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RISSB
RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Data entry – draft starts next page

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Preface

The aim of this Standard is to describe the hydrological and hydraulic requirements (functions, performance, design constraints and risk attributes) for the design and assessment of railway infrastructure in relation to whole-of-life approach to the management of hydrological and hydraulic design. This approach includes the requirements in relation to hydrological and hydraulic requirements and considers the design, supply, construction and maintenance of track in relation to drainage and flood-prone areas for a range of operational track gauges used in Australia.

All RISSB standards provide controls for hazards contained in RISSB's hazard guideline. In this standard, the reference number of the hazard being addressed is identified in an attached appendix. RISSB's hazard guideline can be found on the RISSB website at www.rissb.com.au.

This standard was prepared by the Hydrology and Hydraulics Development Group, overseen by the RISSB Infrastructure Standing Committee.

Objective

This Standard describes the hydrological and hydraulic functions, performance, design constraints and risk attributes for the design and assessment of railway infrastructure in relation to all forms of drainage in stormwater management.

This Standard is intended to govern public and private railways and railway drainage systems on a whole of life basis and any other drainage related work affecting the rail corridor.

The main purpose of this Standard is to provide a framework that promotes consistency and efficiency in design, construction, commissioning, maintenance, monitoring and decommissioning of track drainage and waterway crossings.

This Standard includes the hydraulic design of surface and sub-surface drainage systems including river and floodway crossings, culverts, pipes, channels, pits and grates.

This Standard aims to provide requirements to support in improving flood event resilience for rail corridor infrastructure. Generally, this involves a combination of flood mitigation, emergency management, flood forecasting and warning measures, land-use planning and infrastructure design.

Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

(a) Requirements.

(b) Recommendations.

(c) Permissions.

(d) Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term 'shall'.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term 'should'.

Recommendations recognize that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term 'may'.

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Constraints – provided by an external source such as legislation. Constraints are identified within the text by the term 'must'.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities or interfacing organisations where the risk may be shared.

RISSB Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix A.

Appendices in RISSB Standards may be designated either "normative" or "informative". A "normative" appendix is an integral part of a Standard and compliance with it is a requirement, whereas an "informative" appendix is only for information and guidance.

Commentary

Commentary *C Preface*

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by 'C' preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

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Section 1 Scope and general

1.1 Scope

The scope of this Standard covers hydrological and hydraulic risk management and requirements for construction of new railways, risk assessment and modifications to existing rail corridors and maintenance activities. Requirements of this standard include:

(a) alignment to federal flood risk management frameworks in the development of flood management plans for rail corridor infrastructure for the impact of flood related events;

(b) hydrological and hydraulic design principles and requirements to improve resilience in drainage and stability of the track formation, supporting embankments, associated cuttings, tunnel and bridge structures and access roads adjacent to the track; and

(c) hydraulic design and hydrology factors throughout the life of the corridor infrastructure including construction, operational monitoring and maintenance service levels and decommissioning.

This Standard covers the management of surface run off only, through either above or underground drainage systems. It is not intended to cover the management of ground water flows (i.e. hydrogeology).

While this Standard does not cover all hydrological or hydraulic circumstances, or address the impacts of hail and snow, the scope includes both surface and underground drainage requirements arising within the railway corridor as well as similar needs arising from the interface with natural waterways along the corridor.

This Standard applies to freight and passenger rail networks as classified in AS 7630.

This Standard is not intended to cover urban on-street tramway or light rail networks, monorail, cane railways, or heritage railways operating on private reservation, but items from this Standard may be applied to such systems as deemed appropriate by the relevant Railway Infrastructure Manager.

1.2 Normative references

The following documents are referred to in the text in such a way that *some* or all of their content constitutes requirements of this document:

- AS 7630, *Railway Infrastructure - Track Classification*
- AS 7636, *Railway Infrastructure - Railway Structures*
- AS 7640, *Rail Management*
- *RISSB Guideline Rail Emergency Management Planning*
- *Australian Disaster Resilience Handbook 7, Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*
- *Australian Disaster Resilience Handbook Collection, Flood Emergency Planning for Disaster Resilience*
- *Austroads Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures*
- *Austroads Guide to Road Design Part 5: Drainage – General and Hydrology Considerations*
- *Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia*

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NOTE:

Documents for informative purposes are listed in a Bibliography at the back of the Standard.

1.3 Defined terms and abbreviations

For the purposes of this document, the following terms and definitions apply:

1.3.1

afflux
change in the water level when comparing proposed flood conditions with baseline conditions

1.3.2
annual exceedance probability (AEP)
probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. Also, **probability of exceedance**

Note 1 to entry: AEP is usually expressed as a percentage, and common references include 1% AEP and 2% AEP.

1.3.3
ballast pocket
depression in the formation layer beneath the ballast where particles penetrate the subgrade and collects moisture

Note 1 to entry: Evidence of ballast pockets can take a variety of forms, including a heaved formation.

1.3.4
batter
backward and upward slope of face of a wall

1.3.5
BoM
Bureau of Meteorology

1.3.6
catch drains
intercept overland flow or runoff before it reaches the track, generally located on the uphill side of a cutting to catch water flowing down the hill and removed prior to reaching the cutting

1.3.7
catchment
land area draining to a point of interest, such as a point on a stream, river or stormwater drainage system, used to determine the quantity of runoff through hydrological assessment. Also, **catchment area**

1.3.8
cess drains
surface drains located at the formation level at the side of the tracks that remove water that has percolated through the ballast and is flowing across the capping layer towards the outside of the formation

Note 1 to entry: Cess drains are primarily intended for protect the formation by keeping it dry.

1.3.9
cross drainage
system of pipes or culverts which convey storm flows transversely across or under a railway

1.3.10

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cuts or cuttings
earth and/or rock excavation that is made below an existing surface to create the railway formation

1.3.11
daylighting
pipe outlet resurfacing to the atmosphere or a swale moving out of a cutting

1.3.12
design event
event for which stormwater infrastructure and mitigation is designed

1.3.13
discharge
rate of flow of water measured as a volume per unit of time

1.3.14
drain block
concrete structures that are typically positioned at the location where a cess drain transitions from cutting to embankment and slows the velocity of water, reducing the likelihood of scour and erosion

1.3.15
encroachment
alteration to the existing topography (such as railway infrastructure or placement of fill) in the floodplain, so that it reduces the area available to convey floodwaters

1.3.16
erosion
process by which the flow of water alters the ground surface in an area by removing layers of soil

1.3.17
flood
high water levels caused by excessive rainfall, storm surge, dam break or tsunami that overtop the natural or artificial banks of a stream, creek, river, estuary, lake, dam or drainage system

1.3.18
flood hazard
potential loss of life, injury and economic loss cause by future flood events

> Note 1 to entry: the degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, isolation, rate of rise of floodwaters, duration), topography and emergency management

1.3.19
flood immunity
measure of the protection provided to infrastructure for a certain flood event (i.e. a bridge that is considered to be immune to a 100-year ARI flood is predicted to not be overtopped during this event)

1.3.20
floodplain
extent of land inundated by the probable maximum flood (PMF)

> Note 1 to entry: a floodplain is usually the flat area to either side of the main channel(s).

1.3.19
floodway
part of the floodplain specifically designed to carry flood flows and ideally capable of containing a defined flood event

1.3.21

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freeboard
difference in height between the calculated water surface elevation and the top, obvert, crest of a structure or the floor level of a building, provided for the purpose of ensuring a safety margin above the calculated design water elevation

1.3.22
French drain
trench filled with gravel or rock or containing a perforated pipe that redirects surface water and groundwater away from an area

1.3.23
gabion
cage, cylinder or box filled with rocks, concrete or sometimes sand and soil; Gabions can be in the form of reno mattresses which are low in height relative to the lateral dimensions

1.3.24
hazard location
potential loss of life, injury and economic loss caused by future flood events; The degree of hazard varies with a severity of flooding and is affected by flood behaviour

1.3.25
hydraulic grade line
line representing the pressure head along a pipeline, corresponding to the effective (free) water surface elevation in the piped portions of the stormwater drainage system

1.3.26
hydraulic gradient
slope of the hydraulic grade line

1.3.27
hydraulics
study of flow characteristics around and through hydraulic structures such as bridges, culverts and weirs

Note 1 to entry: Hydraulics can also refer to determination of the lateral and vertical extent of a particular flood or overland flow path

1.3.28
hydrology
science concerned with the occurrence, distribution and circulation of water on the earth

1.3.29
inspections
method, or means of ascertaining asset condition

1.3.30
meandering
bending or directional curving of a channel, river or creek

1.3.31
mitre drains
drains connected to cess and catch drains to provide an escape for water from these drains

Note 1 to entry: Mitre drains should be provided at regular intervals to remove water before it slows down sufficiently to deposit any sediment that it may be carrying.

1.3.32
model calibration
process of systematically adjusting model parameter values to attain a set of parameters which provide the best estimate of the observed stream flow

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1.3.33
monitoring
assessment of the live flood event and associated infrastructure performance to ensure continued safety of railway operational infrastructure. It is often responsive in nature and unscheduled

1.3.34
probable maximum flood (PMF)
hypothetical flood estimate relevant to specific catchment whose magnitude is such there is negligible chance of it being exceeded. It represents a notional upper limit of flood magnitude, and no attempt is made to assign a probability of exceedance to such an event

Note 1 to entry: PMF also used to define the extent of flood-prone land.

Note 2 to entry: The PMF causes the largest scale of flood emergency and is also therefore often used for emergency management planning.

1.3.35
probable maximum precipitation
greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location and time of the year, with appropriate allowance made for long-term climatic trends

Note 1 to entry: it is the primary input to probably maximum flood estimation

1.3.36
rational formula
expression of peak discharge as proportional to the product of rainfall intensity, catchment area and a runoff coefficient dependent on the catchment basin characteristics. Also, **rational method**

1.3.37
reno mattress
large unit constructed of woven wire mesh and filled with stone at the site of construction to form a flexible structure for river and channel bed erosion protection

Note 1 to entry: Reno mattresses are used for river and channel bed protection, unlike gabions which are located in bank protection or walling works.

1.3.37
rip rap
rocks or other material used to protect shorelines, streambeds, bridge abutments, pilings and other shoreline structures against scour, water or ice erosion which may be grouted or ungrouted. Also, **rip-rap**

1.3.38
runoff
water flow that occurs when the soil is infiltrated to full capacity and excess rainwater flows over the land. Also, **surface runoff**, **rainfall runoff**

1.3.39
standard of service
service provided by flood mitigation or stormwater infrastructure for a certain event

1.3.40
tailwater
receiving water located immediately downstream of an area or structure of interest which includes oceans, rivers, creeks, lakes and basins, and can either be considered as steady state or varying over time

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1.3.41
underground drain
piped drain located in a narrow cutting, tunnel, throughout station pits, platforms, yards or areas within the suburban system which is usually sized to cater for a smaller design storm than open channels due to cost and construction efficiency

General rail industry terms and definitions are maintained in the RISSB Glossary. Refer to: https://www.rissb.com.au/products/glossary/

Section 2 Flood impact management

2.1 Overview

Australian Disaster Resilience Handbook 7 Managing the Floodplain provides a best practice framework for the management of flood risk applicable in Australia. The flood risk management framework (FRMF) takes a national top-down approach when defining key principles for managing risk of flood events and their impact on communities as a whole.

RIMs should align flood management plans to the FRMF to ensure it complies with the requirements of state, territory and local government floodplain management entities.

Flood management plans and resulting emergency management processes developed by RIMs shall be defined by outcomes from local rainfall data collections, previous flood events and the subsequent impact to the railway, flood studies and modelling activities.

The flood management plan and associated emergency response plan related to flooding events shall detail key management and mitigation strategies specific to the operational context of the RIM.

At the RIM level, flood management plans should include details of risk mitigation strategies in relation to:

(a) design requirements of new and upgraded rail infrastructure, including track, bridges, tunnels and supporting wayside systems to improve resilience of rail infrastructure through effective hydrological design;

(b) models that capture impacts of existing corridor and built infrastructure inside the rail corridor, as well as adjacent public and private infrastructure such as roads and property developments to the flood hazard;

(c) operational impacts, including enhanced maintenance requirements, access to affected corridor areas, impacts to services or managing the risk and response to derailment events;

(d) impacts on people and workers in proximity to flood events, including emergency response procedures for derailment, contact with floodwater and recovery activities;

(e) impact on the environment, including changes to flood characteristics such as erosion, scour, sedimentation, debris and potential water quality issues; and

(f) monitoring and assessment as well as continuous review and improvement incorporating learnings from flood event response.

RSOs operating across multiple networks shall have flood emergency response plans that align with the RIMs.

The implementation of an effective flood management plan should seek to improve overall infrastructure resilience to ever increasing severity of flood events through effective hydraulic design, ongoing monitoring and assessment of risks and operational response to the flood events.

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Consideration should be given to the broader stakeholders and entities involved in the management of flood risk for new works or substantial enhancements. See Appendix C for more information.

2.2 Flood management plan

A flood management plan shall be included in the RTOs safety management system and detail operational requirements for the threat, onset, occurrence and aftermath of a flood event.

A flood management plan shall be developed and implemented by the RTO based on the flood risk assessment and include flood impact mitigation measures.

The flood management plan should be a dynamic document that is periodically reviewed and updated by the RTO based on change triggers which may include infrastructure changes, adjacent developments learnings from previous flood events and identified seasonal changes.

A flood management plan should include:

(a) details on the effective management of drainage and modelled flood events throughout the railway corridor;

(b) coordination of risk mitigation and recovery activities between the rim, relevant external agencies and local authorities;

(c) details of location specific flood risks, the identification of extreme or intolerable flood event risks and areas that experience frequent flooding;

(d) how flood events impact the operational procedures relating to conditions affecting the network;

(e) definition of the roles and responsibilities of all stakeholders in addressing existing and future flood risks; and

(f) identified gaps and improvement actions that are needed to address existing and future risks and to better prepare for and manage flood events.

2.2.1 Flood hazard identification and risk mitigation

The RIM shall ensure that potential and known flood hazard locations are identified and the monitoring, maintenance and infrastructure requirements for these hazard locations are defined in the flood management plan.

The flood risk assessment should include:

(a) location of existing flood risks;

(b) tolerability and vulnerability to the existing known flood risk;

(c) resilience to future flood risks;

(d) adjacent land development impacts; and

(e) cultural, social and environmental impact.

RTOs shall adopt their own enterprise risk assessment tools and may incorporate specific flood risk assessment methodologies as detailed in *Australian Rainfall and Runoff: A Guide to Flood Estimation*.

The methods and mitigation strategies shall be determined in the context of the specific location.

2.3 Flood emergency response plan

A flood emergency response plan shall be prepared in accordance with;

(a) *RISSB Guideline Rail Emergency Management Planning*;

(b) *Australian Disaster Resilience Handbook Collection, Flood Emergency Planning for Disaster Resilience*; and

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(c) all relevant federal, state or territory disaster planning requirements.

The flood emergency response plan developed by RIMs and any associated changes shall be communicated with all RSOs that operate within their network.

RSOs shall also develop their own flood emergency response plans that are aligned with the RIMs.

Emergency response plans should include operational responses to:

(d) flood warning systems and how that informs conditions affecting the network, changes to application of safe working rules and operational running;

(e) isolation of impacted workers, passengers and affected community members;

(f) impact on access to safe working systems and key infrastructure;

(g) rolling stock derailment;

(h) contamination of waters/land;

(i) conditions affecting the network; and

(j) communication protocols with affected internal, external stakeholders and first responders.

All flood emergency management and response procedures should be incorporated into daily operations planning requirements and adhered to by RTOs.

Section 3 Flood and drainage design

3.1 Hydrological assessment

3.1.1 General

Hydrological assessment shall be undertaken for all new structures in accordance with the methods provided in the Australian Rainfall and Runoff guidelines (ARR). Hydrological assessment for existing structure shall be conducted by the RIM when the following project drivers are triggered:

(a) Repeat flood history.

(b) Major upgrades identified by RIM.

(c) Infrastructure required for post disaster management.

A hydrological assessment shall be undertaken during the preliminary planning phase of a project and prior to the hydraulic analysis. This ensures that the key factors influencing the hydraulic and environmental performance of drainage infrastructure are identified and understood prior to concept and detailed design.

The hydrological assessment and calculations shall be undertaken to demonstrate that the performance requirements for drainage design as specified are met.

Design for the control of surface and sub-surface water movement should be considered to ensure corridor design and maintenance planning supports infrastructure resilience.

Hydrologic design should seek to reduce the occurrence of common track problems such as loss of alignment, gauge, mud pumping and ballast fouling to enable the track formation to withstand the high stresses from track loads and exposure to peak flood conditions.

A hydrologic assessment should include the following:

(a) Identification of study area (i.e. hydraulic model extent).

(b) Identification of catchment areas and characteristics.

(c) Collection and review of available relevant information.

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(d) Determination of hydrologic computational method.

(e) Defined selection of design events.

(f) Validation and calibration of results.

(g) Sensitivity analysis.

(h) Consideration to upstream and downstream impacts and affected stakeholders.

A risk assessment should be undertaken to determine the complexity of the hydrological assessment required.

Where federal, state or territory legislation identify requirements, the hydrological assessments shall comply with these as relevant.

All hydrological assessments and design shall be completed and certified by appropriately qualified professional engineer for the state or territory.

Different hydrological computational methods may be adopted for various stages of a project.

Commentary *C3.1*
The selection of the hydrological assessment approach will vary depending upon the purpose of the hydraulic assessment, the size and complexity of the catchment and the flood behaviour in the vicinity of the railway infrastructure. The input data required, validation and calibration approach will all vary significantly, depending upon the selected computational method.

3.1.2 Identification of study area (hydraulic model extent)

The study area shall be defined by:

(a) the extent and complexity of the drainage system across or alongside the railway corridor in relation to flooding characteristics;

(b) the influence on catchment delineation by required locations for design inflow from the hydrology model as an input into the hydraulic model; and

(c) potential effect of rises in flood water, changes to floodway alignment, long term channel meandering and downstream flow resulting from rail corridor infrastructure changes or corridor adjacent community impacts.

The hydraulic model extent should be determined prior to the hydrological assessment.

Alteration to the hydraulic model extent may be necessary throughout the hydrologic and hydraulic assessment and design process.

3.1.3 Definition of catchment area

The definition of catchment area shall include:

(a) locations of key rail infrastructure as part of the rail corridor network;

(b) locations of water management infrastructure which forms part of the rail corridor such as dams, diversion drainage, existing bridges, culverts, closed drainage systems, levees, stream training and trapped low points;

(c) topographic characteristics to determine the volume of runoff through the hydrologic model extent or calculations;

(d) catchment and channel connectivity, including potential changes to catchment boundaries and long-term channel meandering downstream impacts to adjacent rail infrastructure and communities. underground water to also be considered;

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(e) potential changes to the defined catchment area such as alterations to local roadways, adjacent property development, embankments and other rail networks; and

(f) rail operational details which can include network diversion opportunities, rolling stock stowage or identified points of infrastructure vulnerability.

3.1.4 Hydrological computational method

3.1.4.1 General

Any design decisions shall be based upon application of the most appropriate technique available and determine the appropriate hydrologic computational model to be used.

Detailed guidance on the most appropriate techniques and methods can be found in ARR guidelines.

Alternate computational methods as agreed between the RIM and technical organization may be used where agreed.

Regional Methods which are based on previous studies and data using regression correlation between flows and catchment characteristics may be used as determined between the RIM and technical organization.

The Rational Method may be considered acceptable providing it is considered in accordance with this standard and *Austroads Guide to Road Design - Part 5* (AGRD05).

The Rational Method may be deemed appropriate for use in small catchments or for assessment of minor table drains or catchments contributing to cross drainage structures. AGRD05 provides guidance on the regions, size and applicability of the use of the Rational Method.

3.1.4.2 Limitations of data availability and modelling type

The limitations of empirical, statistical and regional methods or modelling type shall be individually assessed when selecting the most suitable approach.

Assessment could be limited availability of quality data, especially in regional and remote areas, which can impact studies and network performance.

Assumptions made in lieu of available quality data shall be documented in the hydrological assessment report.

Consideration should be given to ungauged catchments in regional and remote areas as well as the size of defined catchment.

3.1.5 Selection of design events

Selection of design events shall be determined by the study objective, standard of service required for drainage and flood mitigation, and the required immunity of the railway and criticality of railway infrastructure.

A recommended minimum AEP for future infrastructure is 1%. For existing or brownfield infrastructure, the recommended minimum AEP is 2%. These should be taken into consideration as part of the overall design considerations.

As the design process could involve several desired levels of immunity and standards of service, a range of design events should be assessed.

The selection should include a range of design events, including but not limited to;

(a) the design life of the railway and associated infrastructure;

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(b) the consequences of loss of availability of the infrastructure or failure mode identified though a risk assessment;

(c) maximum observed historical flood events;

(d) comparison of peak discharge and changes to the flow regime resulting from the planned infrastructure change;

(e) applicable legislative requirements;

(f) the impact of land zoning and planned catchment development on hydraulic characteristics; and

(g) the impact of chosen design events on interdependent stakeholders in the broader community in the defined catchment area.

The selection of design events may consider the implications of the worst-case scenario in relation to the likely probable maximum flood event as well as the impact of climate change.

The assessment and selection of design events should be chosen with the prior understanding of the criticality and limits of the infrastructure.

The selection of design events that support changes to rail infrastructure shall minimize changes to the flow regime, including flow distributions to avoid impact on downstream properties and receiving environments.

3.1.6 Hydrologic model verification, calibration and validation

Subject to the selection of hydrologic computational method, a full model calibration shall be completed using recorded flow events. Where hydrologic and hydraulic information and data might not be available, a verification of formula or model parameters should be undertaken using comparisons of the results from various methods. ARR provides guidance on model calibration where information is not available.

A suitable method for calibration should be adopted based on the size and scale of the project and catchment.

The form and rigour of calibration should depend upon the rainfall runoff model used and the associated risks.

A validation, using different historical events from those used in the calibration, should be undertaken for all rainfall runoff models.

3.1.7 Climate change

Where climate change needs to be assessed, analysis shall indicate the potential impact of climate change by calculating the next AEP increment to compare the impacts to the design AEP. For example, if the design AEP is 1%, consider the impact of the 0.5% and 0.2% AEP events as indicators of the potential impact of climate change.

The assessment should include the probability of effect of two or more extreme events coinciding.

For all new assets, the potential impact of climate change shall be assessed using appropriate climate change scenarios and the design life and risk profile of the asset. For existing assets, the potential impact of climate change should be considered based on the remaining life of the asset and the risk profile of the asset. The decision to upgrade or to not upgrade the existing asset for climate change adaptability should be based on risk assessment.

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3.2 Hydraulic assessment

3.2.1 General

The hydraulic assessment should utilize the catchment flow results (i.e. hydrograph) from the hydrologic modelling to determine flood depth, extent, velocity and hazard.

The hydraulic assessment shall assess the existing and proposed hydrologic conditions to determine the impact of the design change.

This assessment shall be utilized for:

(a) establishment of baseline flood characteristics under existing (pre-development) conditions to assess the existing hydraulic capacity;

(b) understanding the hydraulic impact of the design and optimisation of the hydraulic structures within the railway corridor;

(c) assessment and minimization of the impacts from the railway structures on upstream and downstream flooding; and

(d) a comparison of flooding characteristics for the existing conditions and post-project construction condition shall be undertaken to assess potential impacts.

3.2.2 Selection of hydraulic computational process

An appropriate hydraulic model should be selected, based on the complexity of the expected flood behaviour in the study area and the magnitude of the hydraulic structures across the railway.

For a large system of interconnected channels and floodplains which include major rivers, tributaries and creeks, an industry approved 2D modelling package should be utilized.

Localized flooding and drainage analysis, including lateral and longitudinal railway drainage, minor creeks and gullies with defined one-dimensional flow path channels should use industry-accepted 1D modelling packages and charts and empirical techniques such as Manning's equation.

3.2.3 Hydraulic model calibration and validation

Calibration of 1D and 2D hydraulic models should be undertaken where suitably recorded flood level data exists within the study area.

Where relevant data exists and is available, model validation shall be undertaken to verify the accuracy of parameters adopted from the calibration process, by testing the ability of the model to accurately reproduce known results. Events used for validation should differ from those used for the calibration data.

Calibration and validation modelling shall be completed by suitably qualified consultants.

3.2.4 Hydraulic model sensitivity analysis

Large scale projects shall undertake a sensitivity analysis to gain an appreciation of how sensitive the key output is based on changes to the associated input parameter value. This can be dependent on local data availability. Smaller scale project may undertake a sensitivity analysis though it is not deemed necessary.

In addition to testing the sensitivity of model parameters, and depending upon the locations of the study area and associated risks, potential impacts from changing hydrological input on flood levels and hydraulic structure design should be tested, such as:

(a) changes in water level; and

(b) assumed rainfall intensity.

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3.3 Hydraulic criteria for design assessment

3.3.1 General

The hydraulic criteria for the assessment of impact to cross railway structures shall be determined at the commencement of the hydrologic and hydraulic investigation to guide the design process.

The hydraulic criteria shall be established for all hydraulic structures, to meet the level of service defined by the RIM for required flood immunity and duration of inundations.

Optimization and design of drainage, waterway crossings and railway encroachment through the floodplain shall meet national legislative requirements and local and industry standards such as *Austroads Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures*.

3.3.2 Afflux

The magnitude of acceptable afflux (if any) should be dependent upon the required or current immunity of the railway, surrounding property and infrastructure assets.

The designer should ensure that any afflux is limited in extent to areas not adversely impacted.

Assessment of afflux shall be included where flooding upstream is sensitive to development, especially in urban catchments. In flood-sensitive areas where zero or negligible afflux is required a longer bridge matching the likely flood width could be required.

The permitted afflux shall be project specific and be determined in consultation with the relevant authorities and stakeholders.

Where local authorities specific additional design standards and requirements, these shall also be obtained and factored into the design assessment.

See Appendix B for an illustrated example of afflux.

3.3.3 Velocity

The design shall calculate and tabulate velocity based on the agreed AEP for the catchment being designed for. The designer should limit velocities to manageable magnitudes.

Limiting flow velocities are to be appropriate for the avoidance or prevention of erosion of the soil type or types through which the system passes.

The designer should assess the ground conditions downstream of the hydraulic structure when adopting a maximum outlet velocity, whilst accounting for the soil characteristics at that location.

The design of outlet velocities at the end of the structure should be less than 2 m/s nominal, subject to site conditions.

For each pipe outlet or waterway crossing where outlet velocities are higher than 2 m/s, the following energy dissipation methods may be used:

(a) rip rap

(b) gabions

(c) reno mattresses

(d) aprons

(e) drop structures

(f) streambed level dissipaters

The velocity of flow, whether in a cater course or overland, is an important criteria dictating the performance of a drainage system and the potential for subsequent erosion and the implications for design.

The presence of high velocities could result several problems, such as erosion and scour, resulting in the undermining of the railway structures and preventing the passage of fish.

3.3.4 Scour

Austroads Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures shall be referenced when determining design mitigation factors to reduce scour.

Designers shall select appropriate and suitable scour protection methods based on the design.

3.3.5 Hydraulic gradient

Hydraulic gradient and part full pipe flow velocities shall be assessed to ensure that water flows through stormwater pipes and the overland flow system in the manner intended.

The outcome of the assessment of hydraulic gradient shall determine the height of the culverts, track formation and other associated infrastructure.

3.3.6 Tailwater level

The hydraulic design assessment shall include the following impact probabilities arising from:

(a) non-tidal tailwater, such as bodies of stored water (e.g., lakes) or another downstream open channel or waterway not influenced by tidal waters;

(b) tidal tailwaters when the water body is influenced by tides from oceans, bays or rivers close to the coast;

(c) tidal tailwaters that are impacted by storm surge; and

(d) potential sea level rise due to climate change.

For the calculation of AEP flood events in coastal areas, the design should include analysis of four different combinations of river flooding and coastal flooding.

Local area and state planning policies provide guidance for the extent of sea rise that shall be considered when completing a hydraulic design assessment.

> Commentary *C3.3.5*
>
> AGRD05 include guidance for the inclusion of assessment of tidal levels in infrastructure design that are applicable to the rail corridor.

3.3.7 Headwater Level

Maximum allowable headwater level shall be determined by:

(a) track formation shoulder level preventing overtopping of the track structure – rail, sleepers and ballast;

(b) risk of damage to key rail infrastructure such as signal detection systems, OHLE and telecommunications systems;

(c) damage to drainage infrastructure; and

(d) risk of interruption to rail operations and associated consequences.

Hydraulic designers shall determine maximum allowable based on the specific track location, operational risks and aligned to the RIM flood management plan.

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3.3.8 Flood hazard

Flood hazard is a good measure to assist in determining the resilience of infrastructure at any given location. It is also useful to assess potential safety concerns to flood incident responders.

Design for flood hazard criteria shall be determined by *ARR Book 6 Flood Hydraulics*, Chapter 7.2 Flood hazard for additional requirements.

3.3.9 Blockage

Design for blockage shall be determined by *ARR Book 6 Flood Hydraulics*, Chapter 7, Blockage of hydraulic structures.

3.4 Hydraulic design and risk mitigation

3.4.1 General

The hydraulic design process shall result in appropriately selected types and sizes of railway drainage structures that mitigate risk of damage to rail and surrounding infrastructure in the defined catchment area.

The hydrologic and hydraulic design assessment process that informs the hydraulic design process shall determine the required drainage structure capacity requirements.

Hydraulic design shall be coordinated with track and civil design to ensure defined drainage design outcome is achieved.

3.4.2 General requirements

Hydraulic design and defined mitigation strategies for rail corridor infrastructure shall meet the following requirements:

(a) The design shall protect track alignment and structural elements as per AS 7636.

(b) Sustainability and resilience factors are built into the hydraulic and rail infrastructure.

(c) The design shall minimize impact or damage to train control and wayside systems.

(d) The design shall factor in criticality of impacted infrastructure in a flood hazard event and the tolerance for network down time.

(e) Safely manage and discharge all volumes of water generated upstream and on the site to an approved point of discharge and method of disposal.

(f) Provide points of disposal and methods of dispersion for stormwater generated by changes in or new railway infrastructure.

(g) Where feasible, maintain the existing flow regime onto adjoining public or private property.

(h) Have sufficient structural integrity in drainage structures and erosion protection measures to minimize erosion and carry all external loads that may be imposed.

(i) Take consideration of all external site influences, such as the impacts of salt water, acid sulphate soils and expansive soils.

(j) Be designed in a manner that allows safe and economical ongoing inspection and maintenance.

(k) Be designed using materials that ensure the required minimum practical design life of 50 years is achieved.

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(l) The peak flow velocity within a pipe should be less than the manufacturer's recommended maximum limits.

Based on the criticality of the infrastructure or complexity of the catchment area, the hydraulic design could require accommodation of multiple interventions or hydraulic treatment types to achieve designed outcome.

If alternative design processes to those of ARR guidelines are used, they shall be approved by the RIM for the project and be:

(m) a formally documented design process based on historical or qualified data for the region;

(n) verified by a professional peer reviewed and accepted by qualified engineers; and

(o) supervised by the owner or sponsor of the design process, to the extent considered appropriate by the sponsor or owner.

3.5 Drainage types

3.5.1 General

This section deals with the design of all types of surface and underground drainage structures associated with the railway infrastructure, including:

(a) longitudinal open channel drainage;

(b) longitudinal underground track drainage;

(c) cross drainage; and

(d) sacrificial low points.

In addition to drainage of the rail line in general, this section also covers the specific drainage of:

(e) yards, car parks, platforms and multiple tracks;

(f) level crossings; and

(g) overhead structures.

3.5.2 Factors affecting selection of waterway crossings and drainage infrastructure

When undertaking the design of waterway crossings and drainage infrastructure, the following impacts shall be taken into account and documented:

(a) afflux

(b) environmental factors (including potential impacts on fauna and flora and the likelihood for debris build-up and/or blockage)

(c) impacts on flow regime

(d) desired level of serviceability or flood immunity

(e) magnitude of discharge

(f) rail alignment

(g) topography, including stream geometry

(h) soil types

(i) provision for maintenance

(j) safety

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3.5.3 Longitudinal open channel (surface) track drainage

Longitudinal open channel track drainage is classified as:

(a) cess drains;

(b) catch drains (or top drains); and

(c) mitre drains.

Cess drains are commonly used to divert run off from a small local catchment that has been cut off by the railway embankment where, due to embankment height and cover requirements, waterway crossings or culverts cannot be installed.

In some cases, several small catchments may be diverted through cess drains and combined into a single culvert crossing.

Other open drains should be designed to provide adequate fall so that water drains freely and the build-up of sediment is reduced.

The necessary performance requirement should be as approved by the RIM.

Cess drains should be designed to allow for a certain degree of sediment build-up to occur while still working effectively.

Catch drains should be located along the top edge of the uphill cutting face. See Appendix B for an illustrated example.

Where the slope of a catch drain is steep, a levee should be provided along the top edge of the cutting as an extra precaution against flows entering the cutting.

Where catch drains are positioned in a trapped low point, the overland flow should be captured and carried down the batter in a lined drain or pipe and with erosion protection provided at the junction with the cess drain. Installation that resembles steps down the batter or with the use of baffles help to control flow velocity. For major flows and deep cuttings, a vortex drop structure might be required. The receiving cess drain of the underground drainage network should be sized to accommodate the additional flow.

Mitre drains shall be provided to divert water flow away from the railway formation.

Mitre drains shall be located at the ends of cuttings where daylighting of cess drains through cuttings occurs.

The outlet ends of mitre drains shall be splayed to disperse water quickly to reduce scouring.

The flow capacity of all open channel track drainage shall be greater than the design peak flow by a factor to be determined by the RIM.

Where practical open channel track drainage should be used in preference to underground drainage, this will facilitate inspections and maintenance.

Open channel track drainage should be applied where the water table is at or near the defined earthworks level.

See Appendix B for an illustrated example of cess drains and mitre drains.

3.5.4 Longitudinal underground track drainage

Longitudinal underground track drainage generally consists of a combination of the following:

(a) pipes

(b) inlets and outlets

(c) sumps, pits, grates and associated covers or cages

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Underground drainage systems should be designed to cater for surface water runoff and water collected from other drainage systems to which the new system is being connected.

If an underground drainage system is required to remove ground water and seepage in addition to surface water, a detailed hydrological and geotechnical investigation should be undertaken to determine the overall volume of water to ensure correct sizing of the underground drainage.

Longitudinal underground track drainage shall be designed with the following factors:

(d) railway infrastructure immunity

(e) outlet velocity

(f) ease of maintenance

(g) environmental issues

(h) available cover and required strength

Surcharging or overtopping of the longitudinal underground track drainage system is permissible under special circumstances, as approved by the RIM, and provided that the duration of surcharging or overtopping is not likely to affect the stability of the track.

Underground drainage should only be used where adequate open channel track drainage cannot be provided due to some restriction or lack of available fall due to outlet constraints, or where use of underground drainage is the only viable method to obtain the required fall.

Locations where these circumstances could occur include:

(i) bridges;

(j) cuttings;

(k) poor formations;

(l) junctions;

(m) sites with multiple tracks;

(n) platforms; and

(o) yards, car parks, provisioning areas and terminals.

Underground drainage shall be designed to withstand rail and maintenance vehicle traffic loads.

Underground drains should be designed so that they are deep enough to avoid damage from any future track renewal or maintenance activity.

If the required depth is not achievable the underground drain should be protected by a suitably engineered encasement beneath the track area.

On a drainage system, pits should be provided at intervals that will permit inspection and maintenance of the drain to be undertaken and reduce the volume of overland flow.

The design should incorporate means to protect the drain against ingress of ballast, gravel, clay, silt, sand or other fine particles.

Underground drainage should be located at a sufficient distance from the track bed for maintenance and, where appropriate, in accordance with culvert load ratings.

Underground drainage and open drains should be designed to provide adequate fall so that water drains freely and the build-up of sediment is reduced.

When designing and specifying the type of underground drainage, the following should be taken into consideration:

(p) The type of environment (i.e. whether the water is abrasive, acidic or alkaline).

(q) Manufacturer's specifications.

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(r) Possible effects on non-standard ballast profiles.

(s) Effects on track geometry of laying longitudinal pipes adjacent to tracks around curves.

(t) Conflict with existing services.

(u) Minimum self-cleansing flow velocities.

Where stormwater pipes are to be placed in soft ground or are likely to flow under pressure, rubber ring jointed (RRJ) pipes should be used to prevent pipe leakage irrigating the subgrade.

3.5.5 Cross-drainage

Cross-drainage generally includes the following:

(a) Pipe culverts.

(b) Box culverts.

(c) Bridges (see the following sections).

(d) French drains.

Cross-drainage shall be designed with the following:

(e) Railway infrastructure flood immunity.

(f) Configuration, including size and number of openings.

(g) Potential afflux.

(h) Inlet and outlet velocity.

(i) Passage of fauna.

(j) Ease of maintenance.

(k) Environmental requirements.

(l) Available cover and required strength.

(m) The height to the formation's upstream shoulder at any flood-critical location shall include allowance for freeboard, as determined by the RIM.

When deciding on whether a culvert or a bridge is required at a given location, the following should be considered and specialist advice sought when the decision is unclear:

(n) Existing flooding characteristics at the site, including design flood discharge, flood levels, flood extent, flow directions and velocities.

(o) Potential impacts of flooding characteristics.

(p) Maintainability.

(q) Existing topography (bank height).

(r) Potential for debris build-up.

(s) Passage of fauna impacts to sensitive flora and other environmental requirements.

(t) Ease of construction, such as the presence of a permanent stream.

(u) Consideration of whole of life cycle costs.

(v) Presence of highly reactive or erodible soils.

The following culvert design guidelines should be considered:

(w) The invert levels and length of the culvert should be extracted from the surveyed ground surface (i.e. DEM) or site survey.

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(x) The culvert should outlet through the embankment, making allowance for the end wall and apron.

(y) The invert level on the upstream side should be taken at the lowest level in the creek/drain so that water does not pond upstream of the culvert.

(z) The expected tailwater depth for the ground existing conditions immediately downstream of the culvert outlet.

(aa) Maximum and minimum cover requirements. The amount of cover and required load capacity will dictate the type and class of pipe (wall thickness) and, therefore, the available flow area.

(bb) Maximum and minimum grade of culvert and tailwater conditions.

(cc) The recommended maximum allowable velocity and appropriate class of outlet protection (See Clause 3.3.2).

(dd) The necessary culvert tie-downs for corrugated steel pipes.

(ee) The size and number of cells selected for single or multi-cell culverts should consider and be compatible with the cross-section of the natural waterway.

(ff) Where practical, cross culverts should be aligned to match the general alignment of the natural waterway.

All assumptions should be documented.

Waterway diversion cross drainage should occur as close as possible to the downstream path:

The outlet of the cross drainage should be aligned as close as possible to the natural path.

See Appendix B for further definition on cross drainage.

3.5.6 Sub-soil drainage

Subsoil drains should be considered where groundwater or seepage is expected.

Flows should be discharged in a manageable manner.

Sub-soil drainage generally consists of one or more of the following:

(a) slotted pipes

(b) aggregate filters

(c) geotextile

(d) flushing points

(e) outlets

(f) cut-off walls

Where aggregate is used in a subsoil drain, geotextile should surround the aggregate so that a filter zone forms between the natural soil and the subsoil drain.

Where a slotted carrier pipe is installed, an additional filter sock may be placed around the slotted carrier pipe to help avoid particles clogging the carrier pipe.

A subsoil drainage system is generally implemented in order to:

(g) intercept sidehill seepage;

(h) lower groundwater in;

(i) wet cuts;

(j) longitudinal cut to fill transitions;

(k) sidehill cut to fill transitions; and

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(l) stabilize wet or saturated earth slopes (and rock slopes).

3.5.7 Sacrificial low point

In locations with specific seasonal hazards such as cyclones or monsoon rains, or other areas that may experience extreme flood flows over wide flood plains, consideration should be given to including a sacrificial low point in the longitudinal vertical alignment of the formation. The sacrificial low point is usually located:

(a) away from significant cross-drainage infrastructure; and

(b) preferably near a shallow (low height) section of the embankment.

The main purpose of providing a sacrificial low point should be to minimize the risk of losing or damaging significant cross-drainage infrastructure during an extreme flood event, thereby improving rail safety and/or reducing disruption to rail traffic, and the costs of repair.

The purpose of preferring to locate the sacrificial low point in a shallow part of the embankment is to minimize the risk of losing a significant volume of embankment material, thereby further expediting repairs and the resumption of rail traffic.

3.5.8 Diversion drains and levees

3.5.8.1 Diversion drains

The alignment of the railway should be reviewed with reference to the diversion drain to obtain an understanding of the topography beyond the rail formation.

The longitudinal fall between cross-sections shall seek to match the natural profile or a maximum slope of 1 in 100, with velocity stops used on steeper ground to achieve these profiles.

The base width should be kept constant throughout the length of the diversion drain.

Where it is considered achievable, a vegetated channel should be provided to reduce velocity.

A drain block should be used when the rail formation changes from a fill to a cut to manage flows within the cut.

Diversion drains should be combined where possible to reduce the extent and sizing's of remaining cross drainage required.

3.5.8.2 Levee diversion

The levee shall be designed to isolate and divert the peak flow from:

(a) a design storm of critical duration for the contributing catchment relevant to the area protected by the levee; and

(b) the estimated level and flow rate of water resulting from a possible failure of other flood mitigation or water storage infrastructure.

The height of the levee shall be designed to accommodate the required design storm or estimated level due to upstream failure:

The choice of height of the levee shall be determined by a risk assessment and is dependent upon the design life of the railway and impact of failure.

The height of any levee shall include allowance for freeboard, as determined by the RIM.

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3.5.8.3 Levee sacrificial low points

A levee crest should incorporate a restricted length of low crest, such that if a flood exceeds the design protection level of the levee, failure will occur at that selected point, and planned areas within the zone may be protected.

A sacrificial low point is an area positioned along the embankment crest of a levee to provide a known location of failure in an extreme flood event.

Sacrificial points can be either:

(a) local depressions in the crest of the embankment; or

(b) areas of fill which are constructed of materials having a lower characteristic strength.

3.6 Standards of service

3.6.1 General requirements

Railway and track infrastructure shall be designed to an appropriate standard of service, measured as an annual exceedance probability percentage (AEP) as specified by the RIM. Table 1 defines the minimum AEP event to be designed for and further information on AEP can be found in Appendix B.

Consideration should be given to existing infrastructure when planning upgrades to account for asset resilience and climate change impacts. A minimum AEP of 1% shall be used for new infrastructure.

The RIM shall specify the standards of service used to design new or existing assets hydraulic assets subject to upgrade or construction.

The standard of service AEP should incorporate the following:

(a) Whether flood hazards in the vicinity of the site are unusually severe.

(b) Location, whether in remote, rural or city/suburban areas.

(c) Risk of damage to outside parties from flooding caused by railway drainage structures.

(d) Risk of damage to railway and related railway structures.

(e) Frequency and length of time of track closures that can be tolerated operationally.

The standard of service may need to be modified if:

(f) flood hazards in the vicinity of the site change;

(g) track classification is upgraded or downgraded as per as AS 7630;

(h) surrounding land use is changed or rezoned (e.g. remote or rural areas become city or suburban areas);

(i) risk of damage to outside parties from flooding caused by railway drainage structures has changed;

(j) track structure or layout has changed;

(k) track traffic volume has changed; and/or

(l) frequency and length of time of track closures that can be tolerated operationally has changed.

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3.6.2 By infrastructure type

The standard of service listed in the table below are the minimum AEP event measures that rail infrastructure shall be designed to. RIMs may define specific AEPs dependent on network specific critical paths and other infrastructure requirements. The figures in Table 1 are specific to new and future assets, existing assets or upgrades will require an individual assessment.

Infrastructure owners shall conduct a risk assessment to determine the criticality of the track. The assessment may consider these classifications as a minimum guide in addition to considering such factors as:

(a) Key freight routes;

(b) Alternative or diversion options if available; and

(c) 4R's - resistance, reliability, redundancy and recovery.

Table 3-1 AEP Figures by Asset

Rail Network or Rail Asset	Specific Component	Suggested Reference Point	Minimum AEP Event			Suggested Minimum Freeboard Allowance	Comments
			5%	2%	1%	300 mm	
Rail Network	Track Formation – Mainline	Formation Shoulder			X	X	Service and design life based on one in 100-year event. Assessment to be completed based on the expected service life of the asset. RIM needs to assess the requirements, priority and usage of the rail network to determine the criticality of infrastructure and adjust the minimum AEP requirement accordingly. Consideration should be given to throughput and axel load to denote the AEP and criticality assessment. RIM to assess and classify branch lines.
	Track formation – Mainline Passenger	Formation Shoulder			X	X	
	Track formation – Mainline Mixed Traffic	Formation Shoulder			X	X	
	Track formation – Mainline Freight	Formation Shoulder			X	X	

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Rail Network or Rail Asset	Specific Component	Suggested Reference Point	Minimum AEP Event			Suggested Minimum Freeboard Allowance	Comments
	Service critical assets**	Base of the asset			X	X	Assets that are critical to the enablement of the permanent way such as: Turnouts Level Crossing Powered Signalling equipment, etc.
Rail Network Asset *	Majoy Waterway – Bridges	Soffit			X		
	Major Cross Drainage – Culverts	Obvert			X		
	Minor Cross Drainage – Culverts	Obvert		X			
	Track longitudinal drainage – open channel	Channel batter shoulder		X			
	Levee banks	Crest			X	X	
	Underground Drainage - Pipes		X				

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Rail Network or Rail Asset	Specific Component	Suggested Reference Point	Minimum AEP Event	Suggested Minimum Freeboard Allowance	Comments

NOTES:

This table applies to general permanent way and environment; exclusions include tunnels, stations and any asset subject to special risk assessment or design

Climate change should be considered in addition to the flood return period with reference to RIM, governmental and project specific requirements

The table mostly applies to new greenfield projects however may be used as a guide for upgrade projects

*Safe Access Points should be designed to allow railway inspection and monitoring during a flood event and need to consider safety and occupational requirements.

**Special wayside equipment that is integral to the safety of the railway or as a bespoke safety control measure should be designed to an appropriate level of flood protection.

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3.6.3 Level of service for existing infrastructure

The hydrology and hydraulic design should seek to upgrade drainage infrastructure to minimums prescribed where possible.

There could be limits to upgrading existing infrastructure due to vertical track alignment and sensitivity to elevation changes which can be kilometres worth of track sections. These requirements should be considered when conducting upgrades in existing infrastructure and network limitations.

RIM should conduct risk and cost-based evaluation to support decisions to upgrade on existing level of service.

3.6.4 Climate change

The AEP measure shall include added increments to accommodate climate change impacts based on the latest information available from AR&R and local authority or state government requirements. See Section 3.1.7 for additional guidance.

The standard of service shall be defined for a specific time period, with a trigger for review based on changes to flood hazard event severity, rail operations or local infrastructure.

Additional factors that can increase the standard of service AEP increments for climate change may include critical nature of the infrastructure of the level of complexity required to change the rail infrastructure to accommodate hydrological changes as a result of climate change.

Further guidance of the application of climate change to the calculation of the standard of service can be found in AR&R, local and state government guidelines as detailed in the bibliography

Section 4 Inspection, monitoring and maintenance

4.1 Inspections and monitoring

4.1.1 General

The RIM shall establish procedures for inspecting, monitoring and maintenance of hydraulic structures as they pertain to flood hazard management.

Special requirements that apply during a flood emergency shall be defined within the Flood Management Plan as detailed in Section 2 of this document.

Inspection and monitoring in a general sense are vital interventions to ensure that hydraulic assets accommodate water flows and perform as required during a flood event.

The RIM shall assess and determine their own cadence of inspection routines in line with their maintenance strategy.

Inspections, monitoring and maintenance activities vary both in terms of frequency and purpose. Typically, the less frequent the inspection, the greater the amount of detail is required to be captured during the activity.

4.1.2 Inspection Overview

Inspection types are categorized by the asset function which they confirm continued performance of, either during, or in the anticipation of, a flood event or peak flows. The function of a hydraulic asset is to convey water; and the function of the permanent way asset is to safely run trains. General asset inspections are aligned to the former and general track inspections to the latter, further to this is remote flood monitoring. The major difference between inspection and monitoring is that the former is undertaken on site, whereas the monitoring is undertaken offsite.

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Asset base inspections are vital to ensure that the subject asset base can accommodate flows and perform as required during a flood event.

Asset inspections are periodic in nature and planned to capture key details preventively to ensure continued fitness for purpose, safety of the railway and adequacy of condition.

During a flood event, general and patrol inspections should be performed as necessary to ensure the continuing safety of the railway and ensure that no assets are compromised.

Inspections vary both in terms of frequency and purpose. Typically, the less frequent the inspection, the greater the amount of detail is required to be captured during the same.

4.1.3 General Asset Inspections

Inspections that are general in nature are designed to capture as much detail about the asset as possible. This may include both structural fabric condition and hydraulic condition in the same inspection. Structural fabric conditions relate to the condition of the physical asset itself whereas hydraulic condition being its ability to convey water in its most unimpeded state.

Structural asset inspection requirements are captured in AS 7640 Rail Management.

4.1.4 General Structure Asset Hydraulic Inspections

These inspections are relevant to railway structure assets that convey water from one side of the track to the other and can be carried out at the same time as general condition inspections.

General inspections shall be scheduled and conducted at an appropriate frequency consistent with the condition of the asset, number of defects identified, their rate of degradation and potential impact on the operational railway and asset hydraulic capacity.

The RIM shall schedule general inspections at an interval appropriate to each location, dependent on its nature, condition, frequency of flooding and other risk factors.

The RIM should undertake and document a risk assessment to ascertain the likelihood of consequential damage to the track system arising from culvert, pipe or bridge defects.

Inspection timeframes shall not exceed 12 months for a visual inspection and 8 years for a detailed inspection. The maximum interval between general inspections should not exceed 12 months.

The purpose of these inspections from a hydraulic and railway safety holistic perspective is to:

(a) confirm continued asset suitability to convey both water and rail traffic in anticipation of a flood event or high flows through the asset;
(b) confirm safe asset condition;
(c) confirm that any identified defects will not impact the holistic integrity of the asset to perform during a flood event whilst maintaining the safety of the railway;
(d) identify any new defects, degradation of existing defects and levels of asset obstruction such as flood debris, blockage matters (e.g., silt), scour or displaced/separated joints;
(e) visually or tactilely inspect all elements of the asset including headwalls, wingwalls and culvert barrel. note that this may require CCTV inspection of difficult to inspect areas due to inaccessibility; and
(f) undertake inspection of the integrity of the culvert barrel checking for any defects that could not be readily identified from the culvert in or outlet.

General structure asset hydraulic inspections shall be undertaken during safe, non-flood conditions.

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In locations with specific seasonal hazards (e.g., cyclones or monsoon rains), general inspections of waterways, drainage systems and flood protection works should be scheduled to take place prior to the risk season.

When conducting general inspections, the defects and conditions to be assessed should include:

(g) scour around culvert walls, ends and barrels;

(h) catchment, waterway, track drain and cess conditions and changes in condition that affect the vulnerability of the infrastructure to future flood events, including those changes resulting from flood damage;

(i) scouring or damage to or around foundations, abutments, wingwalls or temporary supports;

(j) erosion or damage to levee banks or channels;

(k) condition of sumps and pits and pump systems; and

(l) any other blockage or loss of slope of track drains or waterways.

Structures or sections of track which are prone to repeated flood events and washaway shall be categorized and managed as hazard locations by the RIM.

In addition to the inspection of any existing drainage infrastructure, monitoring and investigation should consider the condition of the material surrounding the drain for:

(m) protecting the drain against blockage development through clay ingress, silt, sand or other fine particles; and

(n) allowing effective drainage of runoff (and if appropriate, groundwater) from the track bed.

4.1.5 Flood response inspection

A flood response inspection is conducted before any rail traffic traverse the section in response to a flood event and can also be done during or after the event depending on feasibility and safety of conducting the inspection.

Where an asset that has previously been deemed high risk of failure or is deemed a high risk of failure during an event, by the RIM it should be inspected at a frequency proportionate to the likelihood of failure.

This inspection and assessment should identify, as far as practical from a safe location, defects and evaluate risk of asset failure where the consequence impacts railway safety, property, or is a threat to life and should consider:

(a) levels of scour around the asset;

(b) level of floodwaters relative to the ballast;

(c) risk of longitudinal scour to the railway;

(d) loss of sleeper support;

(e) risk of critical damage to locomotives and nearby properties;

(f) downstream settlement; and

(g) risk of piping failure.

If the risk level is above a normal or unacceptable level, mitigation measures shall be introduced to reduce risk so far is as reasonably practicable. Such mitigation measures may include stopping trains, reducing train speed, piloting trains, increased inspection frequency, or diverting train services.

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4.1.6 Track Flood Patrol inspections

These are inspections, either planned or in response to a flood event, where the track section in question is patrolled using a vehicular platform such as a hy-rail or similar and is conducted before any rail traffic traverse the section in response to a flood event. They can also be done during or after the event depending on the feasibility and safety of conducting the inspection.

The purpose of this inspection is to:

(a) confirm no material change to the railway;

(b) identify defects or conditions that could adversely affect the ability of the waterway drainage system to function as designed;

(c) ensure the continuing adequacy of the infrastructure inspected; and

(d) that it is safe to run trains at line speed.

Non-flood related track patrols should be conducted in accordance with AS 7640 Rail Management.

These inspections should also be carried out to confirm the presence and non-impact to the safety or the operational railway as a result of suspected defects identified from track, patrol or other inspections, automatic rainfall monitoring, or in response to reported flooding or heavy rain in areas prone to flooding (e.g., by drivers), to allow required actions to be determined.

Occupational safety is paramount during flood response. The RIM shall ensure that track patrollers are briefed with an appropriate pre-start and that suitable access and on and off tracking locations have been identified.

The track flood patrol inspection shall, where line of sight and access allows, capture the following defects as a minimum:

(e) Scour.

(f) Blockage or partial blockage of the waterway, track drain or cess, due to debris, rubbish or silt.

(g) Damage to waterways, drains or cesses caused by construction or vehicle access.

(h) Indications of floods overtopping a structure.

(i) Flood water proximity to the ballast toe.

(j) Any movement in earthworks (embankments/cuttings).

(k) Evidence of sudden track geometry defect formation.

(l) Culvert/drain damage or collapse.

(m) Sinkhole formation.

(n) Anything that could cause a hazard to the operational railway.

Sections of track with suspected defects related to inadequate or reduced waterway or drainage capacity should be subject to general inspection.

The RIM should ensure particular attention is paid to conditions at hazard locations of frequent flood inundation.

4.1.7 Special inspections

Special waterway and drainage system inspections are usually undertaken outside the prescribed schedule of general inspections. In certain circumstances, such as locations being nominated as hazard locations and/or when other inspections have identified a need for a special evaluation, it could be necessary to schedule special inspections for waterway and drainage systems.

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4.1.8 Monitoring at flood-prone locations

The RIM shall ensure that sections of track which are known or prone to flooding and identified (e.g., with a history of flood damage) are inspected and maintained at defined service levels to mitigate any risks as identified by the flood risk assessment/management plan.

4.1.9 Remote Flood monitoring

The procedures and tools for flood monitoring shall be clearly defined within the organizations SMS and communicated by RIM/RTOs responsible for the management of track and/or operation of rolling stock through flood prone areas.

Procedures for flood monitoring at locations may include:

(a) monitoring of stream flow gauges; and

(b) monitoring of direct rainfall gauges.

Procedures for flood monitoring shall include:

(c) monitoring of flood and storm warnings through BoM;

(d) flood warnings or advise issued through BoM or professional services providers;

(e) communication with BoM and other relevant authorities; and

(f) communication with all relevant personnel who could be at risk from the flooding.

The RIM should ensure particular attention is paid to conditions at hazard locations of frequent flood inundation.

4.1.10 Flood monitoring – Hazard locations

Following defined events (such as rain events or stream flows as could be indicated by automatic monitoring systems) exceeding a specified magnitude within the catchment of waterway and assets pertaining to the hazard locations, the asset should be subject to additional general flood inspection until rectification or water capacity improvement work can be carried out.

Inspections should collect information on the physical condition of the waterway in flood and monitor the flood conditions until the risk to train operations is assessed as acceptable:

(a) Appropriate inspections could be required for this purpose; and

(b) operating restrictions could also be appropriate at some flood-prone locations prior to and during the flood to mitigate identified risks.

Records shall be maintained to retain the history of rain events which resulted in significant damage to infrastructure. Results of unscheduled general flood inspections for hazard locations should be retained.

4.2 Commissioning of monitoring systems

The RIM shall ensure that all measuring or warning devices are inspected, maintained and recalibrated in accordance with the manufacturer's requirements.

4.3 Record Keeping

Records of inspections should include at a minimum:

(a) the date and method of the inspection;

(b) the faults and defects found; and

(c) any subsequent actions taken or proposed to be taken.

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Records of inspections should be kept for a minimum time as determined by the RIM or, for audit purposes, until the subsequent inspection.

4.4 Maintenance

4.4.1 Maintenance of waterways and drainage systems

Maintenance of railway hydraulic infrastructure shall be undertaken in accordance with relevant national standards, organizational asset management plans and industry good practice.

Drainage systems should be cleared at intervals determined by the RIM to enable the system to function as designed and determined by the asset condition and inspection regime:

(a) The profile and grade should be maintained to remain sufficient to ensure the structural integrity of the track formation and associated earthworks.

(b) All track underground drainage, cross-drainage, open channels and waterway crossings should be maintained to permit the free flow of water.

(c) All drainage infrastructure should be kept free of waste and rubbish.

Care should be taken when undertaking maintenance, particularly at the toe of embankments or other retaining structures, to ensure that they are not undermined such that a slip or collapse could occur.

Waterway crossings shall be maintained so that erosion that could potentially undermine the railway or associated drainage works is minimized. Asset blockages should be risk assessed and removed in a timely fashion.

Where deficiencies in the drainage system are identified, the RIM should prioritize these deficiencies for rectification, considering their potential effect on rail safety and performance.

Investigations undertaken after a flood event shall include, as a minimum, the impacts upon:

(d) drainage infrastructure;

(e) track formation and ballast; and

(f) wayside structures – signal posts, OHLE extensions.

Stream flow gauges shall be maintained on a regular basis to ensure they are working appropriately and as per the manufacturer's requirements.

4.4.2 Adjacent Drainage systems owned by other organizations

Where drainage systems owned by other organizations present an unacceptable risk to train operations, the RIM should ensure that the following action is taken:

(a) Appropriate operational restrictions are risk assessed and implemented.

(b) The parties responsible for the drainage system presenting the risk are informed of their responsibilities.

Where appropriate an interface agreement covering those responsibilities should be enacted between the responsible parties.

4.5 Assessment and actions

The integrity of waterway and drainage system structures, openings and catchments shall be assessed to verify their capacity to safely perform the required function or determine the required actions.

The RIM should consider reassessing the capacity of the existing drainage infrastructure when any of the following have been identified:

(a) Significant changes in condition of the asset, particularly at a hazard location.

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(b) Blockage or partial blockage of the waterway or drainage structures, due to debris, rubbish or siltation.

(c) Loss of cross-section.

(d) Loss of longitudinal continuity.

(e) Scour of formation, culvert walls and barrels, particularly on the downstream side of structures.

(f) Scouring of, or damage to or around, foundations, abutments, wingwalls or temporary supports.

(g) Culvert/drain barrel damage or collapse.

(h) Changes in adjoining properties that could increase water flows.

(i) Erosion or damage to levee banks or channels.

(j) Ineffective or defective sumps.

(k) Inadequate drainage on the upstream side of embankments.

(l) Damage to the track structure of track structure overtopping.

(m) Substantial damage resulting from a flood event.

Where reparation works are undertaken, that there should be no impact on flow rates and flow movement angles.

4.5.1 Decommissioning and disposal

4.5.1.1 Decommissioning

Decommissioning of assets shall be done so safely and in accordance with AS 7636, *Railway Infrastructure - Railway Structures*.

Assessment of any redundant infrastructure and the potential for downstream impacts from hydrology and hydraulics perspective shall be conducted.

4.5.1.2 Disposal of materials

The RIM shall remove any redundant drainage infrastructure or materials from the rail corridor to reduce:

(a) potential for obstruction of the drainage system; and

(b) risk of damage to other assets.

4.5.1.3 Site reclamation

Sites where track drainage or waterway crossings are to be demolished and the area is to be decommissioned and reclaimed, shall be restored and re-established with pre-disturbance vegetation.

Where erosion and scour could occur, suitable mitigation measures shall be put in place.

Remediation methods shall be based on proven and effective technologies. New remediation methodologies or technologies shall only be used on a trial basis where a suitable risk assessment has been completed and as approved by the RIM.

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Appendix A Hazard Register

Hazard Ref. No.	Hazard Description
3.1.1.10	Inadequate site security
3.1.1.11	Inadequate fencing
3.2.1.26	The failure to adequately deploy or maintain preventative security resources
3.2.1.27	The failure to mount appropriate responses with internal or external stakeholders
4.1.1.19	Poor infrastructure maintenance
5.1.1.32	Derailment causing accidental spills
5.1.1.33	Collision causing accidental spills
5.1.1.47	Waste and rubbish
5.2.1.1	Track failure
5.2.1.2	Track failure causing collisions with a wayside structures
5.3.1.1	Electric shock
5.3.1.12	Drowning due to derailment into water
5.3.1.2	Hazardous substances
5.3.1.4	Trips and falls
5.3.1.42	Being bitten or stung by an animal
5.3.1.45	Harm at remote sites
5.4.1.1	Path infringements
5.4.1.14	Poor track quality causing excessive damage to loads
5.4.1.15	Poor track quality causing excessive structural fatigue
5.4.1.16	Poor track quality causing excessive suspension wear
5.4.1.17	Poor track quality causing excessive wheel wear
5.5.1.25	Harm to rolling stock - Unable to maintain timetable

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Appendix B Definitions

Appendix Table B-1 Annual Exceedance Probability (Terminology 1.3.2)

Frequency descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	20
	0.02	2	50	50
	0.01	1	100	100
Very rare	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
	0.0005	0.05	2000	2000
Extreme rare	0.0002	0.02	5000	5000
			↓	
			PMP/ PMPDF	

Source: Ball et al. (2016).

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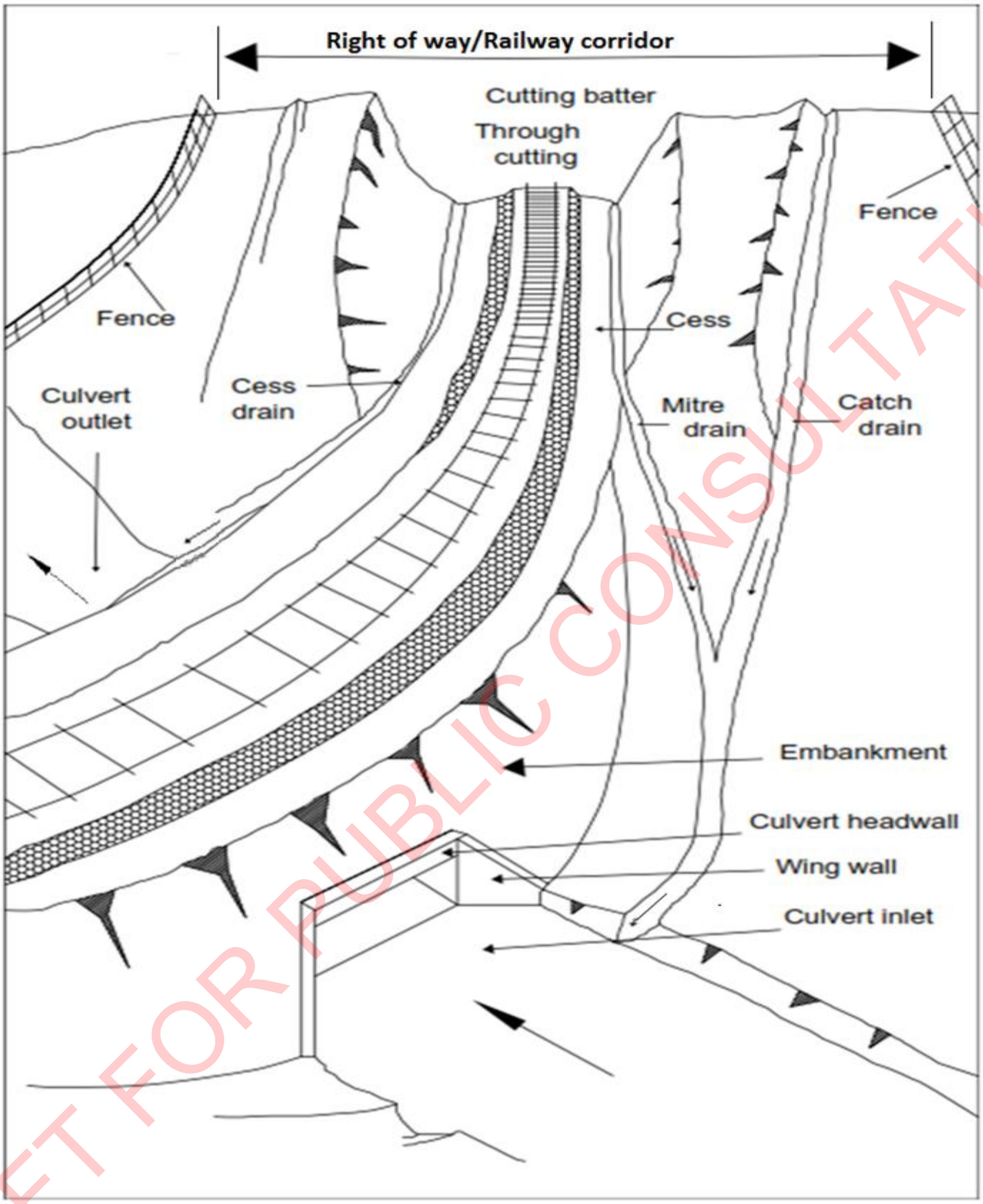

Appendix Figure B-1 Rail corridor and hydrological components

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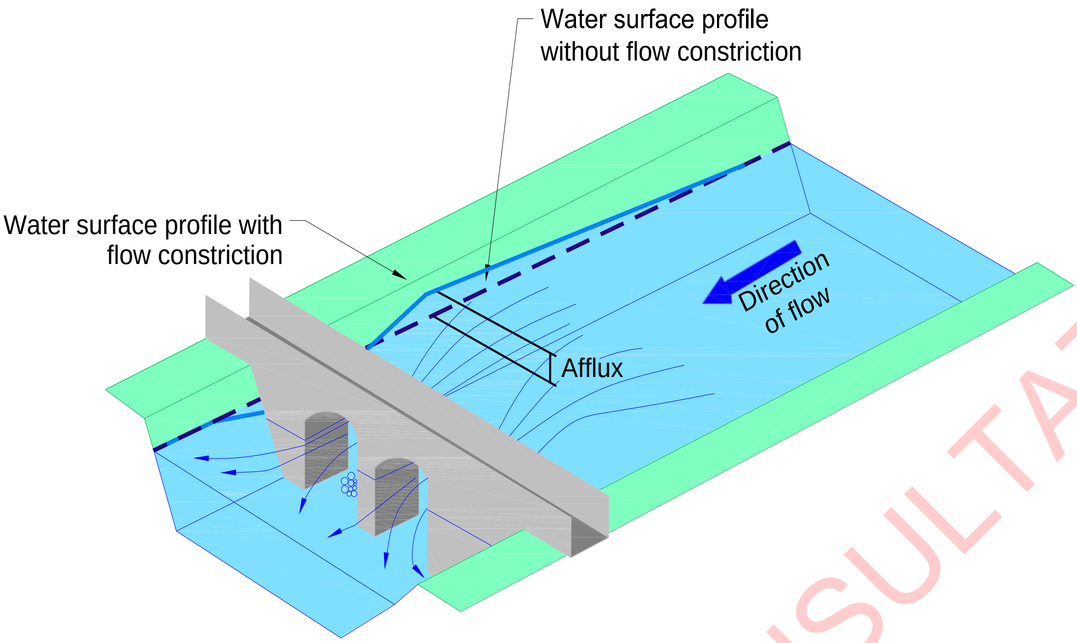
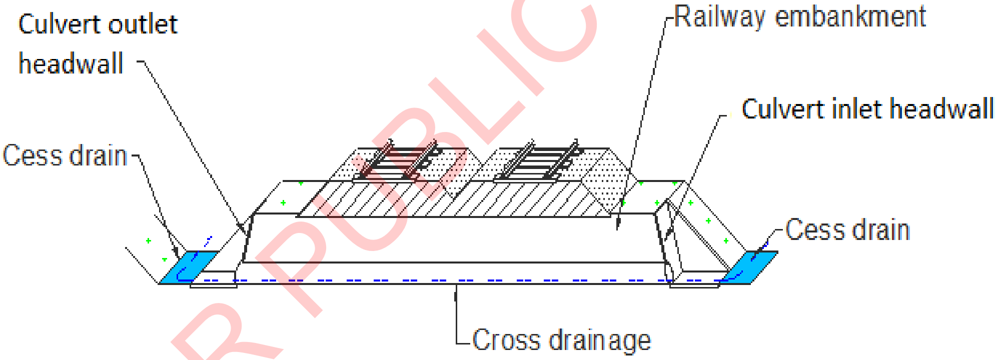


Appendix Figure B-2 Afflux



Appendix Figure B-3 Cross drainage

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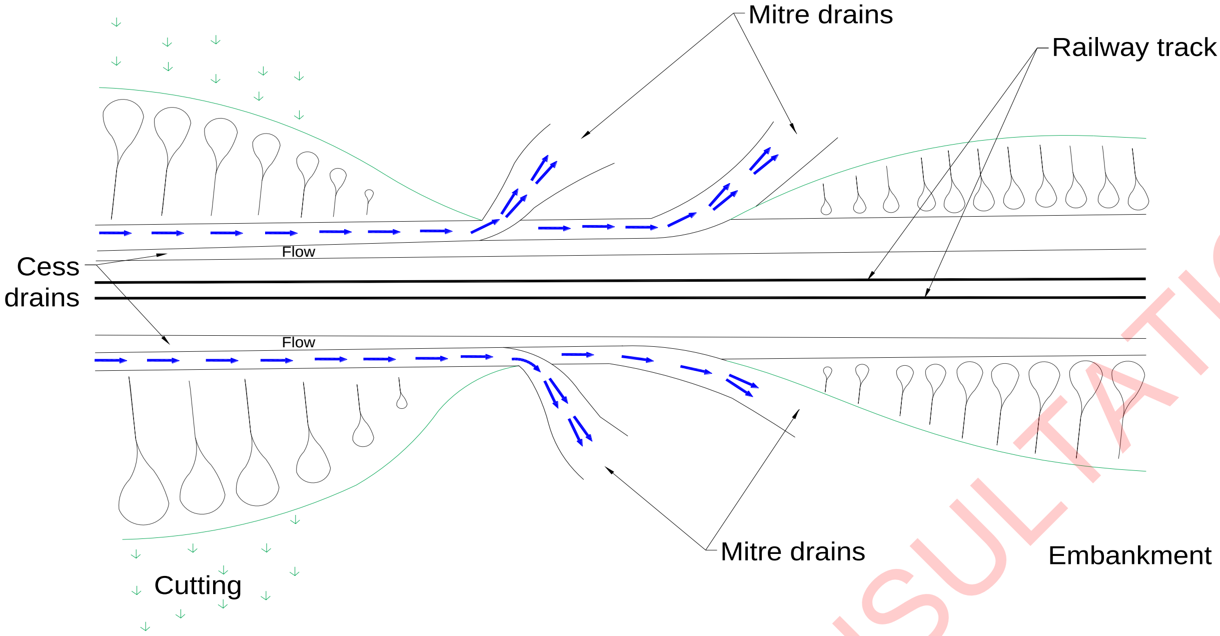
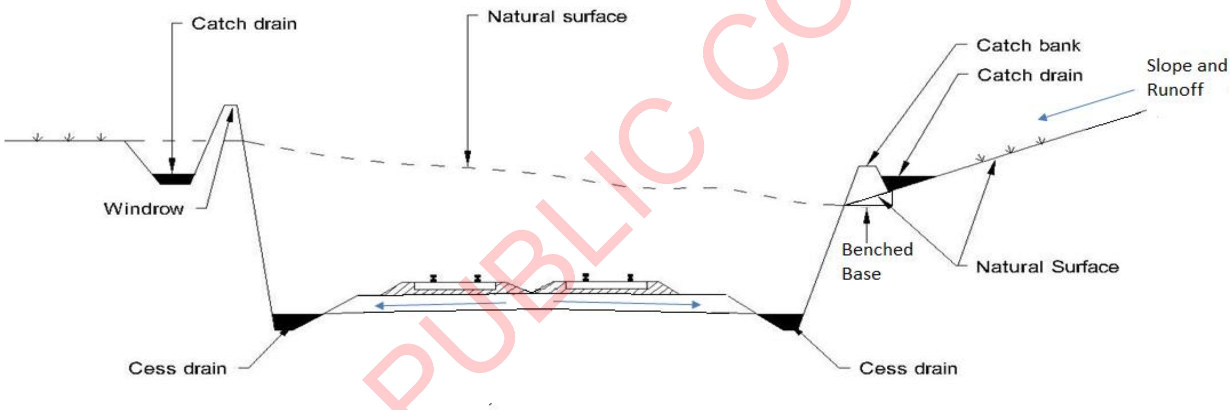


Appendix Figure B-4 Mitre drain



Appendix Figure B-5 Catch drain and cess drain

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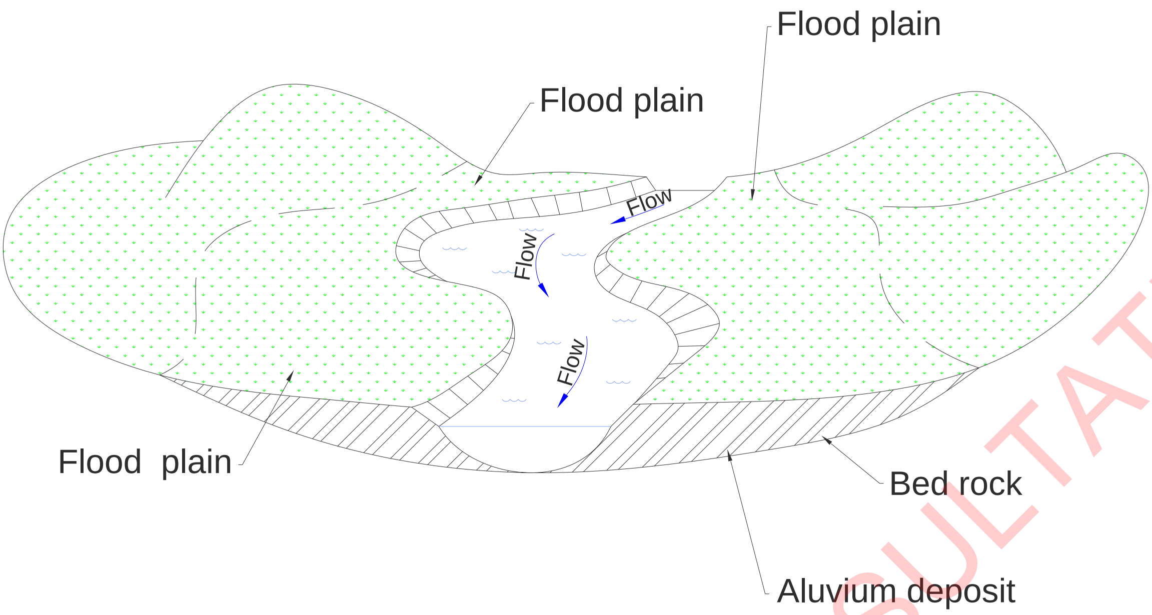

Appendix Figure B-6 Floodplain

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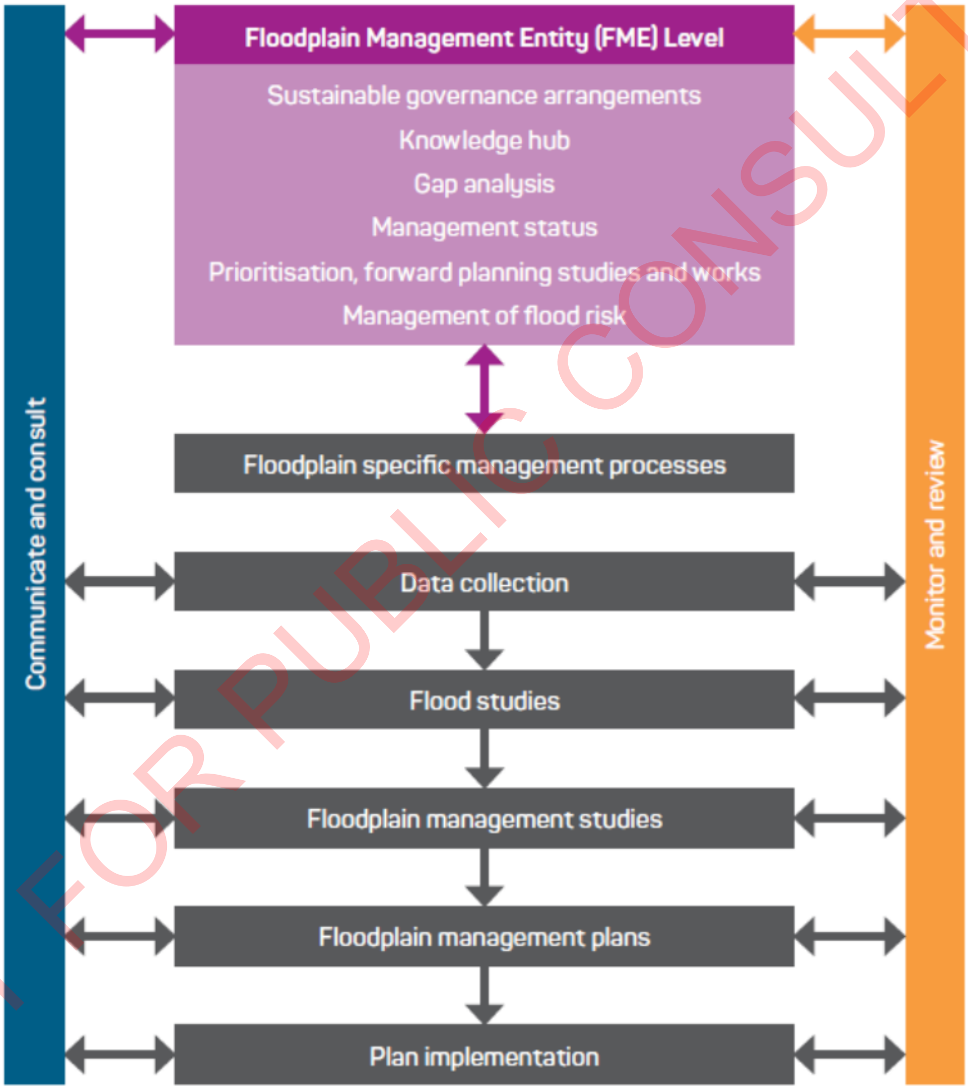
Appendix C Flood Risk Management Framework

FRMF as defined by *Australian Disaster Resilience Handbook 7 Managing the floodplain* defines the following key principles of best practice approach to flood risk management for flood management entities (FME).

FMEs are government-based organizations responsible for flood plain management within a defined administrative boundary. This could include the risk assessment and flood plain management of multiple catchment areas across varying environments and climate influences. The FME provides oversight of the application of the FRMF for the responsible area, including rail corridor, and governance arrangements for key stakeholders identified in the framework.



Appendix Figure C-1 Flood risk management framework

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Appendix D Project Phases and Hydrological Investigations (Informative)

Depending on the type and magnitude of the railway design project, the following detail the levels of hydrology and hydraulic investigation which are best implemented for typical project phases:

Pre-feasibility study:

- Identification of existing major waterway crossings and contributing catchments.
- Identification of general flooding characteristics (i.e. flood levels and extent) along the railway corridor, using existing recorded information or by undertaking broad-scale flood estimation works.
- Identification of opportunities and constraints in terms of existing flooding and potential impacts on the selection of the railway corridor and profile.
- Identification of the desired standard of services in terms of flood immunity.
- Undertaking of an initial risk assessment.
- Local flood risk studies (all stages).

Concept design:

- Identification of all existing waterways and cross-drainage and mapping of the boundaries of contributing catchments.
- Hydrologic and hydraulic modelling to determine existing flood characteristics for all crossings at the railway corridor, including design flood discharge and hydrographs, flood levels, flood extent, flood velocities, flow directions and distributions and flow velocities.
- Preliminary sizing for all potential major drainage infrastructure associated with the railway.
- Assessment of potential impacts on flooding and the flow regime.
- Undertaking of preliminary flood risk assessment.

Preliminary design:

- Further refinement of hydrologic and hydraulic modelling and mapping (as required), to determine detailed design flows and flood information at all locations.
- Optimisation of concept design and selection of preferred options for all major drainage infrastructure and related erosion control structures associated with the railway project.
- Assessment and mapping of impacts on flooding and flow regime.
- Preparation of flood management plans.
- Detailed flood risk assessment.

Detailed design:

- Detailed design of selected drainage infrastructure, including hydraulic grade lines.
- Preparation of construction drawings and specifications for all drainage infrastructure.
- Preparation of erosion control plans.
- Preparation of the required tender documentation.

Bibliography (Informative)

- Department of Regional Development, Manufacturing and Water, *Dam Safety Management Guideline, 2024*
- Queensland Department of Transport and Main Roads, *Hydrologic and Hydraulic Modelling Technical Guideline, 2019*
- Western Australia Government, *Stormwater Management Manual of Western Australia, 2023*
- Australian Infrastructure, *Resilience Principles, 2022*
- McLuckie, D., *Strategic Management of Flood Risk*

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