quality Objectives (WQOs).

Depending on size and condition of a site, relative need and practicality, timeframes, materials and cost, stormwater pollution treatment measures may be applied using either an ‘outlet’ or ‘treatment train’ approach.

The outlet approach involves a single treatment measure at the road corridor catchment outlet that discharges directly into the downstream environment.

The treatment train approach requires a number or sequence of different treatments throughout the road corridor catchment before discharge to the receiving environment. The sequence of treatment measures is designed to remove different types and sizes of pollutants, thus optimising the amount and range of pollutants removed from discharge waters.

The selection of the treatment controls for a road corridor catchment under consideration will depend on a wide range of key selection criteria to enable achievement of water quality design objectives.

The selection of the most appropriate stormwater treatment methods should be influenced by a number of environmental and design elements such as:

- Slope – treatment devices that do not store flow may require small velocities and hence gentle slopes.
- Hydraulic head – head losses in treatment devices can exert a minor to large impact upon the hydraulic grade line. As a result, head losses from a treatment device may adversely impact upon upstream flood levels, particularly when retrofitting a device into an area.
- Soil type – differing treatment devices may be reliant upon either infiltration or storage of stormwater runoff. For example, stormwater infiltration will yield better results on highly permeable soils, while the storage of stormwater will require soils with very low permeability.

- Land availability and catchment area – the availability of sufficient appropriate land within a sub catchment that can be used for a treatment device may be restricted, thereby reducing the size, effectiveness or even the option of using the device.
- Habitat enhancement – treatment devices that can offer either a wildlife and/or aquatic habitat enhancement may improve aesthetics.
- Water table – a high water table depth may reduce the effectiveness for a treatment device relying on infiltration.
- Safety hazard – treatment devices may introduce new safety hazards that may have not been present before installation (such as waterborne pathogens, drowning risk, and so on).
- Water supply – treatment devices, such as wetlands or ponds, may require a permanent water supply to ensure the long-term effectiveness of the device.
- Pests – treatment devices, such as wetlands or ponds may increase the potential for nuisance from pests such as mosquitoes and weeds.
- Maintenance – treatment devices will vary significantly with regard to their maintenance cost, accessibility, equipment and scheduling to ensure the desired effectiveness is consistently maintained.

3.4.4.6 Assess Potential Pollutant Control Devices

New

Refer to Section 3.5.7 of this supplement.

3.4.4.7 Calculate Potential Pollutant Removal

New

The final selection of potential pollutant control devices should be made by comparing all potential treatments as follows with the required water quality design criteria.

- Determine the pollutant removal of each shortlisted control device based on relevant performance data or Table 3.4.4.7.
- Determine the area of the catchment for which the device(s) can treat runoff.
- Factor the mean removal rate of each pollutant parameter by the ratio of area treatable by the device to total catchment area. For example, if a pollution control device has a 60% removal efficiency and will treat 50% of the catchment area, then the overall pollutant removal efficiency will be 30%.

Table 3.4.4.7 – Pollutant removal performance of various treatment devices

Treatment control	**Pollutant removal efficiency (%)**						
	Suspended solids (TSS)		**Total phosphorous TP**	**Total nitrogen TN**	**Oil and grease**	**Litter**	**Notes**
	Coarse sediment	**Fine sediment**					
Primary treatment devices							
Oil grit separators	50–75	10–50	0–10	0–10	50–75	10–50	0–10% reduction in bacteria
Gross pollutant trap	60–100	20–30	20	20	10–20	50–75	0–10% reduction in bacteria
Trash rack	10–50	0–10	0–10	0–10	0–10	10–50	0–10% reduction in bacteria
Secondary treatment devices							
Extended detention	50–75	10–66	10–35			Significant reduction in lead, zinc and bacteria	
Sand filter	60–90	35–80	40–70			Significant reduction in iron and lead, Some reduction in zinc, copper	
Filter strips	5–95 Generally ~ 74%	50–79	50–73				
Grassed swales	80	4–25	-4–11			Significant reduction in lead and zinc	
Tertiary treatment devices							
Constructed wetlands	40–98	-33–97	-9–43			Reduction in metals	
Water quality ponds	30–98	0–80	30–85			Reduction in metals	

Derived from NSW Environmental Protection Agency and Mudgway et al .

Note: These percentages are indicative only and appropriate design procedures should be followed.

3.4.4.8 Implement Treatments

New

Design guidelines for the installation of selected control devices can be found in Section 7.5 of *Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland (Healthy Waterways)*; this document is also accepted for South East Queensland.

Ensure requirements for maintenance are incorporated into the *Road Asset Maintenance Contract* (RAMC) or *Road Maintenance Performance Contract* (RMPC) and suitable budget allowed for to ensure ongoing performance of measures.

3.4.4.9 Evaluate the Working Efficacy of Pollutant Removal Processes and Review if Necessary

New

If stormwater runoff or drainage from a site contains levels of pollutants that do not comply with the requirements, then a review of the working efficacy of the pollutant removal processes is required.

Visual inspections of catchment waters should be undertaken to determine the presence of litter build up, sediment or chemical plumes or other contamination.

An onsite assessment of the physical state (integrity) of the pollutant removal devices should be carried out regularly and any maintenance should be undertaken to restore devices to the desired working condition and standard.

3.4.5 At-source vs Catchment-based Treatment for Roads

Addition

Section 11.3.2 of QUDM should be considered for this section.

3.4.6 Debris Control

Addition

Section 12.5 of QUDM should be considered for this section.

3.5 Water Sensitive Design

Addition

Conventional water management has been compartmentalised with water supply, wastewater and stormwater traditionally treated as separate entities. However, integrated water management needs to consider the total water cycle and this concept is increasingly being accepted and/or adopted.

While the principal concern for the department is related to stormwater drainage, the department also has an interest in a range of other issues, such as the use of water for construction and water quality controls.

Roads may represent a relatively small proportion of the total catchment, but they sometimes contribute significantly to water quality concerns. This is especially the case on roads with high traffic volumes where a number of different contaminants may be produced. Between rainfall events, contaminates can build up and then runoff at a greater rate than normal into receiving waters.

The principles that the department need to consider include:

- consider all parts of the water cycle, natural and constructed, surface and subsurface, recognising them as an integrated system
- consider all requirements for water, both anthropogenic (human activity) and ecological
- consider the local context, accounting for environmental, social, cultural and economic perspectives

- include all stakeholders in the process, and
- strive for sustainability, balancing environmental, social and economic needs in the short, medium and long-term.

The department also needs to be aware of all water-related issues, not only in the road reserve, but also both upstream and downstream.

3.5.4 Performance Objectives

Difference

The Queensland Government, through the *Environmental Protection (Water) Policy* 2009, details environmental values that it is seeking to protect and enhance for the majority of waterbodies within Queensland. Specific water quality objectives are then set for these values.

The environmental values and the water quality objectives for waterbodies that the road is draining into can, therefore, provide an indication of the level of treatment that should be incorporated into road drainage design.

Refer to Section 3.4.4.2 of this supplement for Queensland's specific pollutant load reduction targets.

3.5.5 MUSIC Model

Addition

Water quality modelling

Computer models may be used to estimate runoff quantity and quality from a road corridor to provide estimates for:

- characterising peak, mean and average annual pollutant loads, and
- determining seasonal and spatial characteristics.

A number of water quality and stormwater system models exist, which are designed for use by engineers, managers, planners and other staff from private to public organisations.

A commonly used catchment model used to assist water quality management is the Model for Urban Stormwater Improvement Conceptualisation or ‘MUSIC’ (Wong et al). MUSIC modelling is a decision support tool that can assist in the planning of stormwater quality management strategies.

MUSIC allows the user to determine the likely stormwater quality resulting from specific catchments, predict specific stormwater treatment device performance and create subsequent management plans and evaluate their success.

MUSIC can operate over a range of spatial and temporal scales. It can be used with several other models, such as models used for soils, hydrology, rainfall, operation of culverts, and so on (Wong et al and eWater).

3.5.6 Key Design References

Addition

Design guidelines for the installation of selected control devices can be found in Section 7.5 of *Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland (Healthy Waterways)*; this document is also accepted for South East Queensland.

Ensure requirements for maintenance are incorporated into the RAMC or RMPC and suitable budget allowed for to ensure ongoing performance of measures.

3.5.7 Selecting Treatment Elements

Addition

Each potential pollutant control device needs to be assessed to determine if it is suitable for the site conditions. Each pollutant control device can be accepted or rejected on the basis of screening criteria to provide a shortlist. Table 3.5.7 provides a means of assessing common design elements in order to determine if a particular control device is suitable for a specific site condition.

Table 3.5.7 – Design elements associated with treatment devices

Pollutant control device	Area served (ha)	Slope	Head requirement	Soil type	Capital cost	Maintenance cost	General configuration
Oil grit separators	< 1	Note 1	Low	NA	Moderate	Moderate	
Open gross pollutant trap	> 2 > 40	Note 1	High	NA	High	Moderate High	
Closed gross pollutant traps	< 15		Low	NA	High	Moderate	
Trash rack	< 20 40	Note 1	Low Moderate	NA	Moderate	Low Moderate	
Downward inclined screen		Note 1	High	NA	Moderate High	Low Moderate	
Extended detention basin	> 5	Note 1	Low	All	High	Moderate High	Outlet structures include weirs or outlet pipes. Energy dissipater at both basin inlet and outlet to control velocities.
Sand filter (depth of)	< 2 can be designed larger	Note 1	High	Generally housed in concrete	High	Moderate High	Min filtration depth of 400 mm on recommended filtration time. Energy dissipater at inlet.
Filter strips	< 2	Note 1	Low	All	Moderate	Low	Requires considerable land. Length of strip generally > 6 m.
Buffer zones		Note 1	Low	All	Moderate	Low	
Grassed swales	< 2	< 5%	Low	Sand to sandy loam	Moderate	Low	Recommended min length of 30 m. Bottom width between 0.6 m to 2.5 m recommended

Pollutant control device	Area served (ha)	Slope	Head requirement	Soil type	Capital cost	Maintenance cost	General configuration
Constructed wetlands		Note 1	Low Moderate	Loam to clay feasible in sand to sandy	High	Moderate	
Water quality ponds	< 5	Note 1	Low Moderate		High	Moderate	

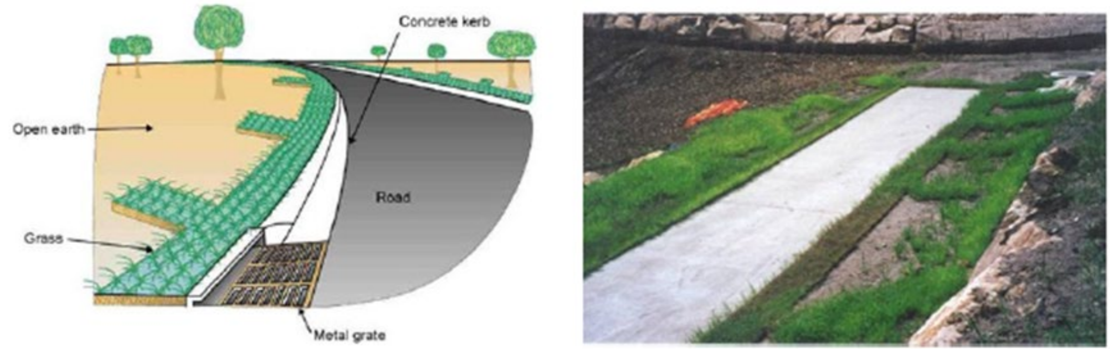
Filter Strips

Filter strips are grassed or vegetated areas used to control polluted runoff from the pavement surface or other disturbed areas within the road corridor, as shown in Figure 3.5.7(a). Flow over filter strips is usually shallow sheet flow. They are generally located adjacent to regions where there is a sensitive receiving environment, such as water course or wetland. They can treat runoff containing sediments, heavy metals, and other pollutants.

Advantages of filter strips include:

- increase rate of infiltration, which can reduce and delay storm runoff
- high removal rates of pollutants
- retention of pollutants closes to source
- improved aesthetic appeal of an area, and
- relatively inexpensive construction.

Figure 3.5.7(a) – Grass filter strip



Source: Catchments & Creeks Pty Ltd

Source: Environmental Best Management Practices (Brisbane City Council (BCC))

Disadvantages of filter strips include:

- limited removal of fine sediment and dissolved pollutants
- sizeable land areas required with limited public access
- a sunny aspect for plant growth
- reduced effectiveness for concentrated flows and high flow depths, and
- strips are only suitable for gentle slopes (< 5%).

Regular inspections are required to assess the condition of the strips.

Design Guidelines

The primary purpose of the filter strip is removal of sediment, with some removal of soluble pollutants by biological uptake and by infiltration into the subsoil. The objective of a filter strip is to generate a dense and diverse vegetation cover to maximise infiltration, provide adequate contact time between runoff and vegetation and to minimise erosion.

Horner et al (1994) cited a technique for sizing filter strips and grass swales. It was developed in Seattle, USA, and the results indicate that optimum pollutant retention occurs when the hydraulic residence time is nine minutes. The performance of pollutant retention deteriorates when the residence time falls below five minutes.

This design technique is summarised in the following 10-point process:

1. Calculate the design discharge for the nominated exceedance years (EY). Pollutant control devices are usually sized for storm events between 4 EY and 1 EY.
2. Determine the bed slope S_o (m/m) of the filter strip. Filter strip performance has been found to reduce if located on grades exceeding 5% and particularly if the slope exceeds 15% (Schueler et al).
3. Set the design flow depth. A maximum depth of flow over the filter strip of 12 mm is recommended.
4. Solve for flow width using suitable methods of hydraulic analysis, such as Manning's Equation:

$$Q = \frac{AR^{2/3}S_o^{1/2}}{n} = VA$$

Where Q = design runoff rate (m^3/s)

R = hydraulic radius = A/P

A = cross-sectional area (m^2)

P = wetted perimeter (m)

S_o = longitudinal bed slope (m/m)

N = manning's roughness coefficient

V = average velocity (m/s)

Suggested Manning's Equation's 'n' values are 0.20 for regularly mown areas and 0.25 for natural grasses or infrequently mown areas. A minimum width of 15 m is recommended for water quality enhancement.

5. Determine the flow area based on the calculated flow width and established flow depth.
6. Calculate the resulting velocity. Reduce the flow, increase the flow width or reduce the depth of flow if the velocity exceeds 0.3 m/s, which is the velocity at which most grasses are knocked over.
7. Using the resulting velocity, calculate the flow length to achieve a residence time in the filter strip of nine minutes. An absolute minimum residence time should be five minutes. To maintain sheet flow, the minimum length of a filter strip will generally be 6 m.

8. To avoid erosion of the filter strip, major storm events should preferably bypass the filter strip. Typically, the major storm would be defined as the AEP 2% or AEP 1% event.
9. Where flow bypass is not incorporated, peak velocities resulting from major storm events should be determined from hydraulic analysis.
10. If the estimated peak velocity is greater than the determined erosive velocity of the filter strip, then the strip must be enlarged to accommodate the flow. Once the flow depth is established, the final dimensions (including depth) of the filter strip can be specified.

More specific design considerations include:

- The slope of the filter strip should be uniform, and the cross-section should be a level plane to maintain sheet flow.
- If grass filter strips are located on slopes lower than 2%, consideration should be given to installing a subsoil drainage system.
- Flow entering the filter strip should be evenly distributed as sheet flow across the upstream end. Level spreaders should be provided to ensure the filter strips does not receive direct discharges.
- Need to establish grasses – watering, weed management.

Additional design information may be obtained from the following design references:

- Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland (Healthy Waterways)
- Camp Dresser and McKee
- Horner et al
- Schueler et al, and
- Standing Committee on Rivers and Catchments.

Grassed Swales

Grassed swales are grass-lined flow paths, often running adjacent to a road pavement, which provide an alternative to concrete kerbing and guttering. They can also be used in road medians and verges. If properly maintained, grassed swales can reduce runoff volumes, attenuate storm flows, enhance infiltration and improve water quality.

Water quality enhancement occurs mainly through the removal of coarse sediments and attached particulates. The improvement in water quality is achieved by increased settling, filtration by swale vegetation and some removal of soluble pollutants through infiltration into the subsoil. Pollutants, such as hydrocarbons, may be digested and processed by soil microorganisms within the swale.

Advantages of grassed swales include that they:

- increase infiltration, thereby reducing and delaying storm runoff
- retain particulate pollutants close to the source
- enhance aesthetic appeal, and
- reduce construction costs as grassed swales are relatively inexpensive to construct.

Disadvantages of grassed swales include that they:

- have limited removal of fine sediment and dissolved pollutants
- require considerable land areas compared with kerb and channel
- may interfere with driveways in higher density development
- are less effective for concentrated flows and high flow depths
- are only suitable for gentle slopes (less than 5%)
- require adequate maintenance to avoid weed infestation, boggy base, mosquitoes and soil erosion, and
- are, in general, most suitable for areas with relatively highly permeable soils.

Design Guidelines

Design guidelines for grass swales follow the same guidelines as those provided for filter strips but with the following amendments.

1. Grass swales should be located on grades of 4% or less. However, slopes of up to 6% can be adopted if small check dams (or mounds) are located in the swale every 15 to 30 m to reduce flow velocities. For slopes of 2% or less, consideration should be given to installing a subsoil drainage system to ensure effective drainage and infiltration.
2. Recommended depth of flow is one-third of the grass height in infrequently mowed swales; half the grass height, to a maximum of 75 mm, in regularly mowed swales.
3. Swales should be trapezoidal, with a recommended bottom width between 0.6 and 2.5 m (Horner et al). If a wider base is required, the flow could be diverted into more than one swale. The side slopes should not be steeper than 1 on 3. If steeper slopes are used, up to 1 on 2, permanent stabilisation may be required. Triangular cross-sections are not recommended, as the flow can become channelised in the bottom of the swale.
4. To maintain sheet flow, the minimum length of a swale is generally 30 m.
5. The maximum flow velocity, as stated in the Austroads *Guide to Road Design – Part 5*, of 0.5 m/s for the one year ARI event, may be disregarded. Maximum flow velocities for the 1% AEP event should not exceed the permissible flow velocities as stated in Table 3.5 of Austroads *Guide to Road Design – Part 5*, and Table 2.6 of Austroads *Guide to Road Design– Part 5B*.

More specific design considerations include:

- The base of the swale should be level, with the longitudinal grade of the swale either uniform or with gradual changes only. Particular attention should be paid to these requirements during construction.
- The integrity of a swale may be impaired if flows greater than the design event enters the swale. Velocities exceeding the design velocity can be expected to result in reduced swale pollutant removal efficiency until the grass has recovered. Such flows may also result in scouring of the swale. A bypass for high flows could be installed to prevent large, concentrated flows eroding the swales.

- The depth to groundwater should be considered when designing a swale. If the water table is shallow, the grass species will need to tolerate this situation. Further, a shallow soil depth for pollutant retention presents a possible risk of pollution entering the groundwater.
- Need to establish grasses – watering, weed management.

Additional design information may be obtained from the following design references:

- *Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland* (Healthy Waterways)
- NSW Department of Housing
- Camp, Dresser, and McKee
- Horner et al
- Schueler et al, and
- Standing Committee on Rivers and Catchments.

Trash Racks

Trash racks can be installed in drainage channels or outlets to trap litter and other gross pollutants. They generally comprise a series of vertical or horizontal steel bars, which form a physical barrier to objects larger than the bar spacings. An example of a trash rack is shown in Figure 3.5.7(b).

Trash racks can be designed to be perpendicular, angled or staggered to the direction of flow. They can be located either 'online' or 'offline'. With an online arrangement, trash racks are placed within an existing channel or drainage system. With an offline arrangement, a flow diversion mechanism is installed, which directs low and medium flows into the trash rack while high flows bypass the trash rack.

Figure 3.5.7(b) – Trash rack

Source: Brisbane City Council

Advantages of trash racks include that they:

- are simple to construct
- trap all pollutants larger than the bar spacing and also retains smaller pollutants when the rack becomes partially blocked
- can be retrofitted into existing drainage system, and
- collect litter at a single point.

Disadvantages of trash racks include that:

- they have potential to cause upstream flooding when material accumulates behind the trash rack (refer Figure 3.5.7(c))
- scouring at the base or sides of the rack if adequate protection is not implemented
- they are maintenance intensive, requiring manual cleaning either on an 'as needs' basis or as part of the programmed works for maintenance, and
- trapped material may be resuspended during large storm events.

Figure 3.5.7(c) – Trash rack and pollutants

Source: Brisbane City Council

Design Guidelines

The most commonly used technique for sizing trash racks is an approach described in *Stormwater Municipal Infrastructure Standards (Ver. 08)* by Transport Canberra and City Services – ACT Government.

Water Quality Ponds

A water quality pond is a relatively deep open body of water, possibly with littoral macrophytes (reeds). Wet basins achieve pollutant removal through sedimentation. Their pollutant removal efficiency depends on the stormwater residence time and the amount of runoff detained in the basin. Pollutant removal efficiency increases with longer residence times and greater used storage volumes.

Advantages of water quality ponds include that they:

- can be used to trap coarse sediments and associated pollutants
- have the potential for stormwater re-use
- have a potentially high aesthetic or recreational value
- provide habitat for wildlife, and
- can generally be constructed at steeper sites than constructed wetlands.

Disadvantages of water quality ponds include that they:

- can be prone to eutrophication and thus have an adverse impact on downstream water quality
- have the potential to breed mosquitoes
- may cause habitat degradation upstream and downstream of the basin, and
- may require flocculation.

Large pond volumes may be required in regions with high rainfall intensities.

Design Guidelines

Ideally, a continuous simulation approach should be undertaken due to the highly variable nature of catchment runoff and associated pollutant concentration. From the continuous simulation an appropriate storage volume could be selected on the basis of long-term performance rather than prescribed performance for a single event.

The size and capacity of water quality ponds should be such that stormwater is detained for as long as possible to promote effective treatment of pollutants but should also guarantee that runoff generated during subsequent storms is captured and treated. The longer the residence time and the more water stored in the pond, the better the pollutant treatment.

Ideally, the pond should be protected from flood flows larger than the design storm flow. Provision of a high flow bypass channel is a means of reducing the risk of pond scouring but it is subjected to the site topographical constraints.

To enhance pollutant removal, the following design features should be considered:

- an effective residence time can be achieved by a pond length to width ratio of between 3:1 and 5:1
- the inlet to the pond should be located as far as possible from the outlet as possible, and
- to increase the length to width ratio or overcome problems with the inlet being too close to the outlet, berms and baffles may be installed to redirect flows.

The proper design of a pond outlet is critical to its performance. One option is to place a low-level culvert at the Mean Operating Level (MOL) of the water quality pond. Between storms, the water level in the pond will drop below the MOL because of evaporation and infiltration losses. During storms, the water level will rise to and beyond the MOL, and water will flow out of the pond through the outlet.

Other outlet options include using orifice outlets, which may enhance flow detention during smaller storms or broad crested weirs. With the latter option, flood attenuation may not be as effective as with culvert or orifice outlets.

An access track should be provided for the maintenance of water quality ponds. Maintenance may include the following:

- mowing of banks and harvesting of macrophytes
- weed removal
- litter removal, and
- removal of accumulated sediment.

Monitoring of a water quality pond should be undertaken after large storm events at intervals not exceeding six months to assess the performance.

Additional design information may be obtained from Environmental Protection Agency (EPA) (NSW), Horner et al, and Schueler et al.

Sediment Basins

Sediment basins are designed as part of a treatment train to improve the water quality of stormwater prior to discharge to the natural environment.

During the construction phase of projects sediment basins are used with drainage, erosion control and other sediment control strategies to manage erosion and sediment. Further information on effective erosion and sediment control is found in International Erosion Control Association (IECA) Australasia *Best Practice Erosion and Sediment Control Guidelines*.

During the operational phase, sediment basins are used in conjunction with other water sensitive design tools and techniques such as swale drainage to reduce the loads of sediment, nitrogen and phosphorus to the receiving environment. Sediment basins for management of water quality during the operational phase of an asset should be considered based on the process outlined in Section 3.4.4.1 of this supplement.

Design Procedure – Sediment Basin for Temporary Erosion and Sediment Control

Appendix B of IECA Australasia *Best Practice Erosion and Sediment Control* is accepted for this section.

Design Procedure – Sediment Basin for Permanent Stormwater Treatment

For guidance on designing sediment basins for permanent stormwater treatment the following documents are recommended:

- Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland (Healthy Waterways), and
- Australian Runoff Quality – A Guide to Water Sensitive Urban Design (Engineers Australia).

Alternative basin designs (such as high efficiency basins) are acceptable for temporary or permanent stormwater treatment provided it is demonstrated that the discharge criteria (temporary) or minimum reductions in mean annual load (permanent) requirements will be met.

3.5.9 Wetlands

Addition

Constructed wetlands are structures built with predominantly natural materials to reproduce the physical, chemical and biological processes of natural wetlands. They are used to remove a range of pollutants, including suspended solids, nutrients, heavy metals and other toxic or hazardous compounds. Their pollutant trapping efficiency varies with the type of pollutant, being moderate for oil and grease, moderate to high for sediments and nutrients.

Wetlands typically comprise an upstream inlet zone, a shallow macrophyte zone and a high flow bypass channel. The upstream inlet zone consists of a relatively deep, open water body or sediment basin with some fringing aquatic vegetation. The downstream macrophyte zone is a more permanent shallow water body with extensive vegetation. The bypass channel is used to protect the macrophyte zone from scour and vegetation damage (*Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland* (Healthy Waterways)).

Advantages of wetlands include that they:

- potentially achieve high sediment and nutrient retention efficiencies
- can be incorporated into the road corridor, thereby providing improved habitat and visual amenity in disturbed areas, and
- potentially can be retrofitted into existing sediment ponds / or detention basins.

Disadvantages of wetlands include that they have:

- either pre-treatment or removal mechanisms at the inlet to remove coarse sediment and litter
- large areas for construction, and
- a reliable inflow to ensure they remain 'wet' unless the wetland is designed to be ephemeral.

In addition, wetlands may:

- have a treatment performance which is highly sensitive to hydrologic and hydraulic design
- take up to three years to achieve optimal performance
- have a potential impact on public health and safety, and
- have adverse interactions (pollutant exchange) with groundwater in some situations.

Constructed wetlands generally require large areas of land, resulting in high construction costs. Maintenance cost of wetlands can be kept relatively low if the design provides for mechanised sediment removal facilities, as well as the inclusion of upstream pre-treatment devices for the trapping of coarse sediment and litter.

Design Guidelines

Urban Stormwater Best Practice Environmental Management Guidelines (CSIRO) outlines a number of design principles to consider before construction. These include:

- Establish a uniform flow distribution throughout the wetland. Avoid creating stagnant areas.
- To enhance sedimentation, maximise the amount of time macrophytes are in contact with flow. This can be done by providing low flow velocities with healthy vegetation.
- Provide adequate wetland pre-treatment.
- Minimise organic matter loading.
- Maintenance requirements must be met to manage sediment build up and weed occurrence.

The design procedure outlines five general steps in the design of constructed wetlands and the reference, *The Constructed Wetlands Manual*, Department of Land and Water Conservation (NSW) 1998, is relevant to these five design steps:

1. **Wetland Location**

   Constructed wetlands can be located on a watercourse or adjacent to a watercourse. For road corridors, the preferred location is adjacent to a watercourse. In this case, the drainage system of the road can be designed to direct runoff from the local catchment and pavement surface into the wetland, rather than directly into the watercourse. A high flow bypass channel around the wetland system can be designed such that sediments and vegetation within the wetland are not damaged during flood events.

   The location of a wetland will depend on a number of factors, including:

   - aquatic habitat and riparian vegetation of the receiving environment
   - wetland size and available space in the road reserve
   - topography
   - reliability of low flows to maintain a permanent wetland

- groundwater conditions, and
- maintenance requirements.

2. **Wetland Size**

   The components of the wetland that need to be sized are the temporary and permanent storage volumes. The permanent storage zone encourages biofilm growth on the macrophytes (plants such as reeds, rushes and sedges) and maintains sedimentation. The temporary storage zone can be used to attenuate peak flows and to increase hydraulic residence time, thereby maximising the rate of pollutant removal.

   As a rule of thumb, wetland areas in South East Queensland should cover 2–4% of the contributing catchment area.

3. **Pre-treatment Measures**

   The removal of coarse sediment upstream of the wetland will minimise changes to depth profile and damage to macrophytes. The installation of a sediment trap and trash rack upstream of the wetland are recommended and will assist greatly in reducing the frequency and cost of maintenance.

4. **Macrophyte Planting Requirements**

   A wetland should be divided into a number of zones to encourage macrophyte diversity. An open water zone will encourage UV disinfection and oxygenation. Shallow marsh, marsh and deep marsh zones encourage macrophyte diversity and uniform flow across the wetland.

5. **Outlet Structure**

   Outlet structures are important as they control the water level within the wetland. An appropriate water level optimises water quality improvement, achieves macrophyte diversity and provides for weed and mosquito control.

   Four outlet varieties discussed in Victorian Stormwater Committee (1999) are risers, weirs, culverts and siphon outlets. These outlet devices should be assessed to determine the appropriate water level or hydraulic regime each would have on a wetland. The choice of outlet type will also be influenced by the basin morphology and hydrology.

   Additional design information may be obtained from:

   - *Water Sensitive Urban Design: Technical Design Guidelines for South East Queensland* (Healthy Waterways)
   - *Guidelines for Stabilising Waterways* (SCRS), and
   - *Bioretention Technical Design Guidelines* (Water by Design).

3.5.10 Treatment Train

Addition

The treatment train approach requires a number or sequence of different treatments throughout the road corridor catchment before discharge to the receiving environment. The sequence of treatment measures is designed to remove different types and sizes of pollutants, thus optimising the amount and range of pollutants removed from discharge waters.

The selection of the treatment controls for a road corridor catchment under consideration will depend on a wide range of key selection criteria to enable achievement of water quality design objectives.

The selection of the most appropriate stormwater treatment methods should be influenced by a number of environmental and design elements, such as:

- Slope – treatment devices that do not store flow may require small velocities and hence gentle slopes.
- Hydraulic head – head losses in treatment devices can exert a minor to large impact upon the hydraulic grade line. As a result, head losses from a treatment device may adversely impact upon upstream flood levels, particularly when retrofitting a device into an area.
- Soil type – differing treatment devices may be reliant upon either infiltration or storage of stormwater runoff. For example, stormwater infiltration will yield better results on highly permeable soils, while the storage of stormwater will require soils with very low permeability.
- Land availability and catchment area – the availability of sufficient appropriate land within a sub-catchment that can be used for a treatment device may be restricted, thereby reducing the size, effectiveness or even the option of using the device.
- Habitat enhancement – treatment devices that are able to offer either a wildlife and/or aquatic habitat enhancement may improve aesthetics.
- Water table – a high water table depth may reduce the effectiveness for a treatment device relying on infiltration.
- Safety hazard – treatment devices may introduce new safety hazards that may have not been present before installation (such as waterborne pathogens, drowning risk, and so on).
- Water supply – treatment devices, such as wetlands or ponds, may require a permanent water supply to ensure the long-term effectiveness of the device.
- Pests – treatment devices, such as wetlands or ponds, may increase the potential for nuisance from pests such as mosquitoes and weeds.
- Maintenance – treatment devices will vary significantly with regard to maintenance cost, accessibility, equipment and scheduling to ensure the desired effectiveness is consistently maintained.

3.6 Erosion and Sediment

3.6.1 General

Addition

The department strongly encourages the early installation of permanent water quality treatment systems and use of these permanent devices during construction phase, where appropriate.

It is now expected that temporary erosion and sediment controls to manage construction impacts should be implemented in line with the guidance and requirements found within:

- Best Practice Erosion and Sediment Control (IECA Australasia)
- Transport and Main Roads Technical Specification MRTS52 *Erosion and Sediment Control* and Specification (Measurement) MRS52 *Erosion and Sediment Control*, and
- Transport and Main Roads *Soil & Revegetation Management Guideline – State Wide Edition*. Departmental employees can access this document via the Environmental Management System SharePoint site. External parties can request a copy from the department via roaddesignstandards@tmr.qld.gov.au.

In particular:

- Information on field dispersion testing and erosion properties of the department's Soil Groups can be found within Chapter 3 of the department's *Soil & Revegetation Management Guideline – State Wide Edition*. This manual also contains design, construction and maintenance practices suitable for standard and specialised environments.
- Methods for determining erosion risk using Revised Universal Soil Loss Equation (RUSLE) including R values can be found in Book 2 Appendix E of *Best Practice Erosion and Sediment Control* (IECA Australasia).
- Control selection criteria is available in Chapter 4 of *Best Practice Erosion and Sediment Control* (IECA Australasia). Detailed design fact sheets and Transport and Main Roads standard drawings are also available in this manual (Book 4 and Book 6 respectively). This material can be accessed from the IECA Australasia website (http://www.austieca.com.au/publications/publications).
- Erosion and Sediment Control Plan (ESCP) requirements and design AEP requirements are outlined in Transport and Main Roads Technical Specification MRTS52 *Erosion and Sediment Control* . For further assistance in preparing an ESCP, please refer to the departments Construction Administration System – Standard Checklists *CAC057M – Erosion and Sediment Control Plan*. This is available on the department's website (http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Contract-administration-system/CAS-Standard-Checklist.aspx).
- For assistance in the inspection of erosion and sediment controls, please refer to the departments Construction Administration System – Standard Checklists*: CAC005M – Erosion and Sediment Control.* This is available on the department's website (http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Contract-administration-system/CAS-Standard-Checklist.aspx).

3.6.4 Erosion and Scour Protection Measures

Difference

As may be seen by comparing columns two and three in Table 3.10 of Austroads *Guide to Road Design Part 5*, there is usually some distance downstream of the culvert where the flow is decelerating, and the streambed and banks require protection by rock beaching. Where for some reason, such as a steep culvert slope, the culvert velocity exceeds the allowable value in Table 3.10 column two, an energy dissipator **is to be considered** (see Section 3.6.10 of this supplement).

3.6.5 Rock Protection

Addition

For further details the department accepts Section 9.9 of QUDM.

3.6.6 Gabions

Addition

For further details the department accepts Section 9.9 of QUDM.

3.6.7 Rock Mattresses

Addition

For further details the department accepts Section 9.9 of QUDM.

3.6.10 Energy Dissipators

Addition

For further details the department accepts Section 9.9 of QUDM.

3.7 Blockage

Addition

Book 6, Chapter 6 of ARR is accepted for this section.

Design blockage for new transverse drainage structures shall be assessed using the approach detailed in Book 6, Chapter 6 of ARR. Compliance of flood immunity shall be demonstrated assuming design blockage at all new cross-drainage structures. Impact assessments (afflux) shall be undertaken assuming a no blockage scenario at all cross-drainage structures. Sensitivity testing shall be undertaken to assess impacts under design blockage scenario and review outcome at critical receptors such as dwellings.

3.7.1 Procedure

Addition

Book 6, Chapter 6 of Book 6 of ARR is accepted for this section.

3.8 Miscellaneous

3.8.2 Tidal Waters

Addition

In the past, Highest Astronomical Tide (HAT) and Mean High Water Spring (MHWS) datum levels (AHD) could be sourced from the Tidal Planes tables published by Maritime Safety Queensland (MSQ). However, information from this source can no longer be relied on as there has been no adjustment to those since 2010. Therefore, datum tidal levels need to be obtained and validated from alternative sources, such as the Department of Environment and Science.

3.8.3 Storm Surge

Addition

A storm surge is the rise (or fall) of open coast water levels relative to the normal water level and is due to the action of wind stress and atmospheric pressure on the water surface.

Storm surges occur as part of major storms such as cyclones where there are low atmospheric pressures, and the wind blows overreaches of the ocean.

Many local authorities in Queensland have prepared reports and maps showing storm tide risk in coastal areas. These reports can be found on relevant council websites.

In the absence of specific storm tide information, the Department of Science (DES) has recommended a default level. This level is 1.5 m above HAT in south-east Queensland and 2.0 m above HAT in the rest of Queensland. There is no probability associated with this recommendation, so it is assumed that this applies to 1% AEP + climate change events out to the 2100 planning horizon. These values are a conservative estimate including an allowance for future sea level rise, so adoption of this level will usually result in a higher flood level than would be found from a more specific analysis. A less conservative approach is to adopt HAT as an approximation of a coincident storm surge in addition to a MHWS tide level.

Coincident Probability Assessments

Book 6, Chapter 5 of ARR outlines methods to assess the interaction of coastal processes and severe weather events. The additional complexity of joint probability modelling means that the methods described in ARR should only be implemented by users with sufficient understanding of the theoretical basis of each method. However, ARR suggests that where there is little difference between complete dependence and independence, the analysis should assume complete dependence, which will result in a degree of conservatism.

Design Guidance

Consideration of storm surge and storm tide is important in design of the department's infrastructure and must be considered appropriately to ensure that the design considers the flood risk correctly. There is a possibility that the design may be overly conservative if flooding, high tides and storm surge are all assumed to be coincident. In practice, there is a slightly higher probability that they are associated, but the assumption of full dependence is generally too conservative.

The recommended design procedure for the hydraulic assessment of the department's drainage infrastructure located close to the coast, where tidal influences may be an issue is as follows:

- Obtain MHWS, HAT and storm tide levels relevant to the infrastructure.
- In most cases it is acceptable to simply adopt the higher levels resulting from independent storm tide and riverine flooding with HAT tailwater conditions. This approach includes some degree of dependency in the design.
- If a more detailed analysis is required, undertake pre-screening exercise to determine if there is significant difference between:
  - full dependence: flood levels based on riverine flooding with storm tide tailwater levels
  - partial dependence: maximum flood levels resulting from either storm tide levels or riverine flood levels with HAT tailwater condition, and
  - full independence: maximum flood levels resulting from either storm tide levels or riverine flood levels with MHWS tailwater condition.
- If the difference is sufficiently small to accept, adopt the 'full dependence' or the 'partial dependence' case as the design condition, which will usually result in a slightly conservative design.

- If the assumption of full or partial dependence has significant impacts on the design of the infrastructure, a joint probability analysis in accordance with Book 6, Chapter 5, Section 5.5 of ARR is recommended to determine the required design levels of the infrastructure.
- As a check, the catchment floods should also be analysed with a lower tailwater level to check for design flow velocities to determine scour potential. The lower tide level should be mean sea level or mean low water springs (MLWS).

3.8.6 Acid Sulphate Soils

Addition

The DES is the lead agency for information and advice on acid sulphate soil (ASS) and is continually developing ASS risk maps that show areas dominated by actual (AASS) and potential (PASS) ASS. These maps present information on presence or 'depth to' AASS horizons and presence or 'depth to' PASS horizons. They are available in hard copy and electronic forms at a range of scales.

For more information and mapping:

- access the department's Geographic Information Systems (GIS) (MapInfo) via Geospatial Technologies, Engineering and Technology Transport and Main Roads
- access the Department of Resources fact sheets, such as *Acid sulfate soils in Queensland*
- contact the Queensland Acid Sulphate Soils Investigation Team (QASSIT), Department of Resources, and
- access Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the National Committee for Acid Sulphate Soils (NatCASS) soil databases.

3.8.9 Drainage Shadow

Addition

The issues and methodologies described in this section are limited to roadworks adjacent properties in rural, parkland or similar zones where uncontrolled surface flow may be acceptable.

4 Drainage Considerations

4.3 Design Considerations

4.3.1 Identifying Design Considerations

Addition

Whole-of-life considerations dictate that the design of a road takes proper account of both expected and potential changes that will or may occur as traffic grows and the surrounding land use develops or changes.

If designs ignore the requirements for future upgrading, future projects will be more difficult and much more expensive to implement than they would have been if appropriate provisions were included in the original design.

The fundamental elements to be addressed in designs to allow for future upgrades include:

- carriageway or formation widening (such as for an additional through, auxiliary and/or overtaking lane, for a noise barrier, for a safety barrier)
- duplication of carriageways, and
- intersection and interchange changes or upgrades.

Providing for the future cross-section and ultimate road configuration when designing drainage systems requires careful consideration of the various components of the drainage system.

Lawful Point of Discharge

Section 3.8, Section 3.9 and Section 3.10 of QUDM accepted.

4.5.1 Flood Immunity

Addition

Flood immunity – This is defined as the AEP of a flood that just reaches the height of the upstream shoulder of the road. In other words, the road surface remains above / is immune to the flood of set AEP. Furthermore, freeboard may be required to raise the road level further to keep the pavement dry and/or provide a buffer in case of error in calculation.

4.5.2 Trafficability

Addition

Trafficability – In the past, some design criteria have been set to allow traffic to continue to use the road while floodwater crosses the road surface. However, recent research shows that modern passenger vehicles become buoyant and susceptible to flood forces at much lower levels of roadway inundation than those used to describe closure criteria in previous publications of this manual. Additionally, the public safety campaign, “If it’s flooded, forget it”, has been widely publicised and adopted as policy by the department. Therefore, for the purposes of departmental projects, the focus of calculations should be on Time of submergence (TOS) and Average annual time of submergence (AATOS) analysis.

4.6.1 Kerbed Drainage

Addition

Refer to Section 7.3.16 of QUDM for further details.

4.6.2 Underground Piped Networks

Addition

Refer to Section 7.16.6 of QUDM for further details.

4.6.3 Drainage Basins

Addition

Refer to Section 5.7 of QUDM for further details. The freeboard design criteria stated in QUDM for drainage basins are to be considered additional to those stated in Austroads *Guide to Road Design – Part 5*.

4.7 Other Considerations

4.7.5 Self-cleaning Sections

Addition

For cross-drainage culverts, flow velocities must be no less than the "absolute minimum" as stated in Table 7.11.1 of QUDM; however, lower velocities are permitted where design is constrained by fish passage requirements where very low maximum allowable velocities are specified for frequent AEP events. Some culverts are designed to be buried to facilitate a natural bed substrate within the culvert.

Where the department's regional offices or the design brief / contract documents require that pipes or culverts must be "self-cleaning", Section 4.7.5 of the Austroads *Guide to Road Design – Part 5* is accepted for this section.

4.8 Extreme Events

Addition

Road infrastructure is not designed to be immune from all rainfall and flooding events. Bridges and roads can be overtopped frequently, and some might even be purposely designed to be overtopped and inundated for short periods of time. Design elements are to be chosen that enhance the infrastructure performance in these conditions, such as bound pavements, asphalt surfacing, subsoil and pavement drainage to cope with near surface water flows and high-water tables, batter and scour protection, debris loading, and so on.

Resilience to large and extreme rainfall and runoff events can be improved by:

- improving the road network's ability to survive future flooding events by reducing the extent of damage sustained in a large and extreme event, and/or
- reducing the work and/or time required for the network to be reinstated to unrestricted use following a future event without changing the design flood specification.

It is important to note that any outcomes (adverse or otherwise) resulting from an extreme rainfall event could occur within both the road and external environments, therefore, identification of possible outcomes should not be limited to the road reserve and/or chainage limits of the project.

The erodible soil environments and excessive flooding are situations where the design of a project should be assessed for adverse outcomes and risks that may occur during an extreme rainfall event. However, other situations may also exist where assessment should be undertaken, therefore, careful engineering consideration and judgement should be exercised. Assistance in identifying or confirming situations requiring assessment and at what level (AEP) assessment should be undertaken at can be provided by Director (Hydraulics and Flooding), Hydraulics and Flooding Unit, Engineering and Technology Branch, Transport and Main Roads.

4.8.2 Planning and Design

Addition

In the planning of a road corridor, link or project, the flood immunity expected / required is an important consideration. However, the assessment / determination of flood immunity for a road is extremely difficult.

The accepted practice is to assess / prescribe the flood immunity for individual types of drainage infrastructure, such as cross-drainage and surface drainage infrastructure, along the road. The department's general design criterion for flood immunity for cross-drainage on state-controlled roads is to achieve a design that provides for an AEP of 2%. Projects on roads within Auslink usually require immunity for an AEP of 1%.

While all road planning and design projects should aim for these objectives, there are several considerations that affect this objective in particular circumstances. This section discusses some of these circumstances and outlines how these additional issues can be incorporated into the process.

For the project concerned, additional considerations are needed in the assessment of flood immunity required. These include:

- Project economics – in some circumstances, provision of a required level of flood immunity may come at a very high cost, which may be difficult to justify because of the function of the road. This situation often occurs in large flat floodplains, where there is an extensive length of road across the floodplain.
- Road alignment and corridor – in some situations, the road alignment and corridor width may make a high level of flood immunity difficult to achieve and a lower level may need to be adopted. This situation usually occurs in areas with significant controls or constraints where there are environmental issues or in urban areas.
- Community impacts – these impacts may affect the flood immunity standard to be adopted, especially in flat areas. Often in these situations, there will be a significant width of flow in the natural or existing environment. If the road is to be upgraded to a higher level of flood immunity, a significant flow must be directed under the road, which will tend to concentrate the flow. In this case, afflux is difficult to manage without a significant amount of cross-drainage. A lower level of flood immunity will allow extra flow across the road and, thereby, result in a better outcome related to afflux. This benefit may be greater than the concern with the reduced flood immunity.
- Flood immunity along a road link – in this case, the flood immunity along a whole road link needs to be considered. If there is a drainage crossing on the road link where it is clear that it cannot be upgraded to a 2% AEP flood immunity, the upgrade of other crossings on the link may not be justified, because the whole link may be closed anyway whether or not the particular crossing is upgraded. This issue can be influenced by the availability of an acceptable alternate route.

In all of these cases, the required level of flood immunity would usually be technically achievable, though at a cost that cannot be justified for the benefit gained. For example, the Murray River Crossing in north Queensland, as shown in Figure 4.8.2, has been designed based on a Time of Closure (TOC) criteria, as the cost to construct the highway to normal levels of immunity was prohibitive.

The consequences of adopting a lower level of flood immunity can be analysed by consideration of the extent of traffic disruption and the economic impacts of this disruption. This can be considered in conjunction with the assessment of TOC discussed here.

While it may be acceptable to adopt a flood immunity standard for a project that does not meet the general criterion, in all cases it is essential that the justification for the decision should be clearly detailed.

Figure 4.8.2 – Murray River Crossing of Bruce Highway

4.8.3 Impacts of Extreme Events on Erodible Soil Environments

Addition

Part of the road drainage design process is the determination of acceptable or maximum allowable velocities for stormwater flows. It should be noted that these velocities are largely based on research that identified the velocity when erosion / scour started to occur in different soil / stream types. The maximum allowable velocities for a project are then used in the design of various drainage structures / devices (for example, culverts and channels) to ensure design discharge through those devices is below the set maximum allowable velocity for that location.

4.8.4 Very Rare and Extreme Events

Addition

Higher peak water levels upstream of a drainage structure in extreme rainfall events may produce larger flow velocities through the structure than for the nominated design AEP event. The higher velocity may cause scour problems or could cause the catastrophic failure of the structure itself.

Where flood impacts would be significant / very severe, it is necessary (and can be specified in design / contract documentation) to consider floods up to the Probable Maximum Flood (PMF). The PMF is defined as the largest flood event that can reasonably be expected. In some situations, extreme events, though smaller than the PMF, may be more appropriate.

If the situation of excessive flooding is considered applicable on a project, specialist advice needs to be sought from the department's Hydraulics and Flooding Unit or a suitably prequalified consultant.

4.9 Waterway Structures

4.9.2 Bridges – General

Addition

Hydrologic and hydraulic analysis for bridge design must be undertaken in accordance with the Transport and Main Roads *Hydrology and Hydraulic Modelling* Technical Guideline.

Scour analysis for bridges must be undertaken in accordance with the Transport and Main Roads *Bridge Scour Manual – Supplement to Austroads Guide to Bridge Technology, Part 8, Chapter 5: Bridge Scour*.

Additional information on the design of bridges can be found in:

- Austroads *Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures*, and
- Transport and Main Roads *Design Criteria for Bridges and Other Structures.*

4.9.5 Bridge Geometry

Addition

Reference should also be made to the RPDM Volume 3, Part 3 *Geometric Design* for details on road geometry in relation to bridges.

It is important to note that it may be a legal requirement for other departments / authorities to approve bridge spans and vertical clearance. Further advice in relation to this should be sought from Road Design, Hydraulics, Design and Spatial, Engineering and Technology, Transport and Main Roads.

Design of scour protection must be undertaken in accordance with Transport and Main Roads *Bridge Scour Manual: Supplement to Austroads Guide to Bridge Technology: Part 8, Chapter 5: Bridge Scour*.

Reference should also be made to Transport and Main Roads *Design Criteria for Bridges and Other Structures*.

5 Operations and Maintenance

Addition

Reference should also be made to the Transport and Main Roads *Road Maintenance Performance Contracts Manual* and the *Road Asset Management Contract*.

The intent should be to use the maintenance process for identifying failures in the drainage system and to assist learning from these failures to prevent future failures.

Legal Aspects

Applicable requirements of key legislation, such as the *Work Health and Safety Act* 2011 (Qld), EP Act and *Environment Protection and Biodiversity Conservation Act* 1999 (Cth), apply to the department's operation and maintenance activities with respect to road drainage. Furthermore, the department has a legal responsibility / duty of care to ensure that the road under its jurisdiction is maintained to provide an acceptable level of safety to the public and road users, and to protect the environment from harm. It is important that supervisory staff overseeing these activities understand the applicable requirements of the legislation to ensure compliance.

To ensure appropriate and timely maintenance, it is important that regular inspections be conducted, followed by appropriate remediation works (where required). With respect to road drainage, it is recommended that inspection of this infrastructure should be conducted shortly after significant rainfall / flood events, when failures are more likely to occur. Any remediation work would depend on the severity of any damage / failure identified.

Furthermore, the department must also ensure prompt response to emergency situations, such as water over the road or subsidence of the roadway occurs, where rapid remediation works are required.

In both situations presented above, failure to act appropriately exposes the department and its officers to increased risk of investigation and/or legal action.

5.3 Maintenance

5.3.1 Maintenance Process

Addition

Transport and Main Roads is the steward of the state-controlled road network. Part of this role is to maintain the road network to a standard which ensures the safety and efficiency of the travelling public and protection of the environment.

5.3.2 Types of Maintenance

Addition

With respect to drainage, the RMPC covers predominantly two maintenance types.

The first, and most dominate type, is routine maintenance. Routine maintenance work includes those activities that keep the road corridor in good order, such as the cleaning and repair of drainage systems.

Emergency maintenance work relates primarily to work performed immediately following an emergency (for example, vehicle accident, natural event) to ensure the safety of motorists and/or pedestrians using the corridor. Other routine maintenance work may be necessary after making the situation safe.

5.5 Remediation

5.5.1 Introduction

Addition

Metal Culverts: the remediation / rehabilitation of metal culverts can be difficult and specialised, therefore, maintenance engineers are referred to the latest version of the department's manual, *Criteria for Inspection, Life Extension and Rehabilitation of Circular Corrugated Metal Culverts*, for further guidance.

Fish Passage requirements for remediation treatments: where the remediation treatment may result in an adverse impact to fish passage from what is existing, it is necessary to consider the legislative requirements for constructing or raising a waterway barrier. That is, fish passage considerations may apply to remediation work such as lining, re-sleeving, concrete inverts, replacement of culvert sections, raising of floodway, resurfacing of road surface over floodway.

Where remediation works are identified, review the DAF *Waterways for Waterway Barrier Works Mapping*. Seek advice from the department's Environmental Advisor via Program Management and Delivery Unit, Transport and Main Roads.

6 Hydrology

6.4 Probability and Risk

6.4.1 Introduction

Addition

When planning the desired immunity level of a road link, an important concept that is often not understood or implemented well, is the assessment of the risk of closure. This concept or issue is particularly important where there is no realistic alternative route available.

The key part of the risk assessment that is poorly understood is the link between the design AEP for cross-drainage structures and the probability of closure of the road link. The probability of closure for an existing road link is not simply based on the minimum AEP standard of all cross-drainage structures along the road link. Equally, it is incorrect to set the acceptable level of risk of closure for the road link and then adopt this level (in the form of an AEP) for the design of each drainage crossing. This will not necessarily achieve the desired level of immunity or risk of closure.

The department usually designs individual cross-drainage structures to a standard of 2% AEP. Statistically, this means the probability of the road being closed at one of these crossings is 2% annually. However, due to the independence of rainfall events over time and potentially between catchments, any drainage crossing along the link could close, due to a greater than 2% AEP event, independent of all other crossings. This situation, when considered across the whole road link, could greatly increase the risk (probability) of closure of the road link.

The assessment of probability of closure for a road link requires the determination of dependency between the crossings and to understand if crossings along a road link are independent of each other. The level of dependency influences the level of probability and, therefore, risk of closure.

This can be explained by use of an example. Assume a road link with five drainage crossings, each designed with a flood immunity of 2% AEP. If all of the crossings on the road link are totally dependent, then a single rainfall event greater than 2% AEP will close all of the crossings at the same time. This gives the road link a probability of closure of 2% (1 in 50). However, if the crossings are fully independent, each crossing can be subjected to its own greater than 2% AEP rainfall event at different times to the other crossings. Therefore, the risk of closure of each crossing is independent of what occurs at the other crossings. This situation can give the road link a probability of closure of about 10% (1 in 10).

Normally, the crossings are dependent to a certain extent and the risk will be between the two cases described. In this case, a single event may affect more than one crossing at a time on some occasions, but they will be affected independently at other times.

Crossings will be fully dependent if the length of the road link is small, and a single rainfall event will always affect all crossings together. The dependence decreases as the length of the road link increases and the probability of a single rainfall event affecting all catchments reduces. The dependence is low when there are many small catchments. In this case, each small catchment may be affected by a localised short duration storm event, which will only extend over a limited geographical area, and these events may occur anywhere along the road.

For example, if there is a long length of road with 50 small catchment areas, each with its own crossing designed for a 2% AEP flood event, the risk of closure of the road link is quite high every year.

The analysis of this risk is complex and depends on an assessment of the catchment types, the expected rainfall mechanism and the distance between crossings.

Calculation of the risk of closure of the whole link needs to consider the flood immunity of each individual crossing as well as the degree of independence of the crossings.

The analysis of this combined risk is a complex statistical analysis. However, it should be considered in many projects, to ensure that there is a good understanding of the total risk of closure. For further discussion and/or advice regarding this type of analysis, contact the Director (Hydraulics and

Flooding), Hydraulics and Flooding Unit, Engineering and Technology Branch, Transport and Main Roads.

6.5 Data for Drainage Design

6.5.1 Introduction

Addition

The various forms of data used in the planning and design of drainage infrastructure are broadly categorised as either 'strategic data' or 'project data'.

Designers should ensure that collected data is appropriately stored for easy retrieval, not only during the preconstruction activities of the project, but also in the future.

6.5.2 Categories of Data

Addition

Types of Data

Data is progressively collected, analysed and used throughout all preconstruction activities at a level of detail that is appropriate for the purpose being considered.

In the development of specific project proposals, the strategic data needs to be reviewed and expanded with the introduction of more detailed, project-specific data. As a project proposal progresses through various preconstruction activities, refinement of data occurs through various investigations and studies and as new design specific data is obtained.

During the construction activities, more data is collected, usually as as-constructed detail. Once a project is completed and becomes operational, further data regarding the operations and maintenance of the road should be recorded as part of the asset management process.

Data collected during preconstruction, construction and operational / maintenance activities is defined as 'project data'.

Both strategic and project data, with respect to drainage, is useful not only to the department, but also to others who are interested in information such as flood levels and so on. Local authorities, developers and consultants may refer to the department for assistance in providing observed flood levels and so on in areas of interest and this assistance should be given where relevant / appropriate.

Data that has been obtained from various sources for use in planning and design work should be retained as part of the documentation for the project.

Strategic Data

Strategic data is usually regional in nature and is required for network planning and the preparation of Road Route Strategies / Road Link Plans. It may also be required for the planning and design of drainage infrastructure. It can be considered in four types of information:

- Type 1 – Planning instruments, such as:
  - regional strategic land-use plans
  - statutory and advisory land-use management plans
  - land-based and marine national parks
  - land-based and marine estuarine environmental protection and management plans

  - other land and water-based management plans
  - Australian Government planning instruments
  - local authority town planning schemes, and/or
  - urban and rural drainage management plans, initiated under Queensland Government legislation.
- Type 2 – Naturally occurring events, such as:
  - storm event data
  - flooding event data
  - abnormal highest astronomical tide event data, and/or
  - storm surge event data.
- Type 3 – Drainage and water management infrastructure, such as:
  - specific drainage infrastructure
  - water catchment storages (such as aquaculture, fish), and/or
  - irrigation schemes.
- Type 4 – Private or Public Utility Plant (PUP), such as:
  - communications systems
  - municipal services
  - trunk distribution systems for oil, gas, water and effluent
  - electricity transmission lines, and/or
  - state and interstate railways and industry narrow gauge rail systems.

Planning Instruments

The department may be a participant in the planning processes that create some of these instruments to ensure appropriate road service delivery is provided through Queensland. However, planners and designers need to work within the overall statutory and advisory planning framework when developing various strategic network plans and when planning and designing specific projects.

As these instruments may change over time, it is not advisable to attempt to store this type of data, but rather obtain current information at the start of each new project and review the currency of this information as the phases of a project progress.

Land-use planning is one form of data that can change within the department’s planning and design time frame. In rapidly developing urban areas, upstream and downstream land-uses could change through:

- issue or the review of a regional land-use plan
- amendments to the planning scheme, and/or
- the completion of a new planning scheme.

All relevant Transport and Main Roads regional and district offices need to be part of the regional planning and local authority planning processes to ensure that drainage infrastructure is consistent with land-use planning.

Drainage and Water Management Infrastructure

Local authorities and various statutory authorities manage urban and rural drainage systems that are designed for:

- existing and future land-uses in the catchment
- specific hydrological and environmental parameter, and
- local drainage parameters.

Planners and designers need to obtain data relating to the design of these facilities so that the department's drainage infrastructure is compatible with local authority planning and design.

Drainage infrastructure located in the catchments of existing or planned municipal water storages may need to conform to requirements of the relevant catchment authority, particularly in matters of water quality and erosion and sediment control. Planners and designers should consult with the catchment management authority to ascertain requirements for drainage in the catchment under review.

Authorities managing irrigation schemes may have similar requirements for drainage infrastructure to municipal catchment management authorities and these requirements should be obtained. Details of existing irrigation infrastructure should be confirmed by survey and any expansion plans obtained from the authority.

Private / Public Utility Plant

As the department generally approves the location of service infrastructure within the road corridor, documentation associated with these approvals provides an initial source of data for new drainage projects. This data needs to be verified with the agency involved and any information supplied should be confirmed with site measurements and ground survey.

Existing services in the vicinity of drainage infrastructure needs to be located by survey to ensure:

- that the service installation does not impair drainage performance
- maintenance of drainage infrastructure can be completed without damage to the service or the drainage, and/or
- the extent of any PUP relocation requirements to enable drainage to be correctly installed can be determined.

Project Data

Project data is more relevant to the planning and design of specific projects and largely relates to the physical characteristics of a site and the surrounding catchment. It may be collected or measured at varying times in the different phases of the planning process and at different levels of detail.

Project data includes:

- land-use
- topographic information
- catchment information

- rainfall data
- stream flow and flooding information
- stream flow patterns
- tidal information
- waterway characteristics and stability
- water quality
- sedimentation issues
- soils data
- erosion history
- vegetation constraints
- acceptable time of inundation
- fauna habitats
- downstream conditions
- service installations, and
- obstructions.

Specific project and routine maintenance inspections provide opportunities to obtain data and to review the in-service performance of the infrastructure. Inspections should have similar objectives to those outlined in Section 4.8.1 of the Austroads *Guide to Road Design – Part 5* for inspections following extreme events, and the findings recorded in the district database.

The quality of data collected has a direct bearing on the successful design and implementation of drainage infrastructure and is strongly linked to an effective site assessment and planning process. It is important that adequate data is collected in the early stages of a project and that it is stored in a readily available format for use in all subsequent phases.

For example, the collection of soils data at the planning or design phase of a project will facilitate the selection of appropriate erosion and drainage controls and the preparation of an appropriate Erosion & Sediment Control Plan (ESCP) for the construction phase.

Site assessment is also strongly linked to risk assessment. A thorough site assessment, where data is added at each stage of the project, will lead to a reduced risk of adverse impacts to the surrounding environment or to the road itself. This, in turn, will lead to reduced costs in the long-term.

The identification of special environmental characteristics of a project site is a key requirement while undertaking a site assessment, though it is expected that most such characteristics will be identified as part of the environmental assessment process. Knowledge of special conditions and factors which influence sensitive environments facilitates environmentally responsible drainage design.

Sources of Data

Different phases and steps during the preconstruction process may use the same data. This data may be obtained from field investigations, studies and recorded information in various forms, such as:

- existing field inspection records
- topographic maps
- documentation obtained during the environmental assessment process
- existing design drawings
- geotechnical investigations
- survey records
- land resource manuals
- aerial photographs
- published references (such as ARR)
- previously published reports and investigations (being feasibility studies)
- concept and link studies
- acid sulphate soils (ASS) maps
- vegetation maps
- flood maps, and
- various electronic data sources (such as geospatial data, MapInfo, Queensland Globe). Transport and Main Roads, Engineering and Technology, Geospatial Technologies Unit can assist with this.

Data is available from various departmental sources, from landowners and organisations, such as:

- BoM (federal)
- DES (state)
- DSDILGP (state)
- Department of Resources
- Queensland Rail
- historical societies
- local authorities
- port authorities
- industry organisation, and
- environmental groups, including catchment management groups and river trusts.

Table 6.5.2 has been prepared to indicate the type of data available from each of these external organisations.

Table 6.5.2 – Data Sources

Data type	External organisation
Rainfall data (historic)	1, 2, 5, 8
Flood levels (historic)	1, 2, 3, 4, 5, 8
Tidal data	1, 6, 8, 12
Cross-sections	2, 3, 5, 6
Topography	2, 5, 11
Soil information	2, 11
Flora and fauna	2, 5, 7, 11
Survey data	2, 3, 5, 6
Water quality	2, 5, 7
Existing infrastructure	2, 3, 5, 6, 8, 9
Aerial photography	2, 5, 10

Notes:

1 Bureau of Meteorology	**2** Relevant State Departments
3 Queensland Rail	**4** Historical societies
5 Local authorities	**6** Port authorities
7 Environment groups	**8** Local residents
9 Service providers	**10** Web-based data sites
11 Department of Transport and Main Roads geographic information systems	**12** Department of Transport and Main Roads (Maritime Safety Queensland)

6.5.4 Rainfall Data

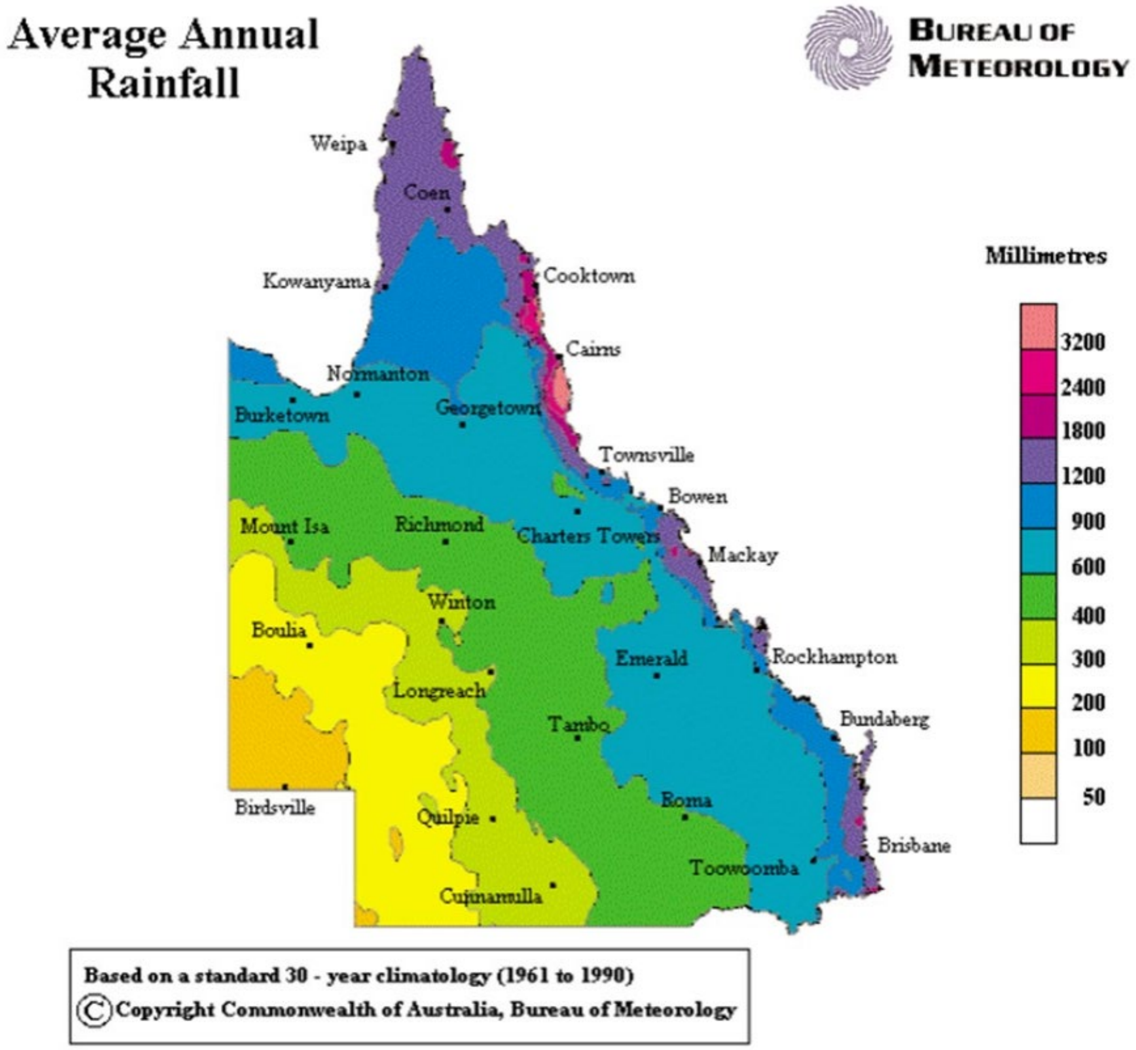
Addition

The duration and intensity of rainfall are major components with respect to the determination of runoff and of erosivity potential. Both vary with geographic position and with the time of year. Thus, rainfall distribution, seasonality and intensity must be considered to determine flow rates and the potential for erosion. For more detailed explanations, reference may be made to the latest release of ARR.

Rainfall distribution

The distribution of median annual rainfall across Queensland is shown in Figure 6.5.4. The rainfall isohyets shown in Figure 6.5.4 are generally parallel to the coast, except where topographic features modify the pattern. In particular, significantly higher rainfall occurs between Ingham and Cooktown, Proserpine and Sarina, and north and south of Brisbane, where there are high ranges aligned perpendicular to the main onshore winds.

Figure 6.5.4 – Annual median rainfall for Queensland



Rainfall seasonality

Rainfall is summer dominant throughout the state, but the volume of rain that falls during the other months varies considerably between regions. South of the Tropic of Capricorn and east of a line between Emerald and Mitchell, there is a significant winter peak in many years.

Rainfall intensity

Rainfall intensity varies with the type of rainfall event (such as advective, cyclonic or frontal), but is generally higher during the summer months than the winter months.

6.5.5 Water Levels

Addition

While the majority of structures are sized using statistically derived flows, the collection of historic flood data can also provide valuable information. Flood data can consist of:

- gauging station records
- recorded peak levels
- mapping of flow patterns

- debris marks
- water stains
- photographs or videos, and
- anecdotal evidence.

Sources of historic flood data can include landowners, local authorities, Queensland Rail (for example, design drawings often highlight peak flood levels), Department of Resources, and BoM.

All data obtained must be evaluated for accuracy and correlated across different sources where possible. This is particularly true with respect to anecdotal evidence of flood heights provided by individuals as:

- the observations did not coincide with flood peak
- there was a lack of visibility (night-time flood)
- a significant time (years) has elapsed since the observation, and
- personal observations can change as time passes.

To be useful, it is essential that all flood height information be related to a recognised level datum.

For large scale and some urban projects, historic flood data may be used for the calibration of mathematical models. Information should also be sought in relation to flood gradients, rates of rise or fall, velocities and flow patterns (directions of flow).

For smaller projects, flood data is often scarce and, hence, may only provide an indication of historic peaks, with no means available to estimate the average exceedance probability (AEP) of the flood event.

6.5.6 Streamflow Data

Addition

An understanding of drainage and flow patterns is required to help ensure that adequate provisions are made for upgraded or future drainage infrastructure. This is particularly important at sites where there is no existing drainage infrastructure.

While flow patterns may be simple to ascertain in waterways, careful consideration is required in relation to overland or floodplain flow.

Drainage and flow patterns may be determined through the review of available topographic maps and aerial photography, and through field inspection. For many sites, all three techniques should be used.

Elements that need to be considered include:

- direction of flow particularly in flat areas
- width of flow
- possible backwater from downstream impacts, such as rivers or weirs
- potential for spill into or from adjacent flow paths, and
- obstacles to flow.

Waterway Characteristics

The characteristics of a waterway may be considered in terms of geometry, hydraulics and the environment.

Geometric characteristics are based on the physical dimensions of the waterway and include:

- channel width and depth
- cross-section
- bed slope, and
- channel form.

Channel form relates to the geomorphic characteristics of the channel and notes should be made of the following issues:

- Is the waterway straight or meandering?
- Is the channel clear or obstructed by banks or islands?
- Are there sequences of pools and riffles?
- Is there a clear distinction between channel and floodplain?
- Is the stream in a pristine state or has it been degraded?
- Are the banks steep?
- Are the banks stable?
- Is there any evidence of current or past bank slumping?
- Are there any other signs of erosion or deposition of material? If so, what type of material is evident?
- Does the waterway appear to be stable in location?
- Is the low flow channel likely to alter in location?
- Is the waterway consistent in appearance, or are there pool and riffle sequences?

Hydraulic characteristics relate to the actual flow within the waterway. It is important to note that most field inspections occur during times of little or no flow and, hence, the data collected is unlikely to provide a good indication of flood characteristics. Hydraulic characteristics include:

- flow depth
- velocity (note locations where velocities show variation)
- backwater effects (that is, inundation by downstream water levels, which may drown out or control upstream water levels), and
- nature and state of vegetation within channel / floodplain.

The environmental characteristics of a waterway may also be characterised by its water quality, soils and vegetation. These are discussed in subsequent sections.

6.5.7 Catchment Data

Addition

Topography

The collection of topographic data is relevant to the assessment of both flow and the potential for erosion. Topographic information is required to allow catchment definition and, in the absence of survey, an assessment of the longitudinal gradient of waterways.

Topographic data is normally obtained from digital terrain models. These are based on aerial laser survey and photography and are often held by relevant state and local authorities or created for specific projects. In the absence of any accurate topographic data, less accurate information from the Shuttle Radar Topography Mission (SRTM) can be used to delineate catchment boundaries and estimate stream slopes.

Survey

In obtaining survey for a project, reference should be made to the current departmental surveying standards. In particular, reference should be made to the relevant geomatic survey section, as well as the general information section. These standards are available on the department's intranet and internet sites. The geomatic type, 'Bridge Surveys', provides comprehensive details as to the requirements for bed levels, bed gradient and channel cross-sections. Reference is also made to the need to identify additional information as described in other sections of this chapter.

When specifying requirements for survey, it is important to ensure that cross-sections are surveyed perpendicular to the direction of flow, both within the channel and on the floodplain.

The most appropriate and cost-effective method of data capture should be assessed for each project. Options include traditional ground survey, photogrammetry and Airborne Laser Scanning / Light Detection and Ranging. Also, any existing geographical data (within GIS) should be reviewed.

For advice and/or additional information, refer to the regional or district survey manager and/or Geospatial Technologies Unit within the Engineering and Technology Branch of Transport and Main Roads.

Aerial imagery

Aerial imagery is a valuable source of information for the design and assessment of drainage infrastructure, though it is important to be aware of the dates and times at which the image was captured. Aerial imagery may be used to determine, at the time of capture:

- extent, density, and patterns of vegetation
- delineation of overland flow paths
- locations of active erosion (such as meanders)
- waterway dimensions where access is poor, and
- land use.

Historical photographs and imagery can also be a valuable source of information in relation to assessing historic flood heights, flow patterns, and waterway characteristics.

Care must be taken in the assessment, where the date and time of the capture is not known. Field inspections should be used to confirm the currency of existing information.

Vegetation

The vegetation surrounding a project site reduces raindrop impact on the soil, as well as stabilising the soil. These factors are important in erosion control. The vegetation also filters runoff containing sediment. Knowledge of the vegetation characteristics of the project site:

- assists in the determination of the existing degree of disturbance (if any) of the site and its potential for erosion
- enables the protection of species with conservation significance
- guides the selection of species for revegetation
- assists in determining roughness (Manning's Equation's 'n')
- contributes to the determination of the coefficient of runoff, and
- assists in the identification of constraints to drainage design.

The collection of vegetation data, both terrestrial and aquatic, is an important process. This data is then used in other assessment and design processes referred to in this manual.

The environmental assessment for a project should gather the following data (with mapping) where possible:

- extent and location of all vegetation types (terrestrial, littoral, intertidal, aquatic, trees, shrubs, vines, and grasses) in and around the road environment
- description and location of any vegetation corridors that traverse the road environment
- description of the conservation significance of vegetation communities within the study area
- description of any rare or endangered species
- extent and location of any cleared vegetation and incidence of exotic species and weeds, and
- description and location of flora used traditionally for food, spiritual and/or cultural purposes.

Natural Soils

Information on the distribution and description of soils within Queensland is available from the Department of Transport and Main Roads, DES and CSIRO.

Soil information may be available, from these organisations, in the following formats:

- printed hardcopy maps produced following soil surveys of specific study areas
- published soil survey reports that accompany the maps and describe the soil mapping units in more detail – some of these reports also contain chemical and physical analytical data for samples taken from soil profiles representing the major soils present within the study area
- digital GIS soil maps of specific study areas, most commonly provided as either ArcInfo Export, ArcView / ArcMap Shape or MapInfo TAB files
- digital GIS databases associated with the maps and often providing additional information such as landform, geology, dominant soils within each mapping unit, associated soils and the proportion of the mapping unit that each cover

- digital ACCESS databases that contain additional information for the mapping units, and
- digital ACCESS databases that provide soil profile information for all sites recorded as part of the soil survey.

Specific soil maps and associated reports have also been produced for selected transport corridors.

Care should be taken when using published soils information as the quality of the data may vary due to:

- original purpose of the survey
- mapping scale (or level of intensity) of the survey information, and/or
- methodology used in the survey.

Any associated chemical laboratory methods may vary over time and should be checked before proceeding with data interpretation.

Acid Sulphate Soil Information

Refer to Section 3.8.6 of this supplement.

Existing Infrastructure

At all locations, it is important to identify existing infrastructure and PUP, which may act as constraints to the design and location of future drainage measures. At all sites, it is important to note the location and existence of:

- adjacent dwellings or other buildings with floor levels
- existing culverts and bridges
- infrastructure associated with the supply of services such as communications, gas, water supply and sewerage
- industrial pipelines, and
- irrigation infrastructure.

The existence of infrastructure may exert a strong influence on the design of hydraulic structures. Constraints can include:

- maximum allowable upstream water levels (for example, based on potential for flooding of existing buildings and infrastructure)
- obstructions to flow
- diversion of flow, and
- need to maintain pedestrian safety.

For larger projects, it may also be necessary to obtain details of major infrastructure, such as dams or weirs.

6.5.9 Environmental Data

Addition

For every infrastructure project, the department has a responsibility to consider the project’s potential environmental effects and/or impacts and to then develop appropriate mitigating measures as necessary. Therefore, an environmental assessment for the project is required and this assessment should be undertaken as early as possible in a project's development.

Vegetation

Refer to Section 6.5.7 of this supplement.

Fauna

Recognition of the impacts of road corridor development on fauna populations has led to modifications in the way that roads are now designed. Fauna can influence drainage design significantly.

Research has been undertaken on developing practices that help facilitate fauna movement through passages in the road corridor via drainage structures in a way that minimises fauna mortalities on the road. The provision of fauna passage is important and may influence the physical dimensions of a drainage structure.

The location of drainage structures and discharge points may also affect fish or bank-dwelling species such as platypus.

Again, the environmental assessment for a project should gather the following data (with mapping) where possible:

- species diversity and abundance for terrestrial, littoral, intertidal and aquatic and avifauna
- description and location of any rare or endangered species
- fish habitat / passage requirements
- occurrence, distribution, and requirements for migratory species
- species important for traditional, recreational and/or commercial fisheries, and
- any local terrestrial, aquatic or avifauna used traditionally for food, spiritual and/or cultural purposes.

6.5.10 Field Investigations and Site Inspections

Addition

Field inspections of catchments, existing drainage and possible sites within a proposed project area are essential for the planning of major drainage works and for the design of all drainage systems.

Field inspections provide opportunities to understand the site and to assist in formulating the risk profile for the project. Where possible, field inspections by the designer should be organised to be completed in conjunction with field survey, soil and environmental investigations to provide a more integrated data collection process.

More specifically, site inspections allow the designer to:

- obtain an appreciation of the site and its constraints
- validate the reliability and currency of existing records and information (including anecdotal information)
- verify characteristics and parameters that are to be used in the drainage planning and design process

- speak to landowners regarding site issues, drainage, and flooding history, and/or
- identify and photograph site features that may impact on the selection of future drainage infrastructure.

In particular, field inspections should focus on obtaining an understanding of:

- drainage patterns
- waterway characteristics
- evidence of flooding through existence of debris level
- evidence of erosion or deposition
- soil types
- extent and type of vegetation including vegetative communities
- potential sources of debris
- existing infrastructure
- location and level of adjacent buildings, and
- locations for future controls (such as retardation or sediment basins).

6.6 Hydrology Methods for Road Drainage and Flood Design

6.6.1 Introduction

Addition

Hydrologic analysis shall be undertaken in accordance with the latest version of Transport and Main Roads *Hydrologic and Hydraulic Modelling* Technical Guideline, available on the department's website.

6.7 Design Inputs

6.7.9 Recommended Methods for Specific Road Design Applications

Addition

Regarding the use and applicability of the Rational Method for departmental projects, the Rational Method as a primary flow estimation method is only supported for small rural catchments, or small developed / artificial catchments in the road corridor with times of concentration of up to 30 minutes. Also, the Rational Method as a validation method of a flow estimation is supported for longitudinal drainage or for small rural catchments with catchment areas of up to 25 km² and/or corresponding times of concentration of less than two hours.

Refer to QUDM for further details regarding Rational Method calculations and examples.

6.10 Specific Design Issues

6.10.1 Flood Impact Criteria

Addition

The discussion in this section of Austroads *Guide to Road Design – Part 5* is generally accepted as a best-practice guideline. Please note, however, that the various suggested acceptable impact limits quoted in this section of Austroads *Guide to Road Design – Part 5* (including Table 6.19) do NOT represent departmental policy – Transport and Main Roads sets allowable afflux / impact targets on a project-by-project basis.

State transport projects in Queensland are delivered under the *Transport Infrastructure Act* 1994 (Qld) (TIA). In relation to the department fulfilling its obligations under TIA in relation to transport infrastructure, the department is to ensure value for money when applying resources to the construction, maintenance, and operation of transport infrastructure.

Regarding hydraulic impacts / afflux, the obligation of the department is to minimise impacts (outside of the transport corridor) to the extent reasonably practicable. The department also wishes to minimise risk associated with any common law stormwater / flooding nuisance claims arising from adjacent property holders.

Allowable afflux / impact targets are set on a project-by-project basis, considering issues including local council requirements (under local planning schemes), existing and proposed land use, precedent, and best-practice guidelines. The department's typical impact targets are to achieve minimal / no impact for design flood events up to 1% AEP, and to avoid excessive or severe impacts for design flood events between 1% and 0.05% AEP (or more extreme events if deemed appropriate).

The department will typically assess cross-drainage options and iterate a design in order to achieve a minimum impact for a given context. Reducing the afflux may lead to higher costs for drainage infrastructure and it may be impossible to reduce the afflux at some sensitive locations, even with extensive mitigation measures. In these cases, careful assessment of the hydraulics and potential impacts is needed to determine what is reasonably practicable and the residual risks. In areas where residual impacts remain, it is important to demonstrate and document why the adopted option is preferred and why other options are not preferred. Mitigation measures should also be investigated and implemented where possible. Consultation with impacted landholders is a project-by-project decision driven by the district communications team and the communications plan for the project.

References

Transport and Main Roads publication references refer to the latest published document on the departmental website (www.tmr.qld.gov.au)

Addition

Austroads. (2019). *Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures*. Sydney, NSW

Austroads. (2023). *Guide to Road Design. Part 5: Drainage – General and Hydrology Considerations*. Sydney, NSW

Austroads. (2023). *Guide to Road Design. Part 5A: Drainage – Road Surface, Networks, Basins and Subsurface*. Sydney, NSW

Austroads. (2023). *Guide to Road Design. Part 5B: Drainage – Open Channels, Culverts and Floodways*. Sydney, NSW

Brisbane City Council. (1996). *Environmental Best Management Practice (Volume 1) for Erosion and Sediment Control and for Waterways and Wetlands*. Brisbane: Brisbane City Council

Camp, Dresser, and McKee. (1993). *California Storm Water Best Management Practice Handbooks: Municipal* (prepared for California Stormwater Quality Task Force). Unknown

Department of Agriculture and Fisheries. (2018). *Accepted development requirements for operational work that is constructing or raising waterway barrier works*

Department of Environment and Heritage Protection (QLD). (2012). *Queensland Coastal Plan*

Department of Environment and Science. (2009). *Queensland Water Quality Guidelines* (QWQG). Brisbane: EPA

Department of Environment and Science. (2014). *Stormwater Guideline – Environmentally Relevant Activities*

Department of Main Roads. (1997). *Roads in the Wet Tropics – Planning, Design, Construction, Maintenance and Operation Best Practice Manual*. Brisbane: Queensland Government

Department of Main Roads. (2000). *Fauna Sensitive Road Design, Volume 1 – Past and Existing Practices*. Brisbane: Queensland Government

Department of State Development, Infrastructure, Local Government and Planning (QLD) (DSDILGP). (2017). *State Planning Policy*. Brisbane: Department of State Development, Infrastructure, Local Government and Planning

Department of Transport and Main Roads. *Criteria for Inspection, Life Extension and Rehabilitation of Circular Corrugated Metal Culverts*. Brisbane: Queensland Government

Department of Transport and Main Roads. *Design Criteria for Bridges and Other Structures*. Brisbane: Queensland Government

Department of Transport and Main Roads. *Climate Change Risk Assessment Methodology* (Engineering Policy 170). Brisbane: Queensland Government

Department of Transport and Main Roads. *Climate Change Risk and Adaptation Assessment Framework for Infrastructure Projects*. Brisbane: Queensland Government

Department of Transport and Main Roads. *Environmental Process Manual*. Brisbane: Queensland Government

Department of Transport and Main Roads. (2010). *Fauna Sensitive Road Design Manual Volume 2*. Brisbane: Queensland Government.

Department of Transport and Main Roads. *Hydrologic and Hydraulic Modelling Guidelines*. Brisbane: Queensland Government.

Department of Transport and Main Roads. *Road Asset Management Contract* (RAMC). Brisbane: Queensland Government

Department of Transport and Main Roads. *Road Landscape Manual*. Brisbane: Queensland Government

Department of Transport and Main Roads. *Road Maintenance Performance Contract* (RMPC). Brisbane: Queensland Government

Department of Transport and Main Roads. *Supplement to Austroads Guide to Bridge Technology, Part 8, Chapter 5: Bridge Scour*. Brisbane: Queensland Government

Department of Transport and Main Roads. Technical Specification MRTS52 *Erosion and Sediment Control*. Brisbane: Queensland Government

Engineers Australia. (2006). *The Australian Runoff Quality – A guide to Water Sensitive Urban Design. Australia*, Engineers Australia

Environmental Protection Agency (NSW). (1997). *Treatment techniques, Managing urban stormwater series*. Sydney

eWater. (2008). *Catchment Modelling Toolkit*. Canberra: eWater Cooperative Research Centre (CRC)

Frankcombe, M., and Coventry, R. 2001. Townsville City Council, Revegetation Contractors, Natural Resource Assessment, Catchments & Creeks. *Erosion and Sediment Control Planning for North Queensland*. Unknown

Horner, R. R., Skupien, J. J., Livingston, E. H., and Shaver, H. E. (1994). *Fundamentals of urban runoff management*. Washington DC: Terrene Institute

IECA (Australasia). (2008). *Best practice erosion and sediment control*. International Erosion Control Association (Australasia)

Institute of Public Works Engineering Australasia (IPWEAQ). (2017). *Queensland Urban Drainage Manual* (QUDM), 4th Edition 2016

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844

Moreton Bay Waterways and Catchments Partnership (MBWCP). (2006). *Water Sensitive Urban Design – Technical Design Guidelines for South East Queensland*. Brisbane: Moreton Bay Waterways and Catchments Partnership

Mudgway, L. B., Duncan, H. P., McMahon, T. A., and Chiew, F. H. S. (1997). *Best Practice Environment Management Guidelines for Urban Stormwater*. Australia: CRC for Catchment Hydrology

Peterson, S., and Batley, G.E. (1993). *The fate of endosulfan in aquatic ecosystems*. Environmental Pollution, 82(2), pp.143-152

Queensland Government. *Environmental Protection Act* 1994 (Qld).

Queensland Government. *Environmental Protection (Water) Policy* 1994 (Qld).

Queensland Government. *Transport Infrastructure Act* 1994 (Qld).

Schueler, T. R., Kumble, P. A., and Heraty, M. A. (1992). *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Non-point Source Pollution in the Coastal Zone*. United States of America: US Environment Protection Authority

Victoria Parliament Standing Committee on Rivers and Catchments. (1991). *Guidelines for stabilising waterways*. Armadale: Rural Water Commission of Victoria

Water by Design. (2014). *Bioretention Technical Design Guidelines* (Ver.1.1). Healthy Waterways Ltd. Brisbane, QLD

Wong, T. H. F. (2000). *Improving Urban Stormwater Quality – From Theory to Implementation*. Water – Journal of the Australian Water Association, Vol. 27 No. 6, November / December 2000, pp.28–31

Wong, T., Fletcher, T., Duncan, H., Coleman, J., and Jenkins, G. (2002). *A Model for Urban Stormwater Improvement Conceptualisation* (MUSIC) (Version 1.00). Melbourne: CRC for Catchment Hydrology

Wright, I., Davis, P., Jonasson, J., and Findlay, S. (2010). *Impact on runoff quality by the concrete drainage system*. Proceedings of Stormwater 2010, 1st National Conference of the Stormwater Industry Association of Australia, November 2010. Sydney, NSW

Appendix B – Drainage Construction Material Considerations

Addition

Refer to Section 3.6.7, Section 3.6.8 and Section 3.6.12 of RPDM Volume 3, Part 5B *Drainage – Open Channels, Culverts and Floodway Crossings* for amendments.

Appendix D – Rational Method Background and Application

Addition

The materials in this section are superseded and are for information only. Refer to QUDM for further details regarding Rational Method.

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