Department of Transport and Main Roads

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Natural Disaster Program Design and Eligibility Guidelines

Program Management and Delivery

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AMENDMENT RECORD

Rev No.	Summary of amendments
A	Initial Draft (based on existing design guidelines)
B	Draft (based on input/advice received from TMR E&T)
C	2nd draft (Response to feedback/comments received from TMR E&T; RPOs; Training Awareness sessions)
1.0	Full release (Response to ARRB's review of the guidelines and response to feedback/comments received from TMR E&T and RPOs)
2.0	Updates to funding eligibility for road widening, inclusion of amendments notices, and other specific changes
3.0	Updates of funding eligibility and additional scenarios, with major review of design guidelines and removal of components now covered in other TMR design manuals
4.0	Updates to eligibility section in line with DRFA, review of design content, updates links to related documents and contact details
5.0	Updates to remove NDRRA references, include additional eligibility examples, review design content, and update links to related documents and contact details
5.1	New appendix with additional guidance on eligibility of treatments on unsealed roads
6.0	Updates to reference betterment and subgrade replacement, review design content and update links to related documents
6.1	Updates to clarify eligible expenditure requirements.

Revision Register and Amendment Notices:

Revision 6.1 includes additional guidance on eligible expenditure requirements. This guideline provides an overview of key design and eligibility principles, with links and references to the relevant business-as-usual TMR guidelines and manuals where design criteria are outlined in further detail.

To ensure you are using the most current version of this guideline, refer to the Natural Disaster Program SharePoint site on PDO Connect.

Notice:

This guideline is the Department of Transport and Main Roads' reference for people engaged in the planning and delivery of natural disaster works funded under the Disaster Recovery Funding Arrangements (DRFA). It is acknowledged that this guideline will not cover all situations and additional reference materials may need to be examined and/or relevant experts consulted, as required.

This guideline is not a substitute for professional expertise and skills of qualified practitioners for the planning and delivery of natural disaster works.

Where there are (unintended) inconsistencies between this guideline and the Australian Government *DRFA Determination*, the Determination will prevail.

The purpose of this guideline is to provide guidance for all DRFA-funded projects to be designed and built in accordance with an agreed set of corporate standards that include considerations of local circumstances. Competent planners and designers should apply this guideline to the particular circumstances of a DRFA-funded project. Variations from the design intent of this guideline will require the appropriate approval from the District Director or delegate.

Contents

1. Introduction

1.1 Background

The Natural Disaster Program (NDP) responds to damage caused to the state-controlled road network as a result of natural disaster events activated under the Disaster Recovery Funding Arrangements (DRFA), which are jointly funded by the Commonwealth and Queensland Governments.

Transport and Main Roads (TMR) seeks funding under these arrangements to help communities recover from the effects of eligible natural disaster events by reconstructing infrastructure assets to their pre-disaster function.

TMR applies a three-stage response to natural disaster events to align with TMR's emergency management framework and requirements of the Commonwealth funding process:

- Incident response – TMR immediately begins traffic management, checking for damage and restoring access to the transport network after weather events.
- Emergency works – temporary repairs to return the network to a safe and trafficable condition. Emergency works must be completed within three months from the date the essential public asset becomes accessible. Immediate reconstruction works to fully reconstruct an essential public asset within the emergency works period may only be undertaken with written approval from the NDP Team.
- Reconstruction works – permanent treatments to restore or replace damaged assets. Reconstruction works must be completed within two financial years after the end of the financial year in which the relevant disaster occurred, unless specified otherwise.

The Queensland Reconstruction Authority (QRA) coordinates the Queensland Government's program of infrastructure reconstruction within disaster-affected communities and is responsible for administering funding on behalf of the Commonwealth Government.

The NDP Team within Program Management and Delivery (PMD) in Program Delivery and Operations (PDO) Branch oversees delivery of the natural disaster program of works by PDO districts.

1.2 Purpose

The purpose of these guidelines is to:

- provide guidance on the eligibility of natural disaster works and case examples
- provide guidance on the engineering criteria for planning, design and delivering works funded under the DRFA.

The guidelines have been developed with the following intentions:

- To clarify what works are considered eligible under the DRFA.
- To reference current TMR design documents whenever possible to minimise repetition
- To include new design criteria that have not yet been released into the various TMR design documents.

1.3 Funding sources

There are three potential funding sources for natural disaster works:

- Category B (Reconstruction of Essential Public Assets) under the DRFA – this is the major funding source for reconstruction activities and can be used to return assets to their pre-disaster function
- Category D (Exceptional Circumstances) under the DRFA – where certain criteria are met, disaster-damaged assets may be rebuilt to be more resilient to future disaster events through a betterment program

- Complementary funding e.g. Queensland Transport and Roads Investment Program (QTRIP) funding – this is used to fund improvements to the road network or other complementary works.

1.4 Structure and application

This guideline is for natural disaster works – that is, for use on parts of the state-controlled road network that have been damaged by an activated natural disaster. These guidelines are presented in the following parts:

PART A – ELIGIBILITY

This part provides an overview of the funding sources and funding eligibility for the key components generally covered in reconstruction of the road network following an activated disaster event. It also provides advice on the eligibility of different types of expenditure. It is expected that not all work or expenditure types are covered within this section – where there is potential ambiguity in the eligibility of any works or expenditure, contact the NDP Team in PMD.

PART B – DESIGN

This part is structured by each key design component involved in reconstruction activities that are generally involved with natural disaster works. This part includes design criteria that are unique to natural disaster works and references where the technical design information and criteria are currently located in other TMR design manuals and guidelines. Where there is any ambiguity in the design criteria to be adopted, contact Engineering and Technology (E&T) Branch or the senior design personnel in the district.

Some districts may determine that elements of the new design criteria in these guidelines are fit-for-purpose for use on QTRIP projects. Where this occurs, District Director approval must first be given before applying the criteria to QTRIP projects.

Objectivity and consistency in the application of the technical guidelines is extremely important. However, it is recognised that there will be subtly different solutions submitted across the state due to specific local circumstances.

PART C – DESIGNING FOR RESILIENCE

This part provides information to assist designers to improve the resilience of TMR infrastructure. Part A – Eligibility is to be the governing factor as to what component of the resilience works can be claimed under the DRFA or should be considered as part of a betterment program (if available) or complementary works.

PART D – COMPLEMENTARY WORKS

Complementary works seek to improve the standard of existing infrastructure. This part provides guidance and criteria for work types that may be undertaken for which DRFA funding cannot be claimed. Such works, which are titled ‘complementary works’, are funded through QTRIP.

PART E – APPENDICES

Additional information referenced throughout Parts A–D.

1.5 Fitness for purpose

Generally, there is sufficient flexibility in the guidelines for fit-for-purpose solutions to be designed. These guidelines will not (indeed, cannot) explicitly cover every situation that will be encountered. All design is a compromise between the ideal and what is fit for purpose and affordable. Relevant engineering experience, professional judgement and an understanding of the technical fundamentals, principles and safety aspects of design criteria and practices are necessary when making trade-offs between competing priorities. Importantly, reconstruction solutions must not create any increase in safety risk than existed prior to the activated natural disaster event.

With constrained budgets, application of the guidelines to the damaged network requires compromises and some residual performance risks will remain. It is expected that experienced practitioners working with district staff will apply the guidelines to deliver fit-for-purpose outcomes within available budgets. Where it is not possible to achieve the requirements of the guidelines, the following may be required:

- Adoption of a design exception/s, if able to be justified and suitable mitigating devices are used
- Adoption of a lesser work type e.g. a basic maintenance solution in lieu of reconstruction and/or

- Identification of treatments to be implemented in future QTRIP programs.

All such decisions must be agreed with the district and may be justified by the suitability of the residual risks and/or by whole-of-life cost considerations.

1.6 Safety

As a minimum, the existing level of safety is to be maintained, however additional safety intervention levels may be required where safety deficiencies exist. *TMR Road Safety Policy* specifies minimum safety standards required to manage safety risks. The DRFA will fund safety treatments to mitigate new risks caused as a direct result of the activated event (where the treatments satisfy funding eligibility criteria) to ensure that this outcome is achieved. If mandated by recognised legislation and building codes, DRFA funding may be available to fund the provision of low-cost treatments to enhance safety. Where the safety initiatives do not satisfy eligibility criteria, complementary funding should be considered.

If a road safety audit identifies costly design solutions for implementation, complementary works funding should be sought.

1.7 Interaction with other programs and guidelines

When planning and undertaking natural disaster works, districts should consider other current or proposed TMR business programs (e.g. Maintenance, Preservation and Operations, Safer Roads Sooner and Black Spot). Where natural disaster works and one or more of these other programs overlap or are in close proximity, greater project efficiency will usually result if the works are coordinated, rather than undertaken as separate projects.

1.8 Responsibilities

Various responsibilities are detailed throughout the guidelines and summarised below. Please note that this is not an exhaustive list and additional responsibilities are likely to apply.

1.8.1 District Director or Delegate

The responsibilities of the District Director or delegate, include the following:

- Ensure the works undertaken and included in funding submissions are eligible for reimbursement under the DRFA. Where works are considered ineligible by the administrating authority, these funds will need to be transferred out of the Natural Disaster Program and into the district's QTRIP.
- Approval of variations from the design intent of this guideline (e.g. reduced design lives for structural design of pavements, reduced cover over expansive clay subgrades, staged works)
- Sign-off acceptance of documentation justifying where Extended Design Domain (EDD) or Design Exceptions (DE) are to be used or retained – EDD design criteria and DE processes are covered in detail in the *TMR Road Planning and Design Manual (RPDM) 2nd Edition*. Guidance for capturing and registering EDD and DE Reports is found in TMR's *Drafting and Design Presentation Standards Manual* (DDPSM).
- Secure funding and approvals to undertake natural disaster works and complementary works
- Sign-off acceptance of decisions to delay responses to risks identified in new or existing road safety audits or to implement low-cost solutions as relevant
- Approve the use of relevant supplementary requirements in contract documents.

1.8.2 Registered Professional Engineers in Queensland (RPEQ)

The responsibilities of RPEQs involved in the design and delivery of natural disaster works include but are not limited to certifying the following:

- Use of EDD
- Design exceptions

- Pavement designs and pavement rehabilitation designs
- Roadside safety barrier designs
- Engineering drawings
- Sprayed bituminous surfacing treatments and notification of deviation from the requirements of TMR and Austroads guidelines
- Structural assessment
- Structural design works
- Level 3 structural inspections
- Design documents as per TMR's Geotechnical Design Standards
- Built retaining structures by the Contractor's RPEQ Geotechnical Engineer who carried out the design and supervised the construction (i.e. works constructed as per the specifications and design requirements, including the foundation bearing requirements).

1.9 Key documentation

Key documents of relevance to these guidelines are listed below.

1.9.1 Key policy documents

Key policy documents referenced in these guidelines include:

- Australian Government Disaster Recovery Funding Arrangements Determination 2018
- Australian Government Disaster Recovery Funding Arrangements Guideline 1 – An Essential Public Asset
- Queensland Disaster Relief and Recovery Guidelines 2018

1.9.2 TMR NDP documents

Specific NDP documents referenced in these guidelines are available on the NDP SharePoint site and include:

- NDP Blueprint and Program Management Plan
- NDP Submission Guidelines
- NDP Evidence Capture and Review Guidelines

1.9.3 Corporate documents

Key corporate documents (other than NDP documents) referenced in these guidelines include:

- Queensland Transport and Main Roads Investment Program (QTRIP)
- TMR Road Safety Policy

1.9.4 Design documents

Key design documents (other than NDP documents) referenced in these guidelines include:

- Drafting and Design Presentation Standards Manual (DDPSM)
- Bridge Scour Manual
- Design Criteria for Bridges and Other Structures in Scope of Works and Technical Criteria (SWTC)
- Geotechnical Design Standard - Minimum Requirements
- Manual of Uniform Traffic Control Devices (MUTCD), MUTCD supplements and TRUM notes
- Pavement Design Supplement (PDS)
- Pavement Rehabilitation Manual (PRM)

- Road Maintenance Performance Contract (RMPC) Manual
- Road Planning and Design Manual (2nd Edition) (RPDM)
- Standard Drawings
- Standard Specifications
- Technical Notes

More specific technical policies, standards and guidelines are referenced in the relevant sections of these guidelines.

1.9.5 Other design documents

Other key design documents referenced in these guidelines include:

- *Australian Standard 1597.1 Precast Reinforced Concrete Box Culverts - Part 1: Small Culverts*
- *Australian Standard 1597.2 Precast Reinforced Concrete Box Culverts - Part 2: Large Culverts*
- *Australian Standard 3600 Concrete Structures*
- *Australian Standard 5100 Bridge Design Code*
- *Austroads Guide to Pavement Technology*
- *Austroads Guide to Road Design*
- *Austroads Guide to Road Safety*
- *Austroads Guide to Bridge Technology*
- *Road and Traffic Authority (NSW) Slope Risk Assessment Methodology*.

PART A – ELIGIBILITY

2. Funding categories and principles

2.1 Introduction

There are three potential funding sources for natural disaster projects:

- Category B (Reconstruction of Essential Public Assets) under the DRFA
- Category D (Exceptional Circumstances) under the DRFA
- Complementary funding (sourced from QTRIP).

These are discussed in the following sections.

2.2 Category B Reconstruction of Essential Public Assets (REPA) funding

Category B of the DRFA will provide funding equivalent to reconstruct an essential public asset to its pre-disaster function. Therefore, the pre-disaster function must be determined to establish the proposed treatment and subsequent estimated reconstruction cost. It is important to note that pre-disaster condition of the asset is still an important factor, and evidence of the asset's condition prior to the disaster event is required as part of the funding claims process.

To assist states in defining the pre-disaster function of assets, the Commonwealth Government has developed an essential public asset function framework. The framework focuses on two key components:

- primary asset function – category and sub-categories/purpose of the asset
- classification – level of service the asset provides (type, capacity, layout and materials).

For TMR assets, the primary asset function category would be Transport. The subcategories would then be dependent on the type of asset (e.g. road, bridge, culvert).

The assets are classified by the level of service provided to the community by detailing the asset type, capacity, layout and materials.

The primary function of the asset is the key consideration when assessing the specific asset type. For example, a road may be classified based on its primary function as an arterial road, a sub-arterial road or a local road. A road may also be classified based on the services being provided to the community before the disaster event, such as road for vehicular traffic, bicycles and pedestrians. A road may also be classified based on the geometry and materials used for construction, such as a four-lane asphalt concrete highway or a two-lane sealed local road.

Defining the asset layout and materials is strongly linked with the capacity of the asset. The engineering specifications of the asset that need to be captured include:

- dimensions and layout
- materials used
- road infrastructure, including barriers, signage, signalling, lighting, noise attenuation, drainage
- footpaths and bikeways.

Refer to *Section 3* for the interpretation of eligible natural disaster works and case examples.

2.3 Category D Exceptional Circumstances (Betterment) funding

For certain disaster events, funding may be made available for betterment works under Category D (Exceptional Circumstances) of the DRFA. The objective of betterment funding is to restore essential public assets damaged by eligible events to a more resilient standard to enable them to better withstand future disaster events. For a site to be considered for betterment funding (if available), the asset must meet the definition of an essential public asset and have sustained damage as a direct result of the DRFA-activated event.

To find out if betterment funding is available and the criteria that apply, contact the NDP Manager (REPA).

2.4 Complementary funding

Works deemed necessary but not eligible for DRFA funding will need to be considered for complementary funding. The source of complementary works funds may be QTRIP complementary funding.

To secure QTRIP complementary funding, follow internal district processes.

3. Funding eligibility

3.1 Introduction

The purpose of this section is to assist with differentiating works that are eligible for DRFA funding from those that are required to be funded as 'complementary works'. All of the work types and case examples assume that the essential public asset (or part of) has been directly damaged by the activated event and there is sufficient evidence to support this fact.

To make funding claims for eligible works, photographic evidence of the degree and extent of damage is required to be captured in the Recording Asset Damage and Restoration TMR (RADAR TMR) application. As outlined in the *NDP Evidence Capture and Review Guidelines*, this evidence must demonstrate that the damage was caused by the eligible event, be captured within specified timeframes and show the completed works are eligible and within approved scope.

3.2 Pavements

Funding eligibility for pavements is provided in Table 1. Case examples are provided in the following sub-section. Additional guidance on the eligibility of treatments on unsealed roads is provided in Section 40 *Unsealed roads – REPA works eligibility guidance notes*.

Table 1: Pavement work types and funding eligibility

Type	Pavement work type	Eligible REPA natural disaster works	Betterment/Complementary works
1	Part-width pavement rehabilitation (Scenario 3.2.2)	Works limited to where isolated pavement failures occur. Such failures include potholes, depressions and bumps, rutting and shoving of pavement and/or asphalt. Width of treatment can be established by width of proposed construction equipment.	If a higher-order work type is chosen. Work to areas that have not been damaged by the event.
2	Half-width pavement rehabilitation (Scenario 3.2.4)	Where there is consistent event-related damage along a segment/s of the cross-section. e.g. • rehabilitating one-lane of a two-lane carriageway • rehabilitating inner and outer wheel paths or shoulders.	If full-width pavement rehabilitation is chosen. Work to areas that have not been damaged by the event. Full-width pavement sealing should be considered in these situations.
3	Full-width pavement rehabilitation (Scenario 3.2.1)	Where there is visible event-related damage across the full width of the carriageway and of a continuous basis.	Work to areas that have not been damaged by the event.
4	Gravel re-sheet – unsealed road (Scenario 3.2.3)	Works to restore the gravel road surface and formation where it can be demonstrated that the road was in a serviceable condition with an appropriate depth of gravel atop.	Re-sheeting of the road where there is no evidence of a reasonably maintained gravel depth pre-disaster and/or there is no demonstration of an effective maintenance regime (i.e. medium or heavy formation grading). Works to widen the formation or seal the road.
5	Change from a road with a sprayed seal surface to a road with an asphalt surface (Scenario 3.2.5 and 3.2.6)	Works to restore the road to its pre-disaster function, which included a sprayed seal surface.	Cost of asphalt works beyond the cost of restoring the road to its pre-disaster function.
6	Replacement of subgrade in area of eligible damaged pavement	Subgrade replacement may be considered eligible where the requirements of the *NDP Subgrade Replacement Procedure* are met.	Additional subgrade strengthening works that are not associated with damage sustained from a DRFA-activated event.

3.2.1 Case examples

Scenario 3.2.1

The inner and outer wheel paths in both traffic lanes of a section of two-lane carriageway have been damaged by an activated natural disaster event.

The reconstruction of the full pre-event (existing) carriageway width (i.e. using full-width pavement rehabilitation) for that section is ***ELIGIBLE*** *for DRFA funding.*

Scenario 3.2.2

There are isolated patches/areas of a road that have been damaged by a recent flood event.

The reconstruction of the part-width and the seal required (initial primer seal and follow-up overlapping seal) for those areas are ***ELIGIBLE*** *for DRFA funding.*

Where a higher-order treatment is proposed (e.g. half or full-width reconstruction) it must be demonstrated that this higher-order treatment is more cost economical than the part-width pavement rehabilitation solution. As a general guide, the part-width pavement rehabilitation works scattered over a consistent area would need to comprise at least 40% of the total pavement area to be considered **ELIGIBLE** for full-width reconstruction following demonstration of the costs of the different solutions.

Any additional seal provided to the remainder of the undamaged pavement is ***INELIGIBLE*** *for DRFA funding. (Note: seal texture differences and age and condition of remaining seal need to be considered when considering the need for a full-width seal.) The district should strongly consider the option to provide a full-width seal to enhance pavement repair, ensure integrity of pavement joints and provide a value-for-money outcome for the department.*

Scenario 3.2.3

A 50km unsealed section of road has been programmed (within the next two years) for upgrade works to seal this section. This unsealed section sustained damage during a recent event. The gravel running surface has been scoured. A decision has been made to bring the sealing works forward to be undertaken when repairing the road.

The pre-disaster standard of the road is gravel. Works to restore a gravel road are ***ELIGIBLE*** *for DRFA funding (subject to demonstration of pre-disaster condition).*

Works associated with sealing the road are ***INELIGIBLE*** *for DRFA funding as these works are above the pre-disaster standard of the road. Funding will be limited to the equivalent cost of restoring the gravel road.*

Scenario 3.2.4

The inner and outer wheel path of a single lane of a section of two-lane carriageway has been damaged by an activated event.

The reconstruction of the half pre-event (existing) carriageway width (i.e. using half-width pavement rehabilitation) for that damaged section is ***ELIGIBLE*** *for DRFA funding.*

The reconstruction of the remaining half carriageway width (i.e. using full-width pavement rehabilitation) for that undamaged section is ***INELIGIBLE*** *for DRFA funding. QTRIP complementary funding must be used for that* ***INELIGIBLE*** *part.*

Scenario 3.2.5

A bitumen-sealed intersection suffered extensive pavement damage during a recently activated flood event. A full pavement reconstruction is required. Due to recent developments on the adjoining road, the number of heavy vehicles using this intersection has increased substantially. Consequently, a 50mm asphalt wearing course has been selected for use when reconstructing.

The pre-disaster standard of the road is bitumen sealed. Reconstruction works of the pavement and initial seal cost are ***ELIGIBLE*** *for DRFA funding (subject to demonstration of pre-disaster condition).*

Costs associated with the use of a 50mm asphalt wearing course are ***INELIGIBLE*** *for DRFA funding. Funds should be sought from QTRIP complementary funding.*

Scenario 3.2.6

An 800m length of bitumen-sealed road suffered extensive pavement damage during a recently activated flood event. Reconstruction works are required. Following lab testing, multiple pavement options were considered by the designer. Reconstruct (dig-out-and-replace) options were eliminated due to known issues with unsuitable materials. Stabilisation of the existing pavement and a 150mm asphalt overlay was identified as the preferred option.

The pre-disaster standard of the road is bitumen sealed. Stabilisation of the existing pavement is ***ELIGIBLE*** *for DRFA funding. The 150mm asphalt overlay and any asphalt surfacing is* ***INELIGIBLE*** *for DRFA funding, however the cost of an equivalent granular overlay and bitumen seal is* ***ELIGIBLE*** *for DRFA funding, subject to satisfactory costings and options comparison of the pavement treatments.*

3.3 Geometry, formation and seal width

Funding eligibility for geometric, formation and seal width issues is provided in Table 2. Case examples are provided in the following sub-section.

Table 2: Geometric issues and funding eligibility

Type	Geometric issue	Eligible REPA natural disaster works	Betterment/Complementary works
6	Seal width (Scenarios 3.3.1 and 3.3.2)	Reinstatement of existing seal width	Increases in seal width above existing seal width must be sought from QTRIP complementary funding
7	Formation width (Scenarios 3.3.1, 3.3.2 and 3.3.8)	Whether overlaying or not, construction to existing formation width	Increases in formation width beyond existing width must be sought from QTRIP complementary funding
8	Opportunities to upgrade single-lane roads to two-lane roads (Scenarios 3.3.6 and 3.3.7)	Reinstatement of existing seal and formation width	Works to extend the width of seal and any necessary pavement upgrades must be sought from QTRIP complementary funding
9	Geometric elements not listed above that do not meet the *Road Planning and Design Manual* e.g. horizontal and vertical alignments, sight distance and intersection turn treatments (Scenario 3.3.4)	None, unless work can be completed for no extra cost	Any work undertaken to improve the substandard geometric parameter must be sought from QTRIP complementary funding
10	Improvements to an identified crash history (Scenario 3.3.3)	Reinstatement of existing seal and formation width, unless work can be completed for no extra cost	Higher-cost improvements must be sought from QTRIP complementary funding
11	Missing links – road sections less than 1km in length remaining between two DRFA-funded sections that require significant pavement works	None	Any works or improvements to undamaged sections must be sought from QTRIP complementary funding
12	Sight distance	None, unless work can be completed for no extra cost	Any work undertaken to improve this parameter with extra cost must be sought from QTRIP complementary funding
13	Roadside stopping places	None, unless work can be completed for no extra cost	Any additional works for lay-by areas must be sought from QTRIP complementary funding

Type	Geometric issue	Eligible REPA natural disaster works	Betterment/Complementary works
14	Land resumption	None	The cost of any land resumption/s may be sought from QTRIP complementary funding
15	Level of road safety (for example, roadside safety, intersection safety, vulnerable user safety and so on.)	All, if work can be completed for no extra cost	Any additional works (for example, layby areas) must be sought from QTRIP complementary funding

3.3.1 Case examples

Scenario 3.3.1

A full-width pavement rehabilitation is proposed on an existing 8m fully sealed road. It has been determined that a structural overlay provides the best value for money solution. It is proposed to reconstruct to the existing 8m sealed width. However, to maintain the 8m seal width and the structural overlay there is an incidental requirement to undertake some formation widening.

> *While formation widening is occurring, the pre-disaster formation width (hinge to hinge) and the pre-disaster seal width is being maintained and therefore these works are considered **ELIGIBLE** for DRFA funding.*

Scenario 3.3.2

Full-width pavement rehabilitation (including a structural overlay) is being undertaken on an existing 9.5m wide carriageway. The *TMR Design Guidelines* indicate that the absolute minimum carriageway width is the interim seal width and a value of 10m applies for this road.

> *The reconstruction to accommodate the existing 9.5m seal width is **ELIGIBLE** for DRFA funding.*
>
> *Any works greater than the 9.5m existing seal widths are **INELIGIBLE** for DRFA funding. The costs to accommodate the 10m interim seal width must be sought from QTRIP complementary funding.*

Scenario 3.3.3

The road in Scenario 3.3.2 has a significant crash history. The vision seal width is 11m. It is proposed to restore the asset to the vision seal width of 11m due to the added safety benefits that can be achieved.

> *The reconstruction to accommodate the existing 9.5m seal width is **ELIGIBLE** for DRFA funding.*
>
> *Any works greater than the existing seal widths are **INELIGIBLE** for DRFA funding. The costs to accommodate the 11m vision seal width must be sought from QTRIP complementary funding.*

Scenario 3.3.4

As a result of a decision to provide additional pavement width to satisfy interim seal width requirements, there is a requirement to widen embankments, lengthen culverts and to relocate ancillary elements (i.e. signs, realignment of drains, realignment of turning lanes, and kerb and channel) to comply with current TMR engineering standards.

> *Any embankment widening, culvert extensions and the relocation of ancillary elements beyond what is required to maintain the existing seal widths would be **INELIGIBLE** for DRFA funding.*
>
> *Where the existing seal width is being maintained but a structural overlay treatment is being adopted, any necessary widening of culverts, raising of headwalls and ancillary elements would be considered **ELIGIBLE** for DRFA funding.*

Scenario 3.3.5

Part-width pavement rehabilitation (involving boxing out of the outer wheel paths and shoulders – no overlay) is being undertaken on an existing 9.5m wide carriageway. The *TMR Design Guidelines* indicate that the general minimum carriageway width is equal to the interim seal width of 10m. A vision seal width of 11m applies to this road.

*The reconstruction to the existing 9.5m carriageway width is **ELIGIBLE** for DRFA funding.*

*Any works greater than the existing carriageway widths are **INELIGIBLE** for DRFA funding.*

Scenario 3.3.6

A single-lane road is damaged to the full formation width of 8m. The road includes a current seal width of 4m.

*The reconstruction of the full 8m formation is **ELIGIBLE** for DRFA funding.*

*The reconstruction of the 4m seal width is also **ELIGIBLE**.*

*The widening of the seal width from the 4m to the 8m formation width is **INELIGIBLE** for DRFA funding.*

Scenario 3.3.7

A single-lane road, 8m formation and 4m seal width, was damaged by a recent flood event and requires a full reconstruction. Road usage data indicates that traffic volumes have significantly increased. To accommodate the increased volumes, it is decided to widen the road to a dual-lane road, 10m formation and 8m seal width.

*The **ELIGIBLE** DRFA funding is limited to the costs to reconstruct the road to the pre-disaster widths, 8m formation and 4m seal width. The additional works associated with widening the road to accommodate an extra lane are **INELIGIBLE** for DRFA funding.*

Scenario 3.3.8

A full-width pavement rehabilitation is proposed on an existing 8m gravel unsealed road. It has been determined that a structural overlay provides the best value for money solution. It is proposed to reconstruct to the existing 8m unsealed width. However, to maintain the 8m seal width and accommodate the overlay, there is an incidental requirement to undertake some formation widening.

*As the existing unsealed width is being maintained, all works, including the formation widening, would be **ELIGIBLE** for DRFA funding. If there are culverts that are required to be extended, headwalls raised or table drains shifted to accommodate the minimum batter slopes from the structural overlay, these works would also be considered **ELIGIBLE**.*

Scenario 3.3.9

A formation grading and gravel re-sheeting is proposed on an existing 8m unsealed road. No widening is proposed. Evidence can be sourced demonstrating re-sheeting of the road within five years prior to the event.

*As the existing width is being maintained, all works would be **ELIGIBLE** for DRFA funding so long as it can be demonstrated that an appropriate thickness of gravel was maintained on the road pre-disaster. If there are no records of the history of gravel works, these works would be considered **INELIGIBLE**. In this case, only the formation grading would be considered **ELIGIBLE** for DRFA funding.*

3.4 Culverts and drainage structures

Funding eligibility for culverts and drainage structures is provided in Table 3. Case examples are provided in the following sub-section.

Table 3: Culverts and drainage funding eligibility examples

Type	Damage type	Eligible REPA natural disaster works	Betterment/Complementary works
1	Damage to end walls and scour around structurally unsuitable culverts (does not satisfy current engineering standards) (Scenario 3.4.1)	Reinstatement of end walls and scour protection	Supply and installation of new (structurally adequate) culvert components
2	Damage to full length of culvert (Scenarios 3.4.2 and 3.4.3)	Reinstatement of culvert – same diameter of pipe, same number of pipes, or same pipe class	Additional culvert cells Increased size of cells Improvements/upgrades to increase resilience and immunity Works to repair consequential damage to culvert as a result of other site works (not event-related damage)
3	Large culvert damaged (Scenario 3.4.5)	Replacement with drainage structure (e.g. bridge, box culverts) with same flood immunity (up to the value equal to culvert reinstatement works) with same or higher structural integrity	Increased flood immunity Any costs above the value of culvert reinstatement works
4	Damage to longitudinal table drains adjacent to the road (Scenario 3.4.7)	Reinstating a table drain to the same cross-sectional area unless it can be demonstrated that the cost of a larger drain is equivalent or less than the cost to restore the existing drain	Installing a table drain where none existed prior to event Conversion of a V-drain (pre-disaster) to a drain of a larger cross-sectional area (e.g. trapezoidal drain) where the costs are greater
5	Inclusion of sub-soil/ interface drainage to a damaged pavement that was not included previously	Inclusion of sub-soil/interface drainage to the current design standard and methodology for that type of pavement treatment (e.g. part-width reconstruction)	Additional sub-soil drainage for future pavement widening or additional capacity proposed in the future
6	Build-up of silt and debris	Removal of the build-up of silt and debris that is immediately abutting the drainage structure, and currently impacting on the effectiveness of the drainage structure	Removal of any build-up of silt or debris that is not in the immediate area of the drainage structure and is currently not impacting on the effectiveness of the drainage structure

Type	Damage type	Eligible REPA natural disaster works	Betterment/Complementary works
7	Scour repairs/rock protection	Where scours have occurred to the inlet and outlets of drainage structures, the excavation/ boxing out of the scour and the placement of rock protection is considered eligible where representing value for money, over the use of bulk fill. The extent of rock protection to the inlet/outlet should be limited to the scour area only and up to the level of the culvert apron.	The extension of rock protection outside the areas of the scour and over the level of the culvert apron
8	Grouted rock pitching	The placement of grouted rock pitching should only be undertaken where there is evidence that grouted rock pitching existed prior to the event. The extent of any grouted rock pitching must reflect the extent that existed prior to the event.	The placement of grouted rock pitching where it did not exist prior to the event or the increase in area of pre-event grouted rock pitching
9	Rock reno mattress	The placement of rock reno mattresses should only be undertaken where value for money cannot be achieved through reshaping the inlet/outlet by plant and labour. Where rock reno mattresses are proposed, there needs to be evidence of rock protection works (as a minimum) prior to the event and evidence that they have been damaged by the event.	Rock reno mattress in areas where there was no evidence of any form of rock protection pre-event
10	Culvert or bridge approaches	Construction to existing formation width and reinstatement of existing seal width.	Increase in seal width and formation width above existing seal and formation width must be sought from QTRIP complementary funding.

3.4.1 Case examples

Scenario 3.4.1

The end segment of a 450mm diameter culvert along with the end wall has been separated from the remainder of the culvert as a result of an activated disaster event. This has resulted in the exposure of the remainder of the culvert as well as scour to the embankment. The remainder of the culvert is structurally unsuitable due to the age of the culvert.

> *As the end cell/pipe, headwall and embankment was impacted by the flood event, then only this work (reinstatement of the existing pipe, headwall, embankment and pavement) is **ELIGIBLE** for reconstruction and DRFA funding.*
>
> *However, the unsuitable culvert must be replaced. The cost of supply and installation of the new culvert components and the additional pavement works to the site is **INELIGIBLE** for DRFA funding and must be replaced under QTRIP complementary funding.*

Scenario 3.4.2

The entire length of a two-cell 375mm diameter culvert has been damaged as a result of flood waters. The original two-cell 375mm diameter culvert was designed to 5% (Annual Exceedance Probability) AEP flood immunity. A hydraulic assessment has been undertaken subsequent to the flood event and as a result of a change in the local catchment (not caused by the disaster event) the assessment finds that to provide the same 5% AEP flood immunity an additional cell (three cells in total) is required to be constructed to comply with the current TMR engineering standards.

> *While the three-cell culvert may provide the same level of immunity, the additional cell does increase the capacity of the culvert, which is considered an improvement above the pre-disaster standard of the existing culvert.*
>
> *The replacement of the two-cell 375mm diameter culvert is **ELIGIBLE** for DRFA funding.*
>
> *The installation of the additional cell of the culvert is **INELIGIBLE** for DRFA funding.*

Scenario 3.4.3

The entire length of a two-cell 450mm diameter culvert has been damaged as a result of flood waters. The original two-cell 450mm diameter culvert was designed to 5% AEP flood immunity. The current TMR engineering standard for this location stipulates that Q50 flood immunity must be provided. This flood immunity increase requires an additional cell (3 cells in total) to be constructed to comply with current TMR engineering standards.

> *The replacement of the two cells of the 450mm diameter culvert is **ELIGIBLE** for DRFA funding.*
>
> *As the additional culvert cell provides increased capacity, it is **INELIGIBLE** for DRFA funding.*

Scenario 3.4.4

An existing two-cell 300mm culvert that was constructed pre-1974 shows signs of weathering and deterioration as a result of the age of the culvert. There are no visible signs that the recent disaster event has resulted in damage to the culvert or it being unserviceable. The culvert has been assessed as being unable to withstand the construction loading from the full pavement reconstruction works, which are eligible DRFA works.

> *The replacement of this culvert is **INELIGIBLE** for DRFA funding as it was not damaged by the disaster event. QTRIP complementary funding is to be sought for this work.*

Scenario 3.4.5

A large culvert has been made structurally unsound by a recent disaster event and the entire culvert is required to be replaced. Following an assessment of the replacement options it has been determined that a bridge structure will provide the best value for money outcome.

> *A full cost breakdown of the value for money option as well as a cost breakdown of the culvert replacement to its pre-disaster standard must be submitted for comparison. The options analysis may also be requested to demonstrate all options considered and why the bridge option was the preferred outcome.*
>
> *Providing the cost of the new concrete bridge is the same or lower than the cost of the replacement culvert, the bridge option would be **ELIGIBLE** for DRFA funding.*
>
> *If the cost of the new bridge is greater than the culvert, the **ELIGIBLE** funding is limited to the equivalent cost of replacing the culvert. The additional cost to install the bridge would be **INELIGIBLE** for DRFA funding.*

Scenario 3.4.6

A section of pavement was damaged by a recent flood event and works have commenced to repair the damage. A single-cell culvert, which was not damaged by the event, is at the same site as the damaged pavement. During the reconstruction works, the culvert and the end walls were damaged by the heavy machinery used. As a result, the damaged culvert needs replacing.

> *The cost to replace the culvert is **INELIGIBLE** for DRFA funding. The culvert was damaged by works being undertaken and not directly by the event. Damage to the culvert is known as consequential damage.*

Scenario 3.4.7

A section of V-drain adjacent to the road in flat terrain has been scoured as a result of a flood event and is contributing to the saturation and damage of the adjacent pavement. Current TMR engineering standards require a trapezoidal drain be provided in this instance. The cost of constructing the trapezoidal drain in this location is equivalent to the cost of repairing the V-drain.

*In this case, the cost of constructing the trapezoidal drain is **ELIGIBLE** for DRFA funding. A cost breakdown of each reconstruction option (trapezoidal drain vs V-drain) must be submitted to demonstrate the cost competitiveness.*

*If the cost of constructing the trapezoidal drain is more than repairing the V-drain, the additional cost would be **INELIGIBLE** for DRFA funding, and the eligible funding limited to the amount equivalent to restoring the V-drain.*

Scenario 3.4.8

There is sediment and debris build-up upstream of an inlet to a culvert. The material is not abutting the drainage structure inlet components (i.e. apron, wingwalls) and is not impacting on the effectiveness of the culvert or currently causing any damage to the drainage structure. It may in the future, in the next flood event, make its way to the culvert, when it is expected to impede the flow of water through the culvert.

*As the sediment build-up is not adjoining/abutting the structure and not impacting on the effectiveness of the culvert and has not yet damaged the essential public asset, therefore the removal of this material is **INELIGIBLE**.*

3.5 Bridges and floodways

Funding eligibility for bridges and floodways is provided in Table 4. Case examples are provided in the following sub-section.

Table 4: Bridges and floodways funding eligibility examples

Type	Damage type	Eligible REPA natural disaster works	Betterment/Complementary works
1	Bridges destroyed in the disaster event (Scenarios 3.5.1 and 3.5.4)	Full replacement of structure and damaged approaches and pavement Replacing timber structure with steel or concrete structure – contemporary construction methodology with same or contemporary methods	Providing increased carriageway width Increasing immunity (i.e. raising of bridge deck surface) Increasing length of bridge Cost of approach works where no damage from the disaster event occurred
2	Pier that has sunk or lost load capacity due to scour	Underpinning and/or reinstatement of axial and/or moment load capacity pier with same or contemporary methods/materials	Installation of additional piers to support the bridge structure
3	Damaged bridge barrier (Scenario 3.5.3)	Replacement to existing standard or equivalent (if existing is not available in market)	Replacement barrier with increased capacity Extra cost of bridge deck strengthening as a result of barrier works Cost of realignment of bridge approach barriers to current engineering requirements

Type	Damage type	Eligible REPA natural disaster works	Betterment/Complementary works
4	Embankment washout to floodway causing a gap between approach and floodway (Scenario 3.5.2)	Replacement of embankment Extension of floodway to suit changed conditions (e.g. wider water course where this is supported by an engineering report to be the only option) Repairs to floodway where damage has occurred	Improvements to the floodway (e.g. widening, increasing immunity and resilience)
5	Concrete floodway and apron undermined, batter protection (rock) washed away (Scenario 3.5.7)	Replacement of floodway where undermining has occurred, and floodways structure and integrity cannot be restored by backfilling Reinstatement of rock protection or other treatment that represents value for money considering other local factors (e.g. availability of materials)	Installation of additional batter protection or aprons to current standard and methodologies
6	Damaged pavements on floodway (Scenario 3.5.7)	Reinstatement of pavement to standard, factoring current traffic volumes and loads	Increased underdrainage (e.g. culverts)

3.5.1 Case examples

Scenario 3.5.1

A timber bridge has been made structurally unsound by a recent flood event and is required to be replaced. It is current TMR policy to replace timber bridges with concrete due to the shortage of appropriate structural timber materials and the superior whole-of-life cost-effectiveness of concrete bridges.

Replacing a timber bridge with concrete or steel instead of timber is an acceptable and eligible option under the DRFA. The application of current engineering and building standards for the purposes of DRFA-funded repairs allows flexibility to employ contemporary construction methods and materials.

The cost of the replacement concrete bridge providing the same level of service (i.e. same height, width and length) is ***ELIGIBLE*** *for DRFA funding.*

Scenario 3.5.2

A concrete floodway has been made structurally unsound by a recent flood event. The embankments at the approaches have been severely scoured and washed out, resulting in a large gap between the floodway and the eroded embankment/road. The floodway will need to be extended by 10m to cross the gap left by the erosion as the embankment cannot be safely or cost effectively restored.

The cost of repairs to the damaged floodway is ***ELIGIBLE*** *for DRFA funding. Generally, an engineering report will be required to be submitted outlining the recommendations for restoring the floodway.*

If a new floodway is proposed by the engineering report, the cost to reconstruct the floodway to the same level of service is ***ELIGIBLE*** *for DRFA funding.*

The flood event changed the surrounding environment by eroding the embankments and widening the water course. Reinstating the embankment is not a suitable reconstruction option. The other option is to extend the floodway to suit the new environment. Therefore, the additional 10m length of the floodway is ***ELIGIBLE*** *for DRFA funding.*

Any additional cost relating to any improvements of the bridge (e.g. widening, raising/increasing the level of immunity) is ***INELIGIBLE*** *for NDRRA/DRFA funding.*

*Any ongoing maintenance costs of the bridge are **INELIGIBLE**.*

Scenario 3.5.3

The barriers on a bridge have been damaged due to overtopping and debris impact. After appropriate investigations and analysis, a decision is made to replace the barriers. Current engineering standards require the bridge barriers to provide increased traffic impact capacity. Also, realignment of the bridge approach barriers is required. Because impact loading increases the loading on the bridge deck, there is a consequential need to increase the deck load capacity along both edges of the deck.

*The cost of replacement of the damaged bridge barrier using a product equivalent to the existing barrier (if available in the market) is **ELIGIBLE** for DRFA funding.*

*The cost of increasing the bridge deck capacity and alignment of the bridge approach barriers as a consequence is **INELIGIBLE** for DRFA funding.*

Scenario 3.5.4

A bridge has been badly damaged by a recent activated event and a decision is made to replace it. Investigations show it was originally designed to 5% AEP flood immunity and the current vision standard for the road link is 2% AEP flood immunity.

*The cost of replacing the damaged bridge to the existing functionality (length, width and height) is **ELIGIBLE** for DRFA funding.*

*The cost of raising the bridge to achieve 2% AEP flood immunity and consequential/additional cost of reconstructing the road approaches is **INELIGIBLE** for DRFA funding.*

Scenario 3.5.5

A bridge and abutments have been damaged and a decision is made to improve its resilience against similar future events. Investigations show it was originally designed to 2% AEP flood immunity and the actual flood event in the catchment was analysed and found to be a 2.5% AEP event.

*The cost of repair of the damaged bridge and abutments to existing 2% AEP flood immunity and commensurate resilience is **ELIGIBLE** for DRFA funding. This is the pre-event standard of the bridge. 2.5% AEP flood immunity is less than the 2% AEP.*

*Any additional costs to increase the immunity of the bridge above 2% AEP level would be **INELIGIBLE** for DRFA funding.*

Scenario 3.5.6

A recent flood event caused serious erosion around the abutments and pier footings of a bridge. The floodwaters washed away the creek banks around the pile caps and foundations. The remainder of the bridge is structurally sound with no further damage. An engineering report was undertaken that determined the required treatment should involve further piling to reinforce the footings and rock protection works.

*As an engineering report was undertaken and it was determined that the piling and the rock protection works were the most cost-effective solution, the cost to carry out the piling and install rock protection to the abutments and footings is **ELIGIBLE** for DRFA funding.*

Scenario 3.5.7

A recent flood event has significantly undermined and displaced sections of a concrete floodway and concrete apron, and washed away the rock batter protection. The structural integrity of the concrete floodway cannot be re-established by backfilling the undermined area. Full replacement is recommended.

*As the integrity of the concrete floodway cannot be restored, the replacement of the floodway (to the pre-disaster length, width and height) is **ELIGIBLE** for DRFA funding. If the structural integrity could be restored by backfilling, then eligible DRFA funding would be limited to those backfilling treatments, not full replacement.*

*Reinstatement of the rock batter protection to the pre-event standard is **ELIGIBLE** for DRFA funding.*

*The replacement of the concrete apron is **ELIGIBLE** for DRFA funding.*

3.6 Embankments and batter protection

Funding eligibility for embankments and batter protection is provided in Table 5. Case examples are provided in the following sub-section.

Table 5: Embankments and batter protection damage funding eligibility examples

Type	Damage type	Eligible REPA natural disaster works	Betterment/Complementary works
1	Damaged batters including damaged floodway protection (Scenario 3.6.2, 3.6.3 and 3.6.4)	Reinstatement of area where damage has occurred, including reinstatement of erosion measures and/or stabilisation measures	Cost of resumptions or environmental offsets
2	Damaged floodway aprons and concrete margins (Scenario 3.6.1)	Reinstatement of concrete aprons and margins where they existed prior to the disaster event	Inclusion of concrete/aprons and margins where they did not exist prior to the disaster event (e.g. additional length and/or downstream side)
3	Bridge abutment protection destroyed or damaged	Replacement with similar or cost-effective materials (e.g. rock protection) and similar surface area	Additional cost of providing materials more expensive or additional treatments to enhance resilience

3.6.1 Case examples

Scenario 3.6.1

A recent flood event eroded the rock batter protection to a concrete floodway. The floodway did not sustain any undermining or event-related damage. A concrete apron was in place on the downstream side only of the floodway, however did not sustain any damage. Current TMR standards require a concrete apron be installed on the upstream side. A concrete slab of the floodway had previously (prior to the event) been cracked. A decision was made to replace this concrete slab while workers were on site.

*Reinstatement of the rock batter protection to the pre-event standard is **ELIGIBLE** for DRFA funding.*

*Any works to the downstream side apron are **INELIGIBLE** as the apron did not sustain any event-related damage.*

*The installation of a concrete apron to the upstream side of the floodway is **INELIGIBLE** for DRFA funding. This requirement is not a legislative requirement and is above the pre-disaster standard. TMR engineering standards are not considered legislation for the purposes of DRFA eligibility. Complementary funding may be considered for these works.*

*The replacement of the cracked floodway slab is **INELIGIBLE** for DRFA funding. This damage was not caused by the event. Complementary funding may be considered for these works.*

Scenario 3.6.2

A section of road on embankment in a flood plain area is exhibiting pavement (and seal) distress following inundation by a flood event. The existing batter treatments comprise natural vegetation at some locations and rock pitching at others. The current TMR engineering standard for sections of road that are inundated on a regular basis is a form of concrete batter/margin installed on the embankment.

*The road pavement and seal damage are **ELIGIBLE** for DRFA funding as the damage is a result of the event. The pre-event condition of the road would be investigated, given the section of road is subject to regular flooding.*

*Any event-related damage to the batter would be eligible for repairs. Replacement of lost rock pitching or other treatment that represents value for money, and seeding for stabilising the damaged batter is **ELIGIBLE** for DRFA funding.*

*The proposed works to install a concrete batter/margin are above the pre-disaster standard (it was not in place prior to the event) and therefore the costs of the concrete batter/margin are **INELIGIBLE** for DRFA funding.*

Scenario 3.6.3

A section of batter has slipped/eroded as a result of a flood event. This batter had some grass cover and natural vegetation on the slope prior to the disaster. Geotechnical investigations were undertaken and an engineering report completed, which recommended soil nailing and a shotcrete protection to the batter.

*The cost of reinstating the slope adopting the recommended solutions is **ELIGIBLE** for DRFA funding. The engineering report should investigate a range of treatment options and recommend a solution that is effective and provides value for money.*

Scenario 3.6.4

A section of grass-covered embankment batter has eroded as a result of a flood event. To repair the erosion, fill material will be required and the total cost of these works is $X. To comply with current engineering standards, the batter slope needs to be flattened. To achieve this, additional fill and earthworks will be required and will cost an additional $Y. There is also some vegetation at the bottom of the batter that needs to be removed to accommodate this batter flattening. There is a vegetation offset required as a result of the removal of this vegetation.

*The cost of works to reinstate the embankment to pre-disaster condition ($X) is **ELIGIBLE** for DRFA funding providing.*

*The cost of the additional fill and additional cost $Y to repair the original erosion is generally **INELIGIBLE** for DRFA funding, however consideration will be made where a range of options has been assessed and this option provides the greatest value for money.*

*The cost of the environmental offset as a result of the clearing of the vegetation is **INELIGIBLE** as it is considered a consequential cost.*

Scenario 3.6.5

A section of batter has slipped/eroded as a result of a flood event. Geotechnical investigations were undertaken, and an engineering report completed, which recommended a 4m high gabion basket treatment is required. As a result of introducing this vertical structural treatment, guardrail (which was not there previously) is required to be installed.

*The cost of reinstating the slope adopting the recommended solutions is **ELIGIBLE** for DRFA funding, including installing the guardrail. The engineering report should investigate a range of treatment options and recommend a solution that is effective and provides value for money.*

Scenario 3.6.6

A section of batter has slipped/eroded as a result of all of the natural vegetation being stripped by a bushfire. This batter had some grass cover and natural vegetation on the slope prior to the disaster. Geotechnical investigations were undertaken and an engineering report completed, which recommended wire mesh being installed to stabilise the batter slope while natural vegetation is re-established.

*The cost of reinstating the slope adopting the recommended solutions is **ELIGIBLE** for DRFA funding. The engineering report should investigate a range of treatment options and recommend a solution that is effective and provides value for money.*

3.7 Roadside furniture, delineation and Intelligent Transport Systems

Funding eligibility for roadside furniture, delineation and Intelligent Transport Systems (ITS) is provided in Table 6. Case examples are provided in the following sub-section.

Table 6: Roadside furniture, delineation, ITS and funding eligibility

Type	Damage sustained	Eligible REPA natural disaster works	Betterment/Complementary works
1	Flood-damaged roadside safety barrier (Scenarios 3.7.1, 3.7.2, 3.7.3 and 3.7.6)	Repair or replacement of damaged sections of safety barrier Where repair is not possible, replacement to manufacturer's minimum requirements	Extensions beyond manufacturer's minimum requirements Installations where no roadside safety barrier existed previously
2	Pavement damage requiring new seals and line-marking (Scenario 3.7.4)	Line-marking equivalent to the pre-disaster standard	A line-marking design that is compliant with the TMR *Manual of Uniform Traffic Control Devices* (MUTCD) Additional line-marking above that required by the MUTCD
3	Flood damaged signs (Scenario 3.7.4)	Road signage replaced in accordance with current standards to equivalent pre-disaster quantity	Upgrading road signage arrangements, size or number to meet TMR MUTCD
3	Damaged field ITS infrastructure (Scenario 3.7.5)	Replacement of similar equipment with the same functionality Where technology/software is outdated and no longer available, the cost of an equivalent alternate product, limited to existing quantities and functionality	Improvements to field/edge network ITS devices

3.7.1 Case examples

Scenario 3.7.1

A 10m section of a 40m length of guardrail has been damaged by a recent activated flood event. The guardrail was considered compliant at the time of installation, however due to consecutive overlays carried out in maintaining the road, the height of the guardrail is no longer within the manufacturer's specified tolerances. The end treatments are also now considered non-compliant.

The repair of the 10m of guardrail is ***ELIGIBLE*** *for DRFA funding.*

The cost of replacing the remaining 30m of guardrail to comply with manufacturer's specified height is ***INELIGIBLE****.*

Replacement of the end terminals, unless damaged by the activated event, is ***INELIGIBLE****.*

Scenario 3.7.2

A 10m section of guardrail has been damaged beyond a state of repair by a recent activated event. Manufacturer's standards require 25m of guardrail be installed. In order to replace the guardrail to current engineering standards, the section of guardrail that is required to be replaced is 10m of existing + 15m additional guardrail.

> *The cost of installing the 25m length of guardrail is **ELIGIBLE** for DRFA funding.*
>
> *The cost of installing compliant end terminals is **ELIGIBLE**. An options comparison may be requested to justify the selection of the end terminals.*
>
> *Where a section of guardrail has been damaged and that type of guardrail is no longer included in TMR specifications, installation of the nearest equivalent guardrail is considered **ELIGIBLE**.*

Scenario 3.7.3

A bridge has existing guardrail on both sides of the southern approach of the bridge, but no guardrail on the northern approach. The existing guardrail length on both sides is 5m which was considered compliant with appropriate standards at the time of original installation. During an event, the guardrail at the southern approach is damaged and requires full replacement. Current engineering standards require guardrails to both approaches of the bridge (northern and southern approaches). Industry manufacturing minimum length of guardrail is 10m.

> *The cost of replacing the guardrail at the southern end of the bridge is **ELIGIBLE** for DRFA funding. The replacement guardrail length of 10m is **ELIGIBLE** as this length is the manufacturer's minimum length. Any length shorter than the minimum would compromise the integrity and effectiveness of the structure (and therefore safety of motorists).*
>
> *The cost of installing the guardrail at the northern end of the bridge is **INELIGIBLE** as this measure did not exist prior to the event.*

Scenario 3.7.4

A damaged two-lane road requires pavement reconstruction works following damage caused by an activated event. The road prior to reconstruction works had a broken centre line with white delineation markers. Several delineation markers were lost during the event. During reconstruction works, further road signs were installed as well as additional line-marking to the outer edge of the lanes, as per TMR standards.

> *The cost of replacing the lost delineation markers is **ELIGIBLE** for DRFA funding.*
>
> *The cost of the centre line-marking is **ELIGIBLE** for DRFA funding as it existed prior to the event.*
>
> *The cost of the additional outer lane line-marking is **INELIGIBLE** as this line-marking was not pre-existing.*
>
> *The cost of installing the road signs is **INELIGIBLE** as these road signs did not exist prior to the event.*

Scenario 3.7.5

During an activated event, the intersection/traffic monitoring cameras as well as traffic lights were damaged due to flying debris or water inundation of the switchboards. Following assessment by qualified electrical engineers, it was found that the switchboards needed replacement as they could not be repaired. There were three traffic monitoring cameras previously installed and all three sustained damage and required replacement. The cameras and technology that supported the cameras is no longer available on the market and industry equivalent product will need to be sourced. A business decision was made to install an additional camera at the intersection while undertaking the repair works, to increase visibility of the full intersection in question.

> *The cost of replacing the damaged switchboards for the traffic lights is **ELIGIBLE** for DRFA funding.*
>
> *The cost to replace the three existing traffic cameras with a product similar to the pre-disaster system is **ELIGIBLE** for DRFA funding. The industry equivalent product must provide the same level and standard of service as the previously installed system.*
>
> *The cost to install an additional traffic camera is **INELIGIBLE** for DRFA funding.*

Scenario 3.7.6

During an activated event, an embankment on a curve in the road has eroded, leaving a sheer drop of 5m from the road shoulder edge. Following a geotechnical investigation and report, the use of gabion baskets to support the embankment was considered to provide the best value for money. With the adoption of these gabion baskets there is a requirement to install a guardrail/barrier at the top of the embankment that did not exist prior to the event.

> *The cost to restore the embankment adopting the gabion basket treatment is **ELIGIBLE**. As the guardrail/barrier is an integral part of the gabion basket solution, this barrier is also considered **ELIGIBLE**. Supporting reports and options assessment may be requested.*

Scenario 3.7.7

X number of road signs have been damaged by a recent flood event. In order to repair/replace the signs to TMR *MUTCD* standards, the number of signs that is required to be replaced is (X + Y) number.

> *The cost of replacing X number of signs is **ELIGIBLE** for DRFA funding. The cost of replacing Y number of signs is **INELIGIBLE** for DRFA funding.*

Scenario 3.7.8

For eligible pavement damage, an overlay treatment represented the best value for money and was then adopted. This overlay and change in surface level have, by default, became in breach of existing statutory safe clearance requirements for existing road signage. The road signage that does not comply with the statutory safe clearances is then rectified.

> *The cost of the rectifying the signage to the statutory safe clearances is directly related to the treatments adopted and therefore is considered **ELIGIBLE** for DRFA funding.*

4. Eligible expenditure

Expenditure related to eligible works must satisfy eligibility criteria for reimbursement under the DRFA. Eligible expenditure may include:

- costs that are directly related to the reconstruction of an eligible asset
- protection of eligible public assets or restoring essential services and maintaining public safety. This could include earthmoving works, rock placing, sandbagging, installing tarpaulins, erecting warning signs/barriers, pothole patching, removing silt and debris, cleaning and removing an asset or stores to prevent damage
- immediate post-disaster repairs to an eligible asset to enable it to operate/be operated at a reasonable level of efficiency. This could include clean-up costs, removal of silt/debris and temporary repairs
- extraordinary wages above what would normally be incurred, including:
  - overtime
  - allowances
  - temporary employment costs including consultants and/or contractors
  - backfilling (only the cost of backfilling a person undertaking eligible activities is eligible up to the normal cost of the person in the pre-disaster role, not the salary of the incumbent).

4.1 Direct costs

Direct project costs (i.e. construction) are eligible for funding, provided the works are undertaken on the essential public asset that was directly damaged by the activated disaster event and are in accordance with the approved scope of work. Other eligible direct costs include:

- hire of additional plant and equipment, and operating consumables (fuels, oil, grease)
- vehicle or equipment repairs and additional servicing required as a direct consequence of undertaking an eligible activity.

4.2 TMR employees

Where there is expenditure on wages for staff undertaking eligible natural disaster activities above what would normally be incurred for TMR's business-as-usual operations, these extraordinary costs are eligible.

This includes:

- **Overtime** – Overtime costs of employees undertaking eligible natural disaster activities are **ELIGIBLE** for reimbursement under the DRFA. TMR employees are to gain approval for overtime and reflect the time on the internal timesheet system (CATS).
- **Allowances** – Paid allowances relating to TMR employee overtime only are also **ELIGIBLE** for reimbursement. To be eligible, the allowance must only be paid when overtime hours are worked e.g. meal allowances.
- **Backfilling** – Where a TMR employee is undertaking eligible natural disaster recovery activities and their standard position is backfilled by another TMR employee, only the higher duties component (if applicable) is eligible for reimbursement under the DRFA.

  For example, if an A06 staff member ($106k salary) is offline undertaking eligible natural disaster recovery activities and TMR backfills this person with an A05 ($94k salary) and pays them at A06 level, then the higher duties component of $12k is **ELIGIBLE**.

  Where the backfilling arrangement does not result in any higher duties being paid, then both TMR employees are an **INELIGIBLE** DRFA expense as TMR has not incurred any extra costs to backfill the position.

Where a TMR employee is moved from their substantive position to undertake natural disaster activities and their position is backfilled by a consultant, the cost of the consultant is an **ELIGIBLE** DRFA expense.

Where a TMR employee is undertaking eligible natural disaster recovery activities and their standard position is backfilled on a temporary (fixed term) basis by a resource/person external to TMR, the full cost of backfilling the position including associated on-costs such as superannuation entitlements and workers' compensation is **ELIGIBLE**. Note that the TMR employee working on eligible natural disaster activities is **INELIGIBLE** as the cost of their wages would normally be incurred for TMR's business-as-usual operations.

Where backfilling is proposed to be undertaken, reasons for and details of the requirement to backfill must be documented. If a temporary (fixed term) position is created to backfill a TMR employee working on eligible natural disaster recovery activities, it must be demonstrated that the position is only for the term of the DRFA-funded works and is only for the role that is now working on DRFA-funded activities.

4.3 Consultant and contractor fees

Fees for consultants who have been engaged specifically for natural disaster activities are **ELIGIBLE**. The services associated with the investigations, design, procurement, contract administration, project and program management are eligible costs.

4.4 Travel costs

All travel, accommodation and related expenses for TMR employees, consultants and contractors that is directly related to eligible natural disaster activities is **ELIGIBLE** for reimbursement.

4.5 Soil lab testing

TMR soil lab testing is **ELIGIBLE** for reimbursement when:

- there is no other service provider in the district
- working with/for RoadTek
- where it can be demonstrated that the use of TMR soil testing is more cost-effective than receiving the service from an external contractor/company.

4.6 Other

Other costs that are considered an **ELIGIBLE** expense under the DRFA are:

- insurance excesses paid for claims for insured assets that were directly damaged by an activated event
- repair and replacement costs in excess of any insurance claim settlement/payout, providing only eligible works are undertaken.

5. Ineligible expenditure

INELIGIBLE works/expenditure that are not reimbursable under the DRFA may include (but are not limited to) the following.

5.1 Direct costs

Damage to the road network that cannot be directly related to the activated event is ***INELIGIBLE***.

Damage to the road network as a direct result of the activated event, but which can be attributed to poor maintenance, poor design or poor construction, is ***INELIGIBLE***.

Costs incurred in restoring or replacing an asset to a higher immunity or level of service (unless otherwise agreed) are ***INELIGIBLE***. However, note that DRFA funding may be available (refer to *Section 1.6*) to fund the provision of low-cost safety improvements to align with *TMR Road Safety Policy* and the objectives of the *National Road Safety Strategy*.

Environmental asset restoration – for example, restoration of natural vegetation, natural banks, streams, rivers, beaches and undeveloped public land – is ***INELIGIBLE***.

5.2 RoadTek profit

Following the disaster events of 2011–13, the Australian Government has determined that RoadTek profit is ***INELIGIBLE*** under the DRFA. However, under the commercial business arrangements, RoadTek is required to charge profit. The profit component will remain in the funding submissions to be lodged to the QRA, where the profit component will be deducted, following the QRA assessment.

5.3 Inspections of road network/structures

The costs associated with the inspections of structures and the road network following an activated event are only eligible where TMR undertakes eligible reconstruction works on the asset.

For example, if to inspect 100 structures in the district it will cost $20,000, and only 15 have incurred damage from the natural disaster event, then 15% of the inspection costs ($3000) could be claimed.

Note that the normal time of TMR resources to undertake these inspections are still an ***INELIGIBLE*** DRFA expense.

5.4 TMR employees

Where a TMR employee is undertaking eligible natural disaster activities and their substantive position is not backfilled, normal TMR salaries and wages are ***INELIGIBLE***.

As outlined in *Section 4.2*, when a TMR employee is undertaking eligible natural disaster activities and their substantive position is backfilled, and the backfilling arrangement does not result in any higher duties being paid, then both TMR employees are an ***INELIGIBLE*** DRFA expense.

5.5 Other

Other costs that are considered an ***INELIGIBLE*** expense under the DRFA are:

- insurance premiums or future increases in insurance premiums brought about by claims against an existing policy for a particular disaster event
- costs that are reimbursable under other external funding sources (e.g. insurance policy, Queensland Government Insurance Fund)
- normal maintenance and administration costs – including salaries, labour costs and other ongoing administrative expenditure that would have been incurred even if the disaster had not incurred
- non-specific indirect and overhead costs, including internal administration costs to the agency, such as finance, HR, back-office processing and administration
- consequential losses subsequent to the actual event (e.g. business interruptions, loss of income)
- any land resumptions or action from land resumptions.

PART B – DESIGN

6. Introduction

Part B provides guidance on design processes and principles used for natural disaster projects except for the topic 'Designing for Resilience', which is covered in Part C. It is essential that Part B of this guideline is read in conjunction with Part A – Eligibility to ascertain which works are ultimately able to be funded under the DRFA. For information on design criteria that the DRFA will not fund, refer to Part D Complementary works.

In many regards, the processes and principles for natural disaster projects are the same as those used for any road reconstruction project.

7. Criteria for assessing damaged pavements

Guidance about the methodology to be used for assessing the pavement of road sections for DRFA funding submissions is provided in *Part E – Section 38*.

8. Pavement works

8.1 General considerations

8.1.1 Pavement work types

The reconstruction/repair of damaged pavements following natural disasters will generally fall under one of the following pavement work types:

- Part-width pavement rehabilitation
- Half-width pavement rehabilitation
- Full-width pavement rehabilitation.

Guidance for selecting an appropriate pavement work type is given in *Section 7* and elsewhere in this section. Whole-of-life costs, budgets, resources, district needs and other relevant factors must be considered – refer to the following documents: *Pavement Design Supplement*, and *Section 6* of the *Pavement Rehabilitation Manual* (April 2012). The selected work type must be approved by the District Director or delegate.

Specific pavement strategies, including the selected work type, for each road priority (e.g. Priority 1, 2 and 3 roads) have been adopted in some districts for previous events and proven successful – refer to *Part E – Section 39* for typical previous examples. Where this approach is proposed to be undertaken, the District Director or delegate must approve these pavement strategies and solutions, even for part-width pavement rehabilitation work. District representatives will have intimate knowledge of the pavement solutions that provide the greatest longevity and value for money given the various soil types and drainage conditions that exist within the district.

Where possible, the district should strongly consider the option to provide a full-width seal (noting eligibility as outlined in *Section 3.2*) to enhance pavement repair, ensure integrity of pavement joints and provide a value-for-money outcome for the department.

Further guidance for selecting the appropriate pavement work type, and applicable design criteria, are discussed in *Sections 8.2 to 8.4*.

8.1.2 Identifying the failure mechanism

When developing reconstruction/repair solutions, consideration should be given to the failure mechanism. Confirm the failure mechanism through the following assessments:

- Search for pavement history/recorded maintenance work
- Conduct a visual inspection
- Assess pavement and subgrade conditions through sampling and testing from trenches or pits, including laboratory testing as required by the pavement designer
- Use tools such as Ground Penetrating Radar (GPR), which may assist in identifying the pavement structure(s)
- Test pavement for structural response to load (deflection survey, e.g. using Falling Weight Deflectometer (FWD testing) and back-calculation
- Determine forecast traffic and past traffic loadings (including heavy vehicles)
- Analyse test data
- Verify the pavement to ensure condition is consistent with measured level of deflections.

Refer to *Section 2 – Pavement Evaluation* of the *Pavement Rehabilitation Manual* (February 2020) for further guidance on undertaking these assessments.

For water-damaged pavements, identify:

- How and where water has infiltrated into the pavement or subgrade (e.g. through a cracked surfacing, the side of the formation or through the subgrade). The repair solution should include measures to mitigate water infiltration and treat the effects of it (e.g. reinstating table drains, cleaning subsoil/pavement drains and culverts, repairing surface cracks, drainage blanket etc.).
- Whether it was the base, sub-base and/or subgrade that failed. The repair solution may require the in-situ materials to be made less moisture sensitive by the addition of a binder. Wet or weak subgrades must be either dried out or in situ stabilised in order to achieve the necessary compaction of the pavement layers.

Refer also to *Part C – Sections 23.3 and 23.4* for information on improved resilience for non-flooded and flooded pavements respectively.

8.1.3 Current network condition

Emergency works may have involved a significant amount of patching and/or in situ stabilised pavement repairs. Some of the roads affected may have experienced a number of development stages over time (e.g. original narrow construction later followed by pavement widening, provision of granular shoulders and sometimes strengthening with overlays). Many of these pavements have also been extensively patched prior to the most recent weather events. The condition, strength and suitability of the existing repairs (both recent and older repairs) must be considered when undertaking the pavement design. Solutions may include the following:

- Accept repairs 'as is' (e.g. with or without a geotextile seal or Strain Alleviating Membrane Interlayer (SAMI) in the case of stabilised or failed pavement patching)
- Excavate and replace   if in situ stabilisation is considered as an option for rehabilitation, then existing cement-treated patches need to be profiled and cross-blended with existing unstabilised pavement before the in-situ stabilisation takes place
- Provide granular or bound overlays (full-width pavement rehabilitation).

8.2 Part-width pavement rehabilitation

Part-width pavement rehabilitation is the repair of isolated pavement failures that are less than half of the carriageway, such as:

- a series of localised minor pavement failures
- depressions and bumps
- shoving of pavement and surfacing
- rutting in a single wheel path or shoulder only.

The DRFA will only fund part-width pavement rehabilitation where isolated failures have occurred (i.e. only occurring in the shoulder or the outer wheel path and not across full cross-section of the pavement).

The width adopted of the part-width pavement rehabilitation may consider the sizing of construction equipment to undertake the works. Part width is generally considered up to a maximum of 2.4m.

Where possible, the district should strongly consider the option to provide a full-width seal (noting eligibility as outlined in *Section 3.2*) to enhance pavement repair, ensure integrity of pavement joints, and provide a value-for-money outcome for the department.

8.2.1 Part-width pavement rehabilitation limits

The limit of part-width pavement rehabilitation on a km basis is to be determined by a cost analysis of those works when compared to either half-width or full-width rehabilitation. For cost comparison purposes, the pavement design life of part-width rehabilitation shall be the lesser of the remaining residual life of the surrounding pavement or the minimum pavement design life as specified in Table 8 (*Section 11.3*). If it is then demonstrated that part-width pavement rehabilitation on a km basis is less cost-effective than half or full-width works, the latter may be adopted.

8.2.2 Design criteria for part-width pavement rehabilitation works

The remaining design criteria in these guidelines do not apply for part-width pavement rehabilitation works. Instead, technical requirements for part-width pavement rehabilitation works are as per Volumes 1 and 3 of the *Road Maintenance Performance Contract (RMPC) Manual*. Applicable activities within these guidelines include:

- Activity No. 100 for sealed surfaces, particularly sub-activities relating to pavement repairs
- Activity No. 200 for unsealed surfaces.

Data is to be captured in ARMIS, as per normal project delivery requirements (refer to *Part E – Section 53.3*).

The type(s) of material(s) used for part-width pavement rehabilitation works needs to be carefully considered and specified. For example, use of stabilised part-width rehabilitation in a granular pavement may lead to cracking at joints and subsequent drainage issues. In addition, it will make future rehabilitation treatments difficult if the part-width works first need to be removed. Desirably, the pavement material for part-width works would be the same as that in the existing pavement. However, if this means that the depth of the part-width works is greater than the existing pavement, this may also generate additional drainage issues to be considered. For further discussion on this issue, refer to *Section 14.2* and the *Pavement Rehabilitation Manual* (February 2020).

8.2.3 Consideration of repairs undertaken as emergency works

Pavement works need to consider the performance of pavement repairs undertaken as emergency works. Any repairs undertaken under emergency works showing signs of distress or failure must be replaced (refer to *Section 8.1.3*). If the previous repairs appear sound, the pavement patching works may simply include a reseal over the previous repairs.

8.3 Half-width pavement rehabilitation

Half-width pavement rehabilitation is pavement repairs to one or more segments of the road cross-section, for example:

- rehabilitating one-lane of a two-lane carriageway
- rehabilitating the inner wheel and outer wheel paths or shoulders.

Half-width pavement rehabilitation will often involve:

- boxing out the damaged area/s of pavement and replacing with new material to match the surface level of the residual pavement, with or without treating the subgrade or
- modifying/stabilising the existing damaged area/s of pavement to match the level of the residual pavement.

A road surfacing (e.g. seal) would typically also be included.

The DRFA will fund half-width pavement rehabilitation where there is consistent damage along a segment/s of the cross-section including the inner and outer wheel paths. The DRFA will not fund overlays under half-width pavement rehabilitation works to areas that have not been damaged by a disaster event. Any overlay of the residual pavement must be covered under complementary works.

The residual pavement in this context is the existing untreated pavement that is located transversely adjacent to the rehabilitated pavement (the other half). The residual pavement is not the pavement just outside of the project limits.

Consideration of both half-width inlay and full-width overlay pavement rehabilitation options is required. If, at the design development phase, the cost of full-width pavement rehabilitation is found to be the same or less than the cost of half-width pavement rehabilitation, then full-width pavement rehabilitation should be undertaken. This may occur in the following cases:

- When the width of the (what would be the) residual pavement is quite small
- When the half-width treatment requires subgrade stabilisation whereas the full-width treatment, utilising an overlay, does not.

For full-width pavement rehabilitation to be undertaken under this scenario, the natural disaster funding submission should include a cost comparison to demonstrate that the cost of the full-width treatment is the same, or cheaper than, the half-width treatment.

If, at the design development phase, the cost of full-width pavement rehabilitation is found to be marginally more than the cost of half-width pavement rehabilitation, the District Director or delegate will determine whether complementary works funding will be made available to enable the pavement to be rehabilitated to the full width.

Where possible, the district should strongly consider the option to provide a full-width seal (noting eligibility as outlined in *Section 3.2*) to enhance pavement repair, ensure integrity of pavement joints, and provide a value-for-money outcome for the department.

8.3.1 Soundness of the residual pavement

Half-width pavement rehabilitation should only be considered if the residual pavement is sound. Otherwise, full-width pavement rehabilitation should be adopted. Eligible works under the DRFA can be assessed as per part-width pavement rehabilitation limits outlined in *Section 8.2*.

Complementary funding may need to be sought to cover costs over and above that which are eligible under the DRFA.

The evaluation process for the soundness of the residual pavement is covered in Chapter 2 of the *Pavement Rehabilitation Manual*.

The visual inspection as part of the evaluation process is to be undertaken by an experienced district representative and as per the guidelines in Chapter 2.8.9 of the *Pavement Rehabilitation Manual*. It is recommended that the assessment of the residual pavement and subgrade should also include a desktop study of the pavement history, recorded maintenance work and traffic patterns.

8.3.2 Stabilised pavement and pavement in boxed-out areas

Stabilised pavement and pavement in boxed-out areas, constructed under a part or half-width pavement rehabilitation treatment, are to be in accordance with the criteria in this section and Chapter 4 of the *Pavement Rehabilitation Manual* (February 2020).

8.3.3 Drainage at the pavement interface

Pavement drains are required at the interface of the residual pavement and the new/rehabilitated pavement when the new/rehabilitated pavement comprises cementitious material (stabilised, lightly bound or heavily bound). The cementitious pavement will usually shrink, leaving a gap at the interface. The intention of the pavement drain in this case is to drain water infiltrating through the gap. Consideration should be given to matching in to adjacent pavement layers (depth and material) rather than stabilising and installing interface drains.

8.3.4 Surfacing

It is recommended that the surfacing applied under a part or half-width pavement rehabilitation treatment comprise a polymer-modified seal (includes crumb rubber modified seals). This will help to retain a waterproof seal in the event of cracking at the interface of the residual pavement or of the new/rehabilitated pavement if stabilised.

If funding permits, it is desirable to apply this seal across the entire carriageway to:

- avoid differential friction values resulting from different surface types
- locate the edges of the seal as far away as possible from wheel paths, minimising the likelihood of the edges of the seal 'peeling'.

As a minimum, the polymer-modified seal should be applied across the full width of the lane.

8.3.5 Formation/pavement/seal width

Refer to *Section 10.10* for information on formation widening, pavement widths and seal widths.

8.4 Full-width pavement rehabilitation

This treatment covers rehabilitation of the pavement over the entire cross-section. The DRFA will fund full-width rehabilitation of the pavement when the damage is spread across the full width of the carriageway, and the part-width rehabilitation limits analysis.

Pavement designs under a full-width pavement rehabilitation treatment are to be in accordance with *Section 11*. The pavement design will often require the existing pavement to be strengthened to achieve the specified design life. Three basic methods of achieving additional pavement strength when undertaking full-width pavement rehabilitation works are as follows. For more details, refer to the *Pavement Rehabilitation Manual* (February 2020).

1. Overlaying the existing pavement to increase pavement thickness, generally by a granular or asphalt overlay. An overlay often requires formation widening for the existing pavement width to be maintained (or increased to meet current standards).
2. Stabilising the existing pavement to improve its strength. This is usually only possible where adequate pavement depth exists, suitable materials exist and the subgrade is structurally adequate to enable sufficient compaction of the pavement layers.
3. Boxing-out and replacing existing pavement and, if necessary, an amount of the subgrade. Stabilise the subgrade if required (e.g. with lime if clay subgrade). Although this option is the most difficult to build under traffic because of the time required to construct, it may be the only suitable treatment (e.g. where the road surface cannot be raised due to the effect on drainage, where a weak subgrade is encountered).

Combinations of the above methods are also used (e.g. granular overlay of an existing pavement followed by stabilising/modification). The chosen method will be the one that most appropriately meets the district's needs considering whole-of-life costs, budgets, resources and other relevant factors (refer to the *Pavement Design Supplement*, *Pavement Rehabilitation Manual* and the *Austroads Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design*).

Before deciding on an overlay as the preferred pavement solution, consider whether there will likely be any adverse effects on the surrounding catchment's hydraulic performance (e.g. an increase in afflux leading to unsuitable immunity levels upstream and increased scouring immediately downstream). If uncertain or if it is considered that the effects may be adverse, a full hydraulic assessment should be undertaken to determine whether or not an overlay is a suitable option. If this hydraulic assessment is deemed to be required, this is considered eligible for funding.

8.4.1 Design of the pavement

The design of the pavement is to be in accordance with *Section 11*.

8.4.2 Formation/pavement/seal width

Refer to *Section 10.10* for information on formation widening, pavement widths and seal widths.

9. Road design process

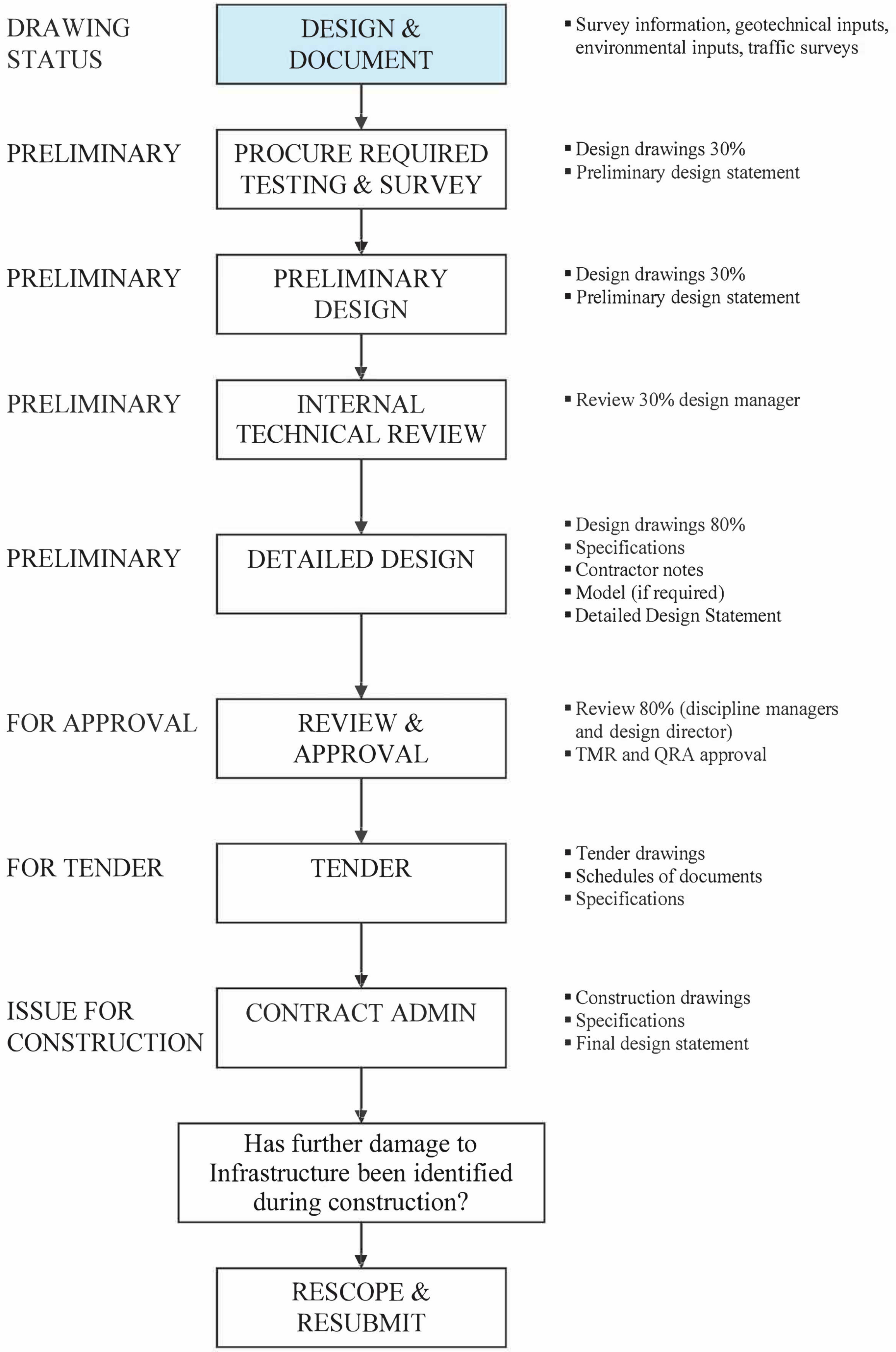
Guidance on design process is given in *Road Planning and Design Manual – 2nd edition (Department of Transport and Main Roads) Volume 3: Part 1: Objectives of Road Design*. The criteria included in this section supplement those in the *RPDM Volume 3: Part 1*.

The scope of works will be determined individually for each site. Scoping teams will undertake the pre-design assessment and formulate a design brief. The brief will identify the works required for rehabilitation, opportunities to improve the existing conditions, and any risks or shortfalls in the design.

During the design process, reviews will be adopted at varying stages, *TMR Road Safety Audit Policy* sets out the details of road safety audits at the various stages. The design brief generated from the scoping report will identify the required internal and external peer reviews. The design brief will also act as a checklist for review items.

An example of a design process for natural disaster projects is given in Figure 1.

Figure 1: Example of a natural disaster works design process (source: ARUP)



Note: Road Safety Audits are required at various stages (refer to Section 9.4)

9.1 Road design classes

With road design in general, there are four road design classes (Classes A, B, C and D). The design approach is different for each road design class. Each class has a design approach that delivers a business case (which includes preliminary design) and detailed design. Refer to *Section 4.4.4 of Part 1, Volume 3 of the* *[RPDM 2nd Edition](#)*.

Pavement patching as undertaken in emergency works is considered maintenance and is not included under Road Design Classes A-D (i.e. road design is not undertaken for pavement patching works).

Considerations for road design classes in addition to the following (below) are given in *Part E – Section 41*.

9.1.1 Road Design Class A

It is likely that there will be no Road Design Class A projects under the DRFA as this design class applies to new roads or major complex, high risk and/or relatively expensive projects. The Road Design Class A requirements have only been included here for completeness.

The design approach or steps are as follows:

1. Understand the requirements in the brief and determine the construction contract type.
2. Establish the safety and design criteria.
3. Understand the likely solutions and gather geospatial information, community inputs, environmental inputs, native title inputs, pavement information, other technical information, cycle network information, external communications, geotechnical data, structural assessment of any existing drainage structures (see *Part E – Section 49*) and immunity criteria.
4. Identify and develop plausible and valid solutions that are acceptable using value management and engineering principles.
5. Ensure that pre-existing road safety risks are identified and managed appropriately.
6. Confirm that there are no issues likely to affect safety during future maintenance.
7. Select the preferred solution and develop the preliminary design, business case and cost estimate to justify the project.
8. Develop detailed design and detailed cost estimate.
9. Prepare tender documentation.
10. Establish construction contract.
11. Construct the works.

9.1.2 Road Design Class B

Road Design Class B is generally appropriate for half-width and full-width pavement rehabilitation projects that involve increases to the earthworks footprint for most of the project length.

The design approach or steps are as follows:

1. Understand the requirements in the brief and determine the construction contract type.
2. Establish the safety and design criteria.
3. Understand the likely solutions and gather geospatial information, community inputs, environmental inputs, native title inputs, pavement information, other technical information, cycle network information, external communications, geotechnical data, structural assessment of any existing drainage structures (see *Part E – Section 49*) and immunity criteria.
4. Check drainage, including surface drainage (i.e. aquaplaning checks).
5. Ensure that pre-existing road safety risks are identified and managed appropriately.
6. Confirm that there are no issues likely to affect safety during future maintenance.
7. Identify and develop plausible and valid solution options.

8. Improve geometric deficiencies (unless prohibitively expensive) by undertaking an assessment of all geometric elements (see Table 1-1 in Volume 3, Part 1 of the [RPDM 2nd Edition] and *Part E – Section 42*). Note that this must be addressed as part of the project scope. However, the program manager or project manager who sets the project scope must be cognisant of this requirement for this design class and must ensure TMR process for handling design exceptions is fulfilled – in which case it is necessary that no new risks are introduced and the level of residual risk is not increased (after all mitigation measures are considered).
9. Correct structural and hydraulic deficiencies of drainage infrastructure where necessary.
10. Check the surface profiles and correct superelevation on overlay or rehabilitation project.
11. Select preferred solutions and develop the preliminary design and business case cost estimate to justify project.
12. Develop detailed design and detailed cost estimate.
13. Prepare tender documentation.
14. Establish construction contract and award contract.
15. Construct the works.

9.1.3 Road Design Class C

Road Design Class C is generally appropriate for full-width pavement rehabilitation projects comprising a structural overlay but with little or no change to the earthworks footprint. Road Design Class C is also appropriate for half-width and full-width rehabilitation projects without a structural overlay or widening but which involve a significant increase in seal width.

The design approach or steps are:

1. Understand the requirements in the brief and determine the construction contract type.
2. Establish the safety and design criteria.
3. Understand the likely solutions and gather structural assessment of any existing drainage structures (see *Part E – Section 49*) and, if appropriate: geospatial information, community inputs, environmental inputs, native title inputs, technical information, cycle network information, external communications and geotechnical data.
4. Confirm that there are no issues likely to affect safety during future maintenance.
5. Ensure that the pre-existing road safety risks are identified and managed appropriately.
6. Identify and develop plausible and valid solution options.
7. Seek to improve the geometry of any feature that has a significant crash history despite appropriate mitigating treatments already in place (see *Part E – Section 41*). Note that this must be addressed as part of the project scope. However, the program manager or project manager who sets the project scope must be cognisant of this requirement for this design class and must ensure TMR process for handling design exceptions is fulfilled.
8. Undertake an assessment of all geometric elements listed in Table 1-1 in *Volume 3, Part 1* of the [RPDM 2nd Edition], i.e. crossfalls, superelevation and flow path depths at curve transitions. Improve surface profile where required, including the reconstruction of superelevation on a curve or crossfall on a straight. For shoulder sealing projects, it is desirable to undertake an assessment of all geometric elements.
9. Select preferred solution and develop the preliminary design and the business case cost estimate to justify project.
10. Develop detailed design and detailed cost estimate.
11. Prepare tender documentation.
12. Establish construction contract and award contract.
13. Construct the works.

9.1.4 Road Design Class D

Road Design Class D is generally appropriate for half-width and full-width pavement rehabilitation projects that do not involve structural overlays, formation widening or significant increases in seal width.

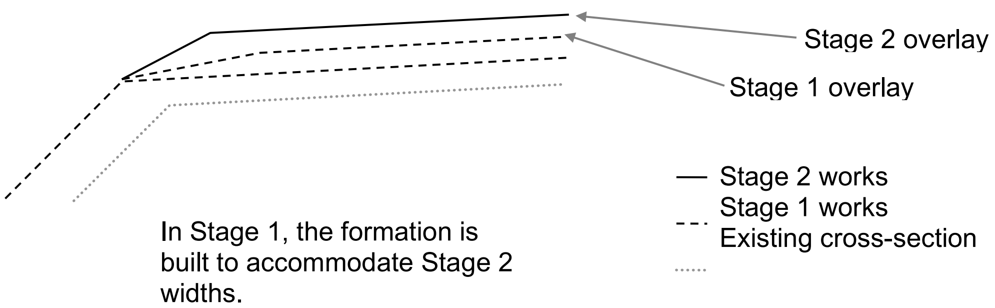
The design approach or steps are:

1. Understand the requirements in the brief and determine the construction contract type.
2. Ensure that pre-existing road safety risks are identified and managed appropriately.
3. Confirm that there are no issues likely to affect safety during future maintenance.
4. Gather structural assessment of any existing drainage structures (see *Part E – Section 49*).
5. Develop detailed design of culvert/floodway replacement (if relevant) and detailed cost estimate.
6. Prepare contract documentation.
7. Establish construction contract and award contract.
8. Construct the works.

9.2 Integrated road infrastructure interfaces

Designers of natural disaster works should consider the importance of ensuring that interfaces between works are appropriate. The design should consider the interfaces of the existing road corridor, ensuring consistent standards between the project area and the existing approaches are maintained, or appropriate transitions between the two are provided to achieve adequate integrated road infrastructure interfaces.
Options that include staging can be considered. For example, the initial stage may involve rehabilitation and widening of the pavement. A future stage may allow for further overlay. For staged pavement options, the minimum widening for the initial stage must accommodate the width required for the future overlay. Refer to Figure 2.

Figure 2: Staging works to accommodate future overlays



Staging could also be considered in constrained locations where it is prohibitively expensive to achieve interim or vision seal widths. However, any safety implications need to be considered along with appropriate mitigating treatments. For example, staging principles may be used where services or other hazards are located close to the carriageway. Geometric design exceptions could be justified in the short term, knowing that a final stage will still be provided in the future.

9.3 Maintenance and operations

Designers of natural disaster works should consider the future maintenance, enforcement and operational requirements of the road. The need for maintenance should be minimised where practical and, where maintenance is required, it should be convenient and safe for road workers to perform. Normal safety in design legislation applies (see *Section 19*).

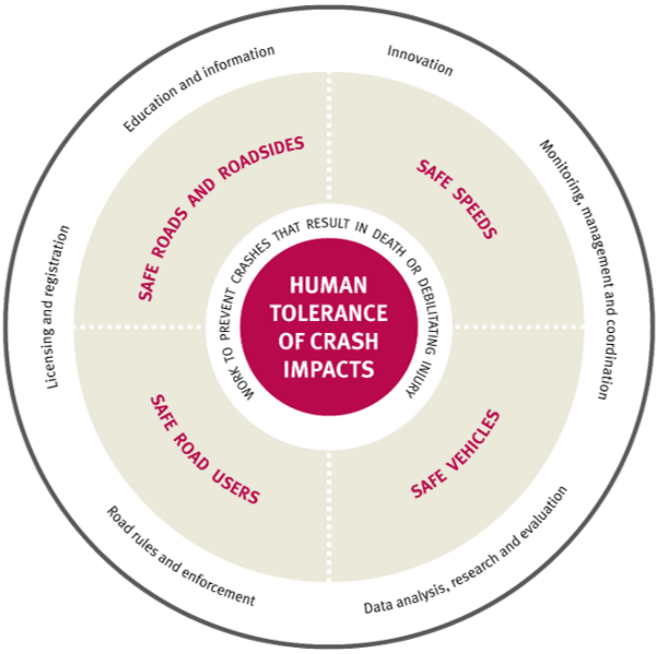
When reviewing designs, obtaining advice from maintenance practitioners is highly recommended.

9.4 Road safety

The Queensland Government has a vision of zero road deaths and serious injuries, as committed to in the *Queensland Road Safety Strategy* and *National Road Safety Strategy*. To achieve this vision, the *TMR Road Safety Policy* commits the organisation to the adoption of Safe System principles, processes and practices.

Acknowledging that humans make mistakes and there is a known physical limit to the amount of force our bodies can take before sustaining debilitating injury or death is the centre of the Safer System approach. The application of Safe System principles, processes and practices to the transport system accommodates the human condition.

The Safe System approach means we adopt safe system principles and apply safe system processes and practices across four pillars – Safe Roads and Roadsides, Safe Speeds, Safe Road Users and Safe Vehicles.



For all projects, the following mandatory road safety requirements (as set out in the *Road Safety Policy* and *Road Safety Audit Policy*) must be included:

- The **Network Safety Plan**, which sets out the safety vision for the corridor to achieve a consistent application of safe system-aligned countermeasures across the network.
- A **Safe System Assessment,** which sets the safety scope for the project to be delivered. This allows all the safe system pillars to be catered for in the concept development of the project, to consider the site-specific considerations.
- A **Road Safety Audit**, which allows safety issues that may either currently exist or may arise during the project to be identified and rectified to allow safe operation of the road.
- All projects will follow the **Safe Systems Project Management Control Checklist** (see Appendix B of *TMR Road Safety Policy*) and Austroads Safe System Assessment Framework across the planning, concept, development, implementation and finalisation phases before project management gating sign-off and approval by Infrastructure Investment Committee, General Manager, Regional Director and District Director.

TMR will implement **Safety Standards** that will be actively applied in the planning and design of road infrastructure and operations projects. These standards reflect default requirements to manage safety risk unless justification is documented in a design exception or planning report.

A single Safe System Assessment is required for each project. This assessment should be undertaken as early as possible in the project's life, preferably at the planning phase. For all subsequent phases of the project a check to confirm that the intent and scope of works aligns with the Safe System Assessment should be undertaken, as indicated in the Safe Systems Project Management Control Checklist, with updating of the Safe System Assessment required if there is a change to the project.

Table 7 below sets out the minimum requirements for when road safety audits are to be undertaken. Some projects may be complex and may need to have more road safety audits undertaken at the discretion of the project manager.

Table 7: Minimum requirements for when safety audits are to be undertaken

Project Type and Scale	Road Safety Audit Type				
	Feasibility Stage	Preliminary Design Stage	Detailed Design Stage	Roadwork Traffic Scheme	Pre-Opening Stage
Type A: Project Value >$10M	✓	✓	✓	✓	✓
Type B: Project Value $1M–10M		✓[1]	✓[1]		✓
Type C: Project Value <$1M		✓[2]	✓[2]		✓[2]

Notes:

1. For Type B projects: a road safety audit is to be completed at either the preliminary design stage or the detailed design stage at the discretion of the TMR project manager.
2. For Type C projects: one road safety audit is to be completed once for the project at the preliminary design stage, detailed design stage, or the pre-opening stage at the discretion of the TMR project manager.

A project may be exempt from conducting a road safety audit if the project value is less than $100,000 and the scope is standard in nature or is considered to be an off-the-shelf product, such as the installation of a sign, installation of Retro Reflective Pavement Markers (RRPMs), changing aspects of lanterns of signals, or filling of potholes. The exemption is at the discretion of the TMR project manager and should be documented.

9.4.1 Safe system assessments

Safe System Assessments (SSA) are required for all road projects, including natural disaster works on an existing road, and are be conducted in accordance with the Austroads Research Report AP-R509-16, Safe System Assessment (note that an account is required to download the report). Please contact the Safer Roads Team for further details about undertaking an SSA.

The Safe System is a road safety philosophy that requires roads to be designed and managed so that death and serious injury are avoidable. The basic principles are:

- Humans are fallible and will inevitably make mistakes when driving, riding or walking.
- Despite this, road trauma should not be accepted as inevitable. No-one should be killed or seriously injured on our roads.
- To prevent serious trauma, the road system must be forgiving, so that the forces of collisions do not exceed the limits that the human body can tolerate.

An SSA is a tool that has been developed by Austroads to assess the extent to which a proposed infrastructure project aligns with Safe System principles and the objective to eliminate fatal and serious injuries. The process allows project options to be compared with a base case (that is, existing conditions) and with each other. An SSA will identify areas where the risk of fatal and serious injury (FSI) crashes is high and identifies design changes that, if adopted, would improve alignment with the Safe System approach. If Safe System principles are being followed and applied correctly, there should be a trend towards zero in the SSA scores when progressing from existing conditions to the initial design options and, finally, to the adopted design.

An SSA provides the following benefits:

- A way of determining how well a project proposal aligns with Safe System principles
- A method to compare project design options from a Safe System perspective
- Information on design and scope changes that will move a project proposal closer to the Safe System objective of eliminating the risk of fatalities and serious injuries
- A method to assist planners, designers and project managers to progress the Safe System approach from theory to practice
- A sound basis for the planning and design of road infrastructure.

Project managers are to maintain records of all SSAs completed, including documentation of assessment findings and recommended treatments. These are to be maintained for a project along with the Safe Systems Project Management Control Checklist, across the planning, concept, development, implementation and finalisation phases before project management gating sign-off and approval by Infrastructure Investment Committee, General Manager, Regional Director and District Director.

9.4.2 Road safety audit

Road safety audits for new road projects, including natural disaster works on an existing road, must be conducted in accordance with the TMR policy *Conduct of Road Safety Audits June 2008*. Please contact the Safer Roads Team (phone 07 3066 2424) for a copy.

A detailed guidance is provided in TMR's *Road Safety Audit Policy Supporting Guidelines* for project managers when determining what audit stages are required for natural disaster works. For all audit stage types, the project manager is to exercise engineering judgement to determine the need for each stage by way of risk assessment.

The following five types of audit stages are illustrated with project type and scale in Section B – Road Safety Audit Selection Matrix for New Road and Traffic Projects and Roadwork Traffic Schemes of the *Road Safety Audit Policy Supporting Guidelines*:

- Feasibility Stage Audit
- Preliminary Design Stage Audit
- Detailed Design Stage Audit
- Roadwork Traffic Audit
- Pre-Opening Stage Audit.

In order to undertake the risk assessment, a minimum of five years' relevant experience is required in road design, traffic engineering and road safety engineering or other closely related road safety discipline. When considering which projects require which stage of audit, the focus should always be on the degree of risk for road users and the likely benefits of a safety audit. At least one member of the audit team must be a registered senior road safety auditor with TMR. These steps are consistent with TMR's current *Road Safety Audit Policy* and the *Austroads Guide to Road Safety Part 6 – Managing Road Safety Audits*.

Auditors are to maintain records of all road safety audits completed, including documentation of audit findings and audit recommendations. This information is to be entered into the TMR departmental tracking system Pursuit.

The cost to implement discretionary recommendations from road safety audits will generally be considered as complementary works.

Significant safety issues must be addressed in any design, particularly where the auditor has identified an issue as priority level A. The designer should assess the risk and identify options to manage the risk. If costly design solutions are needed (e.g. realignment of a tight horizontal curve), complementary works funding should be sought. If not available, the design solution must be documented and added to the QTRIP for future implementation.

As a minimum, the DRFA will fund low-cost treatments to ensure that the existing level of safety is not compromised. Where possible, the DRFA will also fund the provision of low-cost treatments to enhance safety (refer to *Section 1.6*). An example of a low-cost treatment is to install CAMS and/or other curve warning devices instead of realigning a tight horizontal curve.

If the necessary infrastructure improvements are not possible and there is a concern that other mitigating measures may not be successful, speed management measures can be considered.

It is normal practice for a road safety audit to look beyond the limits of a project. It is important to consider safety immediately downstream of a restored section, as any increase of operating speed through the restored section may have a detrimental safety effect on the upstream and downstream section/s. This is particularly true if the geometry of the restored section has been altered.

Once all natural disaster works are completed on a link (or significant part of a link), it may be prudent to undertake an audit of the whole link. This is especially important if an audit of the link has not been undertaken previously or a significant proportion of the link has been restored.

9.4.3 Road safety standards

TMR Road Safety Policy details specific safety standards that are default requirements and are considered good practice in the design and construction of safer road infrastructure. These safety standards address safety issues on Queensland's road network with proven countermeasures that proactively reduce the risk of fatal and serious injury crashes.

10. Geometry

Natural disaster works are to be designed in accordance with the *TMR* *RPDM 2nd Edition*. The following design criteria supplement the RPDM.

10.1 Need for geometric assessment

The geometric elements required to be assessed for the types of works undertaken are defined under Section 4.4.4 and Table 1-1 in Part 1, Volume 3 of the *RPDM 2nd Edition*. If geometric elements are required to be assessed, designers should first start by assessing the design speed (see *Section 10.2*).

10.2 Operating speed model

Design speed should not be less than the 85th percentile vehicle operating speed under low flow conditions. A high speed road (refer to the *RPDM 2nd Edition* Volume 3, Part 3) is one that has been designed for a single design speed and operating speeds are not constrained by geometry of the road, but instead by other factors. Applying the operating speed model to high-speed roads is usually not warranted. Low and intermediate speed roads (refer to *RPDM 2nd Edition* Volume 3, Part 3) are designed with varying design speeds and therefore the use of the operating speed model is appropriate.

10.3 Use of Extended Design Domain (EDD)

Given that natural disaster works will generally retain existing alignments (except in some circumstances as discussed in Part D – Complementary Works), the use of EDD can be considered. However, its use must be justified and this justification must be documented and approved by the District Director or delegate.

Designers must only claim that a design conforms to EDD when the appropriate manoeuvre width is provided. This also applies to cuttings. Where manoeuvre width is not provided, designers should follow the process for design exceptions.

EDD design criteria are as per the *RPDM 2nd Edition*.

10.4 RPEQ responsibilities with respect to natural disaster works

The use of EDD and design exceptions for road geometry are covered in detail in the *RPDM 2nd Edition*.

Following the processes in the above document establishes TMR responsibility for the use of EDD and design exceptions. Nevertheless, this does not absolve the RPEQ who signs off a design brief, design or the drawings from any responsibility. The RPEQ still has the following responsibilities:

- To be satisfied that TMR has followed the appropriate process
- To be satisfied that TMR has not overlooked something that makes the use of EDD or the design exception inappropriate
- To be satisfied with TMR's assessment of the use of EDD or the design exception with respect to safety and the suitability of any mitigating treatments
- To meet all other RPEQ obligations.

The District Director or delegate also signs off where the EDD or a design exception are used/retained.

10.5 Transition curves

Details of transition curves requirements and considerations are defined in *RPDM 2nd Edition* Volume 3 Part 3.

10.6 Curve widening

Curve widening in accordance with *RPDM 2nd Edition* Volume 3 Part 3 must be applied for Road Design Class A and B projects.

10.7 Clearance to bridges

For all road design classes, appropriate clearance to overhead structures must be maintained. Designers should be conscious of this when developing and designing geometry and pavement rehabilitation options.

10.8 Aquaplaning

Aquaplaning potential must be reviewed as a part of natural disaster works, in accordance with Chapter 4, Volume 3,Part 5A, *RPDM 2nd Edition*. Mobile Laser Scanning (MLS) can be used to survey the pavement heights. Aquaplaning issues should be rectified during rehabilitation and/or widening works where practical. The designer must ensure that the new road surface (shape) is not less safe than pre-event condition.

This guidance should be applied for Road Design Class A, B and C projects.

10.9 Intersections

If the pavement or surfacing is being replaced through an intersection, any Auxiliary Right Turn Treatment (AUR) or older Type Basic Right (BAR) turn treatment should be replaced as a Channelised Right Turn (Short) (CHR(S)) layout. While this is subject to the turn treatment meeting all of the design criteria for CHR(S) layouts in Volume 3 Part 4A of the *RPDM 2nd Edition*, EDD allows a CHR(S) that fits within the footprint of an AUR. The *TMR Road Safety Policy 2022* requires AUR at rural intersections to be replaced with at least a short CHR(S).

This guidance should be applied for Road Design Class A, B and C projects.

10.10 Carriageway width

The DRFA will only fund the construction of earthworks and pavement to accommodate **existing** carriageway/ formation widths. Where required, this funding also includes the cost of clearing, widening and extensions to pipes/culverts. In some cases, additional funding in the form of complementary works may be considered to achieve a greater carriageway width, for example:

- an interim or vision width as per the *State-Controlled Priority Road Network Investment Guidelines* (contact the Investment Funding Unit in Portfolio Investment and Planning Branch for further information)
- an EDD or Normal Design Domain (NDD) value as per the *RPDM 2nd Edition*.

It is recommended that the following road sections be given priority for additional carriageway widening:

- Road sections with a high crash history where an increase in carriageway width is likely to reduce the number of crashes.
- The narrowest road sections relative to the remainder of the link.

Where widening of the formation is required to achieve the chosen carriageway width for overlay works, consider the guidance provided in the *RPDM 2nd Edition Volume 3 Part 3*. Although the terms EDD and NDD are used comprehensively throughout this part, other widths may be appropriate for the particular road link (that is, interim and vision widths).

10.11 Seal width

The DRFA will only fund the construction of seal widths equal to the **existing** seal widths. In some cases, additional funding in the form of complementary works should be considered to achieve greater seal width, for example:

- where a whole-of-life costing is carried out and it demonstrates that a full-width seal provides the lowest whole-of-life cost solution
- on the high side of one-way crossfalls, full-width seals should also be provided
- to construct an overtaking opportunity
- to improve the side friction on a dangerous curve
- to achieve an interim or vision width as per the *State-Controlled Priority Road Network Investment Guidelines*.

10.12 Fill batter slopes

It is common practice to increase the slope of fill batters to accommodate pavement widening. However, on fill heights up to 1 metre (desirably 2 metres), this should only be considered if the reconstructed batter slope is limited to 1 on 4 (desirably 1 on 6).

This guidance should be applied to all projects where there is a potential for fill batter slopes to increase.

10.13 Verges

For natural disaster works, the minimum 0.5m verges in Volume 3 Part 3 of the *RPDM 2nd Edition* may be excluded provided the following are met:

- Sealing is extended to the hinge point to protect against natural rounding and
- Batters are quickly grassed/vegetated to protect against erosion.

If designers cannot guarantee that the above will be performed, minimum 0.5m verges must be provided.

A verge width should be large enough to accommodate the deflection of the barrier type that is to be installed. Note that verges should also be provided when roadside safety barriers are anticipated in the future.

This guidance applies primarily to Road Design Class A and B projects, but the above verge width requirement also applies if retrofitting roadside barriers on Road Design Class C and D projects.

10.14 Crossfall and superelevation

During reconstruction works, the crossfall and superelevation should be checked and corrected where required. Designers may need to allow for extra pavement material. This is expected under all works involving overlay, rehabilitation or widening. Further considerations for crossfall and superelevation are included in *Part E – Section 42*.

This guidance applies to Design Class A, B and C projects.

11. Pavements

11.1 Key considerations

11.1.1 Pavement references

Pavements for natural disaster projects are to be designed and constructed in accordance with the following Technical Policies, Standards and Guidelines (TPSG). These are given in order of precedence:

1. *NDP Design and Eligibility Guidelines* (these guidelines)
2. TMR supplementary manuals and specifications (as authorised by the District Director)
3. Transport and Main Roads Specifications
4. For design of pavement rehabilitation treatments:
    a. *Pavement Rehabilitation Manual* (February 2020)
    b. *AGPT05/11 Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design* (Austroads, 2011).
5. For design of new pavements: *TMR Pavement Design Supplement*
6. Other current TMR technical documents, including:
    a. Manuals
    b. Standards/specifications
    c. Test methods
    d. Technical notes.

Refer to the TMR website for all relevant technical documents:

http://www.tmr.qld.gov.au/Business-industry/Technical-standards-publications.aspx

11.1.2 Consideration of future rehabilitation/overlay options

One of the most important principles of undertaking reconstruction projects is to consider future rehabilitation/ overlay options. Designers should **not** provide a solution initially that either:

- makes it difficult to undertake future works or
- will require major interventions/rehabilitation before the end of the pavement's nominated structural design life.

This applies even when undertaking part-width or patching repairs to the pavement where the wrong choice of materials will make it difficult to rehabilitate in the future. It should be noted that any formation widening to account for a future overlay would be ineligible under the DRFA.

11.1.3 General considerations

Other important considerations with respect to pavements are given below:

- Pavement rehabilitation option of cement-modified sub-base and a granular base has been adopted in many districts in recent natural disaster projects. While it is a cost-effective treatment and provides an opportunity for future rehabilitation (i.e. stabilising the base), regular maintenance such as reseals, clearing drainage and so on, should be carried out. Otherwise as the seal gets older, age cracking will allow moisture infiltration. This moisture, which is trapped within the base, leads to high pore pressure development in the base and failures.
- Generally, for in situ stabilisation of existing pavements, a single layer of minimum depth of 250 mm is recommended. Where multiple layers of in situ stabilised pavement are to be constructed, each individual layer is to be a minimum of 200mm thick. This is to be achieved through bonding in to the stabilised layer below. For example, if the bottom-most layer is 200mm thick, the next layer on top should be stabilised to a depth of 230 mm (200mm + 30 mm bonding in to the bottom layer). This will effectively produce a monolithic layer for a series of 200mm individual stabilised layers.
- Before in situ stabilisation of existing pavement material, detailed investigation and laboratory testing are required to ensure the appropriate type and amount of stabilising agent are used. Over-dosage can cause early age cracking and is often costly to repair. Reference should be made to the *Pavement Rehabilitation Manual, Part 5: Pavement Evaluation* and Treatment Design of the *Austroads Guide to Pavement Technology*).
- For all surfacing edges, including those within the deflection zone behind a roadside safety barrier, the surface edge drop-off should be limited to a desirable maximum of 50mm and an absolute maximum of 100mm. Measures should be taken to mitigate the effects of any vertical edge drop-off.

  Where the finished surfacing results in an edge drop-off greater than this, it is desirable that the finished edge have an incline no steeper than 1 (vertical) in 3 (horizontal).

11.2 Emergency works – considerations

The reconstruction treatment must consider the works undertaken as part of the emergency works (e.g. reconstruction works may require removal of patches and replacement with suitable materials) that were undertaken using granular, asphalt and stabilised materials.

The likely natural disaster reconstruction/rehabilitation treatment needs to be carefully considered before adopting a particular approach to emergency works. If in situ stabilisation is considered as an option for rehabilitation, then existing cement-treated patches need to be profiled and cross-blended with existing unstabilised pavement before the in-situ stabilisation can take place. For instance, re-stabilisation of previously stabilised patches is not recommended, and patching can result in a ‘patchwork quilt’ which may make applying a uniform longer-term reconstruction treatment difficult. In some cases, patches will need to be removed before longer-term reconstruction/rehabilitation works are completed.

Further requirements for emergency pavement works are included in *Part E – Section 43*.

11.3 Pavement structural design life

For guidance on the design life, please refer to the *TMR Pavement Design Supplement*.

This section applies to the following types of pavement works under the DRFA:

- Part-width pavement rehabilitation
- Half-width pavement rehabilitation
- Full-width pavement rehabilitation.

This section does not apply to pavement patching works undertaken in the emergency works phase.

DRFA funding will cover the construction of pavements with a structural design life according to the values in Table 8. All new pavements are designed to be in accordance with the values in this table. However, the following exceptions apply:

- The life of the alignment is less than the requirements in Table 8. In this case, the structural design life can be reduced to equal the future life of the alignment.
- The existing pavement is based on a higher design life than that indicated in Table 8. In this case, the new pavement should achieve the higher design life (based on existing pavement depth and material/s).
- There are limitations because of material supply, resourcing issues, timelines, affordability etc. In this case, the absolute minimum values are to be adopted.
- A whole-of-life cost analysis indicates that a lower whole-of-life cost solution can be obtained using a structural design life lower than the minimum structural pavement design life as outlined in Table 8. Where this occurs, the lower whole-of-life cost solution may be used. Examples include the following staged approaches:
  - On roads with potential water-induced subgrade movement (i.e. roads with highly to extremely expansive soil subgrades). Depending on subgrade treatments undertaken, major intervention may be expected after 10 years due to distresses caused by volume change of the subgrade (e.g. roughness and other shape loss etc.). Therefore, the designer must provide an option that includes an intervention, which may be structural, at year 10 as part of the strategy of achieving an overall 20-year design.
  - If there is an existing unbound base layer of good quality and depth, Stage 1 could be to provide a nominal 150mm overlay. Stage 2 may then be undertaken later under QTRIP to be foam bitumen stabilised or lightly bound to a depth of 250mm.

Table 8: Minimum structural pavement design life

AADT	Pavement Design Life
AADT < 1000 vpd	10 years
AADT > 1000 vpd	20 years

Adoption of a structural design life below the values given in Table 8 must be documented and approved by the District Director or delegate. Alternatively, the District Director or delegate may also decide to provide complementary funds to achieve a general minimum value (or better).

Where a structural design life is below the minimum values in Table 8, the designer must identify the future intervention/s necessary to achieve the life indicated by the Minimum Structural Pavement Design Life. All future (staged) interventions must be identified in QTRIP.

11.4 Design method

Pavement design and pavement rehabilitation design must be in accordance with the hierarchical list of documents in *Section 11.1.1*.

Further guidance on the design method for pavement works is included in *Part E – Section 43*.

Pavement designs must be documented in accordance with the requirements in *Part E – Section 44*.

Pavement rehabilitation designs must be documented in accordance with the Pavement Rehabilitation Design reporting requirements (Refer to *Part E – Section 45*).

11.5 Other considerations

Specific considerations about records of emergency works, pavement rehabilitation design and cover over expansive subgrade are included in *Part E – Section 43.*

12. Sprayed bituminous treatments (including surfacing)

The selection, design and construction of sprayed bituminous treatments should be undertaken in accordance with the following documents:

- Supplementary specifications approved for use on natural disaster works by the relevant TMR District Director
- TMR technical specifications (MRTS documents)
- *TMR Pavement Design Supplement*
- TMR Technical Note 175 *Selection and Design of Sprayed Bituminous Treatments*
- TMR Technical Note 186 *Sealing in Cold Weather Conditions*
- Austroads and AAPA Work Tips.

Also refer to Section 11.1 for other relevant documents.

13. Bridge infrastructure

Example of works on structures that may be undertaken as part of the NDP are:

- Replacing bridges destroyed in a natural disaster (refer to *Section 13.1*)
- Replacing abutment protection with material designed in accordance with TMR's *Bridge Scour Manual* and *Design Criteria for Bridge and Other Structures* and Austroads *Guide to Bridge Technology Part 8 – Hydraulic Design of Waterway Structures*.
- Underpinning a pier that has sunk due to scour. Due to the limited number and specialist nature, the criteria shall be agreed in consultation with Deputy Chief Engineer (Structures).
- Replacing the axial and/or moment load capacity of a pier and/or abutment due to scour of the riverbed.
- Reinstating a damaged bridge barrier (refer *Section 13.2* and *Section 16.3*).

The typical TMR standard flood immunity criterion is AEP 1 in 50 years or an agreed AEP to provide the required level of service. In this regard, critical velocity for scour protection is derived from AEP 1 in 100 years.

The design life of bridges and that of abutment protection and pier protection is 50 years for a similar flood event. Refer to *Part E – Section 48* for abutment and pier protection details.

13.1 Design criteria for replacement bridges

All bridge designs including minimum bridge width must be in accordance with the current version of TMR's *Design Criteria for Bridge and Other Structures*.

13.1.1 Replace existing timber bridge

Replacement structures are constructed to current design loads (SM1600 and HLP400) and minimum width. Current legislation restricts the volume of timber that can be removed from state forests for timber bridge maintenance. The yearly quota is committed for timber bridge maintenance. Hence an existing timber bridge can only be replaced by a concrete bridge.

13.1.2 Bridge hydraulics for replacement bridges

Hydraulic analysis of bridges should be undertaken by the Hydraulic Unit of E&T or a suitably TMR-prequalified and experienced consultant. Refer to *Technical Guideline – Hydrologic and Hydraulic Modelling Guideline* for an overview of the general requirements of a hydraulic brief for bridge design.

13.1.3 Flood immunity

The TMR standard flood immunity criterion is AEP 1 in 50 years for all new bridges and this is the usual objective unless there is a documented reason to adopt a different value. For national highways, the flood immunity criterion is AEP 1 in 100 years. Sometimes it is not feasible to adopt an AEP 1 in 50 year or 1 in 100 year criterion because of an extensive floodplain or the wide expanse of shallow flows. This is especially the case for less important roads, where there is likely to be less disruption to traffic. In other situations, it may be preferable to allow flow over the road to limit the afflux when water overtops the road and, in some cases, the limited traffic may not justify high flood immunity. Occasionally, the road geometry may lead to very high flood immunity with the bridge deck well above flood levels. In every case, the flood immunity needs to be calculated and provided in the hydraulic documentation.

Flood immunity is important especially when other factors causing disruption to transport, such as times of submergence and availability of alternative routes when the road is closed by flood waters, also need to be considered.

Disruption to transport is related closely to the times of submergence of the road, as well as the flood immunity, so these can therefore be useful in assessing acceptable flood closures for the road.

In addition, the flood immunity of the total road link should be examined, since it may not be logical to provide high flood immunity on one bridge while the remainder of the link is closed frequently. On the other hand, it is important to consider whether the long-term improvement of flood immunity and an improvement to a level above the remainder of the road may be acceptable if the rest of the link could be scheduled for future improvements.

The design must comply with the current version of TMR's *Design Criteria for Bridges and Other Structures*, Protection against Scour section and TMR's *Bridge Scour Manual*.

13.1.4 Flow velocities and afflux

The velocity of flow through the bridge is a critical design parameter and defines the risk of scour for the bridge. Flow velocity usually increases as the flood size increases, but is often at a maximum for a bridge at the point where the bridge is overtopped. Setting an acceptable flow velocity is usually an important constraint on the size of a bridge, because the flow velocity will increase as the bridge is shortened and the constriction to the flow is increased. As the bridge is made shorter, the velocity increases, but the afflux also increases. The allowable flow velocity depends on the local stream conditions under the bridge, but a velocity of more than 2.0 m/s is often a concern. Assessing the natural stream conditions without a bridge is often useful, since this will indicate the velocities that will occur and provide an understanding of possible limits.

13.1.5 Abutment and pier protection

Abutment and pier protection for replacement bridges should be provided as per *Part E – Section 48*.

13.2 Bridge and roadside traffic barriers

13.2.1 Roadside safety barrier and bridge traffic barrier interface

Roadside safety barrier must be connected and transitioned to the bridge traffic barrier, in accordance with relevant TMR Standard Drawings.

13.2.2 Replacement of damaged bridge and roadside traffic barriers

The replacement bridge traffic barrier (for the damaged bridge traffic barrier) must be designed in accordance with the *Design Criteria for Bridges and Other Structures*. The approach taken here is the same as replacing a barrier damaged by vehicle impact. Accordingly, the following action should be undertaken:

1. The barrier should be replaced with a barrier conforming to AS 5100 if the existing deck has sufficient structural capacity to support the design load.
2. Where AS 5100 specifies a performance level higher than 'Regular', the deck must be modified to provide a higher level of protection. Exemption based on impractical or uneconomic criteria shall be via the normal design exception process i.e. approval by the District Director and certification by an RPEQ (refer to *Section 1.8*).

3. Where a ‘Regular’ level barrier or less is required by AS 5100 and the deck cannot support the current barrier design loads, a risk analysis for an existing bridge should be undertaken in accordance with AS 5100.1. If the bridge conforms to these criteria, a barrier of lesser performance level may be installed. The minimum strength for replacement rails is 50% ‘Low’ performance level.

For timber decks and other existing barriers with inadequate strength (for example, concrete posts with water pipe and concrete posts with balustrades), which do not conform to the above criteria, refer to the Director (Structures Design Review and Standards).

Where roadside safety barriers on the approaches to a bridge and/or bridge traffic barriers have been flood affected, the flowchart in Figure 4 (located in *Section 16*) should be used to determine the works necessary for reinstating the barrier(s) and for compliance with current engineering standards.

Further guidance on roadside barriers is provided in *Section 16.3*.

14. Drainage infrastructure

14.1 Drainage design criteria

The primary reference for the planning, design, operation and maintenance of road drainage infrastructure on projects for which TMR is responsible, including natural disaster projects, is the Volume 3, Part 5, 5A and 5B of the *RPDM 2nd Edition*. The road drainage must be considered in all road infrastructure projects, including natural disaster projects. Hydraulic and structural investigations/assessments are required for all TMR projects to at least confirm that the structure will operate safely (hydraulically and structurally) for the design/service life of the project and freight task for the road link. One of these investigations/assessments is checking the performance of structures for extreme rainfall events. Therefore at least a simple hydraulic assessment is essential for all projects, although more complex hydraulic assessments will be needed in many cases.

Flood immunity is an important requirement, but there are further factors to consider including impacts on neighbouring properties, risk of scour damage, aquaplaning and environmental impacts.

TMR design standards for road projects provide for a flood immunity of 1% to 2% AEP. Projects on roads within the National Land Transport Network (Auslink) usually require immunity for a 1% AEP. There are other flood-related concerns as well as flood immunity where some investigations could be of value.

The *Guide to Road Design: Part 5, 5A & 5B* should be used in conjunction with Volume 3, Part 5, 5A and 5B, *RPDM 2nd Edition*. Other references, such as the *Queensland Urban Drainage Manual* (QUDM), should only be used if referred to by these supplements.

Refer to *Part E – Section 49* of this document for structural requirements for existing structures.

Where an upgrade to drainage beyond the pre-disaster condition is proposed, complementary QTRIP funding will need to be sought.

14.2 Key drainage requirements

Significant rainfall events and subsequent extensive flooding test and stress the road drainage system. This drainage system includes bridges, culverts, floodways, table drains (and blocks), diversion drains (and blocks) catch drains/banks, subsoil drains, pavement drains etc. This system was designed to convey stormwater through/about the road reserve for a specific performance criterion, AEP.

The purpose of DRFA funding is to reinstate the drainage system to its pre-event immunity level using current standards. This may require installation of subsoil and pavement drains. With respect to road drainage, this condition refers to the hydraulic performance/capability the system was designed to handle. Simply replacing ‘like for like’ may not give the same hydraulic performance/capability as originally designed. It is likely that the environment and terrain have been altered by the flooding, which in turn will change the stream dynamics and tailwater levels when compared to pre-event conditions. These changed hydraulic parameters will affect the performance of drainage infrastructure if it is replaced ‘like for like’. Impacts need to be assessed.

It is recommended that the original design and its intent be reviewed and understood to ensure that natural disaster project design work properly reinstates the drainage system to at least match original performance criteria.

The following key aspects are highlighted to ensure compliance with the requirements of Volume 3, Part 5, 5A and 5B, *RPDM 2nd Edition*:

- Drainage structure inspections must include bedding and backfill checks – water/moisture ingress can weaken backfill support material (leaching of fines) and/or cause piping or subsidence failures. These will need correcting to ensure appropriate support for the structure (evidenced by subsidence of pavement (above culvert) and/or embankment, movement of culvert ends and movement/separation of the barrel units).
- Culverts need to be structurally inspected to ensure construction can proceed safely and without damaging the culvert(s), and to ensure safety of continued service (refer to *Part E – Section 49* and Chapter 3, Volume 3, Part 5B, *RPDM 2nd Edition*).
- Scour repairs – minimum should be based on rock protection design procedure (Chapter 3, Volume 3, Part 5B, *RPDM 2nd Edition*).
- Fish passage requirements – assessment and approvals by Department of Agriculture and Fisheries (DAF) using DAF guidelines (also Chapter 3, Volume 3, Part 5, *RPDM 2nd Edition*) for all bridges, culverts and floodways, including temporary works across streams. Please contact your local TMR environmental representative for any questions on the interpretation and application of these requirements.
- Traditional steel culverts no longer meet current structural requirements/standards (design/service life of 100 years). To achieve this requirement, steel culverts must have added protective coatings (Chapter 3, Volume 3, Part 5B, *RPDM 2nd Edition*).
- Reinforced Concrete Culvert (RCC)/cast in situ is no longer a current standard:
  - If damaged, must be replaced with Reinforced Concrete Box Culvert (RCBC).
  - If to be retained/repaired, structural checks and design will be required.
- Due to the lighter weight of precast end units, integral (i.e. fixed to precast units) cut-off walls are a mandatory requirement for both inlet and outlet structures.
- Cut-off wall on in situ outlet structures is mandatory (optional on upstream side) (Chapter 3, Volume 3, Part 5B, *RPDM 2nd Edition* and refer to relevant standard drawings).
- For links to current approved standard drawings, see *Section 14.3*.
- Table drains – the preference is for flat bottom. 'V-drains' should only be used in constrained areas. Check table drain connections between new work and existing drains – transitions may be required, particularly where flat bottom drains flow into a V-drain. Check that the invert of table drains meets the required minimum depth below subgrade/drainage blanket and that the drain is free draining.
- Table drain blocks – important to check original design and reinstate to ensure operation of crossflow structures without adversely affecting the pavement.
- Outlet protection – check and reinstate.
- Sub-soil and pavement drains – clean out and check. Need to ensure they are not choked with silt or damaged from the flood event. Replacement and/or installation of new drains may be required.

If a culvert to be extended is eligible for DRFA funding (e.g. when formation widening to cater for an overlay), the DRFA will fund the lowest-cost option from the following:

- Extending the culvert/s
- Raising the headwall.

Where headwalls to culverts are to be raised (made higher than as specified within standard drawings), structural design/approval will be required. The need for roadside barriers will also need to be assessed – refer to *Volume 3, Part 6 of the RPDM 2nd Edition*.

Any extension of a culvert/s further than that required to achieve the existing carriageway width (e.g. to achieve an interim or vision seal width, if this is greater than the existing width) is to be treated as complementary works.

Drainage infrastructure such as culverts, headwalls and table drains can contribute to the severity of run-off-road crashes. The design needs to ensure that potential road safety risks from drainage features are mitigated.

The majority of existing culverts that are located close to the carriageway and are approximately parallel to the road (typically under turnouts/accesses/driveways) will most likely have standard/vertical-faced ends. The ends of any of these culverts that require replacement or repair from flooding should be fitted with slope-faced ends to reduce crash risk/severity. The difference in cost between standard ends and slope-faced ends should be minimal.

14.3 Drainage, retaining structures and protective treatments standard drawings

Current standard drawings for drainage structures can be located on the TMR website under Technical Publications – Standard Drawings.

14.4 Hydrologic/hydraulic assessment

The hydrologic assessment (determination of run-off from a catchment) and hydraulic assessment (determination of tailwater/flow depths, stream velocities, culvert hydraulics etc.) of culverts are only required if one or more the following apply:

- There has been a change in the road immunity requirements as indicated in the link strategy.
- There has been a noticeable change in the hydrologic characteristics of the structure's catchment as a result of a flood event.
- There has been a noticeable change in the hydraulic parameters (particularly downstream of structure) with respect to cross-section, gradient and roughness etc. of the stream as a result of a flood event (which will affect tailwater levels).
- The culvert is being extended (which may cause an afflux and impacts on neighbouring properties).
- The culvert is being replaced.

A hydrologic and hydraulic assessment is also required if an overlay is proposed in a floodplain.

Assessment and design of river crossings, large floodways or floodplains (with multiple crossings), large creek crossings and large and/or complex catchments require engagement of specialist services (either using the Hydraulics and Flooding Unit of E&T or a specialist external consultant).

For the purposes of checking and replacing culverts and smaller floodways (e.g. single crossing) should be referred to relevant chapters in Volume 3, Part 5B, *RPDM 2nd Edition*.

15. Geotechnical

15.1 Geotechnical design standard

Geotechnical input will be determined during the scope assessment phase. The geotechnical elements for design are categorised into the following items, but not limited to:

- embankments/fill slopes including bridge approaches failure
- cut slopes failure
- natural slopes failure
- bridge and other structure foundations issues
- retaining wall-related issues
- scour/rockfall-related issues.

Geotechnical design must be carried out in accordance with the design criteria in TMR's *Geotechnical Design Standard – Minimum Requirements*. Where the design element has not been covered in this design standard, Australian Standards or other recognised National/International Standards could be used subject to acceptance by TMR Director (Geotechnical). Specifically, for slope remediation works, the designers should demonstrate that the design proposed for the remediation has a minimum factor of safety specified in *Geotechnical Design Standard – Minimum Requirements*, and is consistent with the design methodology used (in terms of partial factors, limit state design etc.). For cases where less than the stated minima may need to be considered, the designer should contact E&T's Geotechnical Unit (refer to *TMR contacts* at the back of this document) for advice.

For embankment failures, the designers should:

- keep the remedial works within the original embankment footprint, as far as is practicable
- provide low-cost design solutions for low traffic volume roads in range sections
- optimise use of drainage works to minimise infiltration and to allow water to drain away quickly.

15.2 Slope risk assessment

Slope risk assessment should be undertaken to assist network prioritisation and planning as per the *Guide to TMR Decision Matrix for Strategic Slope Risk Mitigation* shown in Figure 3. This guide is based on the *NSW RMS Guide to Slope Risk Analysis Version 4*.

On completion of remedial works, the condition of the remediated slope must be assessed by a design consultant who is an RMS-accredited assessor using the *RMS Guide to Slope Risk Analysis Version 4* to capture in TMR's slope risk registration system. The slope risk assessment report must be endorsed by an experienced RPEQ geotechnical professional who is experienced and has full accreditation with *NSW RMS Guide to Slope Risk Analysis*.

For specific reasons (e.g. cost benefit analysis and a site-specific evaluation of acceptable risk), if a district adopts a value for money approach that does not bring the risk level to ARL4 or better (i.e. where any residual risk exceeds ARL4 level), the design consultant must provide a risk management plan that has been developed in collaboration with the district and TMR's Geotechnical Unit. The plan should identify residual risks and provide recommendations on future risk mitigation and remedial actions.

Figure 3: Guide to TMR decision matrix for strategic slope risk mitigation

GEOT067 — **Guide to TMR Decision Matrix for Strategic Slope Risk Mitigation**

Queensland Government

Assessment of risk for slopes

Risk to TMR road network users and TMR property from slope instability is assessed based on the NSW RMS Guide to Slope Risk Analysis. Using the NSW RMS Guide, risks are assessed on the basis of:

a) Likelihood of failure, and

b) Consequences of failure to the element at risk (which may be life, property or road network functionality).

Risk assessment outcomes provide a means for categorising the risk from slope instability and prioritising risk management of slopes at a network level. The assessment procedure involves the identification and risk analysis of hazards from a visual inspection of the slope at a particular point in time. The visual inspection is initially carried out from the road, as well as above or below the road depending on site accessibility.

The risk analysis is based on determining a series of ratings for each hazard identified on a slope. The ratings are based on the judgement of the Geotechnical Practitioner, with varying amounts of information from investigation, geological and engineering analysis, and matrices in the RMS Guide and include:

- Likelihood of failure (L) – the probability of a hazard moving *and* travelling to the element at risk.
- Temporal probability (T) – the probability of a person / vehicle / structure being in the zone of influence at the time of failure.
- Vulnerability (V) – the probability of death occurring as a result of the failure.
- Consequence (C) – for risk to life derived from T and V; for economic loss derived on the basis of repair costs and network disruption.
- Scale of failure (S) – the potential volume of large slides, or size of individual blocks which may fall.
- Rate of failure (R) – from extremely rapid failures with no warning to slow failures with sufficient time to take evasive action.
- Assessed Risk Level (ARL) – the Assessed Risk Level is derived from L and C and is categorised on a scale of ARL1 (highest risk) to ARL 5 (lowest risk).
- Event Magnitude (M) – derived from S and R. An indication of the energy associated with the failure and its capacity to do damage.
- Hazard Classification (H) – derived from M and L, expresses the probability of a potentially damaging event.
- Slope Attribute Score (SAS) – number derived from a scoring system based on the presence of physical features on a slope. Provides an indication of the potential of a slope to generate failures, without consideration of the likelihood or consequences.

The Assessed Risk Level is the key rating for determining risk management and remediation priorities. The other ratings may be used to prioritise risks with the same ARL rating. The assigned ARL is not static and is expected to change over time, as slopes are remediated, or due to changes brought about by the natural environment, or through changes in traffic volume, road configuration or posted speed limits.

Assessed Risk Level (ARL) categories

The Assessed Risk Level is on a scale of ARL1 (highest risk) to ARL 5 (lowest risk). The ARL assigned to a slope is based on the highest risk hazard assessed at the site and may be for risk to life or for economic risk. Each ARL contains a range of indicative probabilities and is subject to uncertainty due to the inherent imprecision of many of the ratings that are assessed in the analysis. ARLs can be linked to indicative annual probability of loss of life, and tolerable or acceptable societal risks as follows.

ARL 1 Represents the highest level of risk to life or property. Corresponds to an indicative annual probability of loss of life (individual) of $>10^{-3}$ /annum. Generally regarded as not tolerable as a societal risk to life, even in the short term, and must be subject to the implementation of an appropriate Slope Risk Management Plan.

ARL 2 Second highest level of risk. Corresponds to an indicative annual probability of loss of life (individual) of $>10^{-4}$ but $\leq 10^{-3}$. May be tolerable in the short term, subject to implementation of an appropriate Slope Risk Management Plan. These slopes will be subject to remedial action to reduce the risk, but with a lower priority than for ARL1 sites.

ARL 3 A moderate level of risk. Corresponds to an indicative annual probability of loss of life (individual) of $>10^{-5}$ but $\leq 10^{-4}$. Generally regarded as tolerable in the short to medium term. These slopes may be subject to remedial action or other means of slope risk management with lower priority than ARL1 or 2 sites. This risk level forms the target level for risk reduction measures for ARL1 and 2 slopes.

ARL 4 Second lowest level of risk. Corresponds to an indicative annual probability of loss of life (individual) of $>10^{-6}$ but $\leq 10^{-5}$. Generally regarded as tolerable under most circumstances. Target risk level for new construction.

ARL 5 Lowest level of risk. Corresponds to an indicative annual probability of loss of life (individual) of $\leq 10^{-6}$. Generally regarded as tolerable.

TMR's application of ARLs

The intent of TMR's slope risk mitigation strategy is to analyse, rank and manage or reduce the anticipated risks associated with the stability of all slopes under the control of TMR. These slopes include cut batters, fill embankments, natural slopes above and below the road, retaining walls and bridge abutment slopes that originate in or may influence the road reserve. The ARL ratings are the preferred planning tool for prioritising slope risk management and remediation works.

Slopes assessed as ARL 1 to 2 require some form of risk mitigation. Generally any slope classified as ARL 1 or 2 should be remediated by appropriate stabilisation works or managed by other means to reduce the level of risk to ARL 3 or lower. Slopes classified as ARL 3 require on-going evaluation, monitoring and periodic re-assessment to maintain risk at existing levels. Further evaluation may be required to determine the cost-benefit of treatment or on-going risk management. ARL4 and ARL5 slopes would generally require no further work outside of routine maintenance. All slopes (ARL1-5 and non – rated slopes) are regularly monitored for observed changes by road patrols. Any changes in slope conditions may result in re-analysis and re-rating.

Decision Matrix for ARL Categories and Strategic Slope Risk Mitigation.

Assessed Risk Level	Relative Risk Level	Probability of Risk (Individual loss of life)	For New Slope Construction	For an Existing Slope	Slope Risk Management Plan	Target Slope Risk Mitigation Strategy
ARL 1	Very High Risk	$>10^{-3}$ /annum	Not tolerable	Generally regarded as not tolerable.	Required	Treatment or risk management to reduce the level of risk to ARL 3 or lower.
ARL 2	High Risk	$>10^{-4}$ but $\leq 10^{-3}$ /annum	Not tolerable	May be tolerable in the short term, subject to closer examination	Required	Treatment or risk management to reduce the level of risk to ARL 3 or lower.
ARL 3	Medium Risk	$>10^{-5}$ but $\leq 10^{-4}$ /annum	Generally regarded as not tolerable. May be tolerable subject to cost-benefit analysis	Generally regarded as tolerable in the short to medium term. May be tolerable in the medium to long term based on cost-benefit analysis and site specific evaluation of acceptable risk.	Required	For existing slopes, maintain risk at this level. Regular monitoring and further evaluation for treatment and / or risk management. Periodic review.
ARL 4	Low Risk	$>10^{-6}$ but $\leq 10^{-5}$ /annum	Tolerable Target for new construction.	Tolerable under most circumstances	Not generally required	Maintain risk at this level. Observation for changes in condition by road patrols. Re-assessment in 5 years or if slope conditions change.
ARL 5	Very Low Risk	$\leq 10^{-6}$ /annum	Tolerable	Tolerable	Not generally required	Maintain risk at this level. Observation for changes in condition by road patrols. Re-assessment in 5 years or if slope conditions change.

Notes

1. This guide is intended as a tool to assist network prioritisation and planning. Specific risk mitigation treatments should be designed according to relevant standards.
2. Risk assessments shall only be conducted by suitably qualified geotechnical professionals who have been accredited for this purpose by the NSW RMS and organisations or individuals contracted by TMR to undertake geotechnical work in Queensland who can provide RPEQ endorsement of assessment reports.
3. In 2011 the NSW Roads and Traffic Authority (RTA) was merged with NSW Maritime Services and now referred to as NSW Roads and Maritime Services (RMS).
4. Management Strategies for specific sites may be influenced by exposure to extreme weather events.
5. Existing agencies should carefully consider the relevance of this matrix for specific projects, site conditions and local standards, and if necessary consult with TMR Geotechnical Section in relation to this guide before use.
6. This guide will be reviewed from time to time as the need arises and in response to improvement suggestions by users.
7. Short, medium or long term are site specific arbitrary measures of time and may relate to or be altered by the influence of wet season and extreme weather events.
8. This guide assumes routine maintenance tasks are performed such that existing risk levels do not increase.
9. A visual inspection of the road network and adjacent slopes in a particular region by the relevant authority is required following extreme weather events.

References

1. Australian Geomechanics (2007) Commentary on Practice Note Guidelines for Landslide Risk Management 2007, Vol 42 No 1 March 2007.
2. Lester, J., Welikala, D.L., Creagh, M. (2013) A strategy to manage the risk of slope instability affecting state controlled roads in Queensland, Australia, 14th Congresso Brasileiro de Geologia de Engenharia e Ambiental, Rio de Janeiro, Brazil.
3. Locke, M. (2004) A risk based approach to stabilisation of rock batters, Australian Geomechanics, Vol 39 No 1 March.
4. NSW RTA Maintenance Matters, MM-00-05 Version 1.0, January 2003.
5. NSW RMS Guide to Slope Risk Analysis Version 4, April 2014.
6. Stewart IE, Baynes FJ, and Lee IK, 2002. The RTA Guide to Slope Risk Analysis Version 3.1. Australian Geomechanics Vol.37/2, pp115-147.

15.3 Major geotechnical projects options analysis

For natural disaster works, the assessment of options and selection of preferred treatments is to be documented using the *NDP Major Geotechnical Damage Templates* . This ensures all elements are appropriately documented to substantiate eligibility for the preferred treatment. The process is outlined in Appendix A of the *NDP Submission Guidelines*.

16. Roadside furniture and delineation

16.1 Signage and delineation

Relocated and replaced signs must be installed in accordance with the Queensland *Manual of Uniform Traffic Control Devices* (MUTCD), MUTCD Supplements, TRUM notes and Technical Notes. Delineation that requires reinstatement is also to be provided in accordance with the *Manual of Uniform Traffic Control Devices*.

16.2 Lighting

Natural disaster event-damaged lighting infrastructure is to meet the current requirements of *Road Planning and Design Manual 2nd Edition* Volume 6.

16.3 Roadside barriers

Natural disaster event-damaged roadside safety barriers must be reinstated to current standards in accordance with the provisions of the *Road Planning and Design Manual 2nd Edition* Volume 3 Part 6. Practitioners, especially the RPEQ endorsing design solutions, must understand the principles described in that document. In addition, the *TMR Road Safety Policy* also contains requirements for road safety barriers (and terminals) related to motorcycle safety standards.

A check needs to be undertaken to ensure that a barrier is still the appropriate solution. Check with the district office to ensure that proposed reinstatement works are consistent with other work programs.

16.3.1 Connection to bridge structures

Use the flowchart in Figure 4 to determine the need for bridge parapets and bridge approach barriers. The flowchart outlines steps to determine the design requirements for bridge traffic barriers and associated roadside safety barriers on bridge approaches. Bridge traffic barriers are to be reinstated as documented in the *Design Criteria for Bridges and Other Structures*.

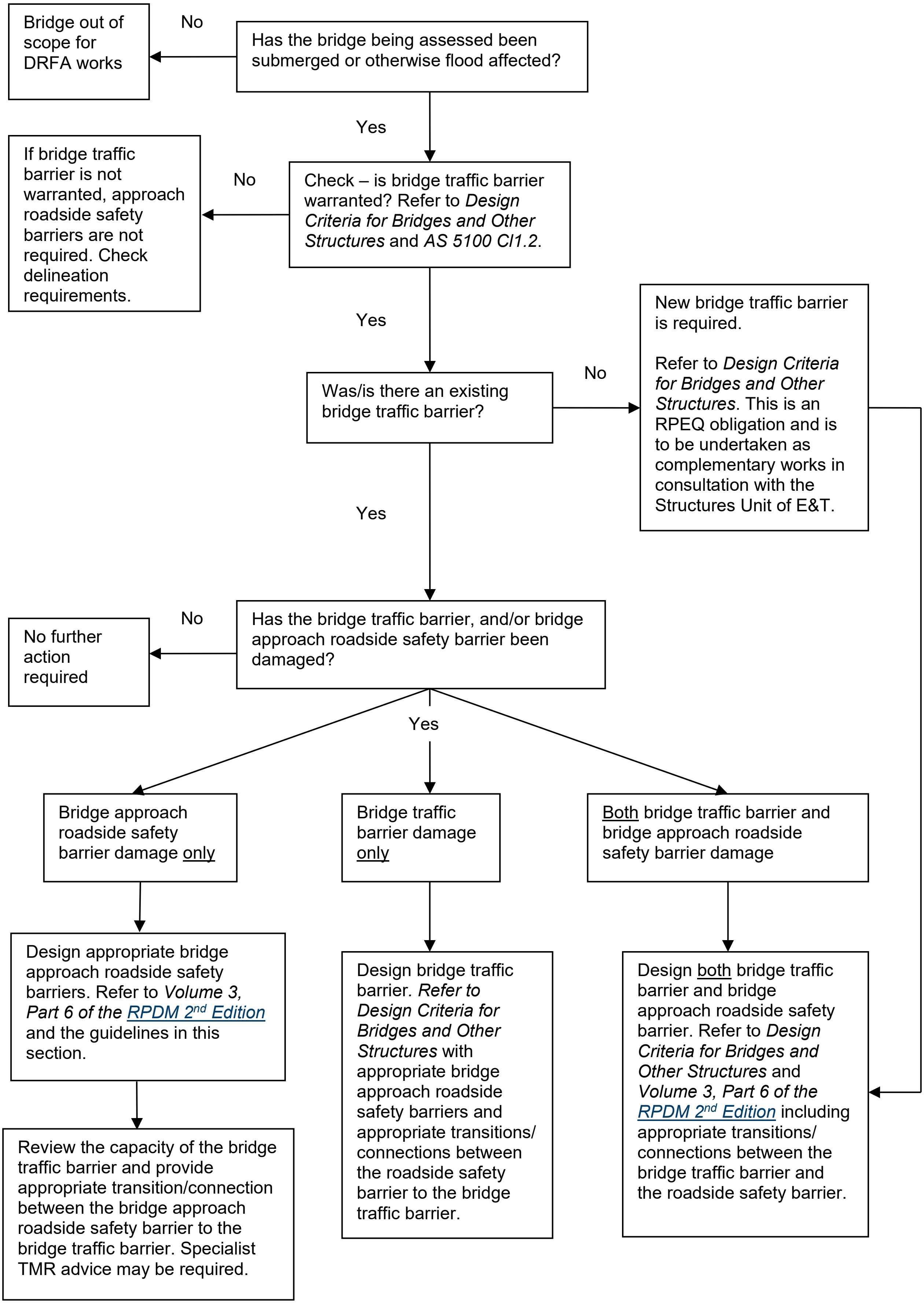
Approach barrier must be connected to the bridge structure to provide continuity. Where there is no existing bridge rail or parapet on the bridge structure, review whether a barrier on the approaches is warranted. If an approach barrier is required and full conformance with the bridge connection options in the *TMR Standard Drawings* cannot be achieved, seek specialist advice from the E&T Structures Unit whenever proposing to connect to structural installations.

16.3.2 Barrier height

The DRFA-funded pavement overlays will often require removal and reinstating of barriers. Where this occurs, the DRFA will fund reinstallation of the barrier to current design criteria.

Further guidance on roadside barriers is provided in *Section 13.2*.

Figure 4: Flowchart for assessing bridge parapets and bridge approach barriers



17. Geospatial considerations/survey information

Design for natural disaster works will need to be based on appropriate survey information (typically obtained via conventional survey and/or mobile laser scanning) together with conventional working plans for all reconstruction work that will involve a pavement overlay that will require more difficult/complex formation widening than simple maintenance type works.

Typically, this will relate to reconstruction works for Road Class A, B or C. Further detail on the types of work that would require survey information and reasons is included in *Part E – Section 50*. For these cases, some combination of mobile laser scanning and conventional survey methods will be required.

While it is acknowledged that reconstruction works after a significant weather event have differing time and cost constraints to a planned project, survey information for these works must still meet some basic requirements of the TMR surveying standards. Therefore, TMR surveying standards regarding qualified and competent surveyors, survey control marks, feature coding (including situational examples), quality assurance and deliverables must be adhered to.

The specific requirements of any survey information, including extents, must be determined by a competent and experienced professional. A fit-for-purpose survey and ensuing design/working plans must not subsequently create an increase in safety risk greater than previously existed.

17.1 Local knowledge

There are many benefits of tapping into local knowledge (i.e. the TMR district survey manager) including:

- obtaining data that already exists in the area of interest
- providing some survey data in a shorter timeframe than engaging an MLS consultant
- advising on the suitability of the site to MLS capture
- ensuring that the delivered product is suitable for future use by all areas of TMR.

Make the TMR district survey manager your first point of call. Alternatively, contact Geospatial Technologies using the details shown in *TMR contacts* at the back of this document, and they will arrange an introduction.

17.2 Deliverables

A TMR fieldbook must be registered to capture all survey information for the corporate record.

Information to be included within the fieldbook is outlined in the *TMR Surveying Standards*.

Along with the fieldbook, all associated electronic information created must be delivered to TMR including:

- point clouds
- derived 12D survey information (including any ground survey collected)
- imagery.

To obtain a fieldbook number or to organise delivery of fieldbooks and electronic information, contact Geospatial Technologies (see *TMR contacts* at the back of this document) or the TMR district survey manager.

17.3 Mobile laser scanning (MLS) technology

It is recommended that MLS technology be considered as a survey technique for reconstruction projects. MLS is a fast, safe and efficient field capture technique and the point cloud and imagery collected from each MLS sortie gives the user a good visual representation at the time of capture. However, the data extracted from the point cloud will only form a part of a traditional TMR survey product. This is due to some limitations of MLS including wet weather, vegetation and line of sight constraints.

It is also recommended that you contact TMR Geospatial Technologies (using the details shown in *TMR contacts* at the back of this document) to help mitigate risks in adopting this technology by facilitating, coordinating and delivering the MLS project.

TMR Geospatial Technologies has developed and published an *MLS Technical Guideline and a Checklist* that has proven crucial to successful MLS outcomes. Refer to the information provided in *Part E – Section 51* for assistance in the decision whether or not to use MLS technology.

18. Environmental requirements

Where the nature of the reconstruction work requires additional disturbance, the processes documented in the TMR Environmental Management System are to be followed. All projects will be required to comply with the *Cultural Heritage Processes Manual (2013)*, the *Environmental Processes Manual (2013)* and follow the *TMR EMS Environmental and Cultural Heritage processes for Infrastructure Projects*. Templates for all documents are located on the Environmental Management System intranet site.

Environmental duty of care will apply to all works carried out under the NDP.

For environmental requirements, refer to the Environmental Management System intranet site.

19. Safety in design

The State of Queensland is responsible for regulating and enforcing its work health and safety laws. All transport infrastructure projects must comply with Queensland's Work Health and Safety legislation, which includes the *Work Health and Safety Act 2011* and *Work Health and Safety Regulation 2011*.

Safe design means the integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risks to health and safety throughout the life of the structure being designed.

The safe design of a structure will always be part of a wider set of design objectives, including practicability, aesthetics, cost and functionality. These sometimes competing objectives need to be balanced in a manner that does not compromise the health and safety of those who work on or use the structure over its life.

Safe design begins at the concept development phase of a structure when making decisions about:

- the design and its intended purpose
- materials to be used
- possible methods of construction, maintenance, operation, demolition or dismantling and disposal
- what legislation, codes of practice and standards need to be considered and complied with.

Safety in design requires more rigorous and documented design processes that use a risk management approach in consideration of construction, operation and maintenance requirements.

For further guidance on safety in design, refer to *RPDM 2nd Edition* Volume 3, Part 1.

20. Design, documentation and other information requirements

20.1 General

As part of natural disaster works, design documentation and other information needs to be prepared and submitted to the department to provide a record of works undertaken. The following are minimum requirements to support future maintenance and departmental reference requirements.

20.2 Engineering drawings

Original engineering drawings in both hard copy and electronic format need to be provided for all natural disaster works and prepared in accordance with the *TMR Drafting and Design Presentation Manual*.

20.2.1 As constructed information

Appropriate records relating to the construction, enhancement and/or maintenance of TMR assets need to be captured in a consistent and timely manner.

Consultants are required to provide TMR with all engineering drawings for all natural disaster reconstruction works. As constructed drawings must reflect precisely how the natural disaster works were built; typically, they are updated after practical completion and issued to TMR within a defined time period.

Refer to the *TMR Drafting and Design Presentation Standards Manual* and *MRTS 50*.

20.2.2 Design certification

In addition to the requirements of the *Professional Engineers Act 2002*, engineering drawings must be certified by a relevant Registered Professional Engineer Queensland (RPEQ).

Certification requirements are detailed in the *TMR Drafting and Design Presentation Standards Manual* and MRTS 50.

20.3 Drawing preparation and presentation

20.3.1 Class D works (maintenance type projects)

Typically, Class D works will involve minimal design and drawing preparation, with estimating being the main design task. Typical drawing and presentation requirements are:

- Estimates should detail costs of DRFA-funded works and complementary works.
- Drawings just need to show type cross-sections and chainage limits for the extents of work.
- For convenience, the extents may be shown on a straight line diagram, superimposed on the working plans for the pre-damage situation, or in conjunction with the type cross-section.
- This form of documentation needs to:
  - clearly define the works
  - clearly define the new pavement and pavement rehabilitation design(s), their extents and all relevant details
  - provide a workable record of the as constructed road afterwards, including details of all the different pavement(s). Note that it will be necessary to also work with the working plans for the existing road in order to obtain full details of the post-reconstruction situation

- show on the type cross-sections any table drains, subsoil drains and pavement drains that need to be reinstated or installed so that they are free draining. Any additional table drain details need to include appropriate turnout/diversion treatment and table drain blocks as required.

Given that the new drawings will complement the working plans for the existing road, the following points need to be taken into consideration:

- A table listing the respective working plans for the existing road must be shown on the new drawings. The relevant chainages for each existing working plan should be included and labelled as approximate since a precise chainage mapping will usually not be available.
- If necessary, post-construction heights of the finished road surface will need to be derived from the new pavement depths and road surface heights on the existing drawings (originally called levels on most existing drawings).
- Chainages on the new drawings may relate directly to those on the working plans for the existing road if:
  - the current plans are in metric units with chainages close (within say 100m) to current gazettal chainage
  - there are no chainage equalities on the existing plans
  - a simple conversion between chainage on the TMR reference point system and/or the GPS trip meter is possible. This will usually mean that the working plans for the existing road are based on a relatively recent survey.
- Otherwise, chainages should relate to gazettal distance. The TMR reference point system and/or the GPS trip meter should be used to establish chainages. Desirably, a tie to some chainage on the working plans for the existing road should be included on the new drawings. This will be necessary when:
  - the existing plans are in imperial units
  - the chainages on existing plans are not close to gazettal distance – and in particular when the chainages are in the opposite direction to gazettal.
- Given that gazettal chainage may change over time, future use of these drawings will involve chainage mapping through features located on the plans and via the TMR reference point system and/or the GPS trip meter. An approximate (but often sufficiently close) chainage mapping may be obtained via comparing plan chainages and Digital Video Road (DVR) chainages at key features such as culverts, intersections and so on. This is no different from how chainages on any working plan have to be interpreted over time.

Note that it may be practical to use this form of documentation for some Class C projects when the road has:

- acceptable geometric shape with respect to grade and crossfall
- short lengths of reconstruction work
- no major culverts that need to be lengthened
- only minor widening on low formation with flat batters (1 on 4 or flatter) – or no formation widening
- geometry that has no design exception that needs to be rectified.

20.3.2 Class A, B and C

Most reconstruction work will involve a pavement overlay that will require more difficult/complex formation widening and/or re-establishment of a geometric control line. Typical drawing and presentation requirements are outlined below:

- Design will need to be based on appropriate survey information (typically obtained via Mobile Laser Scanning). Conventional working plans will be necessary. The use of TMR survey standards will establish the coordinate system and chainage control. See *Part E – Section 53* for details of drawing requirements when the design is based on mobile laser scanning.
- Estimates should detail costs of DRFA-funded works and complementary works.
- Design drawings will need to be prepared consistent with the *TMR Drafting and Design Presentation Standards Manual*.

20.4 Design development reports

For Class A and B projects (refer to *Part B – Section 9.1*), design development reports should be completed. Small and large project versions of this report are referenced from the *TMR* *RPDM 2nd Edition*. Projects also need to complete the Safe System Project Management Control Checklist under *Appendix B* of the *TMR Road Safety Policy*.

Following are some of the requirements expected when submitting design development reports and drawings:

- Each design submission must be submitted together with a design development report that:
  - identifies any differences between the tendered design or the original design requirements set out in the project's design brief for the design element and the final detailed design for the design element
  - states that the design meets the requirements of the project's design brief
  - identifies integration issues and risks with other design components and mitigation strategies
  - identifies the durability requirements for the design element
  - identifies the performance criteria selected for the design element
  - confirms that all safety, environmental, soil and revegetation design criteria have been addressed for the element
  - identifies the design loadings and/or design standards that have been or will be adopted for detailed design of the component
  - identifies compliance with the performance criteria stipulated in the project's design brief
  - addresses where changes have been made to the tendered design or the original design requirements set out in the project's design brief, and provides an update on any changes to the durability requirements, performance criteria, design loadings or design standards to be applied to the design element.
- Each submission must be complete, grouped and self-contained. To be clear, each submission must contain all elements of that part of the contractor's work being submitted.
- Each submission must include at least the following:
  - plans (as applicable)
  - drawings
  - calculations
  - test results
  - design advice that:
    - highlights design assumptions and justifies the reason for adopting the assumption
    - highlights where values less than the desirable minimum are used and explains why the contractor/designer considers that better values can not be reasonably achieved
    - includes a brief description of main changes from previous design submissions (if any)
  - a Road Safety Audit. With respect to *Part B – Section 9.4*, the road safety audits accompanying the design submissions must be undertaken by an independent qualified road safety auditor who was not involved in the development of the design
  - the design development report must contain a detailed section on safety in design pertinent to the submission (refer to *Part B – Section 19*). Alternatively, a separate Safety in Design Report may be produced as an appendix to the design development report
  - completed specification annexures
  - other relevant information that supports the submission and allows the submission to be evaluated without requests for further information. For example, any submission that includes a grade line modification must also include at least the:

- road surface contours
- aquaplaning calculations
- sight line calculations and data
- justification for adopting values less than the desirable minimum (if applicable)
- Road Safety Audit
- other data and documentation as required.

20.5 Geometric Design Model Software

All geometric designs must be undertaken using 12D model software and E&T macros.

- Note that the use of other design software during the geometric design process (even if converted into 12D at the end) does not allow for the transfer of all necessary data attributes into 12D. Further, the accuracy of macros built in other software is not maintained.
- Only those customisations or macros released by E&T should be used for natural disaster works.

20.6 Road Asset Management Data

Details of candidate natural disaster works are required for asset management purposes with the basic data requirements shown as in Table 13 (*Part E – Section 53*). Some of the detailed information is required upfront and some after work has been completed.

The required information should be included with works packages when submitted to the NDP Team in Program Management and Delivery (PMD).

The asset management data requirements for natural disaster works cover the following areas:

- Financial reporting – Queensland Audit Office will require detailed information regarding infrastructure assets impacted by these events
- Investment planning – capture of data is needed to maintain essential information for the following ongoing and future organisational activities:
    - Pavement rehabilitation and surfacing treatment programs
    - Job inventory
    - Element planning process
    - MPO program planning process
    - Maintenance strategy analysis.

Details of the data/information requirements to support these components are included in *Part E – Section 53*.

PART C – DESIGNING FOR RESILIENCE

This part provides information to assist designers to improve the resilience of TMR infrastructure.

21. Introduction

As defined in the *Queensland Resilience and Risk Reduction Guidelines*, resilience is a system or community's ability to rapidly accommodate and recover from the impacts of hazards, restore essential structures and desired functionality, and adapt to new circumstances. One objective of the DRFA is to improve the resilience of Queensland's road and transport infrastructure so that it will not suffer the same magnitude of damage as a result of future events.

Works likely to contribute to network resilience are those that:

- improve the network's ability to survive future similar events by reducing the extent of damage
- reduce the work and/or time required for the network to be recovered to unrestricted usage following a future event without improving its flood immunity.

Examples are pavement structural improvement, shoulder sealing, resurfacing, slope stability work, floodway improvements, drainage and structures scour protection, and drainage scour protection.

Designers must consider improving the resilience of their projects by:

- identifying all infrastructure that has been damaged
- unless unaffordable, designing infrastructure at all damaged sites with an improved tolerance to damage.

Whole-of-life cost considerations can be used to determine what improvements to resilience are justified. Improved resilience, other than incidental resilience resulting from the use of current engineering standards, are required to be funded through complementary works. **Part A – Eligibility is to be the governing factor as to which works can be funded under the DRFA or as complementary works.**

This section provides information on improving the resilience of road and transport infrastructure.

22. Context

Historically, pre-disaster performance (particularly pavements), while considered adequate, may have been influenced by years of low rainfall, drought-type conditions. Major natural disaster events have exposed previously unquantified performance vulnerabilities.

Most damaged infrastructure was designed and built to now outdated standards. Generally, at the time of design, existing and new road and bridge infrastructure was designed to cope with known rainfall and flooding extremes. It was also designed to ensure adequate safety standards, performance standards and asset immunity exist over the intended design life.

This does not mean that road infrastructure is designed to be immune from all rainfall and flooding events. In fact, bridges and roads are frequently and purposely designed to be overtopped and inundated for short periods. Design elements are chosen to enhance performance in these conditions (e.g. bound pavements, asphalt surfacing, and subsoil and pavement drainage to cope with near-surface water flows and high water tables, batter and scour protection, and debris loading).

Major natural disaster events have shown that previous climatic design inputs and therefore impacts may have previously been underestimated on parts of the network. For these major events, the rainfall extended over long periods of time, resulting in raised water tables, ground saturation and moisture infiltration into pavements. Had the excessive rainfall durations and flooding magnitudes been known and designed for originally, the vulnerabilities that were revealed may not have been as extensive or as disruptive.

Current climatic design inputs (rainfall duration, water table and infiltration impacts, flood heights, stream velocities, etc.) must be incorporated into the design of reconstruction works and more resilient treatments considered where vulnerabilities of past designs have been revealed.

Works that are designed for the purpose of improving resilience, rather than meeting current engineering standards, may not be considered eligible under Category B of the DRFA, and may need to be funded as complementary QTRIP works or as betterment works where Category D DRFA funding is available.

Emergency works largely comprise short-life, maintenance-type treatments. Reconstruction works are required to address the vulnerabilities exposed and any residual performance risks that emergency repairs may have introduced.

Simple maintenance treatments (e.g. patching, rut filling, etc.) which are typically short-term fixes are unlikely to achieve even pre-disaster performance outcomes, except on older road sections that were already a priority for rehabilitation on future QTRIP programs.

23. Pavements

23.1 Existing moisture conditions

Reconstruction works may have to contend with above average, wet ground conditions. Regional visits by the Australian Road Research Board (ARRB) in July 2011 highlighted the ongoing consequences of prolonged rainfall following major natural disaster events. Almost without exception, all bridges and culverts had water flowing through them or ponding beneath/in them. Almost all table drains were still wet. Seepages were still active in cut faces and adjacent gullies. Even six months after ‘normal’ rainfall had returned, water tables were still high. In this scenario, pavements are still vulnerable and areas of distress may continue to grow.

The pavement design solutions developed need to allow for existing moisture conditions.

23.2 Design approach

The design of pavement repair solutions needs to address contributory causes. To simply reinstate or replace proven vulnerable pavement materials with the same quality or characteristics will not improve resilience. Contributory causes are identified through relevant testing and investigatory techniques (refer to *Section 8.1.2*).

The best pavement solution will be the one that provides the lowest whole-of-life cost when taking into account factors such as initial construction cost, ongoing maintenance costs, repair and/or rehabilitation costs and frequency, and period of inundation to be expected. In the selection of appropriate solutions, designers should carefully consider whether increased resilience can be economically achieved through complementary funding within the project funding allocation.

Where funding is very limited (e.g. lower-order roads), it is just as important to address contributory causes, even if this does not leave sufficient funds to fully reconstruct the pavement.

The Pavements, Research and Innovation and Pavements Rehabilitation Units in E&T can provide specific advice on pavement resilience for local circumstances (refer to the *TMR contacts* at the end of this document).

23.3 Non-flooded pavements

The guidance in this section applies to pavements that are not inundated for significant periods of time. These pavements are often on grade/s with adjacent longitudinal drains.

Consideration of the issues discussed in the *TMR Pavement Design Supplement*, *TMR Pavement Rehabilitation Manual*, Austroads *Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment* will provide significant protection against damage relative to previous documents. However, applying improved granular base standards will provide additional resilience against high rainfall events. Use of repeated load triaxial test (RLT – Q137) can be used to ascertain the appropriate Degree of Saturation (DoS) value to be used at the time of sealing. This will minimise any premature failures related to excess moisture.

Examples of improved resilience for non-flooded pavements are as follows:

- Reducing the pavement’s moisture susceptibility
    - Providing sealed shoulders to provide extra distance between the outer wheel path and the zone of influence of inundation (i.e. eliminate unsealed shoulders)

    - Modifying/stabilising pavements using cementitious or bituminous stabilising agents to reduce the moisture sensitivity of the in-situ pavement materials where suitable/appropriate. Numerous sections of roadways comprising a foamed bitumen stabilised base layer have withstood inundation on multiple occasions and have survived very well. For guidance on increased pavement resilience using foam bitumen stabilisation, refer to *Section 46* of this document, and Appendix C2 and Chapter 4.9.8 of the *Pavement Rehabilitation Manual* (February 2020).

- Improving pavement drainage
    - Reinstating, regrading and/or deepening table drains
    - Cleaning subsoil drains and culverts
    - Repairing surface cracks
    - Adding a geotextile or PMB seal
    - Adding a drainage blanket.

If there is evidence of pavement distress from water infiltrating from below the pavement (e.g. in cuttings), or there is evidence that the water table is sometimes within or above the pavement, consideration should be given to the installation of deep longitudinal cut-off drains or use of drainage blankets on top of the subgrade. For design guidance see the *Gerke R J (1987) - Subsurface drainage of road structures. Special Report SR 35.* Australian Road Research Board, Vermont South, Australia.

Further information on measures to improve pavement drainage is given in:

- *TMR Pavement Design Supplement*
- *TMR Pavement Rehabilitation Manual*
- *Austroads Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment*.

Of course, designers will need to be conscious of any risks in providing for the increased resilience. For example, stabilised pavements are more prone to fatigue, unless there is adequate depth of pavement to resist this.

23.4 Flooded pavements

The guidance in this section applies to pavements that are inundated for a significant period. These pavements are often at low points located around major cross-drains or in flat terrain.

23.4.1 Pavement performance when flooded

Pavements are at their most vulnerable when subjected to traffic loading in high moisture conditions. The longer that a pavement is flooded, the more likely that its moisture content will increase. Pavements do not dry out quickly, so the longer the combination of traffic loading and high moisture content continues, the larger the loss of service life is likely to be. This is particularly the case for unbound granular pavements.

Pavements will typically suffer loss of service life if the pavement structure, including the subgrade, is trafficked when above its designed operating moisture range. Pavements may provide an acceptable level of resilience (or performance) if restrictions on traffic loads are applied over several weeks and months after periods of inundation. However, this may not meet community expectations and may be very difficult to administer.

23.4.2 Design approach for pavements subject to flooding

It is recommended that priority be given to providing a high level of resilience on the higher-order roads. This may be more easily justified on higher-order roads with higher traffic volumes, particularly if shorter lengths of inundation and stable subgrades apply.

Where, due to whole-of-life cost considerations and/or budget and/or resource constraints, non-concrete pavements, particularly unbound granular, are considered in areas subject to inundation, local knowledge and experience is required to determine how long a particular pavement material could be inundated without significant loss of service. Load restrictions may have to be applied until deflection analysis indicates that there are no signs of weakness, particularly in the outer wheel path.

23.4.3 Examples of increased resilience for pavements subject to flooding

Examples of improved resilience for pavements subject to flooding are listed below. Please note that the level of improvement gained under some of these treatments is not certain. In these cases, local knowledge and experience is required to determine their suitability.

- Reducing the pavement's moisture susceptibility – refer to the first dot point in *Section 23.3*.
- Providing increased flood protection on the downstream side of floodways to resist embankment batter erosion that if left unprotected would result in damage to pavement seals and materials
- Providing more under-drainage for waterways (including floodways), where there is a history of recurrent damage to seals and pavement materials when over-topped due to high velocity flows or long periods of inundation
- Installing concrete pavements on floodways (including approaches)
- Installing concrete pavements on approaches to low-level bridges.

23.4.4 Use of concrete for pavements subject to flooding

Where it is determined that a concrete pavement will be used, the subgrade must have low settlement and low volume change characteristics. These requirements may dictate the use of surcharges, subgrade drainage, raising embankments and/or replacing embankments with low swell material.

24. Surfacing of unsealed roads

For unsealed roads, there may be economic benefits of sealing:

- Road sections that flood (e.g. floodways)
- Steeper sections of roadway that are prone to scour
- Sections where there is a loss of traction and damage under traffic when wet.

Sealing these sections of roadway could be done in association with sealing other sections to improve factors such as safety (e.g. sealing sections comprising tighter horizontal curves). The latter is funded under complementary works.

An assessment should be done when considering such an approach, including a geometric and drainage assessment done in accordance with the *RPDM*.

Refer also to TMR Technical Note TN118 *Sealing of Unsealed Roads with Low Traffic* for further guidance.

25. Drainage infrastructure

25.1 Design approach

Consideration should be given to providing more resilient drainage solutions where damage has occurred, particularly if the damage has occurred often. Whole-of-life cost considerations can be used to determine whether a more resilient drainage solution is justified.

All drainage infrastructure being repaired/replaced should be assessed for performance under extreme rainfall events. All road sections damaged due to overtopping (and particularly those with a history of overtopping damage) that have immunity lower than 2% AEP should be considered for the provision of more resilient overtopping treatments.

In some instances where there is regular overtopping and/or a history of damage due to overtopping, short (in length) road sections may need to be classified as floodways and designed in accordance with Chapter 4, Volume 3, Part 5B, *RPDM 2nd Edition*.

The following apply with respect to scouring:

- The higher the level difference (head) between headwaters and tailwaters, the greater the potential for scouring to occur from overtopping.
- If the difference in head across the road is more than 300mm, then high velocity/supercritical flow can be expected and scour of embankment is likely.
- Other factors influencing scour risk include the velocity and duration of the flood event.

Increased resilience to overtopping can be provided through three broad strategies: increased capacity, reduced difference in head and scour protection. These are discussed in the following sections.

25.1.1 Improved capacity

The risk of scour to drainage structures, embankments and pavements is reduced as more floodwater is channelled under the road. There are also direct safety and economic benefits from minimising the time during which water lies across road carriageways. In many cases a nominal increase in culvert size can be achieved at a low incremental cost to greatly improve under-road capacity/performance.

25.1.2 Reducing upstream and downstream head differences

On some floodways, the risk of scour is reduced if the road surface is at the same level as the ground/base channel – minimising 'damming' effects and resulting in less armouring protection being required. However, there will still be some uplift pressure on the pavement and possible scouring from pooling if there is a high upstream velocity. Obviously, this solution requires a full or partially 'boxed' pavement below natural surface that needs to be specifically designed to operate in saturated conditions at least during normal wet seasons.

This strategy will not be possible if the pavement is to be raised or high embankments already exist.

25.1.3 Scour protection

If it is not possible to improve resilience through the previous strategies, then 'armament' protection against scouring should be considered.

In many instances, protection from scouring will be the only practical option. For example, if a road is on a floodplain and providing increased culvert capacity (i.e. under-flow capacity) would be too costly, then designing for overtopping will be required. In which case, protection against scouring of the embankment may be the only practical treatment that will improve the resilience of that section.

Downstream embankments at culverts and bridges are more likely to scour from over-topping than upstream embankments and will usually require scour protection. However, upstream embankment protection should also be considered on a case-by-case basis. At bridge sites, spill-through abutments may be undermined. Similarly, at culvert locations, overtopping can result in removal of material supporting the culvert.

25.2 Specific drainage design criteria

This section provides additional design criteria to be applied to natural disaster projects to improve resilience.

25.2.1 Cut-off walls

Cross-drainage systems (culverts and floodways) must have a cut-off wall on the downstream side of the structure to mitigate undercutting of aprons. If the upstream embankments are erodible then a cut-off wall should be included on the upstream side as well.

25.2.2 Pre-cast endwalls

If pre-cast end/headwalls are being used, then adequate anchoring (off back of wall into embankment) should be provided to improve stability.

25.2.3 Downstream scour due to overtopping of road embankments at bridges and culverts

Downstream scour due to overtopping of road embankments at bridge and culvert locations represents a high potential for scour of the road embankment. At bridge sites this may result in undermining of the spill-through abutment. Similarly, at culvert locations, overtopping can result in removal of material supporting the culvert.

25.2.4 Overtopping flood immunity

This advice applies to road embankments with flood immunity less than 1% AEP.

25.2.5 Downstream protection for road embankments for culverts

If the height of the embankment is less than 500mm, downstream slope protection is not needed unless there is a history of scour.

Slope protection for culverts is to be in accordance with the following:

- Maximum slope of downstream batter is selected in accordance with the *Road Planning Design Manual*.
- All shoulders must be sealed.
- All downstream headwalls must be permanently physically attached to the culvert even after scour.
- All downstream batter protection must extend to at least the toe of the batter.
- The headwall, apron and cut-off wall must be integral.
- Minimum depth of cut-off wall of 600mm.
- All downstream embankment faces for culverts must be protected with grouted rock, reinforced concrete or wire mattress (except where protecting sand or non-cohesive material). Note that where wire mattresses are proposed for the protection of non-cohesive embankment materials, proper filter protection e.g. geotextile must be designed and installed behind the wire mattresses.
- For culverts only, with a drop less than 2 metres, vegetation may be used if it remains lush and thick for the entire year (typically coastal areas).
- For culverts, batter protection on the downstream side of the road embankment must extend along each carriageway past the culvert (in both directions) for a distance twice the height of the road embankment.
- Precast ends to culverts must have cut-off walls (mandatory on downstream side, optional on upstream side) (Chapter 3, Volume 3, Part 5B, *RPDM 2nd Edition*). For links to standard drawings, refer to *Part B – Section 14.3*.

The Pavement and Structures Unit in TMR's Engineering and Technology Branch can provide further advice on batter protection.

26. Bridge approaches, abutments and piers

Addressing contributory causes of damage to bridge approaches, abutments and piers requires an investigation to establish factors such as:

- the magnitude of the event
- whether the original assumed 'design immunity' for that bridge was meant to cope with such an event
- how well the bridge has performed
- what is now required for the bridge to perform as originally intended
- whether complementary works are required to improve on the bridge's original 'design immunity'.

26.1 Scour protection at abutments and piers

It is recommended that scour protection, in accordance with *Part E – Section 48* of this document be incorporated in all instances where scouring has occurred at abutments and piers.

26.2 Bridge approach batters

For bridges, batter protection on the downstream side of the road embankment must extend along each carriageway past the abutment (in both directions) for a distance three times the height of the road embankment, but not less than 10 metres.

PART D – COMPLEMENTARY WORKS

27. Introduction

Part D provides guidance and criteria for work types that may be undertaken under the NDP, but which the DRFA will not fund. Such works, which are titled 'complementary works', are to be funded through QTRIP.

Complementary works seek to improve the standard of existing infrastructure (e.g. safety, level of service). Examples of complementary works are horizontal and vertical realignments, widening to vision standards, bridge height increases, increased under-drainage, and addition of safety barriers and signage.

Designers must consider what complementary works are applicable in their projects by reviewing the design criteria in this section. It is important to identify complementary works that offer excellent performance for the cost. The project manager and lead designer should discuss all proposed complementary works with the delegated representative from the district office to determine whether or not TMR is prepared to fund the cost of each of the complementary works.

All complementary works should be clearly labelled on plans and in project documentation and justified. The project estimate of cost must provide separate costs for complementary works.

28. Future traffic demands

As a part of natural disaster works, designers should consider the future use of the road. This may be particularly relevant in mining areas. Works to accommodate future traffic demands would be considered as complementary works.

29. Land resumptions

It is possible that some natural disaster works, which are necessary for the purposes of restoring an existing asset to current engineering standards, may need to be undertaken on resumed land. The cost of any land resumption/s is to be funded under complementary works. However, the works that are undertaken on resumed land may be funded by the DRFA or complementary works as appropriate.

30. Geometry

Complementary geometric works are more likely to occur on projects that require a geometric assessment (refer to *Part B – Section 10.1*).

30.1 Infill sections

It is foreseeable that damage to the road network is disjointed. There will be sections of road requiring repair next to existing sections that were undamaged. As /DRFA funding is only targeted towards the damaged sections, the resulting design standard of the road network may be discontinuous and inconsistent. This could have road safety and liability implications.

It is recommended that any road sections less than 1km in length be upgraded when they lie between two DRFA-funded sections that require significant pavement works. It is noted that judgement will be needed to determine how this applies on a site-specific basis.

30.2 Realignment of horizontal curves

Large decreases in operating speed between successive horizontal geometric elements are often associated with increased crash histories. For this reason, Table 7.1 of the *Austroads* Guide to Road Design, Part 3 sets maximum decrease in speeds between successive horizontal geometric elements, which are applicable for low and intermediate speed roads. Operating speeds may increase on some sections of road where shoulders have been sealed or cross-sections widened. This creates/increases the safety risk on any adjoining problem horizontal curves.

Designers should consider realigning all substandard curves. Realignment will be easier to justify if one or more of the following apply:

- There is a crash history on the particular curve related to the sharpness of the curve, especially if there are already mitigating devices placed on the curve.
- The horizontal curve is combined with other geometric minima.
- The road is an important route and carries high volumes of vehicles.
- The cost of relocation is not excessive e.g. there are few or little services to relocate, resumptions are not required, little earthworks are required.
- The existing pavement is being replaced (or even rehabilitated).

If realignment is too costly, then other lower-cost treatments should be considered in the options analysis to manage the road safety risk, such as a review of the speed limits and widening the shoulders on the outside of curves.

If a particular substandard horizontal curve is being retained, consider what mitigating devices should be incorporated e.g. chevron alignment markers, safety barriers etc.

On lower-order roads, it may be more acceptable to retain larger decreases in speed between successive horizontal curves, if many of the curves are sufficiently similar in terms of size and the speed reduction that drivers or riders come to expect. For these locations, contact TMR E&T for advice on justifying the design exceptions.

30.3 Realignment of vertical curves

ARRB research has identified that sharp vertical crest curves have a higher crash rate than larger radii crest curves. Designers should consider realigning all substandard crest vertical curves to at least an Extended Design Domain (EDD) standard, especially when one or more of the following apply:

- Minimal earthworks are required (e.g. <1m cut)
- The subgrade material is easy to remove and particularly if the material can be used elsewhere
- Replacement of the existing pavement is required (or even rehabilitation)
- There is an unsatisfactory combination with other geometric minima.

If a particular substandard crest vertical curve is being retained, consider what mitigating devices should incorporated e.g. fencing on roadside to keep animals (hazards) from being on the pavement, provision of manoeuvre widening.

Designers should consider at least providing some manoeuvre widening for design exceptions.

30.4 Carriageway and formation widths

As discussed in *Part B – Section 10.10*, TMR places importance on allowing for future width requirements and future upgrades during the design process. It is undesirable to undertake works now that will make future upgrades very difficult.

If rehabilitating/overlaying the pavement in the first instance requires formation widening, consider extending the widening so that it is sufficient to cover at least the next round of rehabilitation/overlay.

Complementary works will be required to cover additional widening above existing (pre-disaster) carriageway widths (including that amount required for the future rehabilitation/overlays). In such cases, where it is desired to construct to an interim or vision seal width, a funding request may be lodged with the district seeking possible QTRIP funding (QTRIP to fund the width greater than the pre-disaster width). Refer to *Part A – Eligibility* for further information.

30.5 Cycle network facilities

Wherever natural disaster works fall on a Principal Cycle Network route (search for 'Principal Cycle Network Plan' on the TMR website), project managers must review the design for opportunities to provide positively for cycling (either bike lanes in urban areas or sufficient sealed shoulders in rural areas).

If there is sufficient seal or formation width to achieve this without widening, whether through lane narrowing, using parking space, lane reconfiguration or other suitable measures, this must be included in the scope of works even over short sections.

If there is insufficient existing formation/seal width to create bike lanes or a compliant shoulder without widening, then the project manager is to identify whether the roadway is a high priority cycling route in the cycle network plan. If so, incorporate widening into the project scope.

Elsewhere, works must be 'cycle-friendly' to the greatest extent possible – using existing shoulder width, eliminating (or not creating) squeeze points, widening on crests and curves if possible.

It is desirable for asphalt surfaces to be used on Principal Cycle Network routes.

30.6 Seal width

Complementary works funding will be required to provide any increases in seal width from what existed prior to the disaster events. Therefore, extra works required to upgrade single-lane roads to two-lane roads will be considered as complementary works. In the same way, any seal applied to existing unsealed roads will be considered as complementary works. In these cases, a funding request may be lodged with the district seeking possible QTRIP funding (QTRIP to fund the width greater than the pre-disaster width). Refer to *Part A – Eligibility* for further information.

30.7 Grading into floodways and low-level bridges

It is highly desirable that approaches to floodways and low-level bridges at least meet EDD sight distance criteria. Where insufficient sight distance is provided, the grading should be improved, especially for the first occurrence of a particular creek/stream along the roadway. If this is deemed uneconomical, mitigating devices are required e.g. warning signs and/or ITS solutions such as Flooded Roadway Warning Systems.

30.8 Sight distance

Sight distance should be checked for all mid-block locations, intersections, driveways and floodways. Non-conformances should be either rectified and documented to at least an EDD standard or, if justified, documented as a design exception. If retaining a design exception, appropriate mitigating treatments must be incorporated.

30.9 Roadside stopping places

Designers must ensure that formal roadside stopping places are provided in accordance with *Section 3.4* of the *Road Planning and Design Manual 2nd Edition, Volume 3, Part 6B.*

In addition, it is necessary to ensure that there are frequent opportunities for discretionary stops completely clear of the road when the shoulder is 1.5m or less (maximum spacing 1km, maximum slope 1 on 10). These informal areas, called 'lay-bys', can be provided by flattening batter slopes on low fills or making provision at the transition of cut and fill. These areas do not have to be paved or sealed. Construction of new areas is not required where there are existing opportunities to stop completely clear of the road, such as the following:

- Widened shoulders at low-volume intersections and accesses
- School bus stops
- Wide shoulders, parking lanes or side streets in townships
- Widenings at bridge approaches
- Formal rest areas/stopping places as described in *Section 3.4* of the RPDM 2nd Edition, Volume 3, Part 6B.

It is especially important to consider lay-bys in guardrail canyons.

30.10 Intersections

If the pavement through an intersection is being replaced, consideration must be given to incorporating intersection turn treatments according with the warrants described in *Section 4.4* of the Road Planning and Design Manual 2nd Edition, Volume 3, Part 4A.

Designers should review the crash history of all intersections that are being restored to determine if there is any repetitive crash pattern or crash safety problem, and what measures are required to overcome the problems and whether they could be incorporated at low cost.

Clearance of visibility obstructions such as vegetation and relocation of poorly placed road furniture may also help in some situations.

For the safety of motorcyclists, running the surfacing material into any adjoining unsealed side roads will help reduce the deposit of gravel on the sealed road.

31. Pavement and surfacing

If damage occurs to only one part of a carriageway (e.g. to one lane of a two-lane cross-section) and a treatment is desired over the full cross-section, complementary works will be required to cover that part of the carriageway that did not receive damage.

32. Bridges

If a bridge requires replacement, consider the following:

- Is it feasible to delete the number of piers by doubling the spans?
- RSS walls at abutments are not permitted if 1 in 100-year AEP flood height is at the foundation of RSS walls – refer to the *TMR Design Criteria for Bridges and Other Structures*.
- Steel post and rails traffic barriers must be used on streams, creeks and rivers with a flood immunity of less than AEP 1 in 2000 years to reduce afflux, if this is a design constraint.
- Whether it is economical to raise the bridge to provide improved flood immunity. This would be more likely to be justified for a low-level bridge with relatively steep grading onto the bridge.
- When replacing a bridge, ensure that the width of the bridge not only meets current bridge standards but also determine whether it is economical to widen to the carriageway width of the approach roadways (if the bridge is wider than the existing approach roadways).

33. Drainage

If a culvert is destroyed or significantly damaged, replacement under DRFA funding will be limited to matching the capacity of the previous arrangement. However, design should be based on current hydraulic conditions. A check design for desired AEP for the link (typically 2%/1%) should always be undertaken to determine whether the difference in cost is excessive or not. If it is not excessive, a design meeting the AEP of the link should be developed and funding sought from the relevant district.

There may be cases where it is desirable to extend a culvert/s further than that required to achieve the existing carriageway width (e.g. to obtain an interim or vision seal width, if this is greater than the existing width). Such extensions are to be treated as complementary works.

The majority of existing culverts that are located near the carriageway and are approximately parallel to the road (typically under turnouts/accesses/driveways) will most likely have standard/vertical faced ends. Consider complementary works to retrofit non-flood damaged culverts with slope-faced ends to reduce crash risk/severity.

34. Roadside furniture and delineation

34.1 Signage and delineation

Any additional signage or delineation proposed (other than that funded by the DRFA) must be funded as complementary works. An example is additional signage or delineation to meet the current requirements of the Queensland *Manual of Uniform Traffic Control Devices* (MUTCD), MUTCD Supplements, TRUM notes and Technical Notes.

34.2 Lighting

Any additional lighting infrastructure proposed must be funded as complementary works. An example is additional lighting infrastructure to meet the current requirements of *RPDM 2nd Edition* Volume 6. Another example is the addition of lighting infrastructure as a measure to lower a high crash rate.

34.3 Roadside barriers

34.3.1 Barrier height

Barriers are required to be installed and maintained in accordance with the registered suppliers' specifications and tolerances. Barrier heights out of specification and tolerance can adversely affect their operation by increasing the risk of a vehicle vaulting or underrunning the system.

Attaining correct barrier heights on known motorcycle routes may facilitate easier retrofitting of rub-rail at lower cost in future if required.

34.3.2 Barrier end treatments

Substandard barrier ends should be replaced with accepted terminals.

35. Road safety

The treatments below should be considered at sites that have been identified as high-risk locations (refer to *Part E – Section 52* for determining high-risk locations).

- Where pavement reconstruction is needed, it may be appropriate to provide a road cross-section to optimise safety outcomes. Consideration should be given to wider shoulders than normally would be provided and, where there are head-on crash risks, wider painted medians with an appropriate road safety barrier.
- To improve safety, in particular reducing the potential for head-on crashes, consideration should be given to the use of Wide Centre Line Treatment (WCLT) – refer to *Appendix G of Part 3, Volume 3* of the *RPDM 2nd Edition*.

- Using high-visibility road markings where there are night-time crashes or visibility issues. Guidance on identifying suitable locations is given in Element 24 – Linemarking of the *Element Management Plan*.
- Installing audio tactile edge and centre lines. The site selection criteria in *Traffic and Road Use Management Manual* (TRUM) *Volume 2: Guide to Road Safety Part 5 Section 4-1 Driver Fatigue* should be used.
- Upgrading intersections to Channelised Right Turn (CHR) or CHR(Short) layout where there is a risk/history of rear-end crashes involving right-turn traffic.
- Installing safety barriers to comply with new standards, particularly end terminals and tapers and the use of motorcycle under-run treatments on the outside of curves on motorcycle routes.
- Using passively safe roadside furniture such flexible guideposts and signs, particularly at locations susceptible to run-off-road crashes.

Recommendations from new or existing road safety audits will generally be funded under complementary works. Exceptions to this include treatments needed to maintain the existing level of safety or low-cost safety improvements. Any outstanding recommendations from existing road safety audits and fatal crash investigations should be implemented – contact the relevant TMR District Director or delegate. Where a high crash risk cannot be addressed with infrastructure treatments, review current speed limits (refer to MUTCD Part 4).

36. Intelligent Transport Systems (ITS)

Past major flood and storm events throughout Queensland have had a major impact on TMR's Intelligent Transport Systems (ITS) network and have caused outages for a number of days in the so-called 'edge' or 'field' network – meaning that some ITS field devices and services were unavailable. Generally, flood or storm events mostly affect the ITS field network and related sites – the core ITS networks are generally unaffected.

A number of *Traffic Operations District Business Continuity Plans* (BCPs) were developed by TMR in 2014–15. These plans were developed to ensure that, in the event of a disaster, TMR-owned, controlled and/or supported ITS core and field infrastructure is appropriately managed.

Business Recovery Plans and related *Continuity Network Recovery Plans* (CNRPs) for each TMR district can be obtained by liaising with appropriate district staff. Alternatively these documents are hosted on the PDO Connect Business Continuity SharePoint page.

These plans provide content to guide what actions are to be performed to restore TMR network services to working states in the minimum timeframe, and the relevant stakeholder roles and responsibilities, and also include post-incident review templates used to analyse the specific local responses to the incident recovery.

37. Design for resilience

Refer to Part C – Designing for Resilience.

Works that are designed for the purpose of improving resilience, rather than meeting current engineering standards, may not be considered eligible under the DRFA, and may need to be complementary funded.

PART E – APPENDICES

38. Guidance for assessing damaged pavements for natural disaster projects

This section provides guidance about the methodology to be used for assessing the pavement of road sections for DRFA funding submissions. Reference should also be made to Chapters 2 and 4 of the *Pavement Rehabilitation Manual* (February 2020).

38.1 Methodology

The assessment of the pavement of a road section may include assessment of:

- deflection data
- rutting data
- roughness data
- visual condition assessments
- trenching, coring and test pits
- field and laboratory material property testing.

Where appropriate, before and after analyses should be completed. This will confirm or clarify whether a particular road section has been affected by the natural disaster. Ideally, assessment will include all of the following:

- Comparison of deflection data obtained before the natural disaster and after it
- Comparison of rutting data obtained before the natural disaster and after it, including rut depth progression rates
- Comparison of roughness data obtained before the natural disaster and after it, including roughness progression rates
- Visual assessments of the condition of the road before and after the natural disaster.

Of these, the minimum level of assessment for determining DRFA-eligible works is the visual assessment. Where a visual assessment is inconclusive, and/or there is historical evidence of poor pavement performance, the other types of assessment should also be employed.

The first three of the above comparisons have the benefit of being more objective than visual assessments. Combining all four comparisons will result in a robust assessment.

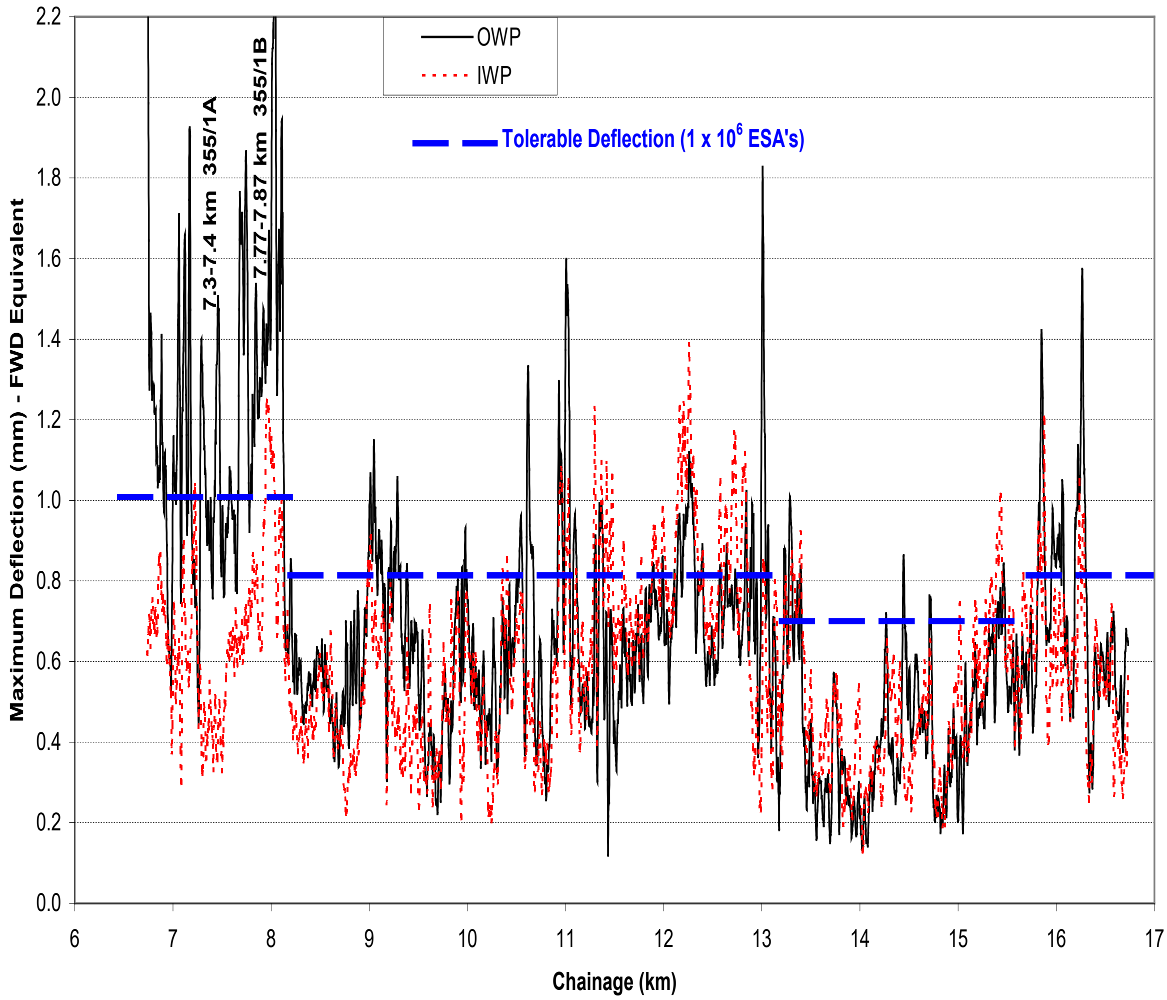
It is important to note that basing a submission solely or substantially on distresses that can be observed visually risks not identifying road sections that have been affected by the natural disaster. Deflection testing has the potential to reveal sections of road that have been affected by a natural disaster but are yet to show visual distress (see Figure 5).

The potential to refine treatments over longer sections of natural disaster-affected road sections should be considered.

It is recommended that field and laboratory testing be completed when the emergency works (e.g. patching) are being constructed.

More detailed comments are contained in the following sections.

Figure 5: Example of use of deflections to assess damage caused by a natural disaster



38.2 Deflection data

Deflection data gathered before the natural disaster does not need to have been obtained just before the natural disaster (e.g. latest could be up to two years old). If more than one set of historical data is available, then they can all be compared. Ideally, test points would be in the same location (e.g. wheel path, gazettal chainage) and the loading, time interval between surveys and the test method (e.g. equipment, load) would be the same. However, if they are not then the information can still be used (e.g. apply conversion factors to data obtained using PAVDEF (i.e. deflectograph) and Falling Weight Deflectometer (FWD)/Heavy Weight Deflectometer (HWD) or Traffic Speed Deflectometer (TSD) to enable a comparison to be made. Deflection testing will reveal sections of road that have been affected by the natural disaster but are yet to show visual distress. Comparison of deflection data should include comparison of the maximum deflections (D_0s), deflection ratios, curvatures and D_{900}s. Irrespective of what apparatus is used to identify natural disaster project sections, it is best to use FWD/HWD test results for the detailed design of reconstruction works. However, PAVDEF results can be used if necessary.

38.3 Rutting data

Rutting data gathered before the natural disaster does not need to have been obtained just before the natural disaster. Data from a number of past rutting measurement surveys is helpful as a historical rut depth progression rate can be derived and compared to recent changes. Ideally reporting sections would be the same, as would the test location (e.g. wheel path, lane) and the time interval between surveys for a particular road section. It is important to note that rutting data can only be compared when the basis of the measurement is the same (use a

1.2m straight edge). This may require conversion of data. Comparison of actual rut depths as well as the historical and recent rut depth progression rates should be used to assess whether the road section has been damaged by the natural disaster.

As a guide for eligibility of rutting or depressions as a result of natural disaster events, the following principles are to be followed:

- Rutting/depressions less than general intervention level (using a 1.2m straight edge) are not eligible for funding under the DRFA.
- Actual rutting/depressions for the entire length of the damaged section must illustrate consistent rutting greater than the general intervention level (using a 1.2m straight edge) **at minimum intervals of 100m** if continuous sections are proposed to be repaired.
- For rutting and depressions to be considered eligible, it must be demonstrated there is a **'step change'** in the condition of the pavement as a result of the natural disaster event. This **'step change**' **<u>MUST</u>** be demonstrated by both of the following:
    - Pre-disaster DVR images that clearly illustrate no noticeable rutting features (i.e. shoving) in the Inner Wheel Path (IWP) and Outer Wheel Path (OWP)
    - Review of pre-disaster ARMIS data that illustrates the **<u>average pre-disaster rutting</u>** (using a 1.2m straight edge) for the entire length of the damaged section does not exceed 10mm. This average rutting value must be demonstrated for claimed wheel path (i.e. IWP or OWP) and impacted traffic lane or both where full-width reconstruction is proposed.

38.4 Roughness data

Roughness data gathered before the natural disaster does not need to have been obtained just before the natural disaster. Data from a number of past roughness measurement surveys is helpful as a historical roughness progression rate can be derived and compared to recent changes. Ideally, reporting sections would be the same, as would the test location (e.g. lane) and the time interval between surveys for a particular road section. To enable a comparison to be made, roughness data must be obtained using the same type of measurement equipment or converted to one equivalent measurement (e.g. IRI). Comparison of actual roughness values as well as the historical and recent roughness progression rates should be used to assess whether the road section has been damaged by the natural disaster.

38.5 Visual assessments

Visual assessments can be done by walking the road, slowly driving the road or by using the department's Digital Video Road (DVR) data and associated software. However, the use of DVR is recommended as it will enable:

- an assessment of road condition before the natural disaster
- an assessment of road condition after the natural disaster
- a comparison to be made.

It may be necessary to use a combination of visual assessment methods if DVR runs after the natural disaster have not been done or are not available (e.g. use DVR data for the 'before' assessment and an assessment by walking for the 'after' assessment).

The type of various distresses and their extent before and after the natural disaster can used to assess whether the road has been damaged by the natural disaster. For example, compare the area of patches and percentage of area fatigue cracked before and after the natural disaster. These assessments are, to some degree, subjective and, when DVR is used, limited by the resolution of cameras used and lighting at the time of the survey. To ensure consistency, the same person should be used to conduct the 'before' assessment and 'after' assessment of a particular road section.

38.6 Laboratory and field testing

It is recommended that field and laboratory testing be completed when the emergency (60 day) works (e.g. patching) are being constructed. The testing regime should be developed to inform the future works as well as the emergency works.

The minimum amount of fieldwork and testing is as follows:

- In situ Dynamic Cone Penetrometer (DCP) California Bearing Ratio (CBR) testing in the Outer Wheel Path (OWP) and Inner Wheel Path (IWP).
- Recording/logging the pavement profile (e.g. layer thicknesses, layer types) including changes in it. This includes longitudinal and transverse changes in the pavement profile.
- Sampling of the subgrade and laboratory testing of the subgrade samples.
- Sampling and testing of the pavement material for any in situ stabilisation mix designs.

The quantity of subgrade sample taken must be enough to allow the completion of moisture content testing in the IWP and OWP of each lane and soaked CBR, Atterberg limits and Particle Size Distribution (PSD) testing on the OWP subgrade. If the subgrade is different in the IWP, or there is evidence of this, a sample should also be taken from the IWP and similarly tested. If the patch is long, the testing and sampling should be done at regular intervals. Test and sample locations should be such that representative results/samples are obtained.

It is desirable that remaining unbound granular layers be sampled and tested as described above for the subgrade samples. If in situ stabilisation is a possibility or proposed, then stabilisation testing should also be completed before a final decision is made about its use.

Engineering and Technology Branch has laboratories in Brisbane that can undertake this sampling and testing. Enquiries about availability etc. should be directed to Materials Services (refer to *TMR contacts* at the end of this document). The involvement of these laboratories is subject to clarification of the funding arrangement for internal work on natural disaster projects/works.

38.7 Refinement of treatments

Some sections affected by a natural disaster are longer than others. One approach is to adopt one pavement rehabilitation treatment for a whole road section even though the degree of damage appears to vary. This is valid for short sections of road. Where the road section is on the longer side and the damage does vary, refinement of the pavement rehabilitation treatment(s) should be considered. For example, if a section is 1km long and 500m is badly affected and the remaining 500m less so, consideration should be given to adopting different treatments. However, the practicality of doing this must be carefully considered. The overall context and strategic approach are important considerations when making such decisions. For example, there may be resource constraints or it may be that one treatment is suitable for most nearby sections so adopting one treatment for them all may be more practical and/or economical.

38.8 Other considerations

The ranking of road sections to establish a priority should be considered (e.g. to help identify the most worthy sections, which can be done first to ensure they are done within the timeframe). This may include consideration of:

- traffic volumes
- road function
- criticality of the link
- severity of the damage
- whether the road can or cannot be trafficked (i.e. is impassable after flooding has receded) or can only be trafficked under certain restrictions (e.g. lower speeds).

Such factors could be weighted.

38.9 Assistance – Engineering and Technology

Engineering and Technology Branch can assist with the above assessments. Enquiries about this or any aspects of this guide note should be directed to the Pavements, Materials and Geotechnical area (refer to *TMR contacts* at the end of this document).

39. Pavement rehabilitation standard design details

Figure 6: Standard design details – full-width and part-width dig-out and replace

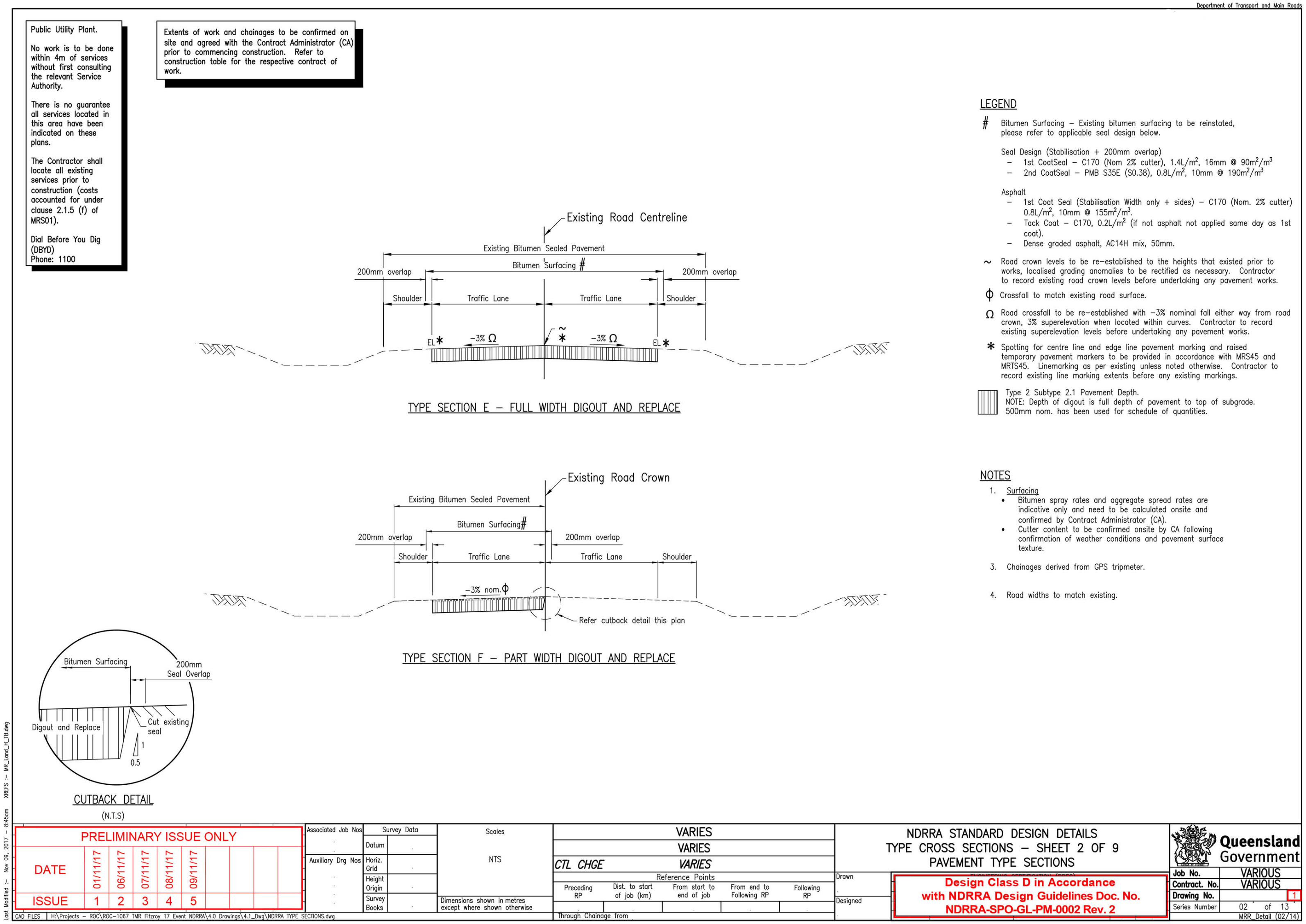


Figure 7: Standard design details – full-width and part-width two-layer stabilisation

Department of Transport and Main Roads

Public Utility Plant.

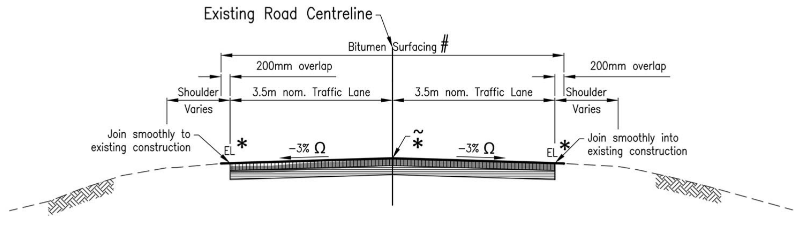
No work is to be done within 4m of services without first consulting the relevant Service Authority.

There is no guarantee all services located in this area have been indicated on these plans.

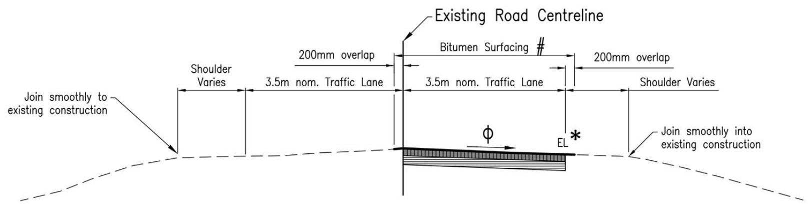
The Contractor shall locate all existing services prior to construction (costs accounted for under clause 2.1.5 (f) of MRS01).

Dial Before You Dig (DBYD) Phone: 1100

Extents of work and chainages to be confirmed on site and agreed with the Contract Administrator (CA) prior to commencing construction. Refer to construction table for the respective contract of work.



TYPE SECTION I – FULL WIDTH TWO LAYER STABILISATION



TYPE SECTION J – HALF WIDTH TWO LAYER STABILISATION

LEGEND

\# Bitumen Surfacing – Existing bitumen surfacing to be reinstated, please refer to applicable seal design below.

Seal Design (Stabilisation + 200mm overlap)
- 1st CoatSeal – C170 (Nom 2% cutter), 1.4L/m², 16mm @ 90m²/m³
- 2nd CoatSeal – PMB S35E (S0.38), 0.8L/m², 10mm @ 190m²/m³

Asphalt
- 1st Coat Seal (Stabilisation Width only + sides) – C170 (Nom. 2% cutter) 0.8L/m², 10mm @ 155m²/m³.
- Tack Coat – C170, 0.2L/m² (if asphalt not applied same day as 1st coat).
- Dense graded asphalt, AC14H mix, 50mm.

~ Road crown levels to be re-established to the heights that existed prior to works, localised grading anomalies to be rectified as necessary. Contractor to record existing road crown levels before undertaking any pavement works.

ϕ Crossfall to match existing road surface.

Ω Road crossfall to be re-established with -3% nominal fall either way from road crown, 3% superelevation when located within curves. Contractor to record existing superelevation levels before undertaking any pavement works.

* Spotting for centre line and edge line pavement marking and raised temporary pavement markers to be provided in accordance with MRS45 and MRTS45. Linemarking as per existing unless noted otherwise. Contractor to record existing line marking extents before removing any existing markings.

Excavation & disposal (Profile 150mm) of material not suitable for stabilisation.

Insitu cement stabilised pavement 160mm with nom. 1% GB cement.

Insitu cement stabilised subbase pavement 200mm with nom. 2% GB cement.

NOTES

1. Surfacing
   - Bitumen spray rates and aggregate spread rates are indicative only and need to be calculated onsite and confirmed by Contract Administrator (CA).
   - Cutter content to be confirmed onsite by CA following confirmation of weather conditions and pavement surface texture.
2. Chainages derived from GPS tripmeter.
3. Road widths to match existing.

PRELIMINARY ISSUE ONLY

DATE	01/11/17	06/11/17	07/11/17	08/11/17	09/11/17
ISSUE	1	2	3	4	5

Associated Job Nos | Auxiliary Drg Nos | Survey Data | Datum | Horiz. Grid | Height Origin | Survey Books

Scales: NTS

Dimensions shown in metres except where shown otherwise

VARIES
VARIES
CTL CHGE VARIES

Reference Points: Preceding RP | Dist. to start of job (km) | From start to end of job | From end to Following RP | Following RP

Through Chainage from

Drawn | Designed

NDRRA STANDARD DESIGN DETAILS
TYPE CROSS SECTIONS – SHEET 4 OF 9
PAVEMENT TYPE SECTIONS

Design Class D in Accordance with NDRRA Design Guidelines Doc. No. NDRRA-SPO-GL-PM-0002 Rev. 2

Queensland Government

Job No. VARIOUS
Contract. No. VARIOUS
Drawing No. 1
Series Number 04 of 13
MRR_Detail (02/14)

Last Modified :- Nov 09, 2017 - 8:45am XREFS :- MR_Land_H_TB.dwg

CAD FILES H:\Projects – ROC\ROC-1067 TMR Fitzroy 17 Event NDRRA\4.0 Drawings\4.1_Dwg\NDRRA TYPE SECTIONS.dwg

40. Unsealed roads – REPA works eligibility guidance notes

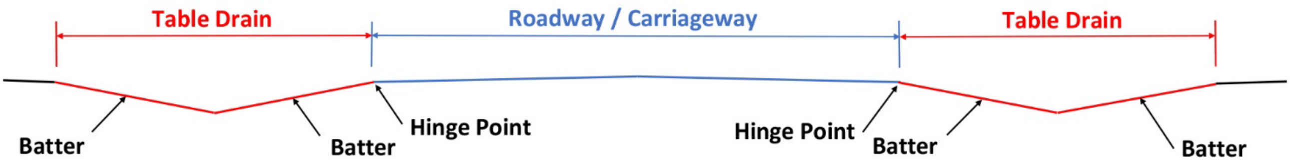
40.1 Purpose

The purpose of this guideline is to provide practical guidance and examples regarding different potential treatments on unsealed roads for Restoration of Essential Public Assets (REPA) works undertaken through the Natural Disaster Program (NDP) during the emergency, immediate reconstruction works and/or reconstruction works phases. These guidance notes are based on the assumption that all damage claimed can be demonstrated to be the result of an activated natural disaster event and the asset has been adequately maintained.

40.2 Unsealed road cross-section

To provide clarification on the terminology and extent of scope of the treatments, a cross-section has been developed to assist in the definition of the treatment specifications below:

Figure 8: Unsealed road cross-section terminology



40.3 Treatment specifications

In line with TMR's *Road Maintenance Performance Contract (RMPC) Guidelines* (2017) the description of the NDP standard treatments for unsealed roads are as follows:

- **Medium formation grade:** is a treatment that involves grading the unsealed roadway only to reinstate the correct profile, and also incorporates water, trimming and compaction. The graded roadway surface shall be watered and rolled to provide a sound tight surface with minimal loose stones and no visible movement.
- **Heavy formation grade:** is a treatment that involves grading the unsealed roadway to reinstate the correct profile to ensure drainage of the pavement and to provide a suitable running course. This will involve tyning the existing pavement, incorporating gravel/material (if required), mixing, compacting and trimming the pavement material. This treatment also includes cleaning and reshaping the adjacent surface drainage/table drain.
- **Clean earth and concrete surface drains:** is a treatment that involves restoring the table drain to the specified standard, including excavating and removing unsuitable material. This treatment may accompany the Light or Medium Formation Grade.
- **Gravel supply:** Pavement gravel material that is required to supplement the Heavy Formation Grading works. This gravel shall only be incorporated where it is clear from the pavement condition that a gravel existed prior to the event.

Other NDP MRS standard treatments that may be adopted to the unsealed road network are as follows:

- **Road excavation:** Removing unsuitable materials, to allow for reconstruction of the formation to be undertaken.
- **Road embankment:** Replacing fill/embankment material to bring the formation levels to that which existed prior to the event.
- **Backfill with select backfill material/rock to scour:** In some cases, where formations/embankments have been severely damaged as a result of a disaster event, backfill/rock material may be required at foundation level to allow for the formation to be reconstructed.

40.4 Eligibility guidance

Medium formation grade

This treatment should be adopted when the loss of shape or material in the roadway **is moderate**. It is expected that the loss of shape in roadway is to such an extent that this can only be corrected through watering, trimming and re-compaction. Some examples of the typical degree of damage for which a medium formation grade is considered eligible are illustrated below.

Heavy formation grading

This treatment should be adopted when the loss of shape or material in the roadway is major and where the gravel crust is broken or where there is a change in surface composition. It is expected that the loss of shape in the roadway also extends into the drainage lines/table drains, which also requires restoration. Some examples of the typical degree of damage for which a heavy formation grade is considered eligible are illustrated below.



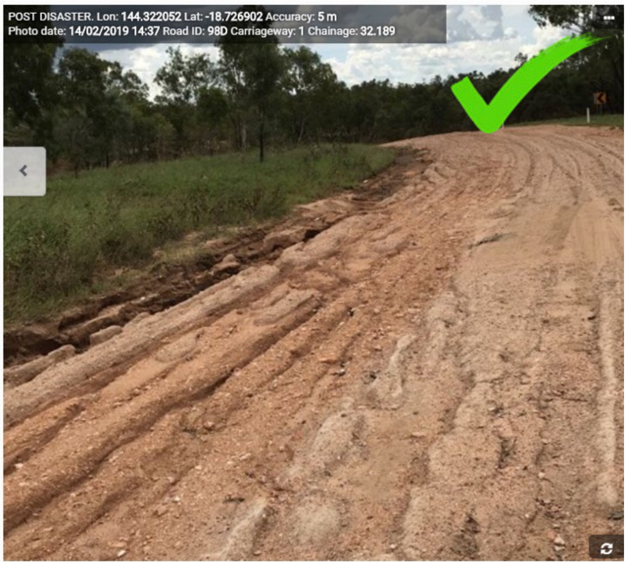



Clean earth/table drains

This treatment should be adopted when there is evidence of damage to the table drain area (such as scours) or a build-up of silt and debris in the previously established table drain. This treatment is not considered eligible where in the pre-disaster photos there is no clear evidence that a form of earth drain/table drain existed prior to the event. Some examples of typical degree of damage for which cleaning of an earth drain may be required are illustrated below.

Road excavation/road embankment/backfill with select material/rock

These treatments shall only be undertaken when it is clear that the natural disaster event has caused a loss of formation that requires reconstruction. These treatments are not to be adopted in circumstances where the formation may be lower than the surrounding ground as a result of the maintenance regime/grading of the road in previous years. It is expected that these work activities are only undertaken on the unsealed roads in discrete locations where a major ‘washout’ or scour has developed as a result of the disaster event. Where possible, the replacement fill/embankment material should be of the same quality that exists in the surrounding formation and is ideally sought from a local borrow pit. Some examples of the typical degree of damage for which road excavation/embankment and backfill may be required are illustrated below.



For further advice about appropriate treatments for specific sites, contact the Natural Disaster Program Team in Program Management and Delivery.

41. Design process: additional technical notes for Part B (Section 9)

For all road design classes, assessment of condition, integrity and structural capacity of any existing drainage infrastructure (e.g. culverts) is required. The inspection/assessment process will determine if a structure is damaged or otherwise and can assist in determination if any remedial work is funded under the DRFA or complementary works. For the retention/reuse of pre-2004 culverts (or part of a culvert), *Part E – Section 49* contains a process to be adopted for determining the assessment/replacement of pre-2004 culverts. Within this process, managers and design engineers must appropriately consider the consequence of failure of the structure over the expected life of road. For example, a 375mm RCP under 1.5m of material will probably only create a minor dip in the road surface with little impact to road users, however a 1500mm RCP under minimum cover will probably create a large open gap in the road surface, creating an unsafe situation to road users.

Furthermore, pre-2004 culverts are susceptible to damage/premature failure due to construction works, particularly where culverts are located close to surface. Project managers/engineers should be aware of this and arrange pre and post inspections in order to monitor this situation (and rectify as required).

For Road Design Class B and C projects, where the existing cross-section is to be upgraded, care must be taken to ensure the road is not made less safe, for example by:

- the improvement giving drivers or riders a false sense or perception of actual capability such that they ‘overdrive’ the road
- reducing shoulder space for vulnerable road users such as cyclists.

Making any aspect of the road less safe is not acceptable, even if the design gives an overall improvement in safety.

For Road Design Class B Extended Design Domain (EDD) principles are used to assess the suitability of the alignment for operating speeds that will occur after the restored road is opened to traffic. Use of the EDD may be justified in these cases, especially if the cost is not excessive, and there is no associated crash history. In addition, an EDD value should generally not be used with other geometric minima.

42. Geometry: additional technical notes for Part B (Section 10)

42.1 Handling of geometric design exceptions

Design Class A and B

As outlined in *Part B – Section 10.1* (also refer to *Table 1-1* and *Section 4.4.4* in *Part 1, Volume 3* of the *RPDM 2nd Edition*), Road Design Class B projects require an assessment of all geometric elements in order to check the adequacy of the existing and restored road sections. With Road Design Class B projects involving pavement overlay and/or pavement widening, the aim should be to bring design exceptions involving sight distance and cross-section width into EDD – otherwise the design exception will be locked in for another 20 or more years due to the substantially enhanced pavement asset. However, any decision to upgrade a road section will be influenced by factors such as:

- crash history
- constructability and traffic management constraints
- project constraints
- cost (e.g. it may not be cost effective to increase the size of a vertical curve through a major rock cutting).

Examples of specific instances where design exceptions should be upgraded include:

- horizontal curves with:
    - a crash history and which already have the appropriate signage or safety barriers
    - an unsatisfactory combination with other minimum parameters
- intersections with deficient sight distance – experience shows it will end up being rebuilt sooner rather than later
- crests – these should be brought into to EDD when:
    - minimal earthworks are required (e.g. <1m cut)
    - rehabilitation or reconstruction of the existing pavement is required
    - there is an unsatisfactory combination with other minimum parameters.

Design Class C

As outlined in *Part B – Section 10.1*, design exceptions for geometric elements such as crossfalls, superelevation, and flow path depths at curve transitions within Road Design Class C projects are normally expected to be upgraded (refer to Table 1-1 and *Section 4.4.4* in Volume 3 of the *RPDM 2nd Edition*). Normally, all other geometric elements comprising a design exception (if known) are not expected to be upgraded. If an unknown design exception is discovered, then the design exception should be documented appropriately, and the associated risk managed responsibly within the project. However, the following are required on all Class C projects:

- Review and upgrade signage if necessary, to comply with the MUTCD.
- Comply with the departmental policy on road safety auditing of projects (see *Section 9.4*).
- Seek to improve the geometry of any feature that has a significant crash history despite appropriate mitigating treatments already in place.
- Mitigate geometric elements with a known crash history by:
    - clearing roadside hazards

- updating/installing safety barriers etc.
- providing additional signage
- applying a speed limit reduction, if justified in accordance with *Section 4* of the MUTCD.

For full shoulder sealing projects, it is desirable to be able to demonstrate that any design exception (or any other geometric parameter for that matter) is not made worse. With these projects, it is desirable to undertake an assessment of all geometric elements in order to determine if there is any adverse effect due to increased operating speeds as a result of changed driver or rider perception of the road (e.g. problem horizontal curves).

Design Class D

Design exceptions for Design Class D projects (if known) require no treatment other than a review of signage and possibly clearing hazards. It is assumed that we are simply restoring the road to its previous state.

42.2 Cross-section

The terms 'carriageway' and 'formation' are as described in the *Glossary of Austroads Terms* (2015). These terms are not the same, but are often used interchangeably due to historic Queensland practice of not adopting verges in many cases. 'Carriageway' refers to the traffic lanes and shoulders and is a subset of 'formation', which covers the top of the cross-section between the batter hinge points.

The 'verge' is the part of the road formation between the outer shoulder edge and the batter catch point. It includes the room provided/needed for safety barriers, rounding, table drains and road-edge guideposts, and provision for future pavement overlays.

There are well documented safety benefits of installing wider cross-sections. The extra width allows additional room for drivers or riders to recover in the instance that they stray from the traffic lane and the extra width can allow installing median traffic barriers.

TMR places importance on allowing for future width requirements and future upgrades during the design process. It is undesirable to undertake works now that will make future upgrades very difficult (at least without good reason). Designers should be aware of:

- future pavement rehabilitation requirements (and therefore future width requirements)
- vision seal pavement widths
- requirements for edge or median safety barriers
- requirements for cycling provision (generally sealed shoulders or bicycle lanes) where works fall on Principal Cycle Network Routes (go to www.tmr.qld.gov.au and search for 'Principal Cycle Network Plan')
- the ultimate number of lanes (for high-volume roads).

If reconstruction of the road in the first instance requires formation widening, the extent of this widening should be made sufficient to cover at least the next round of rehabilitation/overlay, unless there are strong economic reasons not to do this. This additional width required is funded as complementary works (see Part 3). The width of the pavement and surfacing provided initially does not have to extend to the formation edges.

42.3 Crossfall and superelevation

It is common that crossfall and superelevation changes over time, through settling under dynamic traffic loads, shape deformation or more general settlement.

Designers must ensure that the appropriate pavement thicknesses are obtained and at least the minimum overlay thickness is provided at all points along and across the road.

43. Additional technical notes for Part B (Section 11)

43.1 Records of emergency works

Accurate records of the locations of patches and the ‘as constructed’ details must be kept to assist in the selection and design of future works (e.g. reconstruction/rehabilitation treatments). Records should include longitudinal and transverse position, actual depth of stabilisation/treatment, material(s)/binder type(s), final pavement configuration (e.g. layer thicknesses) and actual stabilising agent application rate(s) (if applicable).

43.2 Design method

It is recommended that the General Mechanistic Procedure (GMP) be used to design pavement rehabilitation options.

If the rehabilitation design relates solely to overlay, then the overlay design procedure using deflection data (i.e. design by deflection charts) can be used to check the designs developed, using the GMP where appropriate. The overlay design procedure using deflection data (i.e. design by deflection charts) is only valid for use on existing unbound granular pavements with a thin bituminous surfacing and can only be used to design asphalt (up to thicknesses no greater than 150mm) or granular overlays.

43.3 Cover over expansive subgrade

Rehabilitated pavements

Rehabilitated pavements are those where existing pavement materials are re-used within the pavement, although some imported materials may be added.

Where possible, the cover requirements as specified in the *Pavement Design Supplement* should be considered. This may include in situ stabilisation of the subgrade with lime where the materials and environment are suitable, and removal of subgrade to a suitable depth and replacement with a suitable material.

Options that are less rigid and can therefore deal with movement better than more rigid options should also be considered where expansive subgrades are present.

44. Pavements: new pavement design reporting requirements

At each design stage, the tenderer/contractor must submit a comprehensive pavement design report that includes:

- details listed under *Part B – Section 20.4*
- pavement locations and types
- details of all assumptions, calculations and methodology
- details and justification of relevant departures from typical selections/designs
- test results, including copies of test certificates, for all relevant tests such as subgrade assessment and existing pavement condition
- subgrade treatments
- detailed pavement designs including layer thicknesses and material types, with references to relevant technical standards/specifications
- proposed maintenance, rehabilitation and reconstruction schedule for the full design life
- completed annexures for all relevant technical standards and specifications
- copies of any supplementary technical standards/specifications that are required to achieve the requirements of the natural disaster works.

45. Pavements rehabilitation suggested reporting contents

Executive summary

Introduction

This may include the location and a map of the pavement under investigation.

Preliminary data analysis

This may include road and pavement history, drawings, ‘as constructed’ information, previous pavement condition data (e.g. roughness), details of subsoil drains, maintenance history and maintenance expenditure.

Traffic information

This may include past traffic information, forecasts of future traffic and current traffic patterns.

Pavement performance assessment

This may include descriptions of testing done to the pavement. It may include location of trenches, pits and cores.

Pavement testing results

This may include a visual assessment of distresses, field testing (including deflection), sampling and laboratory testing. Other testing to complete investigation may include roughness, rutting and skid resistance testing where appropriate.

Failure mechanism/s

This may include analysis of all relevant information including the results of testing and back analysis to arrive at the appropriate failure mechanism/s.

Pavement rehabilitation design options

This should include advantages and disadvantages of the pavement rehabilitation options, design detailing of the most appropriate option and a whole-of-life cycle analysis.

Major construction issues for consideration

This may include issues related to constructing under traffic, effect of raising the pavement surface and so on.

Conclusions

All the relevant conclusions from the report.

Recommendations

This is to include the recommended option and relevant details.

Appendices

Appendices may include and not be limited to the following:

- Traffic analysis
- ARMIS data
- Trench and core profiles
- Deflection charts
- Soil test results and reports
- Plans
- Back-analysed result.

46. Increased pavement resilience using foamed bitumen stabilisation

TMR has developed and implemented the foamed bitumen stabilisation technique, in consultation with the Australian pavement stabilisation industry. The technique provides a more flexible, resilient and fatigue-resistant pavement material suitable for Queensland conditions.

Performance to date has proven that the foamed bitumen treatment provides not only a strong flexible pavement but a pavement resilient to **flooding and/or significant wetting periods**. Outstanding examples include 3km of Jacobs Well Road, 14km of the Logan Motorway (west bound), 17km of New England Highway and 3km of Oakey–Pittsworth Road. These projects were either inundated or have survived significant wetter periods over many years. Despite these adverse conditions, pavements continue to perform with very little maintenance requirements. The first two projects mentioned above have exceeded 10 years of traffic loading and continue to perform well. The New England Highway project has now reached 20 years of traffic loading.

Provided proper investigations, mix designs and construction quality control are carried out, superior long-term performance and lower maintenance costs are possible using the foamed bitumen stabilisation method compared to other more conventional stabilisation treatments.

46.1 Recent performance

TMR's investment in research and innovation has paid big dividends in the wake of Severe Tropical Cyclone Debbie in March 2017, with millions of dollars saved through having more resilient pavements. TMR's foamed bitumen pavements, which when constructed in the right environment with appropriate stabilisation design and construction techniques, have survived unscathed in some of the worst-hit parts of the state. They have displayed impressive strength and resilience in the face of flooding and extensive wetter periods.

Foamed bitumen stabilised base overlying stabilised sub-base and subgrade with carefully designed combinations of lime, cement and fly ash has not only provided the required structural strength to cater for the design traffic loading, but has stood up to some of the worst of the event. For example:

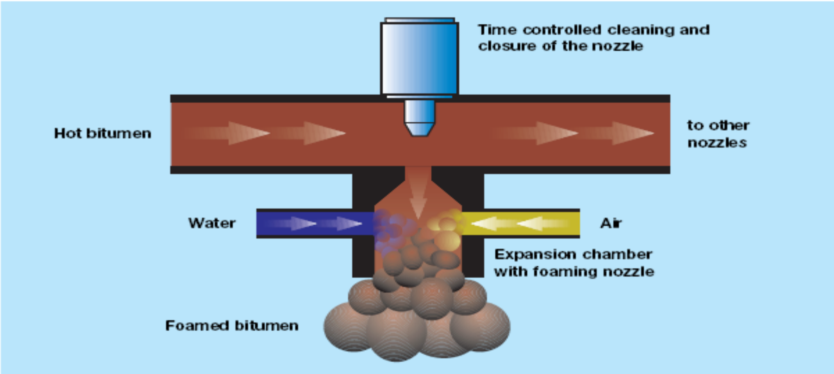
- Bruce Highway (Sandy Gully) near Bowen showed no evidence of damage despite very heavy rainfall
- Pavement construction in Warrill View (south of Ipswich) was able to continue without delay despite the unsealed foamed bitumen pavement being inundated
- Yeppen floodway in Rockhampton has emerged from the deluge with no damage to pavements.

These are just the latest examples of how foamed bitumen is contributing to a more resilient state road network for Queensland. The technology is already used widely in coastal regions of the state, and TMR districts are reporting a success rate of near 100% if the pavement is correctly designed (based on adequate laboratory testing) and constructed applying TMR specifications.

46.2 Foamed bitumen stabilisation methods

Foamed bitumen is a mixture of air, water and bitumen. It is created by injecting hot bitumen and a small quantity of cold water into a mixing chamber (see Figure 8). This produces an instantaneous expansion of the bitumen to about 15 times its original volume, forming a fine mist or foam. This expansion is due to the water being converted into steam by the hot bitumen. In this foamed state, the bitumen is ideal for mixing with fine aggregates. The foam collapses very quickly and therefore vigorous mixing is required to adequately disperse the foamed bitumen throughout the material. During the mixing process, foamed bitumen coats the finer particles. These coated finer particles form droplets that strongly bind the mixture together. Typically, the foamed bitumen contains 97% bitumen, 2.5% water and 0.5% foaming additive.

Figure 9: Foamed bitumen concept



Foamed bitumen stabilisation can be undertaken using one of two methods:

- In situ – foamed bitumen and additives are mixed using special machinery (stabiliser) directly into the in-situ material
- Plant-mixed – quarry material, or alternatively existing pavement material, is milled and hauled to a nearby specialist batch plant where foamed bitumen, new granular material (if required) and additives are added, followed by thorough mixing. The stabilised product is then hauled back to site for laying. If existing material is unsuitable, imported granular material could be used to produce the plant-mixed foamed bitumen.

The in-situ stabilisation process has historically been less costly and quicker than the plant-mixed operation. This is because the material does not need to be milled and hauled between the construction site and batch plant. In situ stabilisation also reduces exposure of the lower pavement layers to the weather, which results in a lower risk with respect to rain damage.

However, advantages are seen with the plant-mixed method through the following operations:

- Removal of the base material allows inspection of the subgrade material, so any defects/weaknesses that are identified can be rectified prior to relaying of the stabilised material
- Allows stabilisation of the sub-base/subgrade
- Allows the rejection of any unsuitable material
- Allows the addition of external materials into the stabilised layer
- With improved and efficient mobile plants currently available, plant-mixed operation has become more feasible and cost competitive
- Allows placement of geo-composite layer low in the pavement profile.

Therefore, it is considered that a more consistent product can be achieved using the plant-mixed operation.

46.3 References

For further information on foamed bitumen stabilisation, reference should be made to the following documents:

- MRTS/MRS07C *In-situ Stabilised Pavements using Foamed Bitumen*
- MRTS/MRS09 *Plant-mixed Foamed Bitumen Stabilised Pavements*
- MRTS/MRS58 *Subgrade Reinforcement using Pavement Geosynthetics*
- *Materials Testing Manual*, Part 2 Application Section 5 Testing of materials for in situ foamed bitumen stabilisation, July 2019

- *Materials Testing Manual*, Queensland Department of Transport and Main Roads, Part 2 Application Section 6 Testing of materials for plant-mixed foamed bitumen stabilisation, July 2019
- *Pavement Rehabilitation Manual*, Queensland Department of Transport and Main Roads, April 2020
- *Pavement Design Supplement*, supplement to Part 2: Pavement Structural Design of Austroads Guide to Pavement Technology, Queensland Department of Transport and Main Roads, July 2018.

47. Treatment of heavily bound or stabilised pavements

Heavily bound or stabilised pavements should be treated with:

- a prime (or an initial seal, formerly called a primer seal, if constructed under traffic and a prime is not practical) and
- provisional 7mm seal (its use depends on the standard of surface preparation achieved by the contractor and the level of shear stress to be applied from traffic) and
- for no asphalt surfacing, a SAM seal.

A geotextile-reinforced seal could also be applied with these pavements, in conjunction with a prime or primer seal. This treatment is to reduce risk of reflection of any cracks that develop in the heavily bound or stabilised layer.

Bleeding of seals may be an issue with foamed bitumen treated pavements. The bleeding can be exacerbated by using cutback primes or primer seals. To minimise the risk of bleeding, foamed bitumen stabilised pavements should have an initial seal as detailed in TMR Technical Note TN175 *Selection and Design of Sprayed Bituminous Treatments* and have a 10mm or 14mm polymer modified binder Strain Alleviating Membrane (SAM). PMB seal can be omitted if the asphalt surfacing is to follow.

The SAM must not be placed until the minimum curing requirements have been met.

48. Bridge infrastructure: scour protection at abutments and piers

This appendix should be read in conjunction with the *TMR Bridge Scour Manual* and *Design Criteria for Bridges and Other Structures*.

48.1 Rigid vs flexible abutment protection

The current standard solutions for abutment protection of the bridges were found to be inadequate for some bridges. Flexible abutment protection can conform to changes in the supporting surface and adjust to settlement, preventing build-up of hydrostatic pressure, hence the preference to adopting the flexible system.

The applications for current TMR standard drawings for abutment and pier protection are given in *Abutment Protection Type Selection Criteria – TMR Design Criteria for Bridges and Other Structures*.

48.2 Abutment and pier protection

The department's *Bridge Scour Manual* provides guidance on how to assess and accommodate scour into bridge design. This manual should be consulted for detailed guidance.

Scour protection must be designed for the maximum of average cross-sectional velocities (V) for floods with an AEP between 1 exceedance per year and 1 in 100 years, and must consider situations such as:

- overtopping bridge and embankment
- effects of local catchments and along road drainage
- scour analysis based on actual particle size of bed material and bed shear stress (in sand, scours to more than 5m are common).

If the overtopping event is greater than the AEP 1 in 100 year event and less than the AEP 1 in 2000 year event, the designer must conduct a risk assessment to determine if the scour protection should be designed to withstand the overtopping event. The risk assessment should consider the criticality of the link and availability of alternative routes, and potential cost of repairs versus the cost of scour protection.

TMR's solution for abutment protection from scour involves installing the abutment protection as outlined in the Abutment Protection Selection Criteria of *Design Criteria for Bridges and Other Structures*. These criteria provide selection of abutment protection types with reference to relevant TMR standard drawings, depending on the protection parameters such as flood velocities. Gabion and mattress protection, rock protection (riprap) or concrete solid block protections are identified as heavy duty scour protection types. Standard drawing 2241 provides standard details of abutment protection using rock-filled gabions and mattresses.

Gabions are containers or baskets made up of wire mesh and that are filled with cobbles or coarse gravel. They are filled with stone on site or in a shop. A thinner version of a gabion is known as wire mattress. Whereas gabions typically take the shape of a brick, wire mattresses have a short vertical dimension and large lateral extension. The wire mesh in gabions and wire mattresses has flexibility, which allows the containers to deform to the support surface.

A solution for scour protection that uses gabions and wire mattresses has several advantages, when compared to other means of abutment and pier protection. These include:

- their loose and porous structure reduces their susceptibility to uplift forces
- they can be stacked easily in stable configurations
- the flexibility of the wire mesh allows gabions to mould themselves to restore their stability and provide adaptability to site conditions
- relatively small rock sizes can be used to provide the protection effectiveness of much larger rock units
- due to its smaller thickness, a lesser quantity of stones is required.

The following recommendations may be used as a rough guide for providing rock protection at abutments and piers. Also refer to *Section 3.6.5* of *Austroads Guide to Road Design Part 5 – Drainage – General and Hydrology Considerations (2023)*.

Rock protection for spill-through abutments – The class of rock protection required to protect an abutment (without a guide bank) is determined from the velocity given by multiplying the average velocity 'V' in the bridge opening by a factor of 1.33, to allow for the turbulently mixing flow action at bridge abutments.

Rock protection should be provided as follows:

- The class and the thickness of rock required to protect the embankment should be determined from Tables 3.11 and 3.12 of the *Austroads Guide to Road Design Part 5*, for the velocity given by 1.33V. Where V is average stream cross-sectional velocity.
- The apron at the toe of the abutment slope should extend along the entire length of the abutment toe, around the curved portions of the abutment to the point of tangency with the plane of the embankment slopes.
- The top of the riprap mat should be placed at the same elevation as the stream bed.
- In some conditions a permeable geotextile fabric or gravel fitter will be required under the riprap mat. If a well graded riprap is used, a fitter may not be needed.

Rock protection for piers – Rock riprap is not a permanent countermeasure for scour at piers at existing bridges and should not be used to protect piers at new bridges. The class of rock protection required to protect a pier from a scour is determined from the velocity obtained by multiplying the velocity of flow approaching the pier by a coefficient, *Kp*, for pier shape.

The average velocity of flow, V, approaching the pier is estimated by taking the average velocity in the bridge opening and multiplying it by a coefficient that ranges from 0.9 for a pier near the bank in a straight uniform reach of the stream to 1.7 for a pier in the main current of flow around a bend. For piers located on the floodplain, the velocity on the floodplain should be used. Where a pier is located adjacent to an abutment and the bridge approach is cutting off significant flow, then some allowances should be made for the resulting increase in velocity caused by the cut-off flow entering the bridge opening.

Coefficient for pier shape *Kp* = 1.5 for round-nose pier

1.7 for rectangular pier.

Rock protection should be provided as follows:

- The class and thickness of rock is determined from *Section 3.4.2* of *TMR Bridge Scour Manual*.
- The riprap mat should extend horizontally at least twice the pier width, measured from the pier face.
- The top of the riprap should be placed at the same elevation as the stream bed.
- In some conditions, a filter cloth or gravel filter will be required under the riprap mat. If a well graded riprap is used, a filter may not be needed.

48.3 Serviceability and strength parameters

The typical TMR standard flood immunity criterion is AEP 1 in 50 years. However, the relevant TMR district should be consulted for each project, prior to the design commencing, to confirm this requirement. As described above, a risk assessment is required if the overtopping event is greater than an AEP 1 in 100 year event and less than an AEP 1 in 2000 year event.

48.4 Sizing of gabions

Sizing of gabions is usually stated in design manuals provided by the manufacturers. The thickness of gabions should be determined based on critical velocity of flow. The critical velocity is the velocity at which the gabions or wire mattresses reach the acceptable limit of deformation. Velocity range stated represents critical velocity (lower value) and limiting velocity (upper value). Selecting the design velocity as the critical velocity for particular gabion thickness provides an extra factor of safety up to the limiting velocity when gabions fail.

48.5 Placement of gabions at embankments and abutments

For placement of abutment protection using gabions, refer to TMR's *Standard Drawing SD2241*.

48.6 Types of wire to be used

The types of wire to be used should be in accordance with MRTS03.

48.7 Constructability

Delivery from long distances will be cost prohibitive. The type and size of gabions should be selected from locally available sizes. In all cases, gabion designs must be based on hydraulic conditions, long-term durability and ease of maintenance. Excavation machines and small cranes may be used for pre-excavation and for lifting and placing of sacks, boxes and mats in position. The crane can be located on bridge approaches (usually shoulder) or adjacent to the riverbed, if access is possible.

48.8 Underwater construction

For rivers with less than a metre depth of water, cofferdams are not required and sandbags may be used. However, cofferdams would be required for greater depths. Watertight timber or steel sheeting should be driven into riverbed. The excavated soil should be placed on the banks for reuse. After placing the gabions, a 150mm to 300mm layer of excavated soil should be placed on top and compacted. Temporary sheeting should be withdrawn and any voids filled. A layer of grass or thin vegetation may be grown to stabilise the topsoil. In locations where the riverbed has eroded due to recent floods, excavation may not be required and gabions may be deposited directly under water by a barge. This is more economical since cofferdam driving costs are higher than the cost of gabions.

48.9 Use of filter layers

On a sand riverbed, a geotextile filter should be placed underneath the gabions to prevent sand leaching. The geotextile filter should be sealed to the pier by a flexible tube containing cable that can be tightened around the pier.

48.10 Durability and maintenance

The following types of failures may occur and may be avoided by good construction practice:

- Failure of meshes and stones fallout due to corrosion, abrasion and damage during construction.
- Winnowing failure due to erosion of underlying bed material through the gabions due to failure of filter layers and inadequate gabion thickness during floods.
- Excessive movement of stone within the baskets may occur at high currents due to poor packing.

48.11 Implementation of environment controls and permits

Stream encroachment and other applicable permits will be required in accordance with the existing environment protection laws.

49. Drainage infrastructure: structural requirements for existing structures

This appendix must be read in conjunction with the Volume 3, Part 5B, RPDM 2nd Edition. Note that this supplement (*Section 3.6*) clarifies the department's requirements for determining design loads on buried structures and required reinforced concrete pipe class.

The remainder of this appendix expands on the requirements of *Section 3.6.2* of the Volume 3, Part 5B, RPDM 2nd Edition in the context of natural disaster works by clarifying the intent and decision making process that project managers, planners and designers must adopt in determining whether to extend the service life of existing pre-2004 culvert structures.

Any structural assessment (excluding inspections as prescribed) and design should only be undertaken/directly supervised by a competent civil engineer and the work is subject to certification by an RPEQ. Engineers can seek assistance and advice, if required, from the Director (Bridge and Marine Engineering) – refer to *TMR contacts* at the back of this document.

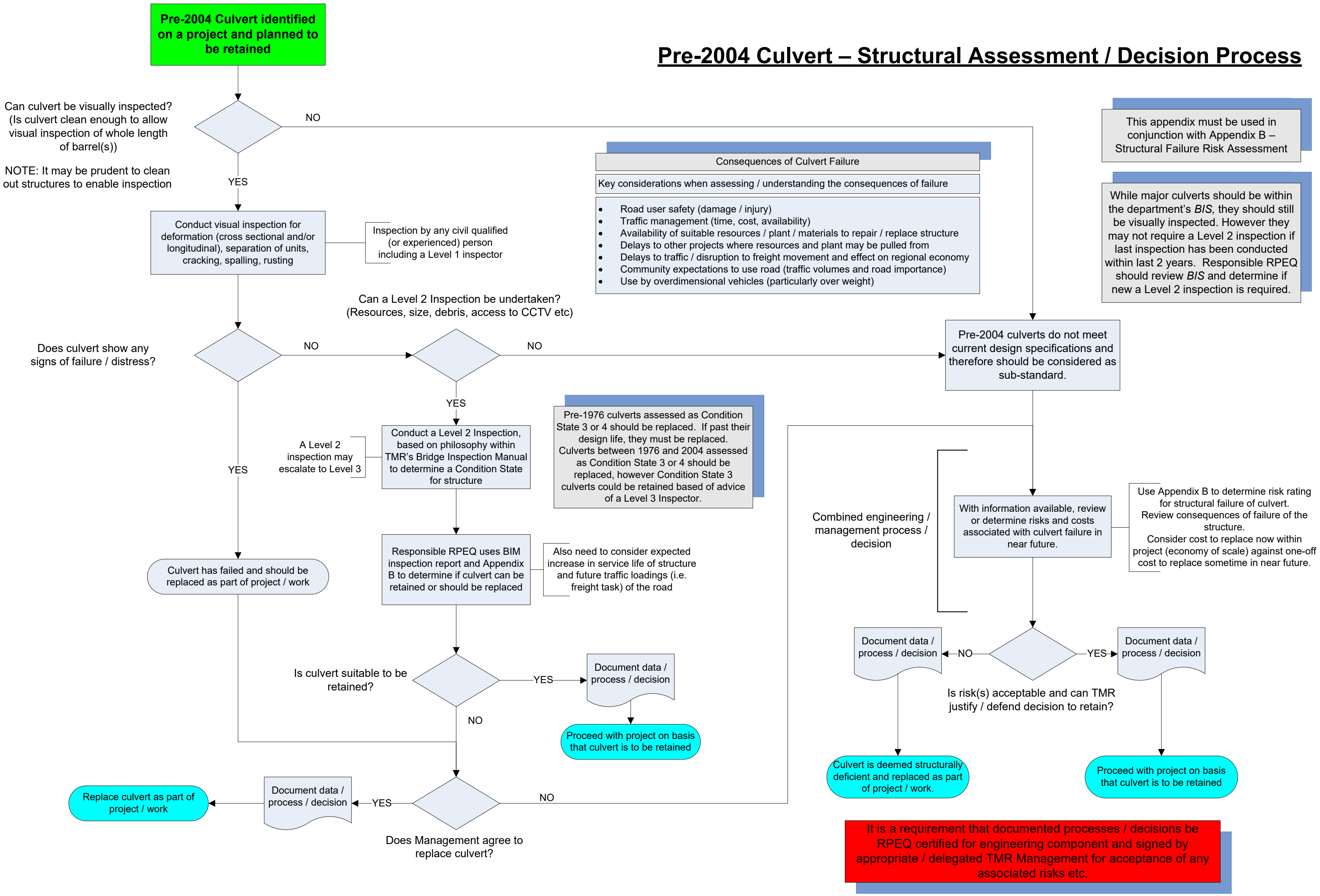
For all planning, design and construction projects (excluding maintenance) on state-controlled or national road links, where it is planned to retain a pre-2004 culvert to maximise service life, the structure must be:

- inspected and, if found deformed (cross-sectional and/or longitudinal), separated, cracked, spalling or rusted, the culvert must be replaced or
- inspected and, if found visibly satisfactory, then a level 2 inspection conducted in accordance with the *TMR's Bridge Inspection Manual*, to determine its structural integrity (findings of level 2 inspection may escalate to a level 3 inspection). The responsible RPEQ engineer must review the findings and determine if the culvert is structurally deficient or not, considering the expected life of the project and future traffic loadings (i.e. freight task) of the road. A structurally deficient culvert should be replaced. A culvert that passes is considered suitable to be retained.

If a culvert cannot be visibly inspected or have a level 2 inspection undertaken (typical for small barrel size culverts) then consideration should be given to the consequences of failure during the life of the project and it may be reasonable/prudent that the culvert be assumed as structurally deficient and replaced.

Figure 10 below (extracted from Appendix F of the Volume 3, Part 5B, RPDM 2nd Edition) provides a flowchart of the above assessment/decision process. Information on how to apply this process to natural disaster works is provided on the pages immediately following Figure 10. Appendix G – Structural Failure Risk Assessment of the Volume 3, Part 5B, RPDM 2nd Edition should be used in conjunction with this process to assist in determining the risk (probability) of structural failure for a given culvert. Further advice in relation to this requirement can be obtained from the Director (Bridge Design) – refer to *TMR contacts* at the back of this document.

Figure 10: Pre-2004 culvert assessment/decision process



The following information explains how the process in Figure 10 can be applied for natural disaster works:

- As a minimum, a Level 1 inspection is to be undertaken on all drainage structures where they are anticipated to have been impacted by the flood event. These Level 1 inspections are funded through the DRFA. This includes all drainage structures within the extent of DRFA-funded pavement works.
    - For culverts where inspection can be difficult – e.g. for RCP culverts <900mm diameter, box culverts <900mm high and steel pipes <900mm diameter, inspect what is possible (e.g. endwalls, first barrel or two each end).
    - Advise the district of which culverts are unable to be fully inspected. The district should follow the NO path of 'Can culvert be visually inspected' from Figure 10 to assess whether or not to replace the culverts. This assessment and any pipes/culverts replaced are funded as complementary works.
- If the Level 1 Inspection identifies structural damage attributable to the flood event, take the following steps:
    - If the full length of the culvert has suffered structural damage, then a Level 2 inspection is not required as the culvert should be replaced and is eligible to be claimed under the DRFA.
    - If only part of the culvert has suffered structural damage:
        - Undertake a Level 2 inspection on the part of the culvert that has not suffered damage. The Level 2 inspection is funded under the DRFA. Advise the district if this part of the culvert fails the Level 2 inspection. The district should follow the NO path of 'Does culvert pass Level 2 inspection' from Figure 10. The district will decide whether or not to completely replace the culvert. The cost of repairing the existing culvert is funded under the DRFA. The difference in cost between repairing the culvert and full replacement is funded as complementary works.
        - If the culvert passes a Level 2 inspection, retain the part that has not suffered damage. The cost of repairing the existing culvert is funded under the DRFA.
- If the Level 1 inspection identifies structural damage for reasons not attributable to the flood event (e.g. spalling, rusting), then a Level 2 inspection is not required as the culvert should be replaced. Replacement of the culvert is funded as complementary works.
- If the Level 1 inspection indicates that the culvert appears in reasonable/good condition and the culvert is not being extended, take the following steps:
    - For RCP culverts 900mm to <1800mm diameter, box culverts 900mm to <1800mm and steel pipes 900mm to <1200mm diameter, advise the district that a Level 2 inspection is desired to be undertaken as part of the RMPC in place for the district. Any Level 2 inspections undertaken and culverts replaced are funded as complementary works.
    - For RCP culverts ≥1800mm diameter, box culverts ≥1800mm high and steel pipes ≥1200mm diameter, check if there has been a Level 2 inspection within the department's BIS undertaken in the past two years:
        - If NO, then notify the district that a Level 2 inspection is overdue and should be undertaken as part of the RMPC. Any Level 2 inspections undertaken and culverts replaced are funded as complementary works.
        - If YES, then no further action is required.
- If the Level 1 inspection indicates that the culvert appears in reasonable/good condition and the culvert is being extended (e.g. as a result of formation widening), take the following steps:
    - Undertake a Level 2 inspection of the culvert, which is funded under the DRFA. Advise the district if the culvert fails the Level 2 inspection. The district should follow the NO path of 'Does culvert pass Level 2 inspection' from Figure 10. The district will decide whether or not to completely replace the culvert. The cost of extending the existing culvert is funded under the DRFA. The difference in cost between extending the culvert and full replacement is funded as complementary works.
    - If the culvert passes a Level 2 inspection, extend the existing culvert. The cost of extending the culvert is funded under the DRFA.

50. Geospatial/survey additional information

Appropriate survey information should be sought for natural disaster projects where overlays and/or formation widening is required. This may be due to:

- a pavement that has failed or is unserviceable. Survey information will allow:
  - optimisation of the overlay depth of the crossfall and changes in crossfall along the road while ensuring the minimum overlay thickness is always provided at all points. This results in improved ride quality and materials and construction savings while meeting structural requirements.
  - re-establishment of a geometric control line
  - superelevation correction
  - avoidance of road surface drainage issues and potential aquaplaning issues
- batter slopes that are steeper than 1 on 4 that may now require:
  - curve widening
  - safety barriers
- horizontal curves that have lost their superelevation over time
- major culverts or floodways – where hydraulic controls may also require transitions between pavement overlay on the approaches and pavement replacement over these structures
- bridge approaches.

Other cases that are likely to require appropriate survey information together with normal design plans are:

- a road where there are frequent changes between flood reconstruction works and unaffected works – it may be necessary to establish a new geometric grade line
- major intersections
- provision of manoeuvre widening where there is restricted sight distance
- where there are no useful plans of the existing road
- where flood reconstruction works can/will be combined with already planned and funded works
- where it may be necessary to improve a curve if the approach speed is increased due to changed driver or rider perception of the road
- where there are likely to be major benefits from widening the formation on one side only
- where there have been significant changes to the outlet channel geometry at drainage structures – tailwater levels that affect the hydraulic performance of culverts and floodways will most likely have changed due to scour. The consequences of changed hydraulic capacity and flow will need to be assessed
- bridge sites where flooding has caused washing out around bridge pile and footings.

51. Mobile Laser Scanning (MLS)

51.1 Coordination through TMR E&T

Coordination of the tendering and quality control processes by TMR's Engineering and Technology Branch through the Geospatial Technologies Unit has the following benefits:

- Adding value through expert knowledge. Geospatial Technologies Unit has experience in developing the technology with industry through:
  - international/national and local research undertaken
  - successful delivery of many thousands of kilometres of MLS
  - partnering with consultants/industry, which has advanced technology to achieve more accurate/quality results
  - developed and published a *MLS Guideline and Checklist*.
- Coordinating and prioritising surveys to maximise use of MLS and benefits to meet overall priorities in collaboration with districts and project managers.
- Streamlining processes to meet critical timelines by maximising the use of MLS suppliers through the tendering process.
- Using a standard brief, the *MLS Guideline and Checklist* developed by the Geospatial Technologies Unit. This ensures MLS consultants are using the same brief to deliver a similar product/service statewide and therefore brings better quality, processes, consistency and accuracy.
- Reducing the risk of rework and low-quality outcomes.
- Enabling partnership with districts/consultants to gain desired benefits.
- Providing expert advice and assistance including training of TMR district staff and consultants.

51.2 Usage

MLS derived survey information will:

- increase the accuracy in estimating quantities
- increase the chance of getting accurate tenders and avoiding variations
- increase the chance of meeting budget
- increase the chance of programming works with correct timings
- increase the chance of getting correct pavement thicknesses from the scanned surface profile generated
- enable better appreciation of extent of damage and extent of design required
- increase designer's familiarity with the site (even without visiting the site)
- provide good surface shape information
- increase the project control for construction
- provide a post-construction survey/audit (as constructed) to 'truth' the design to ensure that value for money has been obtained.

51.3 Benefits

The major benefits of using MLS are:

- long distances are captured in short timeframes (approximately 50km of Pointcloud can be collected in a single shift)
- extracted data will provide a full survey from shoulder to shoulder plus other visible features on, off and above the road surface
- increase in personnel safety as extraction of data is undertaken in the office
- low/no traffic control costs
- better design/construction outcomes when compared to having no survey information, and better pavement surface modelling than traditional surveys
- associated geo-referenced imagery may reduce the need for a site visit to resolve design problems, as the imagery can be operator manipulated to give a good visual
- collateral information about the road network, which is normally beyond the specific purpose of the survey, is collected and can be extracted from Pointcloud for DRN [ARMIS], asset element capture, bridge heights/clearances, as constructed details, construction audits and so on.

51.4 Limitations

Limitations in the use of MLS technology include:

- wet weather (MLS will not penetrate ponded water to record the surface)
- rain and wet surfaces:
    - laser beam of the MLS is not reflected and the result is no data
    - terrestrial imagery is affected by rain drops on camera lenses and under/over exposure
- dense vegetation (tropical forests etc.) and long grass will not allow the surface to be established accurately
- heavily overhanging tree-lined road corridors limit access to GNSS/GPS satellite coverage, which may affect the accuracy of the pavement surface generated
- MLS is a line-of-sight instrument i.e. it only records/surveys what it sees from the scanners mounted on the top of the vehicle at say 2.2 m above the roadway. It will not see/record culvert inlet/outlet details, slopes of high-fill batters, underground services, culverts, kerb inverts when filled with silt, edge of bitumen covered with grass etc.
- when scheduling surveys using MLS technology, the time taken for data extraction should be considered as the field capture time is generally much shorter than the data extraction process
- MLS does not provide information related to pavement condition or distress (e.g. does not detect cracks).

51.5 Accuracy

There are different MLS configurations that can be used to capture survey information. Each company uses different methodologies to produce surveying information and accuracies will vary. Prior to starting an MLS capture, determining which combination will give you the required results is paramount. To discuss options, contact Geospatial Technologies – refer to *TMR contacts* at the back of this document. The best possible accuracy achievable using MLS is as follows:

- On pavement/bitumen including non-heavily grassed shoulders: relative XYZ of 20mm or better.
- Off pavement: depends on vegetation coverage and amount of penetration that can be achieved. No or non-obstructive vegetation coverage will yield accuracy similar to pavements on distinct hard surfaces at distances up to 10m from the MLS capture vehicle.

51.6 Deliverables

MLS deliverables include:

- a grid of points (down to 50mm x 50mm in size)
- cross-sections across pavement (down to 100mm apart longitudinally)
- contours
- 12D strings similar to normal survey information (e.g. lane lines, edge of bitumen, centrelines, changes of grade etc.)
- geo-referenced terrestrial imagery.

52. Road safety risk analysis

The Safer Roads Team developed a Microsoft Excel tool named the Queensland Risk Assessment Model (QRAM) to identify and prioritise road network safety risk. Historical road crash data has been used as an indicator of the level of road safety risk that can be attributed to road infrastructure. Road safety programs have been targeted towards 'black spots' where crash rates are high. TMR has assessed the entire state-controlled road network using the Australian Road Assessment Program (AusRAP). This has provided a second measure of road safety risk specifically related to road infrastructure features that can be used proactively, so risk can be identified at a site before crashes occur. We cannot though completely ignore the sites that are experiencing frequent crashes with severe outcomes, as there may be a separate underlying issue that needs to be addressed. Hence the Queensland Risk Assessment Model (QRAM) uses both the reactive crash risk and the proactive infrastructure risk data when prioritising sites for investigation.

Two systems have been developed, one for mid-block section, at a 1km level, and the other for intersections. Both systems use the similar approach of combining the risk associated with the crash risks and infrastructure risks, with equal weighting applied to each. Due to risk for an individual and for the collective being unique, equal weighting is also applied to each of these so that to get the highest ranking, a site must have a high crash rate, both collectively and for individuals, as well as have a high infrastructure risk, both collectively and for individuals. A spreadsheet list of the road segments, ranked by road safety risk, has been produced to prioritise each intersection and 1km mid-block section.

Refer to QRAM to identify if there is any existing risk on the section of road being examined. Safety risk reduction opportunities should be considered at all locations, irrespective of the existing risk.

53. Design, documentation and other information requirements

53.1 Drawing requirements when using MLS

The area required to be covered by the Ground and Feature Model (GFM) will typically be set by the expected type of reconstruction work. In most cases, the GFM that is supplied from Mobile Laser Scanning (MLS) undertaken for natural disaster works will be limited to a short distance beyond the carriageway or the road formation, unless it is complemented by conventional survey.

Generally, the GFM generated from an MLS survey will not contain many of the key features that are located via conventional survey methods and that would then be recorded on the drawings for future use. In turn, this means that the new drawings will still complement the working plans for the existing road, since the existing working plans provide details of still very relevant features such as:

- drainage details, including watershed areas
- public utility plant
- land details

- accesses
- soil and vegetation details etc.

The following points need to be taken into consideration:

- A table listing the respective current working plans for the existing road must be shown on the new drawings. The relevant chainages for each existing working plan should be included and labelled as approximate since a precise chainage mapping will usually not be available (see Table 9).
- A details plan will need to be included with:
  - survey control stations (see Table 10)
  - design set-out details (see Table 11 and Table 12) – this would include end points of work, tangent points, intersection points and convenient intermediate chainage points in order to ensure that there were no set-out points more than 1km apart
  - details of any ramps or tapers where joining onto existing construction
  - if necessary, any special details for superelevation application, curve widening and so on.
- The new working plans will show on the plan view:
  - relevant survey control points
  - the horizontal alignment control line
  - curve details (radius, transition length, tangent length, tangent points etc.)
  - curve widening details
  - any features that were included in the processed survey model – for example, turnouts or driveways
  - alterations to drainage infrastructure or new drainage infrastructure.
- The new working plans will show on the longitudinal section:
  - the vertical alignment control line with grade and vertical curve details
  - Extended Design Domain sight distance capability, if relevant
  - the extent of relevant pavement, surfacing and type cross-section details
  - depending upon the type of MLS (see below):
    - overlay depths at the control line together with indicative design heights or
    - actual design heights on the control line
  - pavement marking details
  - superelevation details
  - design speeds
  - alterations to drainage infrastructure or new drainage infrastructure.
- The new working plans must show survey data details in the relevant part of the title block.

MLS surveys may be undertaken to different orders of accuracy for natural disaster works. Higher-order MLS survey information is comparable to conventional TMR survey methods in terms of ‘absolute’ position and height, hence making it possible to design the new works to a similar standard.

However, in the interests of expediency and availability, it may be necessary to use an MLS survey where the relative XYZ accuracy on the existing road surface will be lower (that is, numerically greater) than the 20mm achieved by the higher-order MLS. Even so, the MLS in this case provides sufficient accuracy transversely for optimising the type of reconstruction works required (including superelevation correction) and the optimum overlay depth for the cross-section.

Likewise, the longitudinal accuracy is sufficient to indicate whether the longitudinal profile has gone out of shape locally and needs to be corrected through a change in overlay depth at the control line. However, for construction control, it is necessary to work with the overlay depths rather than the design heights (previously called reduced levels) derived from survey heights and overlay depths.

The working plans need to show that the overlay depths are the primary design control and that the control line heights are indicative – that is, may only be used for construction control after on-site verification (see Table 9).

Table 9: Relevant existing working plans

Existing Plan No.	Start Chainage Approximate (m)	End Chainage Approximate (m)
271720	53591.506	55000
271721	55000	55959.754
205515	55700	57600
205516	57600	59500
205517	59500	61400

Table 10: Survey control details

Permanent marks/bench marks/survey station							
Mark	Type	Coordinates		Height	Combined Scale Factor	Approx. Location Chainage	Off-set
		Easting	Northing				
BM 61K PM111742	Star Picket FENO	406852.485 406882.088	7102471.608 7102694.434	252.267 254.436	1.00014727 1.00014733	34806.1 37512.4	-20.23 16.96

Table 11: Design MC10 set-out table

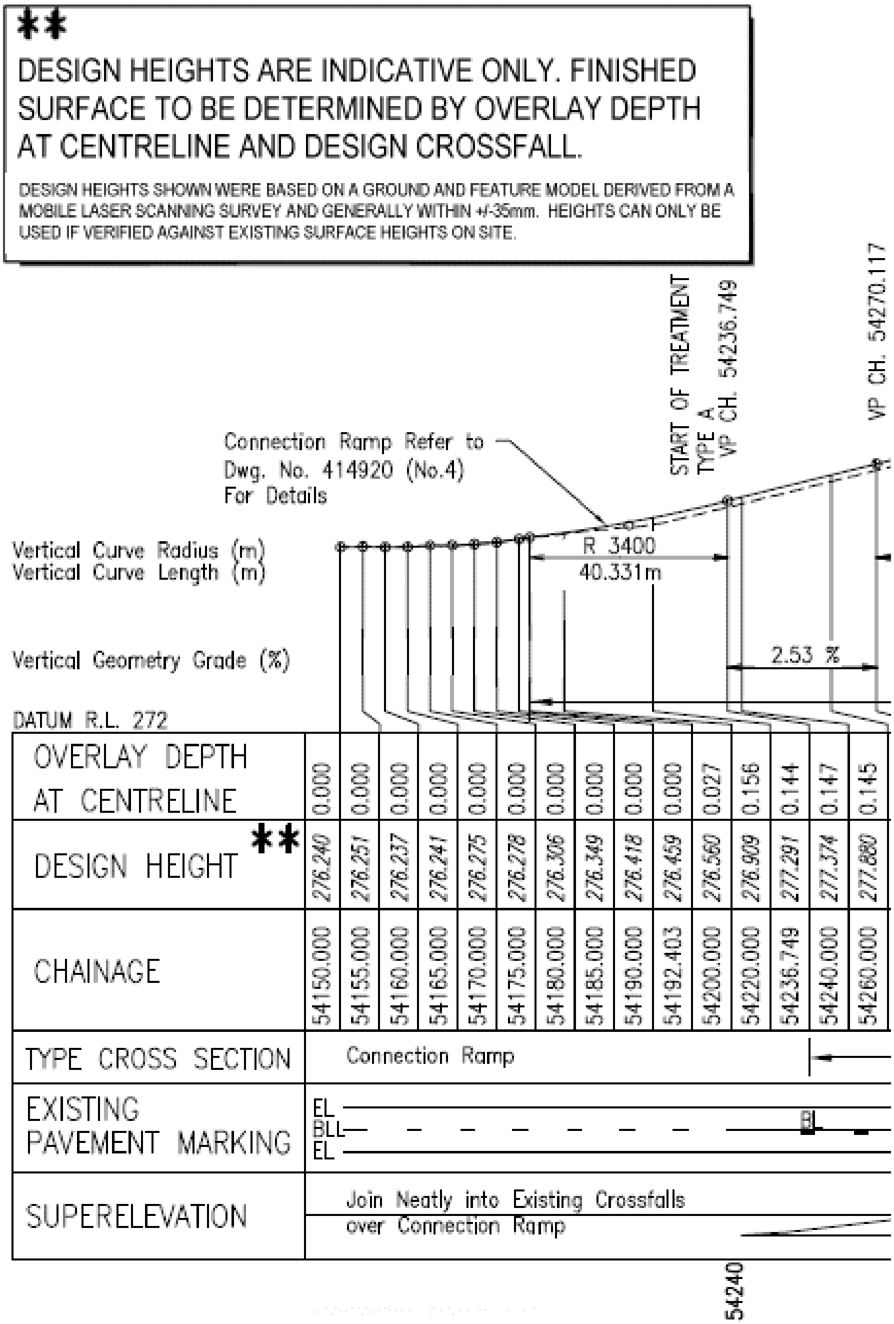
Pt No.	Pt	Chainage	GPS Tripmeter Chainage	Easting	Northing	Bearing
1 (START)	START RAMP	54192.403	54192.518	689128.000	7042167.097	303°11'23"
2	TC	54307.458	54307.257	689031.715	7042230.080	303°11'23"
3	IP2	54526.804	54526.449	688844.471	7042352.561	303°11'23"
4	CT	54746.151	54745.545	688735.873	7042548.183	330°57'49"
5	TC	56310.207	56305.697	687976.733	7043915.654	330°57'49"
6	IP3	56483.928	56479.035	687892.201	7044067.924	–

Chainage Control Point: Ch = 54220
X= 689104.147
Y= 7042181.045

Table 12: Design MC10 set-out table (continued)

Pt No.	Pt	Chainage	GPS Tripmeter Chainage	Easting	Northing	Bearing
7	CT	56657.649	56652.423	687835.262	7044232.513	340°55'01"
8	–	57000	56993.924	687723.335	7044556.050	340°55'01"
9	–	58000	57991.482	687396.397	7045501.096	340°55'01"
10	–	59000	58988.986	687069.460	7046446.142	340°55'01"
11	–	60000	59986.495	686742.523	7047391.188	340°55'01"
12	TC	60547.769	60532.891	686563.436	7047908.855	340°55'01"

Figure 11: Inclusion of overlay depths on working plan when using lower order MLS



53.2 Asset valuation – impairment analysis

Data/information is mandatory for Queensland Audit Office (QAO) and Queensland Treasury as part of infrastructure asset valuation. The required information to enable impairments loss for the annual asset valuation for the network is described in Table 13.

53.3 Job inventory in roads information systems (ARMIS)

Data/information is required as per normal operational practices (future resource requirements, workload planning, asset valuation reporting requirements and for office records for future reference). The required information for district ARMIS is described in Table 13. Note that the format of 'as constructed' details is not prescribed and can be different across the districts. Figure 12 and Figure 13 are examples of an as-constructed form and type cross-section respectively, as used in South West District.

Table 13: Details of the road inventory data capture requirements for asset management regarding natural disaster works

Data item	Purpose				
Information required upfront					
	Asset Valuation	**ARMIS Job Inventory**	**Element Management**	**Maintenance Strategy Analysis**	**Maintenance & Preservation Program Planning**
Project (job) number	√	√	√	√	√
Work description	√	√	√	√	√
Road section ID	√	√	√	√	√
LGA ID / District ID	√	√	√	√	√
Location/s details of each sites at CWAY and lane levels • Start chainage • End chainage *Location identifier for each location (where the work is on a bridge the Structure ID is needed)*	√	√	√	√	√
Activities/ work description	√	√	√	√	√
Width details at lane and carriageway levels	√	√	√	√	√
Area of damage	√			√	
Estimation of renewal and total cost	√		√	√	√

Data item	Purpose				
Inspection and approval status	√				
Planned start date and planned completion date	√	√			√
Type of construction method, i.e. contract, minor work, agreed price performance contract		√	√		
Source of funds (business programs such as NDP, MPO rehabilitation, MPO Program Maintenance, state capital funding etc.)					√
Details of the source (quarry) of cover aggregate used in seals			√	√	√
Information required after work has been completed *					
Notification of completion of the works. *If the project involved a number of locations, then notification of when each location was completed.*		√			
Actual start of construction, physical completion and open to traffic dates for each location		√			
Actual project location/s.		√			
As constructed plans for those projects that will have the above information *This is to show actual pavement details and extent of work.*		√			
Project number, description, locations with associated pavement and width details at lane and carriageway levels		√			

** Note: Documents and/or design plans for those projects that will have most of this information. If no documentation, they will require project (job) number, description, site details, i.e. road sections with locations of proposed works, pavement and width details at lane and carriageway levels.*

Figure 12: Example of an 'As constructed' form (from South West District)

South Western District

AS CONSTRUCTED DATA – CONSTRUCTION, REHAB, RESEALS

	JOB NO	247/93a/NDRRA (Page 1 of 1) 674	
Start date of Construction	01/10/2010	Date of Completion	15/11/2010
TICK PROJECT TYPE	Construction /Rehab (use Section 1) X	Maintenance (Reseals/Asphalt) (use Section 2)	

SECTION 1 - CONSTRUCTION &/or REHABILITATION WORKS

1.1 Was the project constructed in accordance with the prototype plans?	Yes		
	No	X	IF NO – As Constructed drawing to be attached

1.2 Complete details below:

Chainage Start (Tistkm)	Chainage End (Tdistkm)	SW LHS (m)	SW RHS (m)	Total new Seal Width (m)	Total New Formation Width (m)	Pavement Type & Depth (mm)		Surface	1st Coat Bitumen	1st Coat Aggregate	2nd Coat Bitumen	2nd Coat Aggregate
Refer to Note number		1	1	-	7	2	3	4	5	6	5	6
91.131	91.43	4.0	4.0	8.0	8.0	S	200	S	B	14		
93.023	93.264	4.0	4.0	8.0	8.0	S	200	S	B	14		
102.32	103.311	4.0	4.0	8.0	8.0	S	200	S	B	14		
104.518	104.535	3.7	3.7	7.4	7.4	S	200	S	B	14		

K1

Notes: 1. SW = Seal Width Widened LHS or RHS in metres; only applies to widening jobs
2. Pavement Type = **G** for Unbound Granular Pavement or **S** for insitu stabilised or modified paving gravel
3. Depth of Gravel in mm.
4. Enter Surface type either **S** = Bitumen Seal or **A** = Asphalt
5. Applies to Seals & Asphalt. Enter **B** for Class 170 bitumen or **P** for Polymer Modified Bitumen or **G** for Geotextile Seal.
6. Enter the nominal aggregate size used on the NEW work
7. Formation Width = distant from shoulder edge to shoulder edge; width available for safe running of traffic; incl unsealed shoulder if applicable.

MAJOR CULVERTS

Show Chainages of NEW Drainages Structures with **Height > 1.8m &/or Waterway>Area 3m²**

SECTION 2 – MAINTENANCE (Reseals, Asphalt)

1.1 Was construction in accordance with width & chainages in Scheme Tender Schedule?	Yes		No		Complete details below OR attach marked-up Tender Schedule

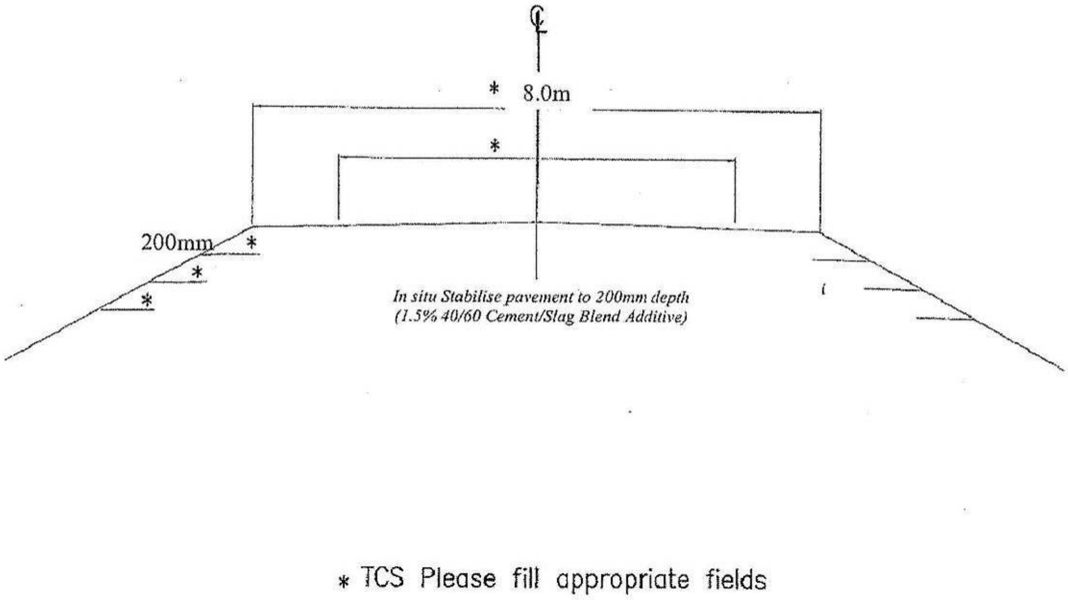
Chainage Start (Tdist km)	Chainage End (Tdist km)	Seal Width (m)	Surface Type	Bitumen Type	Aggregate Size (mm)
Refer to NOTE number:		-	4	5	6

Signature of Data Collector: [signature] **Date** 15/02/11

PROCEDURE NOTES:
1. This form is to be **completed immediately following Practical Completion.**
2. Data Collector to give original form to RISC.

3. RISC
A. Data entered into ARMIS. ☐ __/__/__
B. Place original completed form on job file ☐ __/__/__
C. Forward marked-up dwgs to PCC ☐ __/__/__
D. Forward copy of this form & RI01 to RIPA team ☐ __/__/__

Figure 13: Example of an 'As constructed' type cross-section (from South West District)



53.4 Element planning process

Data/information is needed for future rehabilitation, routine maintenance or resurfacing planning. The required information for the element planning process is the program of natural disaster work with chainages and work type, as detailed in Table 13.

53.5 Maintenance Preservation and Operation (MPO) program planning process

Data/information is needed to enable planning to manage the impact on MPO funding and district capacity. The data about natural disaster works that is needed to inform MPO allocations is also shown in Table 13.

53.6 Proactive maintenance strategy analysis

Data/information is needed for planning for future and preventive work. The required data about natural disaster works for this analysis is shown in Table 13.

53.7 Other recommendations and actions

To assist with collation and delivery of the required information for Transport System Asset Management Unit in (Policy, Planning and Investment Division), districts should:

- establish communication between ARMIS/Bridge Information System (BIS)/RMPC coordinators within every district
- ensure as constructed information as per standard business practice is entered into ARMIS/BIS as soon as practical following completion of works.

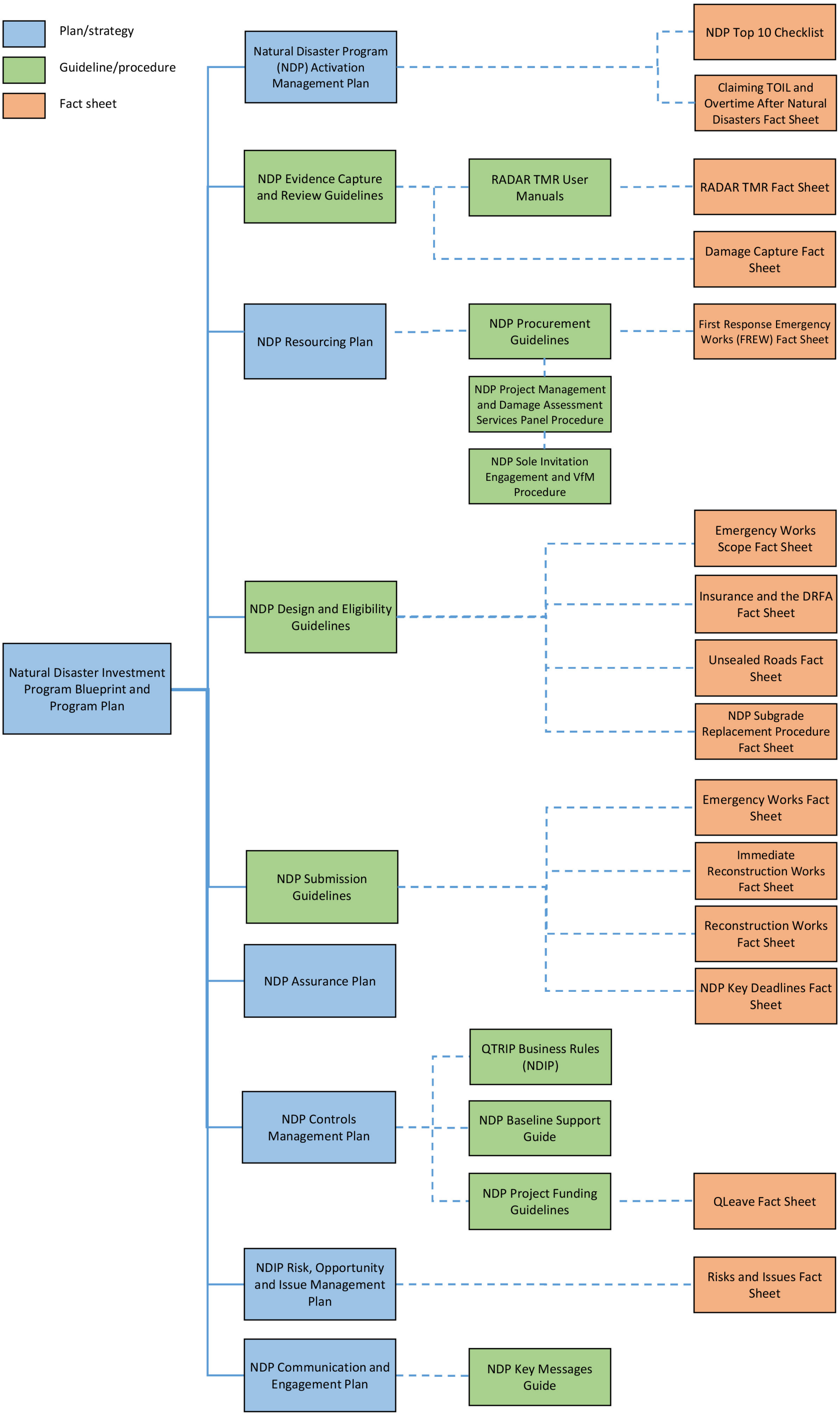
54. Acronyms

Acronym	Expansion
AAPA	Australian Asphalt Pavement Association
AEP	Annual Exceedance Probability
ARMIS	A Road Management Information System
ARRB	Australian Road Research Board
AUR	Auxiliary Right Turn Treatment
AusRAP	Australian Road Assessment Program
BAR	Basic Right Turn Treatment
BCP	Business Continuity Plan
BIS	Bridge Information System
CAMS	Chevron alignment markers
CBR	California Bearing Ratio
CHR	Channelised Right Turn
CHR(S)	Channelised Right Turn (Short)
CNRP	Continuity Network Recovery Plan
DCP	Dynamic Cone Penetrometer
DDPSM	Drafting and Design Presentation Standards Manual
DE	Design Exception
DRFA	Disaster Recovery Funding Arrangements
DRN	Digital Road Network
DVR	Digital Video Road
E&T	Engineering and Technology
EDD	Extended Design Domain
ESA	Equivalent Standard Axles
FSI	Fatal and Serious Injury
FWD	Falling Weight Deflectometer
GFM	Ground and Feature Model
GMP	General Mechanistic Procedure
GPS	Global Positioning System
GPR	Ground Penetrating Radar
HILI	High Load Intensity Low Intervention
HWD	Heavy Weight Deflectometer
ITS	Intelligent Transport Systems
IWP	Inner Wheel Path
MLS	Mobile Laser Scanning
MPO	Maintenance Preservation and Operation
MRTS	Main Roads Technical Specifications
MUTCD	Manual of Uniform Traffic Control Devices
NAASRA	National Association of Australian State Road Authorities
NDD	Normal Design Domain
NDP	Natural Disaster Program
OWP	Outer Wheel Path
PMD	Program Management and Delivery
PSD	Particle Size Distribution

Acronym	Expansion
PVC	Polyvinyl chloride
QAO	Queensland Audit Office
QRA	Queensland Reconstruction Authority
QRAM	Queensland Risk Assessment Model
QTRIP	Queensland Transport and Roads Investment Program
QUDM	Queensland Urban Drainage Manual
RADAR TMR	Recording Asset Damage and Restoration TMR
RCBC	Reinforced Concrete Box Culvert
RCC	Reinforced Concrete Culvert
RCP	Reinforced Concrete Pipe
REPA	Restoration of Essential Public Assets
RMPC	Road Maintenance Performance Contract
RMS	Roads and Maritime Services (NSW)
RPEQ	Registered Professional Engineer of Queensland
RPDM	Road Planning and Design Manual (TMR)
RRPM	Retro Reflective Pavement Markers
RSS	Reinforced Soil Structures
SAM	Strain Alleviating Membrane
SAMI	Strain Alleviating Membrane Interlayer
SWTC	Scope of Works and Technical Criteria
TMR	Transport and Main Roads
TPSG	Technical Policies, Standards and Guidelines (Publications of Transport and Main Roads)
TRUM	Traffic and Road Use Management
TSD	Traffic Speed Deflectometer
VPD	Vehicles Per Day

55. Document hierarchy

Below is a diagram representing the NDP document hierarchy.



56. TMR contacts

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Flooded roadway warning systems	Thushara Werrakkody	Principal Engineer (ITS Technologies)	30660998	thushara.r.weerakkody@tmr.qld.gov.au
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Discipline	Name	Position	Phone	Email
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Speed controls – *Manual of Uniform Traffic Control Devices: Part 4 Speed Controls*	Simon Harrison	Director (Safer Roads)	30662202	simon.j.harrison@tmr.qld.gov.au
Traffic and Road Use Management Manual (TRUM) *Volume 2: Guide to Road Safety Part 5 Section 4-1 Driver Fatigue*	Simon Harrison	Director (Safer Roads)	30662202	simon.j.harrison@tmr.qld.gov.au
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