QUEENSLAND

State Natural Hazard Risk Assessment 2017

Queensland Government

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Thank you

The State Natural Hazard Risk Assessment 2017 was a collaborative effort, bringing together the expertise of multiple stakeholders. QFES would like to thank all the organisations and individuals who assisted us in developing this document. Particular thanks to the Queensland Police Service, Geoscience Australia, the Australian Bureau of Meteorology, the Queensland Department of Science, Information Technology and Innovation, the United Nations Office for Disaster Risk Reduction, Queensland Reconstruction Authority and local governments throughout Queensland.

Foreword

Katarina Carroll APM
Commissioner, Queensland Fire and Emergency Services

Disaster events affect the lives of all Queenslanders and have a significant impact on the economy and our environment. Whether of natural or human origin, disasters are becoming increasingly extreme and complex, exacerbated not only by the effects of climate change but also our globally interlinked economies. There is a need to improve our collective capability to assess and more deeply understand disaster risk as the first step towards the development of resilience including prevention, preparation, response and recovery planning. This is also reflective of the international focus on understanding disaster risk as priority one of the Sendai Framework for Disaster Risk Reduction 2015-2030.

Queensland is exposed to a range of natural hazards which can lead to significant consequences for our communities. Within the last decade we have experienced natural disasters of a size and scale that are almost unprecedented; certainly we have endured some of the most significant events in recent history.

These events reinforce the need to understand disaster risk in sufficient detail to meet the community's needs and communicate appropriate risk information across the three tiers of Queensland's Disaster Management Arrangements (QDMA): Local, District and State. Starting at the local government level, the communication of risk information between each tier can inform communities and government, emergency services and all emergency management partners in making decisions to prevent, prepare for and respond to and recover from natural disasters.

The information contained in this report, including the hazard specific risk profiles, together with the more detailed local and district risk assessments and disaster management plans can be used by stakeholders across government and practitioners throughout the emergency management sector.

This scope of the 2017 State Natural Hazard Risk Assessment includes the hazards of Tropical Cyclones, Riverine flooding, Bushfires, Severe Weather, Earthquakes, Heatwaves and Coastal Inundation. Tropical Cyclones and Riverine flooding remain the hazards whose impacts pose the greatest risk to Queensland.

The Queensland Emergency Risk Management Framework (QERMF) was developed to build on and enhance the risk assessments and plans developed by local governments and disaster districts. Therefore, the QERMF is a holistic disaster risk management paradigm to be applied across all levels of QDMA.

The collaborative workshops that accompany the risk analysis and the expected outcomes of the implementation of the QERMF give rise to a number of significant enhancements to Queensland's safety. As noted by the United Nations Institute for Disaster Risk Reduction, the contemporary international focus represents a shift from managing disasters to managing risk; from focusing on disasters to focusing on risk.

If disaster risk exists then action of some kind needs to be taken; the very existence of risk requires that action be taken to at least reduce it and, at the same time, to ensure that new risk is not created. The success of both the Sendai Framework and of the QERMF will be measured against the safety of our communities and whether the impact of hazards is reduced substantially from current projected impacts and costings. Meeting this challenge requires working on three synergistic pathways: preventing the creation of new risk, reducing existing risk, and strengthening resilience. Of course understanding risk in depth is the starting point and we are well on our way as this report represents a maturing capability in the identification and analysis of natural hazard risk that will inform the development of risk-based plans across the multi-tiered QDMA. Risk-based planning is one of the cornerstone enablers for the Queensland community to be better able to prevent, be prepared for, respond to and recover from natural disasters.

I thank all stakeholders for their contribution to the 2017 Queensland Natural Hazard Risk Assessment and their continued support and commitment towards our community's disaster resilience. I would also like to specifically thank the Queensland Police Service for partnering with QFES on this initiative, the Queensland Reconstruction Authority for their support and local governments for their ongoing cooperation.

I encourage all Queenslanders affected by disaster risk to consider this valuable report and use it to inform the management of risks applicable to their interests and responsibilities.


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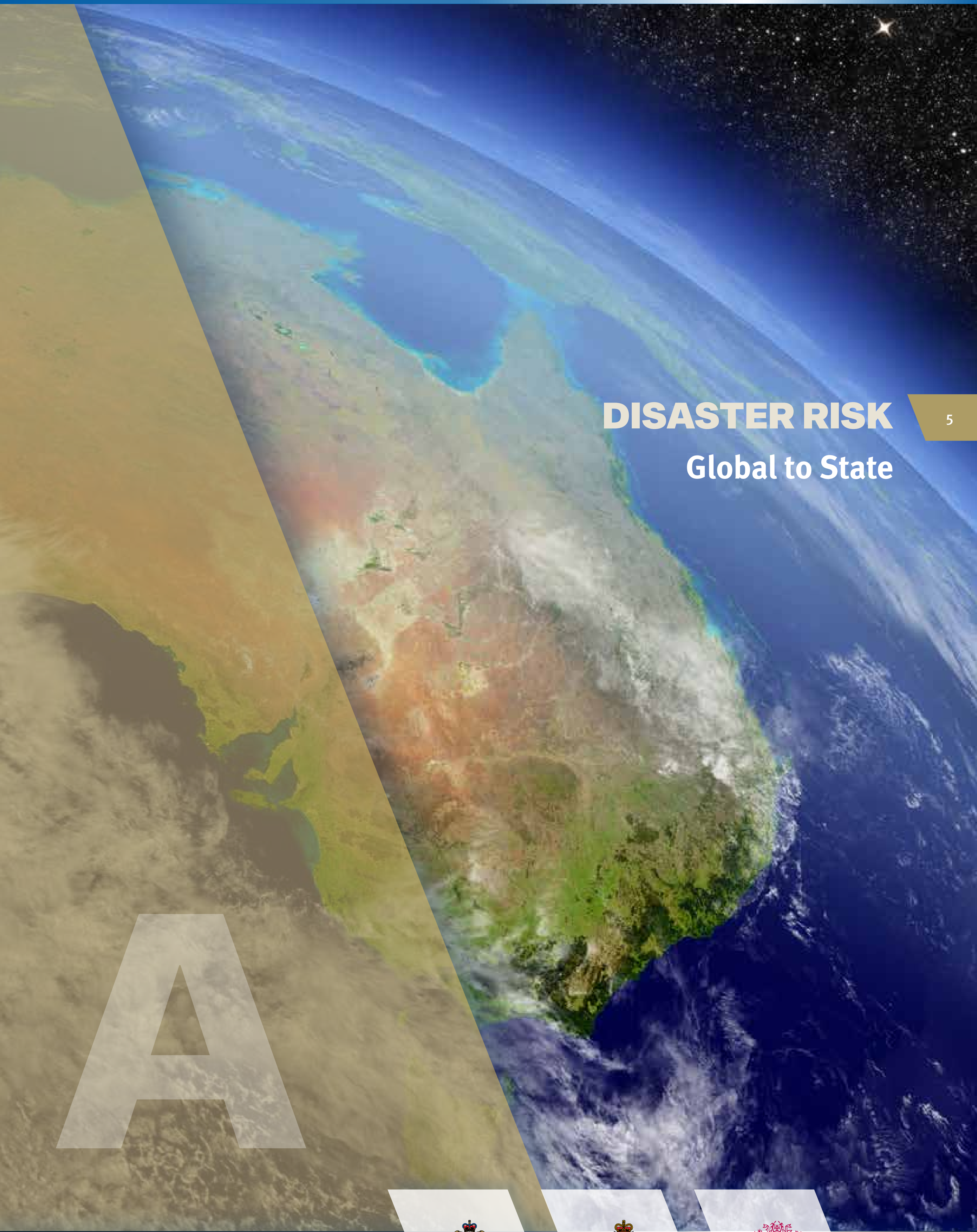


DISASTER RISK

Global to State

A

Introduction

The Queensland Fire and Emergency Services (QFES) has responsibility under the *Queensland State Disaster Management Plan* to prepare a State Natural Hazard Risk Assessment. In addition, all Australian States and Territories agreed via the Law, Crime and Community Safety Council to conduct State level risk assessments by 30 June 2017 for collaboration and discussion at the national level.

In 2015, QFES researched international best practice in natural hazard risk assessment. This research led to the development of a methodology that harnesses scientific data relating to each hazard and uses geospatial information systems to analyse historical and/or projected impacts to identify exposures, vulnerabilities and subsequently risk.

This approach also promotes sense-checking between scientific data, mapping and modelling with local knowledge during the risk analysis stage, which is of paramount importance.

A proof-of-concept was assessed at the Disaster District level across Queensland in 2016 and this methodology was found to be effective in the identification of risk and, more specifically, in the identification of residual risk, for disaster management planning at and between all levels of government.

In November 2016, the Queensland Disaster Management Committee endorsed the continued development of the Queensland Emergency Risk Management Framework using this methodology to facilitate enhanced risk based planning so that we may better prevent, prepare for, respond to and recover from disaster events.

Concurrently, in 2016 the United Nations Office for Disaster Risk Reduction (UNISDR) commissioned the development of guidelines on national disaster risk assessment (NDRA) as part of a series of thematic guidelines under its "Words into Action" initiative to support implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 (see Figure 1).

The guidelines, to which Queensland contributed, are the result of the collaboration between more than 100 leading experts from national authorities, international organisations, non-governmental organisations, academia, think tanks and private-sector entities.

They focus on the Sendai Framework's first Priority for Action: Understanding Disaster Risk, which is the basis for all measures on disaster risk reduction and is closely linked to the other three Priorities for Action.

Similar to the UNISDR Guidelines, the Queensland Emergency Risk Management Framework is intended to:

- Provide consistent guidance in understanding disaster risk that would act as a conduit for publicly-available risk information. This approach would also assist in the establishment and implementation of a framework for collaboration and sharing of information in disaster risk management, including for risk-informed disaster risk reduction strategies and plans.
- Encourage holistic risk assessments that would provide an understanding of the many different dimensions of disaster risk (hazards, exposures, vulnerabilities, capability and capacities). The assessments would include diverse types of direct and indirect impacts of disaster, such as physical, social, economic, environmental and institutional.

Both of these outcomes may take several years to mature. However, by keeping abreast with scientific and technological advancements and by also remaining connected at the local level, they are achievable and will produce tangible enhancements to the safety and resilience of the Queensland community.

Chart of the Sendai Framework for Disaster Risk Reduction

2015-2030

Scope and purpose

The present framework will apply to the risk of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disasters, caused by natural or manmade hazards as well as related environmental, technological and biological hazards and risks.
It aims to guide the multi-hazard management of disaster risk in development at all levels as well as within and across all sectors

Expected outcome

The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries

Goal

Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience

Targets

Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015	Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015	Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030	Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030	Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020	Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this framework by 2030	Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030

Priorities for Action

There is a need for focused action within and across sectors by States at local, national, regional and global levels in the following four priority areas.

Priority 1
Understanding disaster risk

Priority 2
Strengthening disaster risk governance to manage disaster risk

Priority 3
Investing in disaster risk reduction for resilience

Priority 4
Enhancing disaster preparedness for effective response, and to «Build Back Better» in recovery, rehabilitation and reconstruction

UNISDR
The United Nations Office for Disaster Risk Reduction

Figure 1

The Sendai Framework for Disaster Risk Reduction (2015-2030) is an international accord on disaster risk reduction endorsed by the UN General Assembly in June 2015.

Source: United Nations Office for Disaster Risk Reduction (www.unisdr.org/we/coordinate/sendai-framework)

International perspective on disaster risk

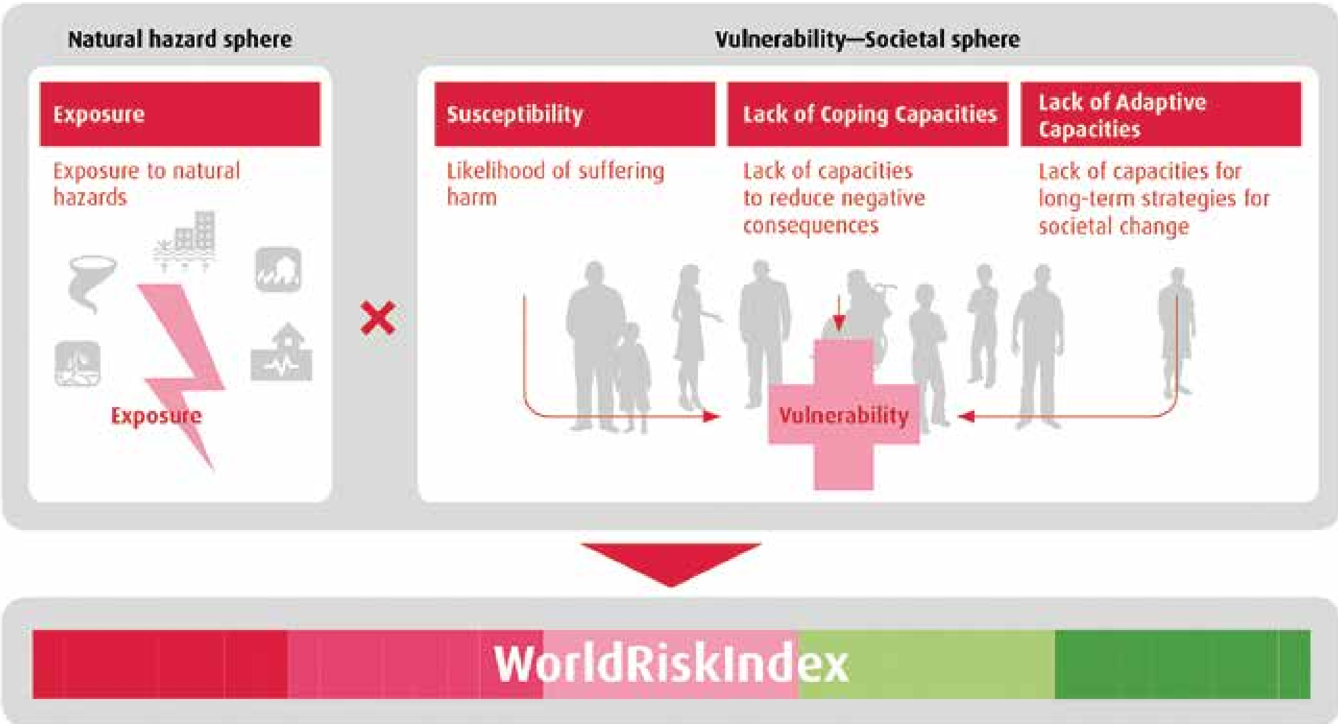
The Global Facility for Disaster Risk Reduction (GFDRR) identifies the three key global factors influencing the manifestation and impact of natural hazard risks as population growth, urbanisation and climate change.

To assist the development of community resilience, the GFDRR notes that the international community needs to prioritise disaster risk assessment methodology that directly informs collective planning with accurate and actionable risk information.

Another consistent international theme is that the foundation for effective disaster risk management lies in understanding the hazards, the exposure and the vulnerability of people, assets and environment to those hazards. Governments, communities and individuals can make much better informed prevention decisions by appropriately identifying risks and anticipating the potential impacts of hazards.

Successful risk assessments produce information that is targeted, authoritative, understandable and usable. This can only be achieved if the process of creating and using risk information is transparent and if there is communication and collaboration among all involved parties: scientists, engineers, decision makers, governmental authorities and community representatives.

A risk assessment that embraces these elements enables the identification and development of information useful for risk mitigation.



The WorldRiskIndex and its components. ©Bündnis Entwicklung Hilft: WorldRiskReport 2016

Figure 2

The WorldRiskIndex and its components identify the potential vulnerabilities of countries to natural hazards.

Source: WorldRiskReport (www.weltrisikobericht.de/english)

From a public policy perspective, risk information can be sensitive information as it requires government, private sector, community and the individual to decide on action (or inaction) to reduce the impacts of potentially hazardous events.

The chance of risk information translating into action, then, depends to a large extent on sensitive negotiations between government and affected communities.

Humans can only influence to a degree whether, and with what intensity, natural events impact our communities. However, we can take precautions to help prevent the manifestation of a natural phenomenon from becoming a disaster event.

It is the potential vulnerability of communities that forms the basis for the WorldRiskIndex which calculates the disaster risk for 171 countries by multiplying vulnerability with exposure to natural hazards.

According to the WorldRiskIndex, Australia rates as 'low' on a global scale, despite our reasonably high level of exposure to natural hazards. Our rating is partly due to the global comparisons of population sizes and rates of poverty in less developed countries (where many hundreds of thousands of people may experience significant vulnerability and risk from natural hazards with relatively little means of assistance per head of population).

Australians also enjoy more comparatively stable economic and political systems which afford more options toward resilience.

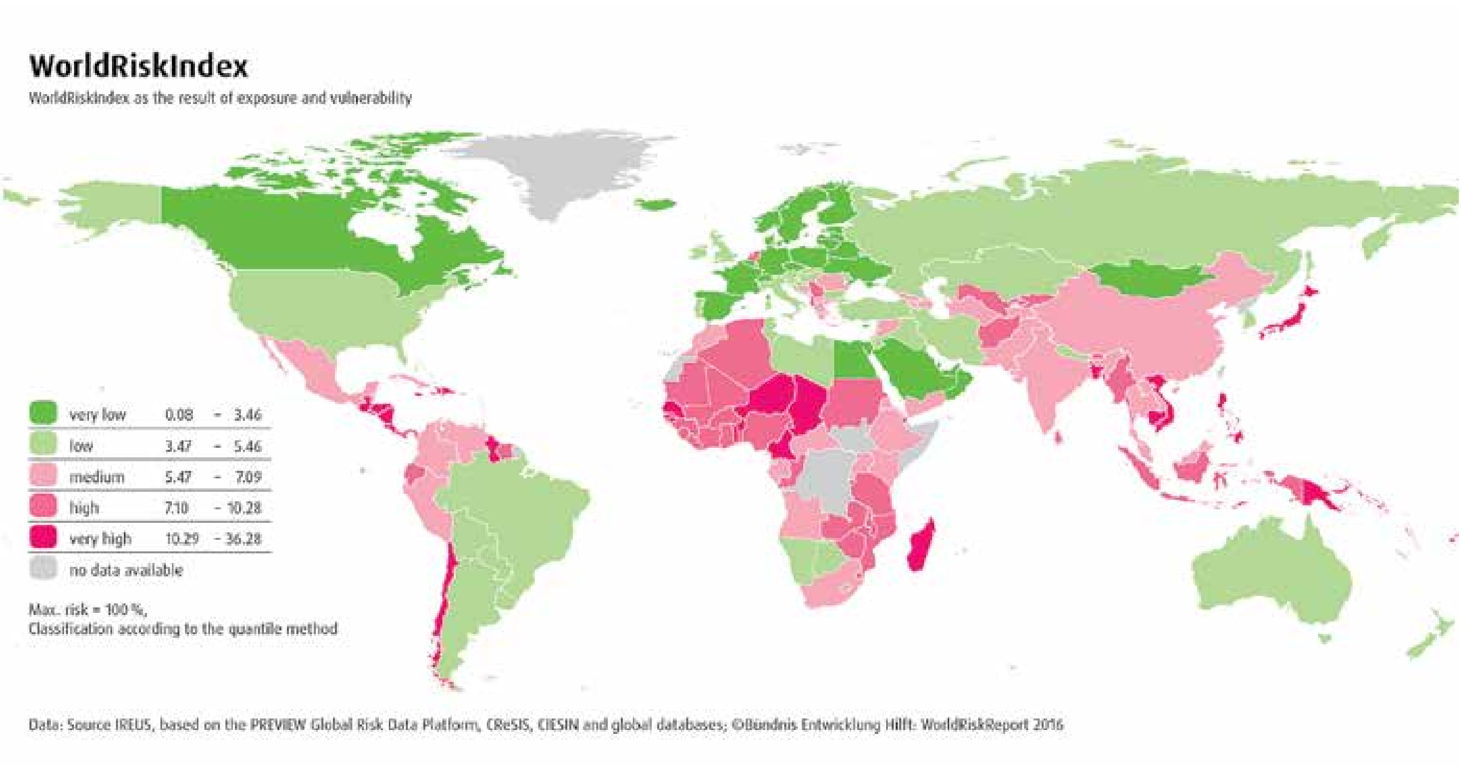


Figure 3

The WorldRiskIndex map shows the disaster risk for 171 countries by multiplying vulnerability with exposure to natural hazards.

Source: WorldRiskReport (www.weltrisikobericht.de/english)

World Economic Forum – Global Risks Report 2017

The World Economic Forum Global Risks Report 2017 features perspectives from nearly 750 experts on the perceived impact and likelihood of 30 prevalent global risks and 13 underlying trends that could amplify them or alter their interconnections over a 10-year timeframe.

These risks are categorised into five areas: economic, environmental, geopolitical, societal and technological.

During the past decade, a cluster of environment-related risks – notably extreme weather events and failure of climate change mitigation and adaptation – have emerged as a consistently central feature of the global risk landscape.

This year, environmental concerns are more prominent than ever, with all five risks in this category assessed as being above average for both impact and likelihood.

Extreme weather events have risen to be the number one global risk in 2017 with major natural disasters being recorded as the third highest.

2014	2015	2016	2017
Income disparity	Interstate conflict with regional consequences	Large-scale involuntary migration	Extreme weather events
Extreme weather events	Extreme weather events	Extreme weather events	Large-scale involuntary migration
Unemployment and underemployment	Failure of national governance	Failure of climate-change mitigation and adaptation	Major natural disasters
Climate change	State collapse or crisis	Interstate conflict with regional consequences	Large-scale terrorist attacks
Cyber attacks	High structural unemployment or underemployment	Major natural catastrophes	Massive incident of data fraud/theft

- Economic
- Environmental
- Geopolitical
- Societal
- Technological

Figure 4

The World Economic Forum has identified the top five global risks. In 2017, the risk of extreme weather events is ranked highest, with major natural disasters ranked as the third-highest worldwide.

Source: World Economic Forum (www.weforum.org/reports/the-global-risks-report-2017)

The Global Risks Landscape 2017

What is the impact and likelihood of a range of global risks?

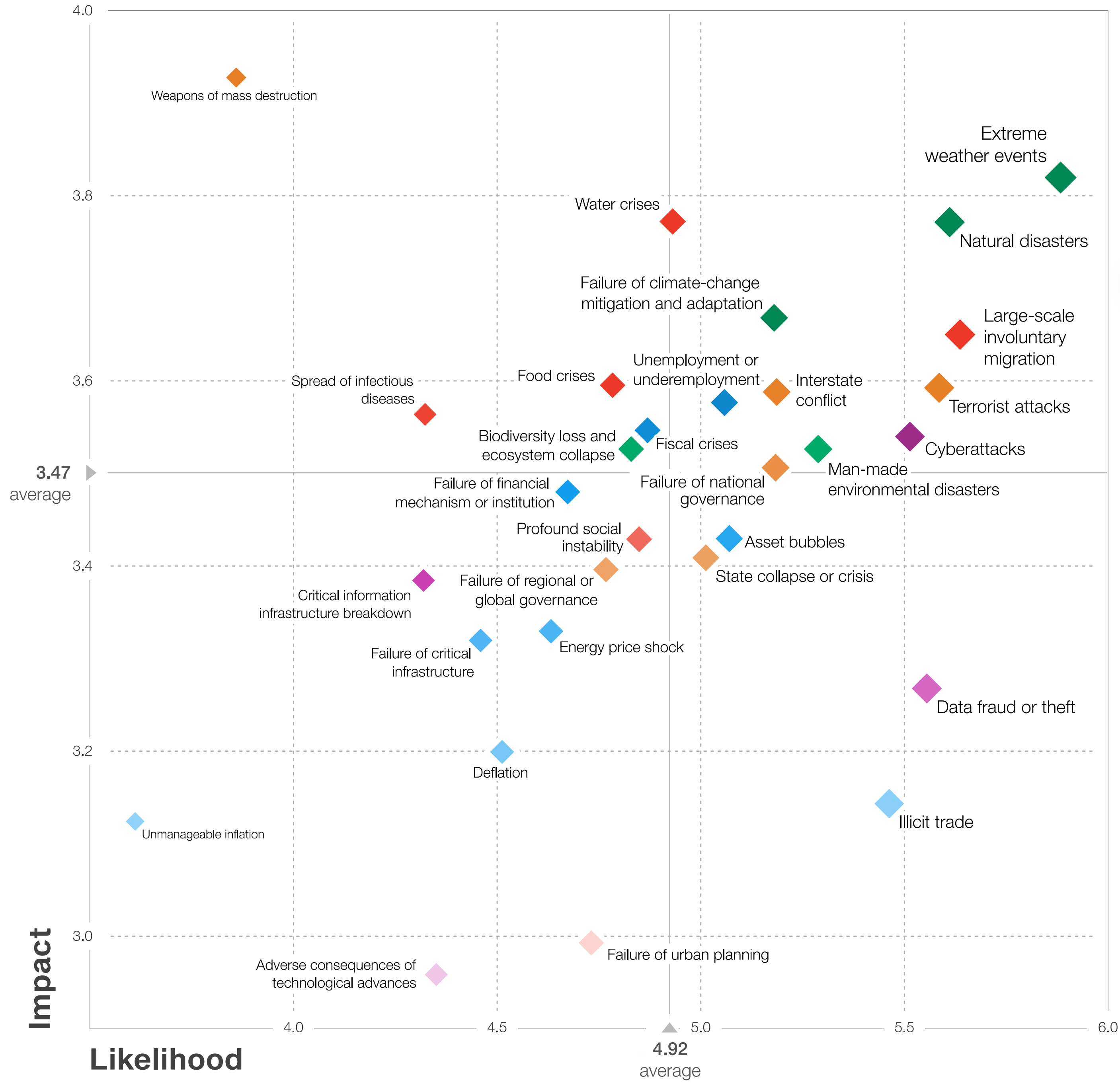


Figure 5

The World Economic Forum Global Risks Report maps the perceived impact and likelihood of 30 prevalent global risks.

Source: World Economic Forum (www.weforum.org/reports/the-global-risks-report-2017)

Understanding disaster risk components

The international review of disaster risk methodologies by the UNISDR in 2017 noted that the conceptualisation of disaster risk has undergone a transformation.

The UNISDR observed the use of the classic disaster risk concepts, which describe risk in terms of likelihood and consequence, however further stated that, in order to identify and evaluate the best measures for reducing risk, an assessment should also analyse hazard, exposure, vulnerabilities and capacities, as well as the direct and indirect impacts.

Queensland's methodology embodies this approach to understanding disaster risk.

The Sendai Framework for Disaster Risk Reduction 2015 – 2030 marks a crucial shift from managing disasters to managing disaster risk. The UNISDR noted that the long term benefits of risk informed disaster risk reduction strategies and plans significantly outweigh the initial outlay costs of conducting risk assessments. The UNISDR further noted that the financial cost of conducting risk assessment is marginal to the total cost of the impacts of disasters.

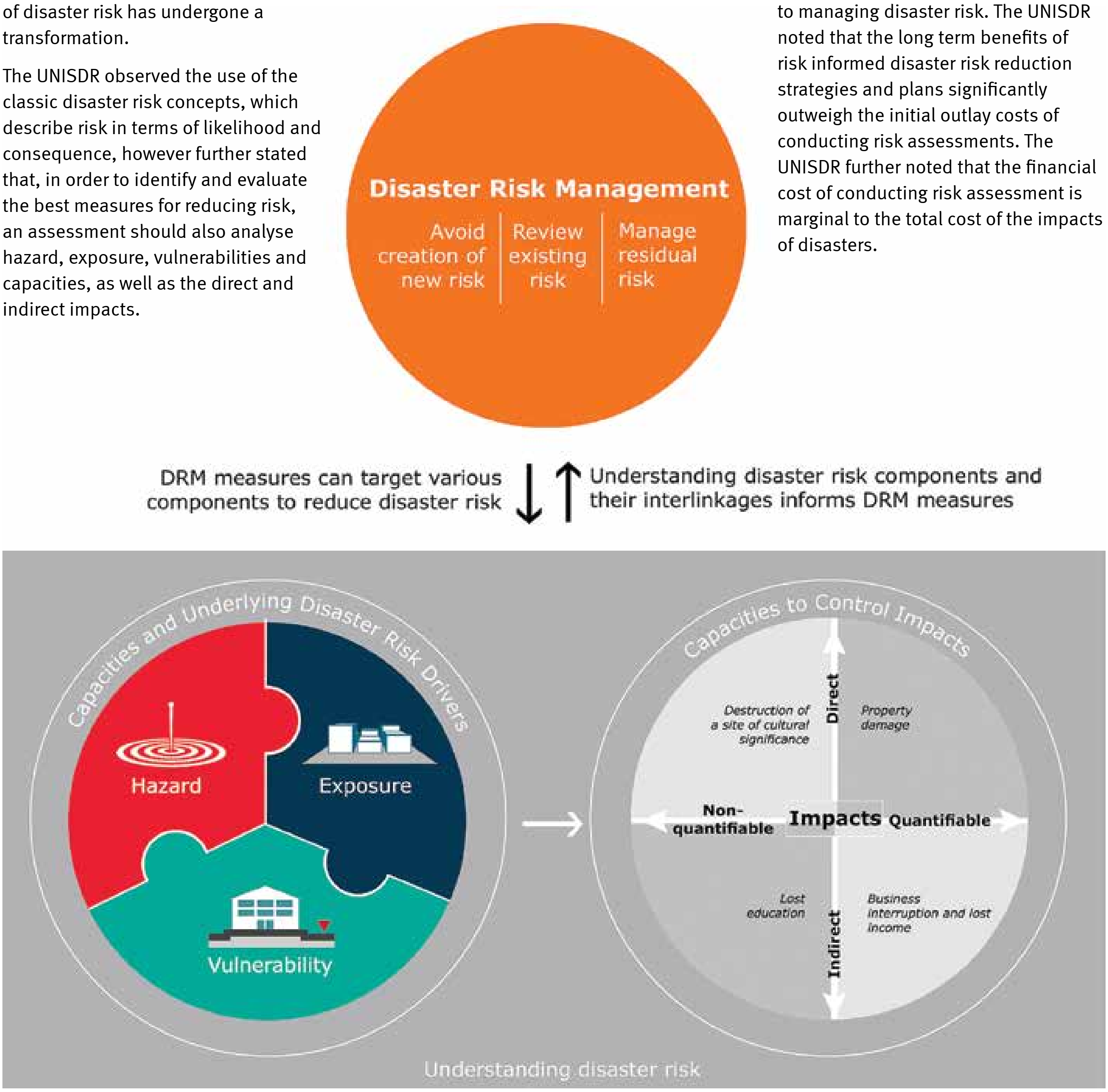


Figure 6

UNISDR's Understanding disaster risk model; comprehensive understanding of disaster risk empowers effective and inclusive disaster risk management.

Source: United Nations Office for Disaster Risk Reduction (www.unisdr.org)

The economic cost of disaster to Australia

The Australian Business Roundtable for Disaster Resilience and Safer Communities' *The economic cost of the social impact of natural disasters* 2016 report states that the true cost of natural disasters is at least 50% greater than previous estimates when the cost of social impacts is incorporated.

When both tangible and intangible costs are included, estimates are that the total economic cost of natural disasters in Australia in 2015 would have exceeded $9 billion, or 0.6% of GDP.

This is expected to double by 2030 and to reach an average of $33 billion per year by 2050 without considering the potential impact of climate change.

Comprehensive information on all costs of natural disasters is required to understand the full impact of natural disasters on our communities and economy and to also understand the extent to which expenditure on mitigation and resilience measures is effective.

Multiple Australian Business Roundtable reports (as listed on page 21) outline the projected costs of natural disasters and indicate that investment in resilience measures may reduce the costs of disaster relief and recovery by more than 50% by 2050.

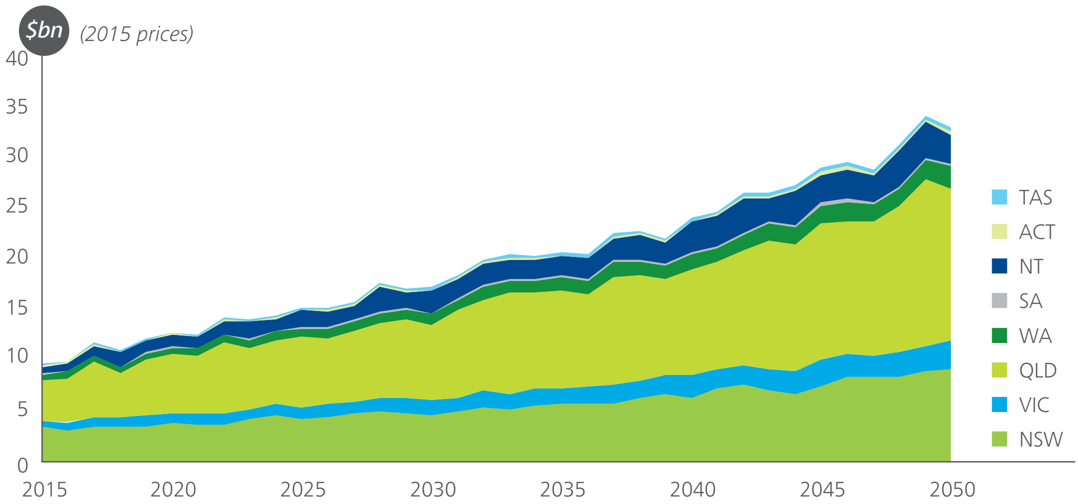
This estimate does not include less visible and intangible costs such as increased mental health issues, family violence, alcohol consumption, chronic and non-communicable diseases and short term unemployment.

The work of the Australian Business Roundtable has highlighted, where data allows, the intangible costs of natural disasters and found that:

- Natural disasters can have a devastating impact on individuals, families, local communities, businesses and governments. In particular, the social impacts are complex, interrelated and difficult to quantify.
- There is clear evidence social impacts account for a substantial part of the total economic cost of natural disasters.
- Placing a monetary value, where possible, on these social impacts will assist in better understanding the total economic cost of natural disasters and thereby strengthen the case for building individual and community resilience.

1. In line with the Productivity Commission report, costs in this report are defined as:
- **Direct tangible costs:** those incurred as a result of the hazard event and have a market value such as damage to private properties and infrastructure
- **Indirect tangible costs:** the flow-on effects that are not directly caused by the natural disaster itself, but arise from the consequences of the damage and destruction such as business and network disruptions
- **Intangible costs:** capture direct and indirect damages that cannot be easily priced such as death and injury, impacts on health and wellbeing, and community connectedness.

Chart ii: 2015–50 forecast of the total economic cost of natural disasters, identifying costs for each state



Source: Deloitte Access Economics analysis

Figure 7

The Australian Business Roundtable has forecast the total economic cost of natural disasters to Australia to highlight the need for a holistic strategy.

Source: The Australian Business Roundtable: The economic cost of the social impact of natural disasters report, 2016 (www.australianbusinessroundtable.com.au)

The Queensland Emergency Risk Management Framework

Even though substantial challenges remain in fully assessing disaster risk, significant progress across multiple areas has occurred, including:

- hazard data and models for identifying and analysing risk have grown in number and accessibility
- risk data and mapping are increasingly being made freely available to users as part of a larger global trend toward open data
- there is a deeper understanding – on the part of governments as well as development institutions such as the World Bank – that disaster risk management requires many partners working cooperatively and sharing information.

The Queensland Emergency Risk Management Framework (QERMF) is underpinned by this multidisciplinary approach, uniting international and Australian best practice, the strategic direction of world risk management leaders and using operational geospatial intelligence to undertake exposure and vulnerability analysis which can directly inform the State's multitiered disaster management arrangements and planning.

The QERMF derives risk methodology from:

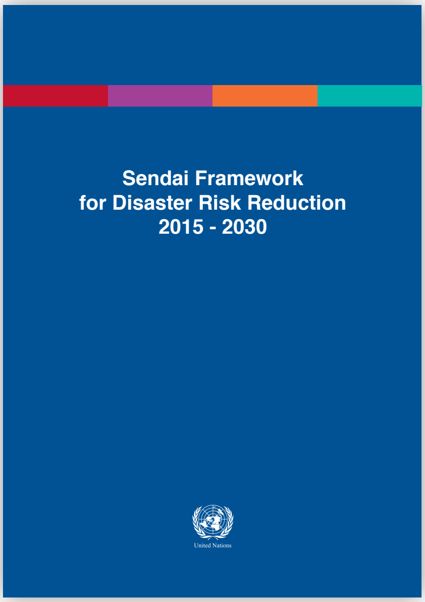
- *ISO 31000:2009 Risk management – Principles and guidelines*
- *SA/SNZ HB 436: 2013 Risk management guidelines – companion to AS/NZS ISO 31000:2009*
- *SA/SNZ HB 89:2013 Risk management – Guidelines on risk assessment techniques*
- *AS/NZS 5050: 2010 Business continuity – Managing disruption related risk*
- *National Emergency Risk Assessment Guidelines (Australian Emergency Management Institute, 2015).*

In addition to meeting the above international and national standards, the QERMF also upholds international best practice as championed by the UNISDR and the Global Facility for Disaster Reduction and Recovery (GFDRR) and seeks to literally enact the Sendai Framework for Disaster Risk Reduction's "Priorities for Action".

The QERMF also recognises the relevant elements within the Emergency Management Assurance Framework (EMAF) as published by the Office of the Inspector-General Emergency Management, Queensland.

The QERMF applies analysis techniques from the field of geospatial intelligence to conduct broad area/geographic assessments. This intelligence comprises relevant environmental, built, community and hazard information to gain a true appreciation and create a comprehensive profile of risk.

This approach also makes risk assessments a fundamental enabler for effective pre impact analysis and planning within disaster operations.



The ability to develop, access and use geospatial data, information and knowledge is essential to providing the most cohesive representation of exposure, vulnerability and risk. As geospatial information is managed and coordinated by various agencies, cooperation and communication is vital.

The multidisciplinary approach that underpins the QERMF directly informs the identification of risk treatment options that fall into two broad categories:

- Proactive approaches involving prevention and preparedness measures which may influence the potential and/or scale of disruptive events.
- Contingency plans and contingent capability (response) to minimise the impact of potentially disruptive events. Development of contingency plans and contingent capability can assist to reduce and stabilise the impacts of events, restore and expedite restoration of normalcy (recovery).

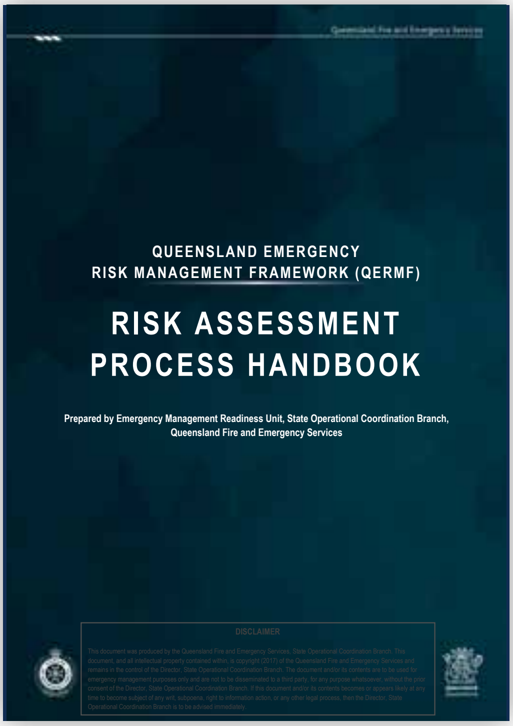


Figure 8

Queensland's Emergency Risk Management Framework embraces leading industry standards, pictured below, and is further detailed in the Risk Assessment Process Handbook, shown above.

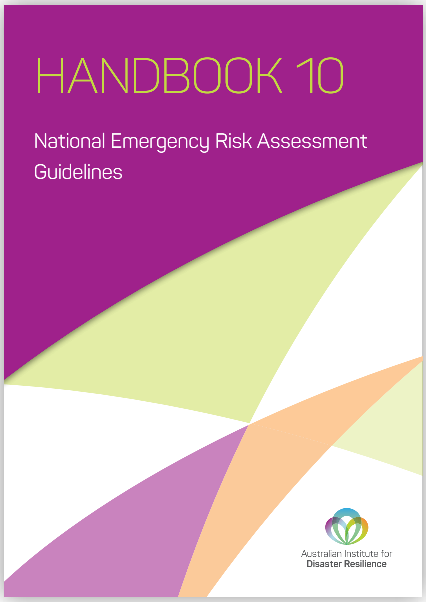
Sources (below, l to r):

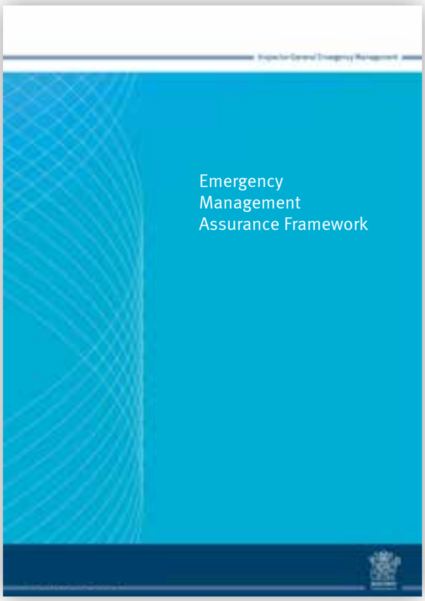
www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

www.iso.org/standard/43170.html

www.aidr.org.au/media/1489/handbook-10-national-emergency-risk-assessment-guidelines.pdf

www.igem.qld.gov.au/assurance-framework/Documents/IGEM-EMAF.pdf#search=EMAF





Queensland Government

Queensland's Disaster Management Arrangements

The Australian Emergency Management Arrangements are formed around three levels of government: Local, State and the Australian Government.

The Queensland Disaster Management Arrangements acknowledge these three levels of government and also include an additional tier between Local and State Governments – known as Disaster Districts.

The *Disaster Management Act 2003* denotes that Local Governments are primarily responsible for managing events in their area and must establish a Local Disaster Management Group (LDMG). Part of an LDMG's function is to improve and foster effective disaster management through regular reviews and assessments of disasters which, in turn, enables the Local Government to develop its Local Disaster Management Plan (LDMP).

A District Disaster Management Group (DDMG) is established for each Disaster District. Part of a DDMG's function is to develop effective disaster management for the District, including a District Disaster Management Plan (DDMP). This plan is developed through regular review and assessment of the disaster management of the Local Governments within their District and their LDMPs.

The State Disaster Coordination Group and the State Disaster Coordination Centre (SDCC) sit at the State level. The SDCC is an operational venue for the provision of State level support to disaster management operations.
The most senior level of committee is the Queensland Disaster Management Committee (QDMC). Part of the QDMC function is to ensure effective disaster management is developed and implemented for the State through preparation and regular review of the State Disaster Management Plan (SDMP) and to also provide strategic direction during disaster events.

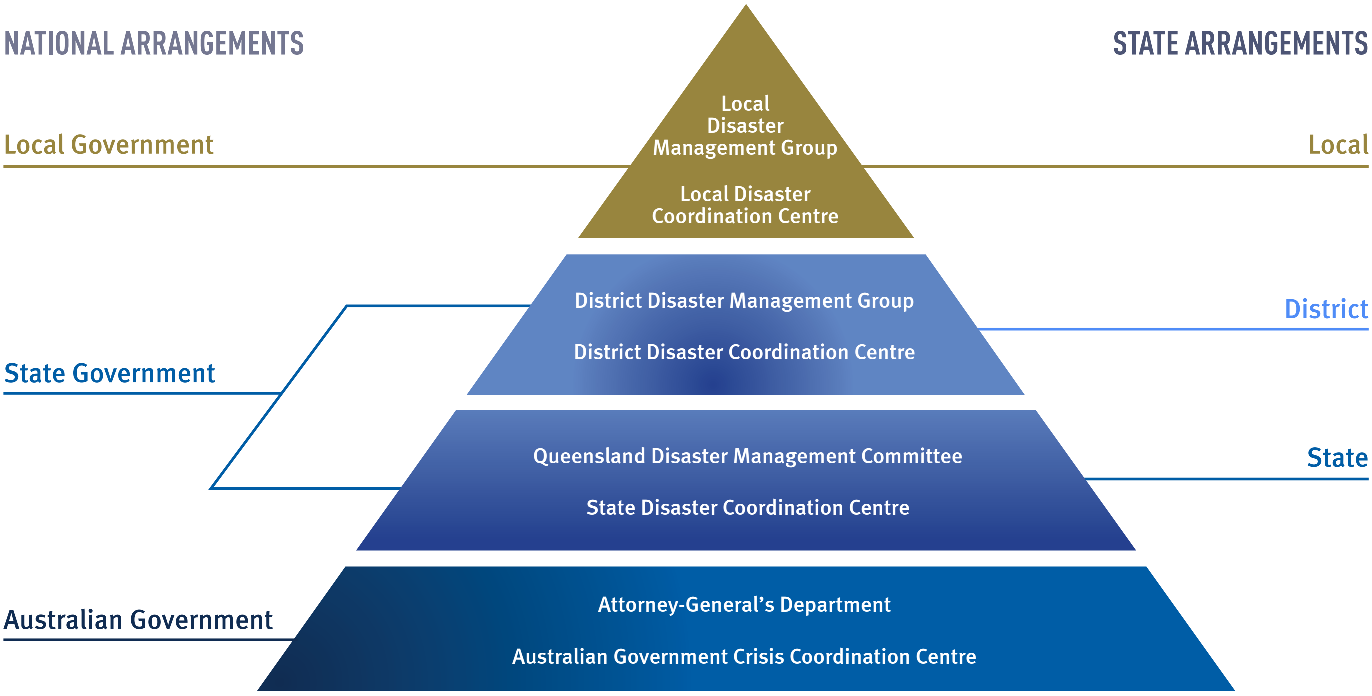


Figure 9

Queensland's Disaster Management Arrangements comprise four tiers, including a Disaster District array for improved efficiency and effectiveness.

Source: www.disaster.qld.gov.au

Queensland Government

Queensland's developing approach to risk based planning – the Queensland Emergency Risk Management Framework

The Queensland Emergency Risk Management Framework (QERMF) is underscored by multiple, standardised and integrated tools that assist in identifying, assessing, analysing and managing risk.

The successful foundation for disaster risk management lies in clearly identifying and understanding the level of exposure and vulnerability to a community and its assets against particular hazards.

The model below (Figure 10) depicts the overarching risk based planning methodology within the QERMF. This model shows the four clear steps to ensuring the identification, analysis and management of risk.

This methodology provides a comprehensive and systematic approach to ensure that all potential risks are identified via exposure and vulnerability analysis which directly informs risk based planning.

Assessing risk using this methodology assists in:

- gauging the probability that a hazard may manifest
- using geospatial analysis to determine where the hazard may manifest and what key local elements could be exposed to that hazard; geospatial broad area analysis also enables a more strategic overview to be conducted to directly observe interconnectedness of Local or District areas as well as the infrastructure systems

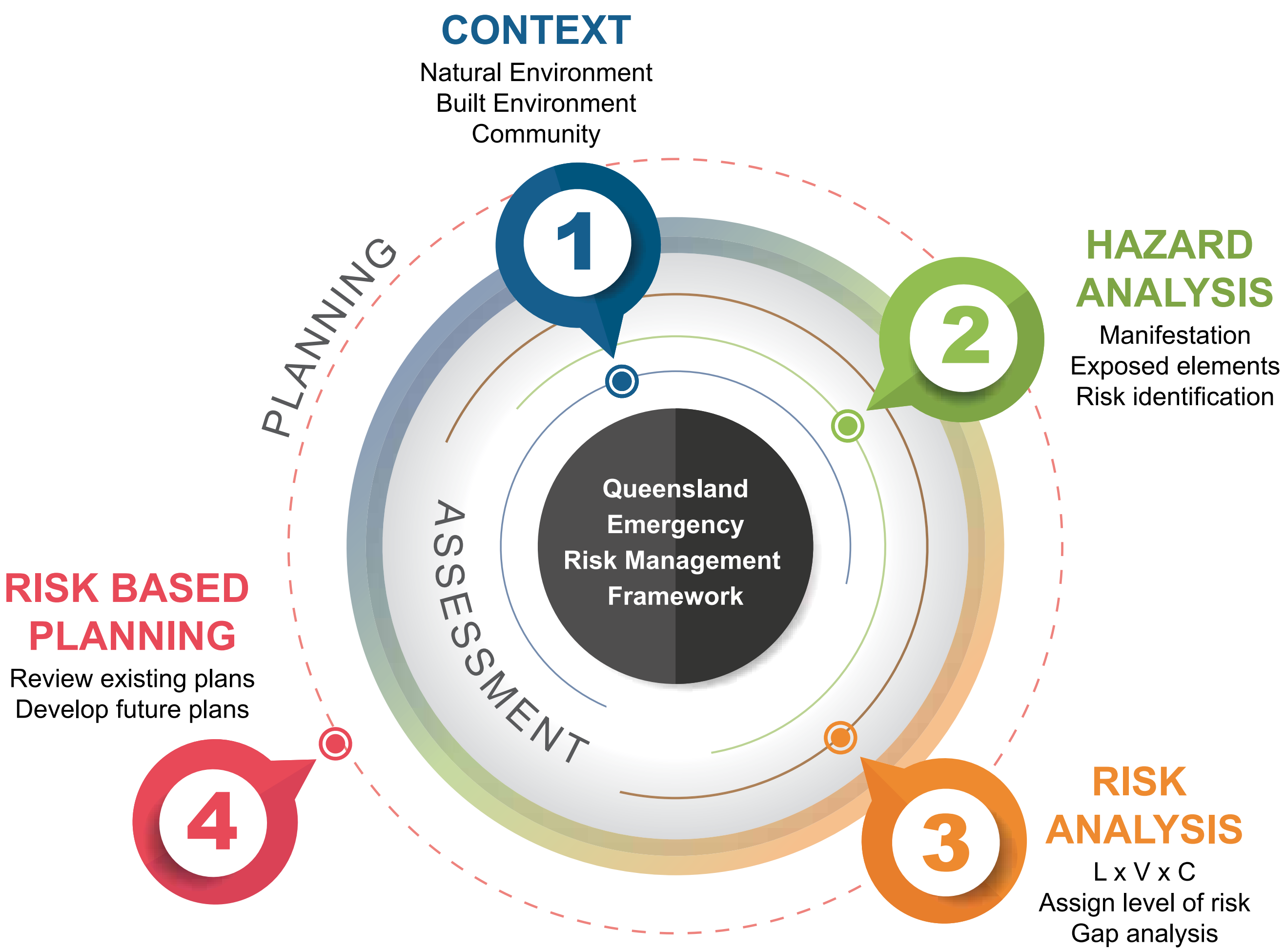


Figure 10

The Queensland Emergency Risk Management Framework's Approach integrates a range of assessment elements to assist in risk based planning.

Source: Queensland Fire and Emergency Services

- evaluating the effect of a hazard manifesting, based on the assessment of the severity of exposure and the level of vulnerability
- informing risk prioritisation, treatment, resource allocation and planning, and measuring this against the capability and capacity to manage the identified vulnerabilities.

The processes shown within **Step 1 Context** in Figure 10 establish the context using a layering approach that includes the natural environment such as geomorphology, demography and the built environment. It is particularly important to also identify critical and essential infrastructure networks during this stage.

The majority of this information can be displayed in geospatial layers as developing a shared understanding of the interconnectedness of infrastructure within the area of interest is a precursor to commencing the actual risk assessment process.

It is also important for sites or areas important to the communities, that may not necessarily be infrastructure, to be identified in these layers. Identifying what is of value to communities, such as areas of cultural significance, and therefore what they would want to protect or prioritise for mitigation is also very important.

Step 2 Hazard analysis, focuses on how hazards manifest and their interaction with the natural and built environments, as identified in Step 1.

Collecting hazard specific data via scientific studies and historical analysis is essential.

A wealth of information is available within Local Governments, via State Government departments such as the Department of Science, Information Technology and Innovation and the Department of Natural Resources and Mines, or from national sources such as Geoscience Australia and the Australian Bureau of Meteorology. Multiple research institutions from the tertiary and corporate sector can also provide valid, recognised and credible data.

Once overlaid onto the natural and built environment, geospatial analysis indicates exposures which, when investigated further, may give rise to specific vulnerabilities and therefore lead to the identification of risks. This process must be sense-checked against local knowledge, ideally with local representatives involved in the collection and analysis of the relevant information.

Step 3 Risk analysis formalises the analysis process and reviews existing controls including capability and capacity at the respective level (Local, District or State).

This in turn identifies residual risk – the risk that remains in unmanaged form, even if controls are in place, and is the key to risk-based planning.

Step 4 Risk-based planning aims to determine and implement the most appropriate actions to treat (control or mitigate) the identified risks at the respective level as well as to address the residual risk between levels. These actions typically comprise both short and longer term strategies to address immediate impacts and the resultant ongoing issues.

Risk treatment strategies and residual risk

When identifying risk treatment strategies, it is important to prioritise responses to inform decisions about what is to be done, when and by whom. This requires understanding of attributes such as urgency, controllability and response effectiveness to execute the actions effectively and in a timely manner to make the best use of available resources. Once treatment of risk measures have been identified, planned or put into place, it is important to then consider the residual risk.

Residual risk is the risk that is beyond the capability and/or capacity of the Local or District community or communities and existing disaster management plans to treat or mitigate.

Residual risk must either be accepted as tolerable or should be transferred to and/or shared across the next level of the disaster management arrangement (upon consultation).

This will allow for the residual risk to be understood and treatment or mitigation measures and plans to be developed as per the Risk Based Planning Equation shown in Figure 11 on the following pages.

Residual risk

The risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained.

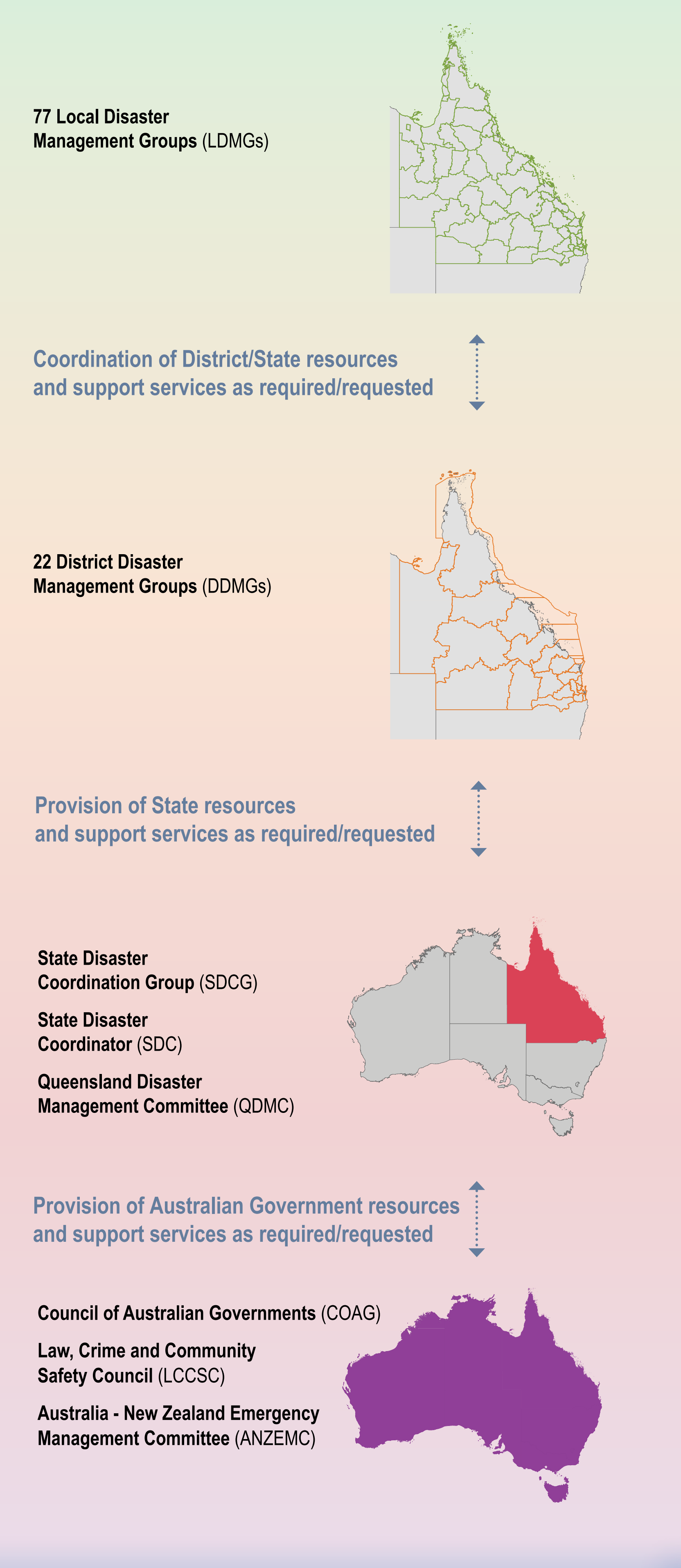
Source: United Nations Office for Disaster Risk Reduction

Risk Based Planning Equation

Figure 11

The Risk Based Planning Equation shows the interrelatedness and passage of residual risk between the three levels of Queensland's Disaster Management Arrangements as well as the linkage to the Australian Government if support is required.

Source: Queensland Fire and Emergency Services



Sources of information

Global disaster risks

- The Sendai Framework for Disaster Risk Reduction (2015-2030): www.unisdr.org/we/coordinate/sendai-framework
- The WorldRiskIndex: www.weltrisikobericht.de/english
- The World Economic Forum Global Risks Report: www.weforum.org/reports/the-global-risks-report-2017

Understanding disaster risk components

- UNISDR – Words into Action Guidelines Governance System, Methodologies, and Use of Results 2017, Consultative version: www.unisdr.org

The economic cost of disaster to Australia

Australian Business Roundtable reports:

- March, 2016: Building Resilient Infrastructure
- March, 2016: The Economic Cost of the Social Impact of Natural Disasters
- July, 2014: Building an Open Platform for Disaster Resilience Decisions
- June, 2013: Building our Nation's Resilience to Natural Disasters: australianbusinessroundtable.com.au

Risk-based planning process

A Risk Assessment Process Handbook has been developed which outlines, in more detail, the processes involved in the Queensland Emergency Risk Management Framework, which will be further developed into guidelines with relevant training and capability development.

LOCAL LENS

Conduct Local Risk Assessments and develop Disaster Management Plans

DISASTER MANAGEMENT ACT 2003	
4A GUIDING PRINCIPLES (C) LOCAL GOVERNMENT RESPONSIBLE FOR MANAGING EVENTS IN THEIR LOCAL AREA	DIV 3, S30 – (A) (F) LOCAL GROUP TO ENSURE CONSISTENCY WITH STATE (POLICY & OPS) (C) PREPARE A LDM PLAN (D) ADVISE DISTRICT RE SUPPORT SERVICES REQUIRED (H) IDENTIFY AND COORDINATE USE OF RESOURCES THAT MAY BE USED FOR DM OPS

Local Risk Assessments and Plans

Residual Risk = Inherent Risk – (Local capability + capacity)

DISTRICT LENS

District Risk Assessment based on all Local Residual Risk to identify capability and capacity support requirements

DISASTER MANAGEMENT ACT 2003	
4A GUIDING PRINCIPLES (D) DISTRICT GROUPS AND THE STATE GROUP SHOULD PROVIDE LOCAL GOVERNMENTS WITH APPROPRIATE RESOURCES AND SUPPORT TO HELP LOCAL GOV CARRY OUT DISASTER OPS.	DIV 2, S23 – DISTRICT GROUP TO ENSURE CONSISTENCY WITH STATE (POLICY & OPS) (C) PREPARE A DDM PLAN (D) (II) REVIEW AND ASSESS LDMPS (G) COORDINATE STATE RESOURCES AND SERVICES PROVIDED TO SUPPORT LOCAL (H) IDENTIFY RESOURCES THAT MAY BE USED FOR DM OPS IN DISTRICT (I) MAKE PLANS FOR ALLOCATION, COORDINATION OF USE OF RESOURCES IN (H)

District Risk Assessments and Plans

Residual Risk = Inherent Risk – (District capability + capacity)

STATE LENS

State Risk Assessment based on all District Residual Risk to identify capability and capacity support requirements

State Requests for Assistance

NATIONAL LENS

Australian Government capability and support mechanisms

NATIONAL STRATEGY FOR DISASTER RESILIENCE

QUEENSLAND

The State context

B

Geography

Queensland is the second largest state in Australia and covers more than 22% of the total Australian continent, an area of 1,730,648 square kilometres.

The coastline of mainland Queensland is approximately 6,973 kilometres long.

Queensland has a diverse landscape that is dominated by its extensive coastline which is home to more than 60% of its resident population.

Queensland is essentially a state of extensive plains which merge into high country of sharper relief to the east and north-west. To the north, the country falls gradually to meet the coastal plain which reaches the Gulf of Carpentaria as a broad tract of salt flats.

The far north-west is occupied by a rugged uplands region, rich in minerals.

Eastward, the country rises towards the Great Dividing Range which runs from the southern border to the northern tip of the State and is the main watershed between the coastal and inland rivers.

East of the Great Dividing Range, the country drops seaward in a variety of ranges separated by lowlands.

This structure is continued in a chain of mountainous offshore islands sitting on the continental shelf. Beyond them is the Great Barrier Reef, a series of coral formations stretching for about 2,000 kilometres.

Outback Queensland is in stark contrast to the coast with its vast landscape and mining country with flat plains that connect to the inner arid terrain of Central Australia.

Queensland shares its borders with the Northern Territory in the west, New South Wales to the south and South Australia in the south-west corner.

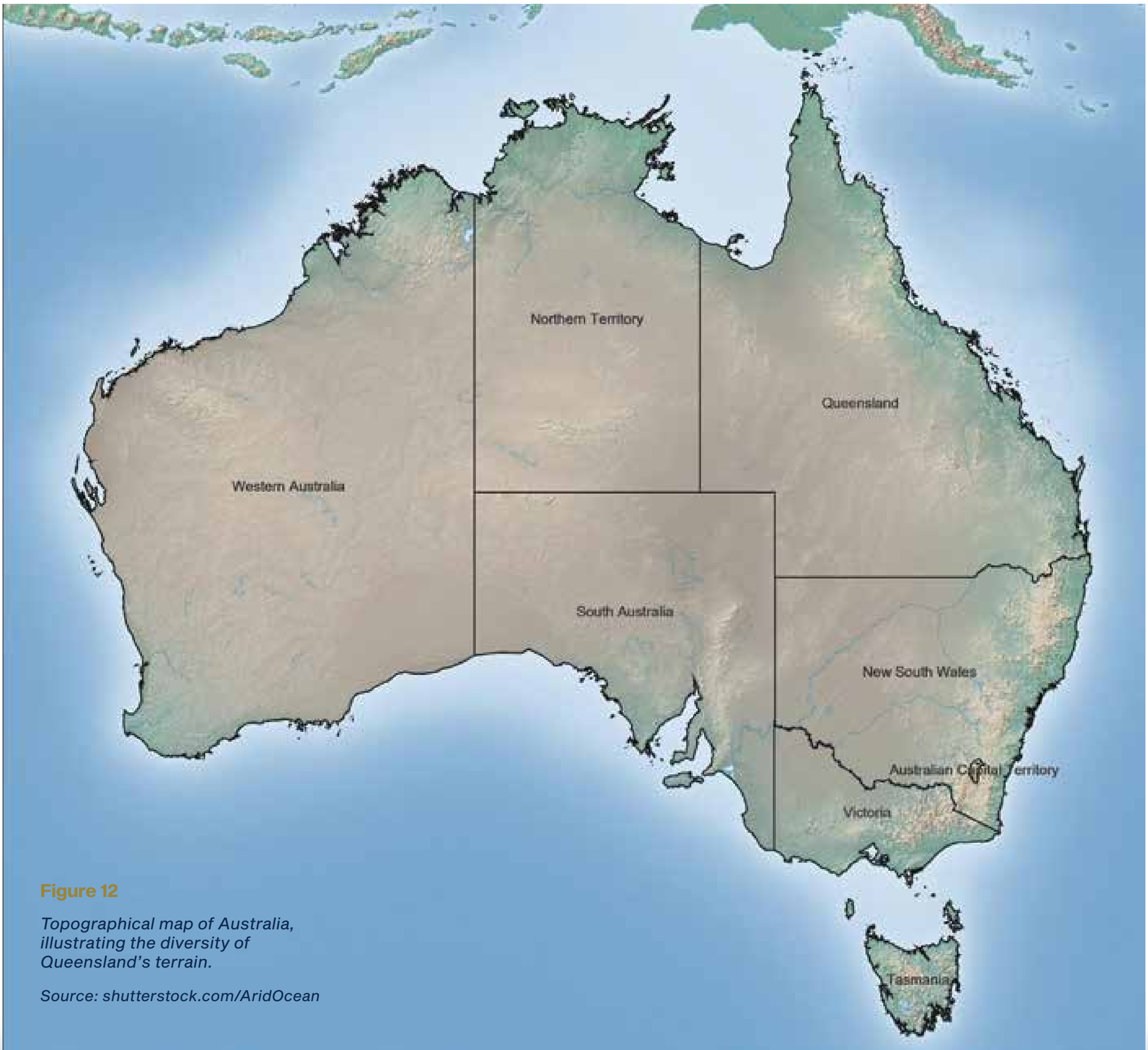


Figure 12

Topographical map of Australia, illustrating the diversity of Queensland's terrain.

Source: shutterstock.com/AridOcean

Queensland's economy

Growth in the Queensland economy is forecast to strengthen over the coming years from 2.4% in 2015-16, to 2¾% in both 2016-17 and 2017-18, and 3% in 2018-19. The 2017-18 Budget is focused on supporting continued growth and creating jobs for Queensland, while enabling the State's $300 billion economy to be more innovative, diverse and productive.

The 2017-18 Budget includes a range of measures which will boost productivity and support ongoing longer-term employment including significant infrastructure projects in both South East Queensland and regional Queensland as part of a $42.75 billion four year capital works program.

Operation Queensland Recovery is well underway to recover, reconnect and rebuild more resilient Queensland communities following Severe Tropical Cyclone (STC) Debbie. As at 2 June 2017, in the first two months after the cyclone, more than 118,000 people have been assisted.

Close to $30 million in assistance has already been distributed through the Personal Hardship Assistance Grants and Immediate Hardship Assistance Grants funded under the Natural Disaster Relief and Recovery Arrangements (NDRRA).

A $14.7 million Community Recovery Fund has been established and additional funding of $2 million has been provided for the government's Go Local campaign to support the agricultural industry in disaster affected areas.

The Queensland Government is also expecting to spend over $1 billion to restore essential public assets before reimbursements from the Australian Government through the jointly-funded NDRRA. This investment will rebuild vital infrastructure and supporting communities and stimulate significant short term construction activity and jobs in these regions.

More importantly, however, it will re-establish productivity enhancing infrastructure and restore the productive capacity of affected economies, thereby supporting ongoing growth and employment across the State.

As noted above, the Queensland economy is forecast to strengthen, from the 2.4% recorded in 2015-16, to 2¾% in both 2016-17 and 2017-18, and 3% in 2018-19. Based on forecasts by the Australian Treasury, this is stronger than expected national gross domestic product (GDP) growth of 1¾% in 2016-17 and in line with it in 2017-18 and 2018-19.

Queensland growth forecasts for 2016-17 and 2017-18 would have been higher but for the impact of STC Debbie, which is estimated to have detracted around $2 billion or ¾ percentage point from economic growth across these years.

Major impacts from STC Debbie include the loss of around 10 million tonnes of coal exports due to damaged rail infrastructure, around $300 million of losses to sugar exports and a considerable hit to tourism in the Whitsundays region. With the impact of the resources boom largely reflected in exports and population growth broadly in line with the national rate, Queensland's gross state product growth (GSP) is expected to remain in line with national growth in the projection years, at 3%.

Business investment continues to adjust in 2016-17 from the record levels experienced during the Liquefied Natural Gas (LNG) construction boom. Despite bright spots in tourism and education and ongoing spending in the coal seam gas (CSG) sector, business investment in Queensland is expected to be broadly unchanged in 2017-18, before returning to moderate growth from 2018-19 onward, consistent with the national growth profile.

Overseas exports are expected to grow solidly over the forecast period, generally between 3% and 4% per annum. In addition to the long-expected ramp up in LNG exports, coal exports are expected to recover from the fall in 2016-17 induced by STC Debbie.

The 2017-18 Budget features a range of further initiatives aimed at optimising the use of the State's land and natural resources, including promoting exploration and mining activities through the $27.1 million Strategic Resources Exploration Program.

Key elements of this initiative also form part of the government's overall package of $39 million over four years to deliver initiatives to support the North West Minerals Province, including implementation of the Queensland Government's Strategic Blueprint aimed at facilitating a strong and prosperous future for the region.

To protect the State's natural assets and ensure they continue to create wealth for current and future generations of Queenslanders, this Budget also allocates $175 million to improve water quality in the Great Barrier Reef, safeguard and respond to biosecurity related risks, and develop a Climate Change Strategy to assist Queensland to meet its national and international obligations related to CO_2 emissions targets.

The government's comprehensive Great Barrier Reef Water Quality Program, totalling $175 million over five years, is in addition to the $100 million provided in 2015-16 to address the recommendations arising from the Great Barrier Reef Water Science Taskforce. The Budget also includes $40 million to revitalise and leverage value from our national parks through increased tourism and other activities.

Queensland's economic growth is estimated to strengthen to 2¾% in both 2016-17 and 2017-18, with the ramp-up in LNG shipments continuing to boost overseas exports. This improvement is despite the impact of STC Debbie, which is estimated to have detracted around ¾ percentage point from economic growth across these two years.

GSP growth is forecast to strengthen further to 3% in 2018-19, with an anticipated recovery in business investment and a solid contribution from public sector capital spending supporting stronger domestic activity, as LNG exports plateau.

With the exception of the period of the GFC and natural disasters, Queensland has traditionally recorded economic growth rates above that nationally, underpinned by sustained resources sector investment and exports, as well as stronger population growth.

With these trends becoming less dominant and as growth becomes more broad-based across the major components of domestic demand, growth in Queensland is expected to remain in line with national growth in the projection years, at 3%.

Figure 13

Severe Tropical Cyclone Debbie approaches the Queensland coast in March 2017.

Source: National Aeronautics and Space Administration

Sources of information

Information in this section was sourced from the Queensland Treasury and Queensland Government's 2017-18 State Budget Papers.

www.treasury.qld.gov.au/economy/the-queensland-economy
www.budget.qld.gov.au

Economic impacts of Severe Tropical Cyclone Debbie

On Tuesday 28 March 2017, Category 4 Severve Tropical Cyclone (STC) Debbie crossed the Queensland coast around Airlie Beach, then tracked southwest over the next few hours before being downgraded to a tropical low the following day.

STC Debbie inflicted significant structural damage to properties in the Whitsunday Islands, Airlie Beach and Proserpine and dumped a substantial amount of rainfall across the central coast, highlands and coalfields all the way down to the southeast coast regions of Queensland and into New South Wales.

STC Debbie caused damage and distress to households, businesses and public facilities, and the recovery and repair will take an extended time. This assessment is focused on estimating the impact of the cyclone on overall economic output (as measured by GSP). This primarily involves examining any impact on Queensland's resources and agricultural production, as well as on the State's tourism sector. Impacts on the State Budget include the costs to rebuild damaged roads and local government infrastructure, providing assistance to individuals, families and businesses impacted by the disasters.

Overall, the loss to economic output due to STC Debbie is estimated to be around $2 billion or ¾ percentage point of GSP. Losses will be spread across several financial years, but predominantly in 2016-17 and 2017-18. Key sectors impacted include coal exports and agricultural production, as well as tourism in the Whitsundays.

Coal exports

Unlike the 2010-11 natural disasters, when losses were estimated to have reached $6 billion largely due to mine flooding, there have been no reports of substantial damage to mines or ports infrastructure.

The largest impact on coal exports was damage to rail networks, which included:

- the Goonyella network, closed from 28 March to 26 April
- the Blackwater network, closed from 29 March to 10 April
- the Moura network, closed from 29 March to 12 April
- the Newlands network, closed from 28 March to 13 April.

Overall, the effect of these closures is estimated to result in a net loss in exports of around 10 million tonnes in June quarter 2017, with approximately two-thirds hard coking coal and the remainder thermal coal.

Agriculture

The Mackay-Isaac-Whitsunday region is a significant agricultural region, with $1.1 billion of agricultural production in 2014-15, 9.4% of the Queensland total. The region's most valuable agricultural products in that year were beef ($485 million), sugar ($354 million), vegetables ($176 million) and grain sorghum ($64 million).

Looking at losses from previous similar events, such as STC Ului in 2010, Queensland Treasury expects losses in the nominal value of sugar exports due to STC Debbie to be around $300 million in the 2018 calendar year. Sorghum exports are expected to be reduced by $37 million in 2017-18.

However, better water availability is expected to boost wheat and chickpea exports in 2018 and dried shelled beans exports in 2017-18. In addition, despite some impact on fences and other farm infrastructure, graziers in the affected regions largely welcomed the rain accompanying STC Debbie, which in the longer term will assist herd rebuilding following a sustained period of drought.

Tourism

STC Debbie directly impacted the Whitsundays tourism region, including Airlie Beach and Whitsunday Island resorts. Overnight visitors spent an estimated $709 million in the Whitsundays region in 2016 (3.6% of the Queensland total), including spending by 243,000 international and 396,000 domestic tourists.

While no firm estimates of losses have been produced by the industry, Queensland Treasury assumes losses to overseas and interstate tourism of approximately $150 million. The loss of key resort capacity includes:

- Hamilton Island: no significant structural damage, partially re-opened on 8 April, then gradually to return to full capacity from August 2017
- Daydream Island: decided to bring forward $50 million redevelopment, reopening in mid-2018
- Hayman Island: closed and unable to accept new reservations until mid-2018.

Sound pricing of risk and strong investment performance has put the Queensland Government Insurance Fund (QGIF) in a good financial position, with investments held exceeding the provisioning for claims. As a result, $500 million will be drawn from the QGIF surplus to assist in funding the government's response to STC Debbie. On current estimates, this will still leave a substantial surplus in QGIF to respond to future claims.

The Queensland Government will contribute $110 million towards a proposed joint $220 million funding package under the Commonwealth and State-funded NDRRA Category D following STC Debbie.

Queensland's economic sectors

Queensland has significant endowments of natural resources, including minerals, land, water, reefs and its unique natural landscape and heritage. Importantly, key industries relying directly on the use of Queensland's land and natural resources are comparatively more important to regional Queensland, with mining, agriculture, forestry and fishing collectively accounting for only 2% of direct total employment in South East Queensland but nearly 12% in the rest of the State.

In addition, the Queensland tourism industry is linked closely to the State's natural assets (e.g. Great Barrier Reef, national parks, beaches and waterways and outback), many of which are located in regional areas.

Queensland has a modern, diversified economy, underpinned by strong sectors including agriculture, resources, construction, tourism, manufacturing and services.

Queensland's agriculture sector

Agriculture provides the original base for the development of the Queensland economy, accounting for 2.5% of the State's economy and employing over 57,000 Queenslanders. More than half of Queensland's agriculture output is produced in the Darling Downs-Maranoa, Queensland-Outback, Fitzroy and Wide Bay regions.

More than half of the value of Queensland agricultural production is derived from meat (mainly beef) and sugar, however these commodities have been supplemented by a large range of other agricultural products including vegetables, fruit and nuts, and crops such as wheat, sorghum and barley. The bulk of Queensland's agricultural commodities are produced for export, providing a significant contribution to the State's foreign earnings.

Queensland exported $9.1 billion of rural commodities in 2014-15, with the US, Japan and China accounting for over half of that trade.

The industry is sensitive to several external factors including weather events such as droughts, cyclones and flood events, as well as currency movements. Almost 70% of Queensland is currently drought declared and, if these conditions remain more protracted than assumed, this could impact on the production and export of key agricultural commodities.

Queensland's resources sector

The resources sector has been a key driver of growth in Queensland. The State's coal and bauxite reserves are among the largest in the world, and are generally of a high grade and easily accessible. Queensland is the world's largest seaborne exporter of metallurgical coal, with total coal exports exceeding 220 million tonnes in 2014-15.

Queensland also has well-developed coal and minerals industries while the natural gas industry, which has been operating domestically since the 1960s, has undergone rapid expansion and transformation into a major international export sector. The main minerals produced in Queensland are bauxite, copper, zinc, lead, silver and gold, although a wide variety of minerals are produced in the State.

Queensland's construction sector

Construction is another key driver of the Queensland economy. During 2014-15, the sector employed around 217,000 workers, making it the State's third largest employer accounting for 11.1% of the Queensland economy (the largest contribution to total state output).

Based on the Australian Bureau of Statistics, the three broad classes of construction include engineering construction (mines, ports, roads, bridges, rail and other infrastructure), non-residential building (shops, offices, factories, schools, hospitals, churches and theatres) and residential building (new houses, units, apartments and renovations).

Engineering construction work done totalled $28.1 billion in 2014-15, while non-residential construction work done totalled $6.8 billion in the same time period. In addition, residential construction work totalled $10.9 billion in 2014-15, with 21,102 new detached houses completed, along with 16,109 other dwellings, such as apartments and townhouses.

Queensland's tourism sector

Queensland boasts many natural attractions, including the Great Barrier Reef, extensive beaches, island resorts and tropical rainforests, as well as cosmopolitan cities and a unique countryside. International and domestic tourism will always play an important role in Queensland's economy. Rather than being a distinct industry, tourism economic activity covers a wide range of industries including accommodation, cafes and restaurants, transport services, retail trade and cultural and recreation services.

Queensland is Australia's second largest tourism market after New South Wales, accounting for 24.6% of the national tourism output and employing around 130,900 people.

Tourists visiting Queensland come from a diverse range of countries and from different regions within Australia. While international tourism generally gains most attention, it is actually domestic tourists that have the largest impact, accounting for more than two-thirds of total nights spent by tourists in Queensland.

Sources of information

Information in this section was sourced from the Queensland Treasury website.

www.treasury.qld.gov.au/economy/the-queensland-economy

Community

Australia's estimated resident population reached 24.1 million at 30 June 2016, increasing by 337,800 people or 1.4% since 30 June 2015. This growth rate was unchanged from 2014-15.

All states and territories experienced population growth between 2015 and 2016. Victoria had the greatest growth (123,100 people), followed by New South Wales (105,600) and Queensland (64,700).

Queensland's population is now more than 4,800,000 persons, accounting for over 20% of Australia's total population. Queensland was Australia's third largest state by population behind New South Wales and Victoria.

Pimpama on Queensland's Gold Coast recorded the second highest population growth rate in 2015-2016 at 35%.

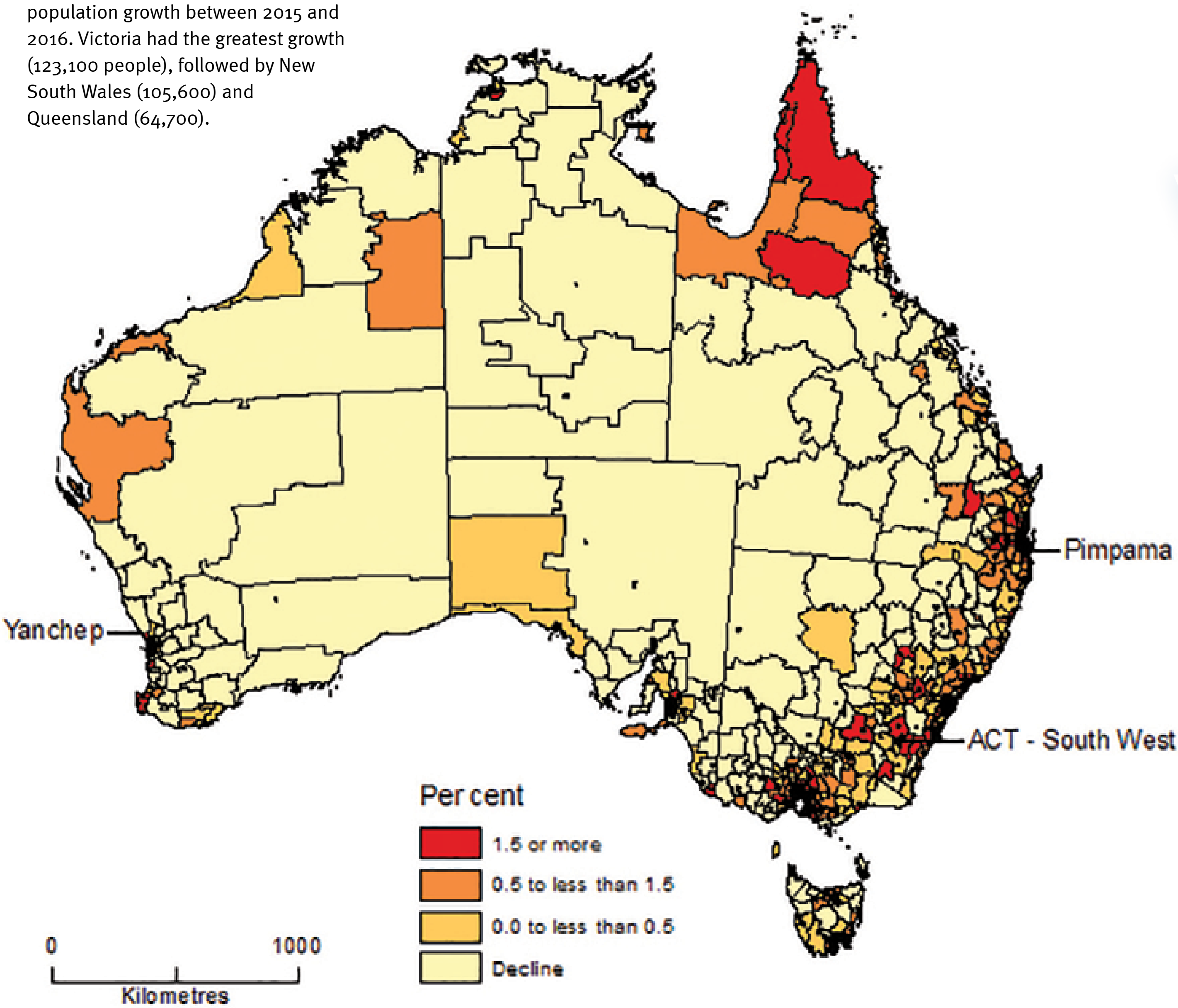


Figure 14

This map shows the change in population between 2015 and 2016 using the Australian Bureau of Statistics' Statistical Areas Level 2 (SA2s); all states and territories experienced population growth.

Source: Australian Bureau of Statistics

Between the 2006 and 2011 Census, the proportion of Queensland residents born overseas increased from 17.9% to 20.5% in the five years to 2011. In 2011, the main languages other than English spoken at home were Mandarin (0.9% of the population), followed by Cantonese (0.5%) and Vietnamese (0.5%).

On Census night in 2011, approximately two-thirds (66.8%) of households in occupied private dwellings included family groups. The mix of household types has remained steady since 2001. In each of the three Census years 2001, 2006 and 2011, approximately four in 10 private dwellings occupied on Census night housed a family with one or more children (of any age and not necessarily dependent). There was a small increase in the proportion of couples without children over the 10 years to 2011, from 25.3% to 26.6%.

The Queensland population is projected to grow to between 6.2 million and 7.3 million persons by 2036, and to between 8 million and 11.3 million by 2061. Annual growth rates are projected to range between 1.2% and 1.9% in 2036, declining to between 0.9% and 1.6% by 2061.

Net overseas migration is projected to continue to make a significant contribution to Queensland's population, adding between 1.9 and 2.9 million persons by 2061. Natural increase is projected to add between 1.2 and 3 million, with net interstate migration adding between 450,000 and 920,000 persons.

While numbers of people in all age groups are projected to increase, the age structure of Queensland's population is projected to change significantly in the 50-year period to 2061.

The number of people aged 65 years and over is projected to more than double by 2036, from 580,000 persons in 2011 to between 1.3 and 1.4 million persons. Further increases to between 2.0 and 2.6 million are projected by 2061. In 2011, this age group represented 13.0% of the total population.

This proportion is projected to increase to between 19.1% and 21.0% in 2036 and between 22.8% and 25.0% by 2061.

Despite the growth in older persons, the number of people aged 0 to 14 years is projected to increase from 892,000 persons in 2011 to between 1.3 and 2.2 million persons by 2061.

Gold Coast is projected to remain the most populous region in Queensland, increasing from 529,000 persons in 2011 to 883,000 persons by 2036. The Ipswich region is projected to have the second largest population in 2036 (increasing from 291,000 to 670,000 persons). Logan–Beaudesert is projected to have the next largest population in 2036, followed by Sunshine Coast, Brisbane's south and Brisbane's inner city (refer Figure 15).

SA4	Population		Population change 2011–2036
	2011	2036	
	– 000s –		000s
Brisbane–East	219.0	271.6	52.5
Brisbane–North	198.5	250.7	52.2
Brisbane–South	328.8	416.5	87.8
Brisbane–West	178.1	200.2	22.1
Brisbane Inner City	236.8	389.1	132.4
Cairns	232.8	324.8	92.0
Darling Downs–Maranoa	125.3	147.3	22.0
Fitzroy	217.1	324.2	107.1
Gold Coast	528.8	882.6	353.8
Ipswich	291.1	669.8	378.8
Logan–Beaudesert	300.2	522.2	222.0
Mackay	171.6	249.9	78.3
Moreton Bay–North	222.3	367.8	145.5
Moreton Bay–South	172.8	258.6	85.8
Queensland–Outback	86.6	96.8	10.2
Sunshine Coast	318.3	514.9	196.6
Toowoomba	144.3	197.5	53.2
Townsville	224.7	333.8	109.2
Wide Bay	280.0	364.8	84.8

Figure 15

Projected population, medium series, at 30 June, Queensland SA4s.

Source: Queensland Government Statistician's Office

Sources of information

Information in this section was sourced from:

Australian Bureau of Statistics. Regional Population Growth, Australia, 2015-16, available at: www.abs.gov.au

Queensland Statistician's Office. Queensland Government population projections, 2015 edition: Queensland and SA4s available at: www.qgso.qld.gov.au

Queensland's State Planning Policy

The State Planning Policy (SPP) is a key component of Queensland's planning system. The SPP expresses the State's interests in land use planning and development. A State interest is defined under the *Planning Act 2016* as an interest that the Minister for Planning considers:

- affects an economic or environmental interest of the State or a part of the State
- affects the interest of ensuring that the purpose of the Act is achieved.

Under the *Planning Act 2016*, each Local Government planning scheme needs to set out integrated State, Regional and Local planning and development assessment policies for an entire Local Government area. The SPP supports this by setting 17 State interests that apply to plan development, and that should be addressed through each Local Government planning scheme (refer to Figure 16 below).

The purpose of the SPP and the State interest policies is to secure a liveable, sustainable and prosperous Queensland. Planning should also contribute to the design and management of our cities, towns, rural communities and landscapes to create better places and spaces to live, work and play. It should do this while protecting our wellbeing and enhancing our natural environment, heritage and culture.

The SPP recognises that mitigating and adapting to climate change is also an important consideration for planning at all levels. All State interests should be applied and considered in the context of a changing climate to support Queensland's people, economy and the environment.

Natural hazards, risk and resilience is nominated as a State interest in planning and seeks to ensure the risks associated with natural hazards, including the projected impacts of climate change, are avoided or mitigated to protect people and property and enhance the community's resilience to natural hazards.

For more information visit the Department of Infrastructure, Local Government and Planning at www. planning.dilgp.qld.gov.au/ planning/better-planning/state-planning

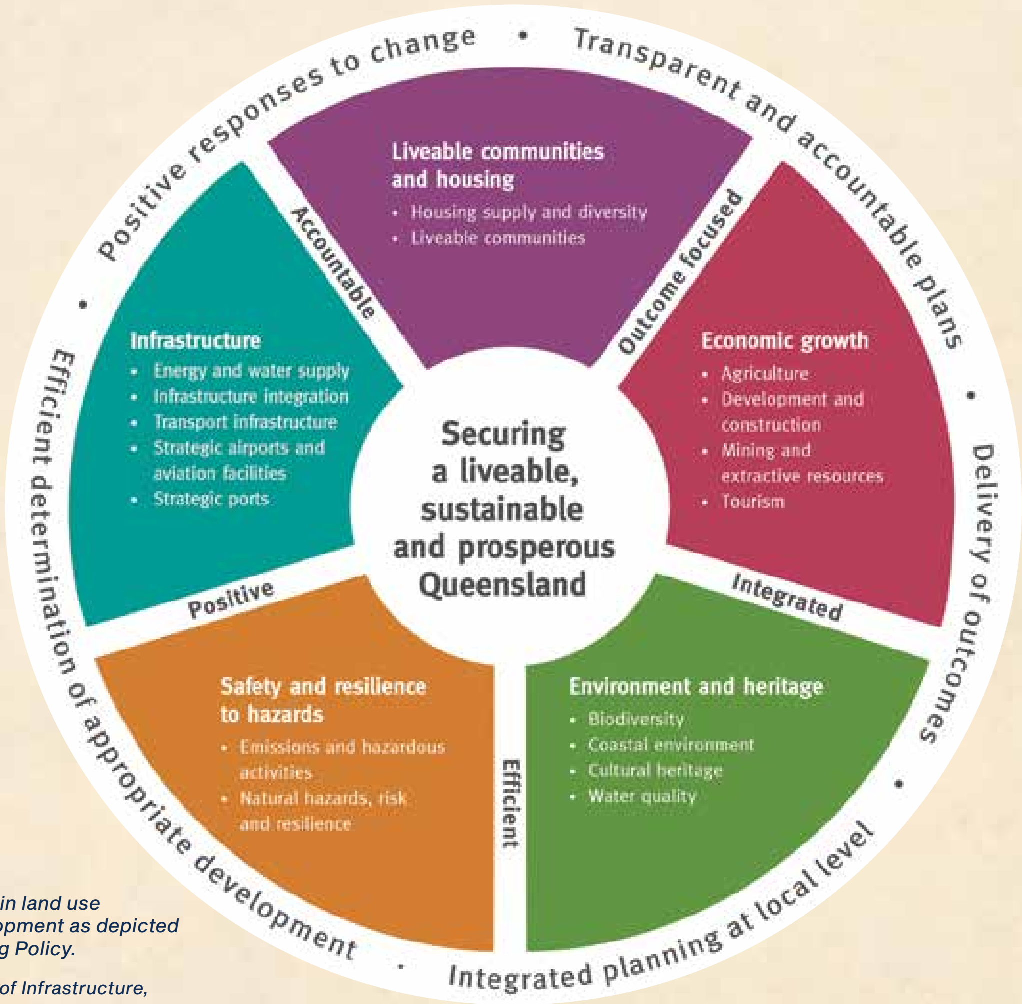


Figure 16

The State interests in land use planning and development as depicted in the State Planning Policy.

Source: Department of Infrastructure, Local Government and Planning

Queensland's climate

Queensland is a vast state with great variations in climate, from the temperate south to the tropical north and the arid west. South East Queensland, which includes Brisbane and the Gold and Sunshine Coasts, experiences warm summers with average maximum temperatures of 29°C and winter maximum temperatures averaging 20°C. The Cape York region's climate is tropical, with high to very high temperatures throughout the year.

Average maximum temperatures range from 32°C during December to February (the humid wet season) to 29°C from July to August. Western Queensland has a semi-arid to arid climate with very hot summers and warm, dry winters. The temperatures range from 37°C in summer to 24°C in winter.

Main climate influences

Australia's climate can vary greatly from one year to the next. The schematic from the Australian Bureau of Meteorology (Figure 17) shows the main influences on the Australian climate, which have varying levels of impact in different regions at different times of year.

The following are the main – but not all – influences on the Queensland climate.

The Madden-Julian Oscillation

The Madden-Julian Oscillation (MJO) is associated with weekly to monthly periods of enhanced and suppressed rainfall over parts of Australia. It is a global-scale feature of the tropical atmosphere and is the major fluctuation in tropical weather on weekly to monthly timescales.

The MJO can be characterised as an eastward moving "pulse" of cloud and rainfall near the equator that typically recurs every 30 to 60 days. Tropical cyclones are also more likely to develop in association with certain phases of a strong MJO event.

The MJO has its greatest effect on the tropical areas of Australia during summer and can influence the timing and intensity of "active" monsoon periods in northern Australia. This can lead to enhanced rainfall in both the intensity and duration.

El Niño Southern Oscillation

The term El Niño refers to the extensive warming of the central and eastern tropical Pacific Ocean which leads to a major shift in weather patterns across the Pacific and occurs every three to eight years.

El Niño Southern Oscillation is the term used to describe the oscillation between the El Niño phase and the La Niña, or opposite, phase. They typically begin to develop during autumn, strengthen in winter/spring and then decay during summer and autumn of the following year.

El Niño events are associated with an increased risk of dry conditions across large areas of Australia. The period of strongest influence is the six months of winter/spring (June to November). The effects of El Niño events are not uniform with the greatest impacts usually over inland eastern Australia.

La Niña, El Niño's opposite phase

La Niña conditions generally result in above average rainfall over much of Australia. La Niña is the positive phase of the El Niño Southern Oscillation.

It is associated with cooler than average sea surface temperatures in the central and eastern tropical Pacific Ocean. La Niña is normally associated with higher than average winter, spring and early summer rainfall over much of Australia.

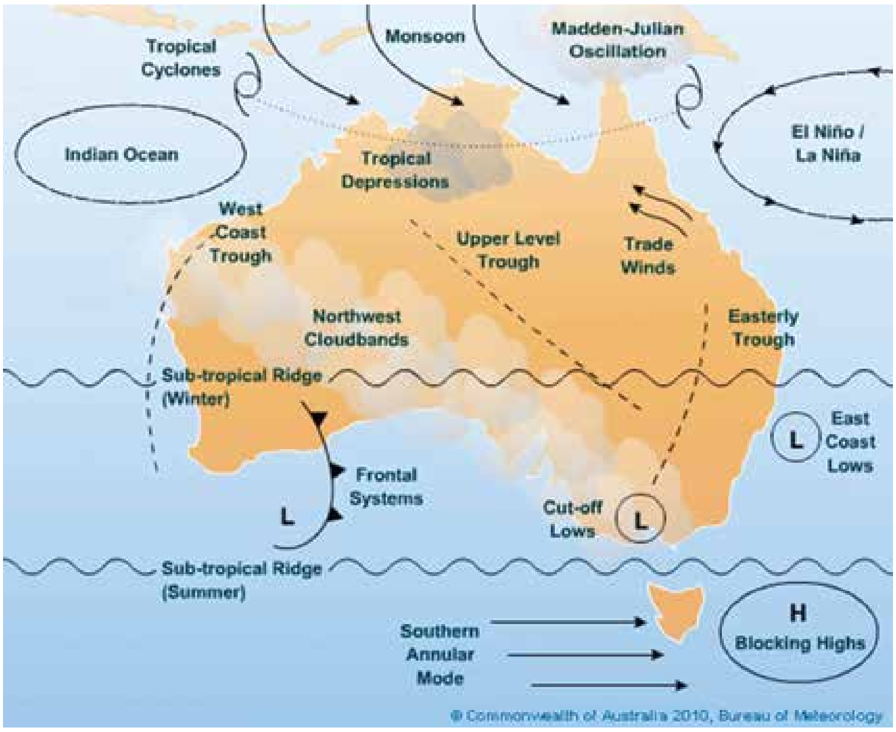


Figure 17

Natural climate influences to Australia.

Source: Bureau of Meteorology

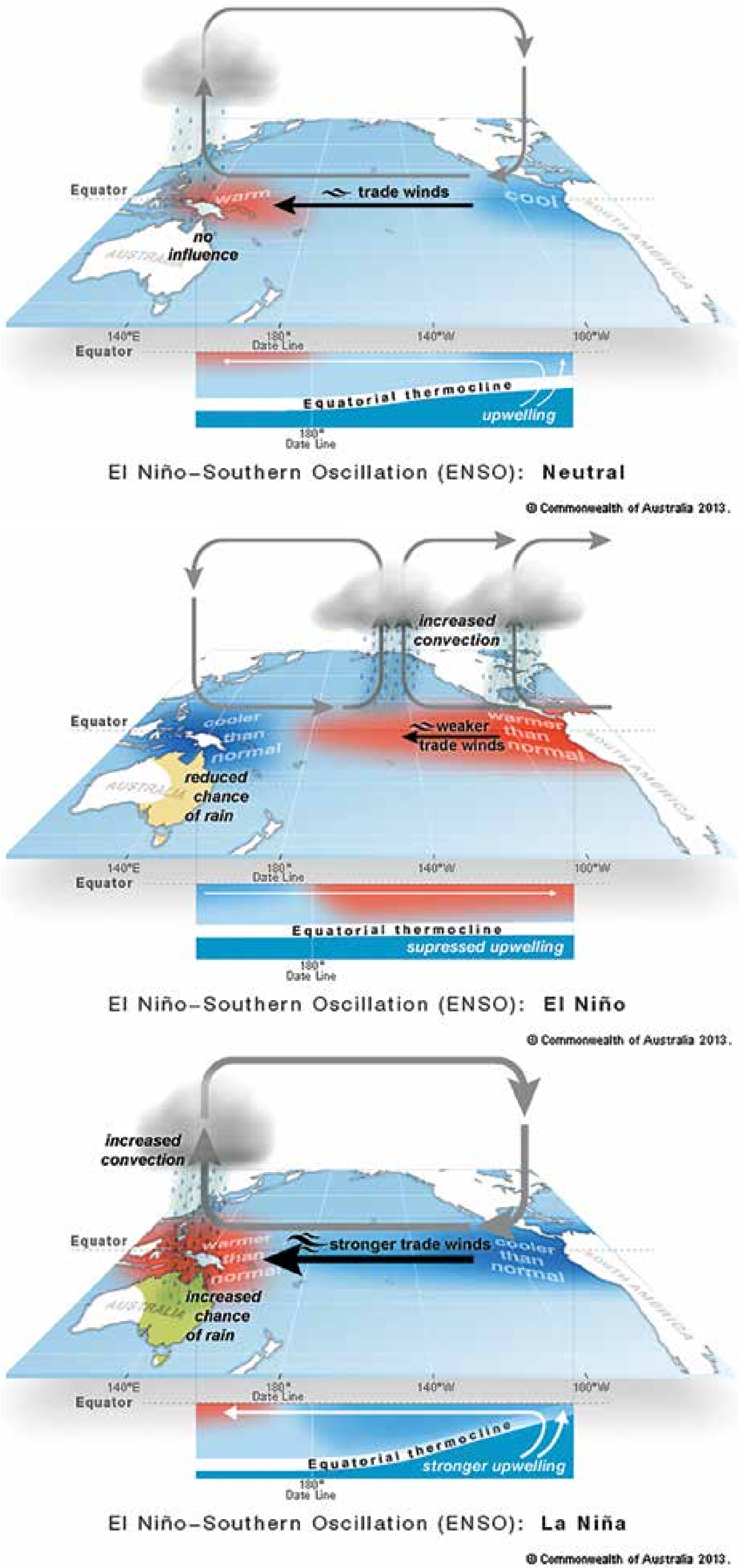


Figure 18

These diagrams demonstrate the oscillation between the El Niño phase and the La Niña, or opposite, phase.

Source: Bureau of Meteorology

East coast low

East coast lows are intense low-pressure systems which occur on average several times each year off the eastern coast of Australia, in particular southern Queensland, New South Wales and eastern Victoria. East coast lows will often rapidly intensify overnight making them one of the more dangerous weather systems to affect the south-east Australian coast.

East coast lows can form at any time of year, however they are most common during autumn and winter with a maximum frequency in June. Individual east coast lows generally only last for a few days. East coast lows are generally associated with strong, gusty winds, sustained heavy rainfall and high seas. They can cause widespread damage over a very short period of time.

Easterly trough

The easterly, or inland, trough is a dominant feature of the synoptic pattern over Australia during the summer months and brings rainfall to central and inland parts of eastern Australia.

The trough is located on the inland side of the Great Dividing Range, forming a boundary between the moist air near the coast and dry air inland. It extends through central Queensland and central New South Wales, sometimes extending right down into northern Victoria.

It is partly formed by the intense heating of the land during the summer months and also is influenced by the topography of the region. Easterly trough begins to form as the land warms up, as such they are most common during the summer months, December to February.

While an easterly trough forms to the west of the Great Dividing Range, a ridge of higher pressure will also form along the coast. This is particularly evident when a high pressure system is located in the Tasman Sea and is accompanied by south-easterly winds along the Queensland coast.

The easterly trough is a major contributor to rainfall in eastern Australia. Rainfall can be particularly heavy when the trough interacts with other features, such as an upper level trough approaching from the west, or when on-shore flow is north-easterly and, as a result, the ridge of higher pressure to the windward side of the Great Dividing Range is absent.

Trade winds

Trade winds are the east to south-easterly winds which blow across much of the southern hemisphere tropics, affecting tropical to subtropical areas of Australia.

The diagram below (Figure 19) shows the trade winds as a part of the global circulation of the atmosphere.

The trade winds affect much of the northern and parts of eastern Australia. They collect moisture as they move eastward over the tropical Pacific Ocean towards the east coast of Australia and are associated with enhanced rainfall to tropical and sub-tropical areas of the east coast.

The trade winds blow all year round as they are a part of the general circulation of the atmosphere. However, they are strongest in the winter months when they have the greatest effect on conditions (generally dry and stable) over inland northern Australia and the top end. In the summer months, the sub-tropical ridge moves south, the trade winds weaken and the monsoon returns to northern Australia.

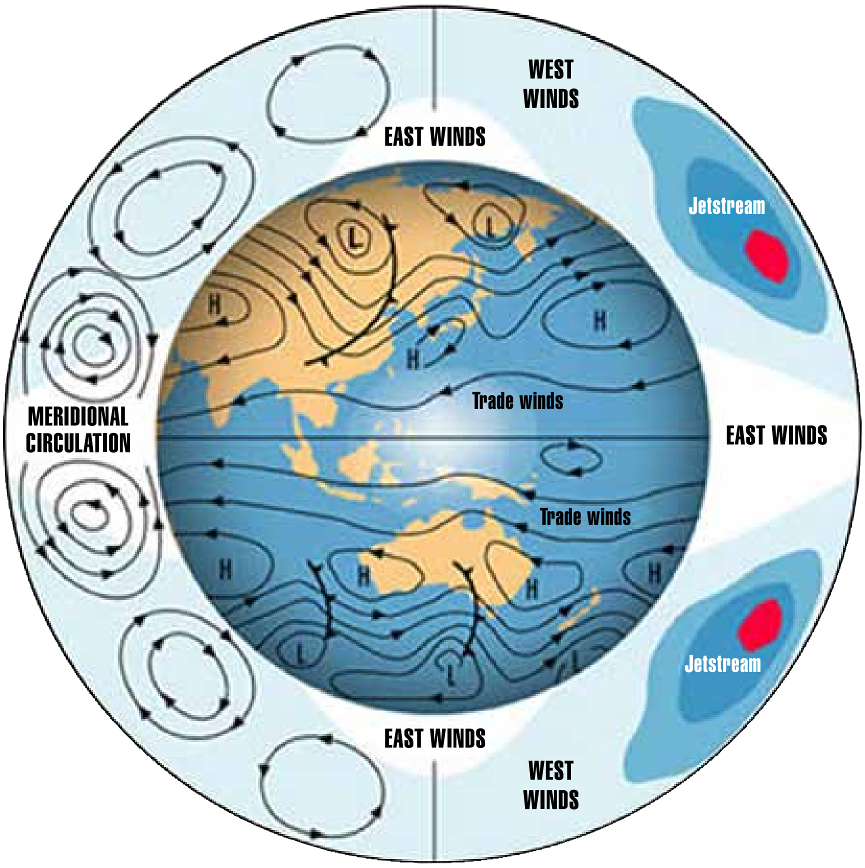


Figure 19

This diagram shows the general circulation of the atmosphere. The trade winds in the southern hemisphere are located to the north of the string of high pressure systems seen over Australia. This region of high pressure is known as the sub-tropical ridge.

Source: Bureau of Meteorology

The flow of the trade winds occasionally becomes disturbed by features such as east coast lows and easterly troughs.

These moisture-rich winds are associated with enhanced rainfall over tropical and sub-tropical parts of the eastern seaboard. The elevated areas of the Great Dividing Range in northern New South Wales and Queensland are most affected. Australia's wettest location, Mount Bellenden Kerr (1,545 metres above sea level) lies on the Great Dividing Range in the path of the trade winds between Cairns and Innisfail, and has an average annual rainfall of 7,708 millimetres.

During the winter months, the trade winds extend through the northern parts of the continent. These dry (continental) winds are thus associated with drier and more stable (fine and sunny) conditions over inland northern Australia, particularly the top end.

Tropical depression

Tropical depressions bring heavy rainfall to affected parts of northern Australia.

Tropical depressions are moderate-strength low pressure systems which occur in the tropics, often in association with the monsoon trough. Tropical depressions are stronger in intensity than weak tropical lows, but are not as strong as tropical cyclones, though they may develop into a tropical cyclone if they remain in the right conditions for long enough. A weakening tropical cyclone is also referred to as a tropical depression once it has decayed to below Category 1 strength.

Tropical depressions can affect Australia at any time between about October to April and can last from a day to a couple of weeks, depending on the environmental conditions. Tropical depressions are associated with occasional thunderstorms, fresh to strong and gusty winds and heavy rain, often leading to the flooding of affected areas.

Sub-tropical ridge

The sub-tropical ridge brings dry and stable conditions to large parts of Australia. The sub-tropical ridge runs across a belt of high pressure that encircles the globe in the middle latitudes. It is part of the global circulation of the atmosphere, as shown in Figure 20 overpage.

The position of the sub-tropical ridge plays an important part in the way the weather in Australia varies from season to season. During the warmer half of the year in southern Australia (November to April), the sub-tropical ridge is generally located to the south of the continent. High pressure systems (also called anticyclones), which are associated with stable and dry conditions, generally move eastwards along the ridge.

In autumn the sub-tropical ridge moves north and remains over the Australian continent for most of the colder half of the year in southern Australia (May to October). Conditions along the ridge, under the influence of the high pressure systems' dry and descending air, tend to be stable and drier.

The sub-tropical ridge is a dynamic feature of the atmospheric circulation, which is present all year round. It is a broadscale feature and, as such, it affects much of Australia. This effect is greatest however over central Australia, where the sub-tropical ridge is dominant for most of the year.

As the sub-tropical ridge moves south during the warmer part of the year in southern Australia, the monsoon trough moves over the northern part of the continent. The southward movement of the sub-tropical ridge is related – through the atmospheric circulation – to the development of the monsoon trough, which brings cloud and rain to northern Australia.

Conversely, as autumn/winter arrives in southern Australia, the south-easterly trade winds begin to dominate the weather in the north of the country. During this time, the monsoon trough is pushed back towards the northern hemisphere and conditions become more settled in northern Australia (generally fine and sunny).

Monsoon

Monsoon is used to describe the seasonal reversal of winds that occurs over parts of the tropics and is part of the usual evolution of the seasons in northern Australia.

Active phases of the monsoon bring heavy rainfall to northern Australia. In northern Australia, the prevailing wind is from the east or south-east for most of the year, but during active monsoon periods (occurring any time during November to April) the winds shift to become north-westerly at the surface.

As the Australian summer approaches and the continent heats up, low pressure is created, which effectively draws the monsoon trough – a zone of low pressure and rising air – over northern Australia. This trough draws in moist air from the surrounding oceans and this influx of moist air is referred to as the monsoon.

The monsoon can be in either an active or inactive phase. The active phase is usually associated with broad areas of cloud and rain, with sustained moderate to fresh north-westerly winds on the north side of the trough. Widespread heavy rainfall can result if the trough is close to, or over, land. An inactive or "break" period occurs when the monsoon trough temporarily weakens or retreats north of Australia. It is characterised by light winds and isolated shower and thunderstorm activity, sometimes with gusty squall lines.

Transitions from active to inactive monsoon phases may be associated with the Madden-Julian Oscillation, a large-scale slow-moving band of increased cloudiness that travels eastwards in the tropics and discussed earlier in this section.

The monsoon trough frequently spawns individual low pressure systems, producing heavy rain and flooding.

The northern wet season extends from about October to April in the far north of the Northern Territory, but generally starts later and ends earlier elsewhere.

Active monsoon periods may occur at any time during this period, however the initial monsoon onset, as defined by the reversal of the winds, normally occurs in late December around Darwin. Later than normal onsets are often associated with El Niño conditions in the Pacific Ocean, while La Niña is usually associated with an early onset.

A typical wet season consists of a prolonged inactive period during the buildup (period before initial onset), followed by two or three active/inactive cycles, each full cycle lasting from about four to eight weeks. Inactive periods are usually longer than active ones.

The monsoon is associated with cloudy conditions, lengthy periods of heavy rain, occasional thunderstorms and fresh to strong squally winds. This often causes flooding in affected areas.

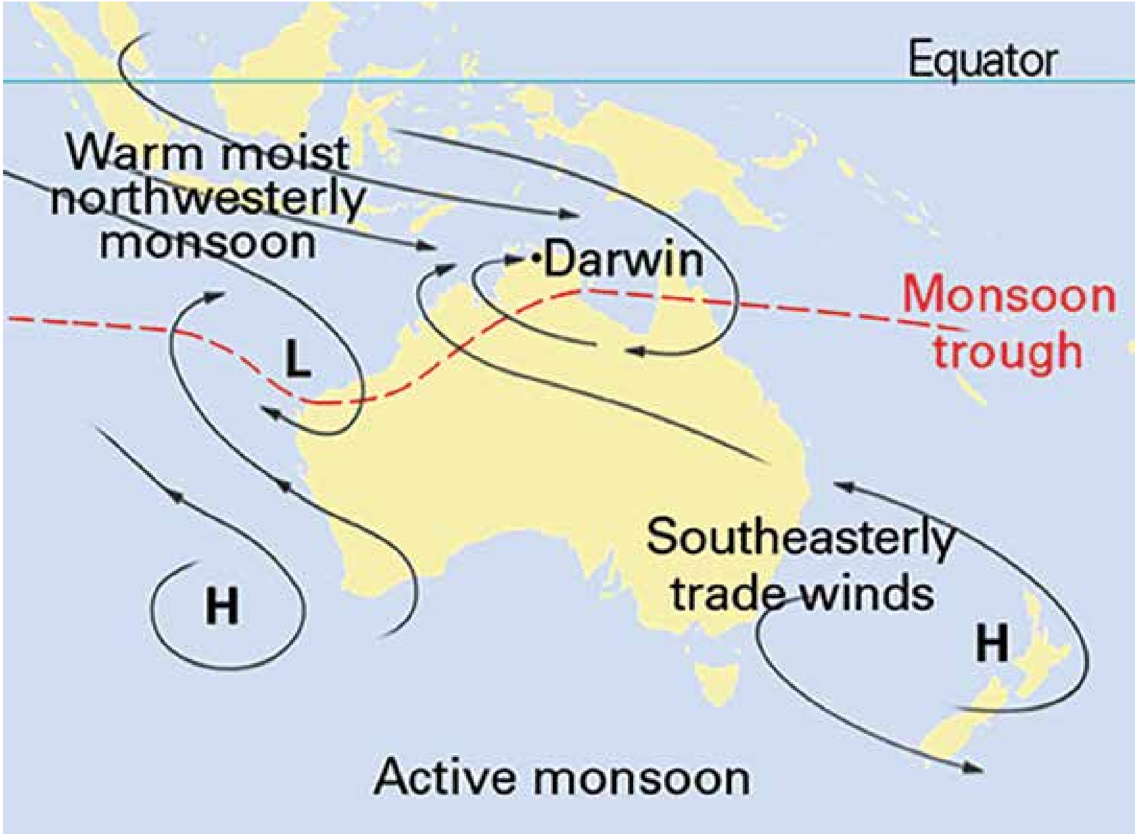


Figure 20

This diagram shows the synoptic patterns typically associated with the active phase of the north Australian monsoon. The dashed red line indicates the position of the monsoon trough, which will shift slightly as weather systems progress across the continent. The monsoon trough is an area of low pressure along which broad-scale convergence and convection occurs.

Source: Bureau of Meteorology

Sources of information

Information in this section was sourced from the Australian Bureau of Meteorology.

www.bom.gov.au

Climate change projections

The Climate Council of Australia has noted that the basic physics that govern the behaviour of the climate system show that extreme weather events are now occurring in a significantly warmer and wetter atmosphere. This means the atmosphere contains more energy, facilitating more severe extreme weather.

The State of the Climate 2016 report written by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Australian Bureau of Meteorology (BoM) highlights the key impacts of climate change for Australia:

- the climate has warmed in both mean surface air temperature and surrounding sea surface temperature by around 1°C since 1910
- the duration, frequency and intensity of extreme heat events across large parts of Australia has increased
- extreme fire weather, and a longer fire season, across large parts of Australia has increased since the 1970s
- rainfall has reduced by around 19% during the May to July period in the south-west of Australia since 1970
- rainfall has declined by about 11% in the April to October growing season in the continental south-east since the 1990s
- rainfall has increased across parts of northern Australia since the 1970s
- oceans around Australia have warmed and ocean acidity levels have increased
- sea levels have risen around Australia which amplifies the effects of high tides and storm surges.

How will climate change affect Queensland?

The State will experience higher temperatures, hotter and more frequent hot days, harsher fire weather, fewer frosts, reduced rainfall in the south-east, more intense downpours, less frequent but more intense tropical cyclones in the north, rising sea level, more frequent sea level extremes, warmer and more acidic seas. Climate change is influencing all extreme weather events in Australia as these events are now occurring in an atmosphere that is warmer and wetter than it was in the 1950s:

- heatwaves are becoming hotter, lasting longer and occurring more often
- extreme fire weather and the length of the fire season is increasing, leading to an increase in the probability of bushfire, particularly for southern and eastern Australia
- the sea level has already risen and continues to rise, driving more coastal inundation during storm surges.

These extreme weather events are projected to worsen as the climate warms further:

- extreme heat is projected to increase across the entire continent, with significant increases in the length, intensity and frequency of heatwaves in many regions
- the time spent in drought is projected to increase across Australia, especially in southern Australia with extreme drought expected to increase in both frequency and duration
- southern and eastern Australia are projected to experience harsher fire weather
- the intensity of extreme rainfall events is projected to increase across most of Australia
- the increase in coastal flooding from high sea level events will become more frequent and more severe as sea levels continue to rise.

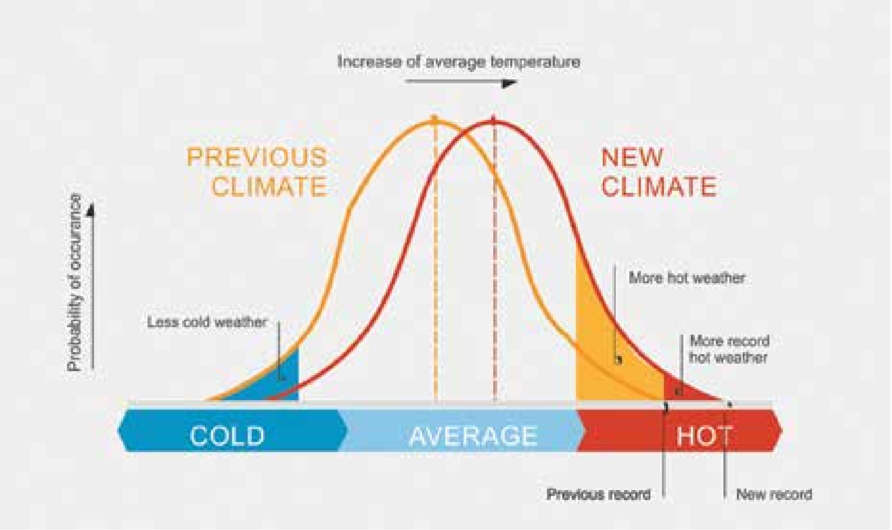


Figure 21

This diagram shows how a small increase in average temperature has a large impact on the prevalence of extreme heat.

Source: Climate Council

The Queensland Government has allocated $15 million from 2015 to 2018 to tackle climate change impacts.

Queensland is working with a broad group of partners to develop and implement the Queensland Climate Adaptation Strategy (Q-CAS) and roll out the Climate Change (Coastal Hazards) Adaptation Program (CHAP) in partnership with the Local Government Association of Queensland and coastal councils.

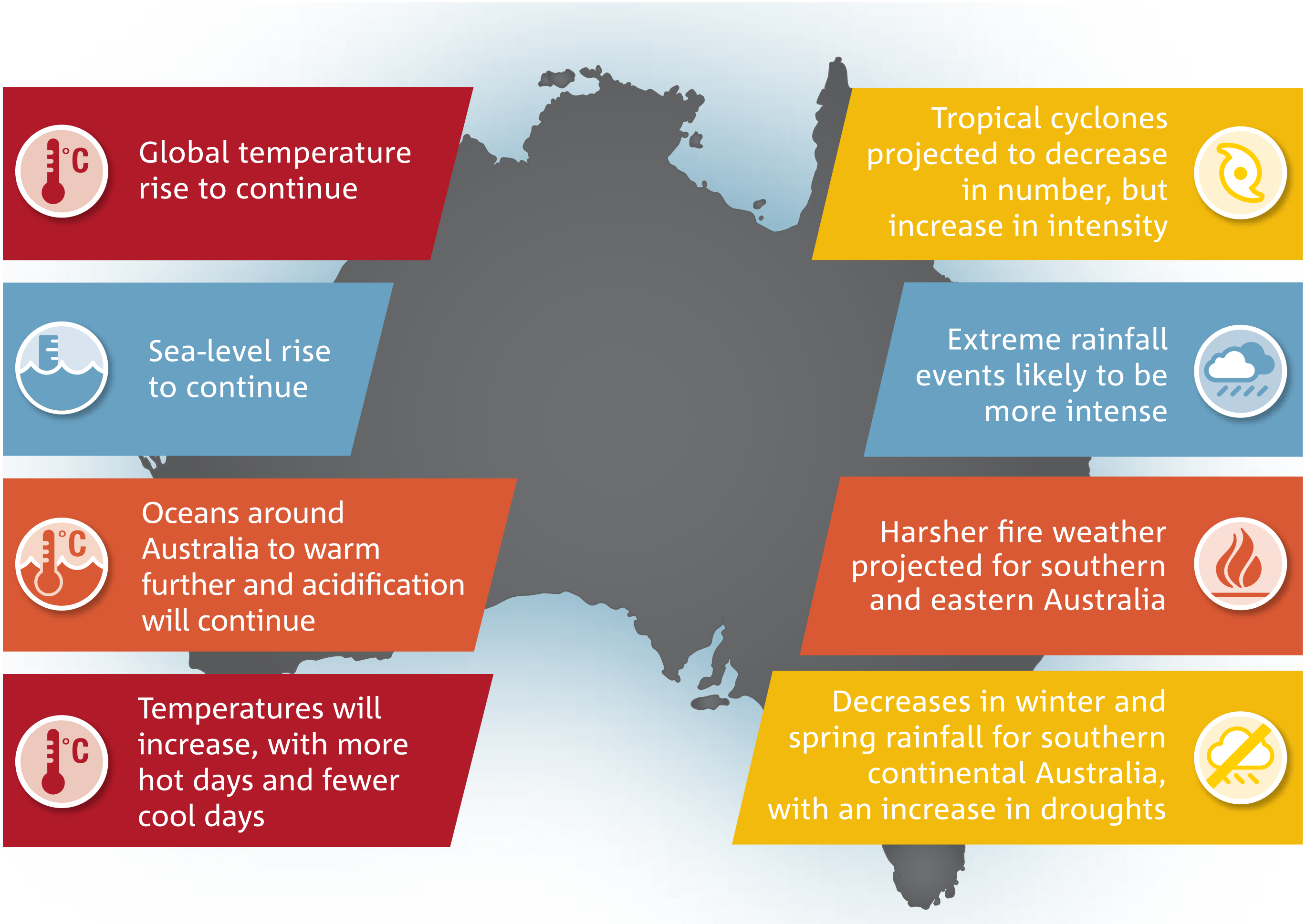


Figure 22

Summary of climate change effects on Australia.

Source: Bureau of Meteorology

Sources of information

Information in this section was sourced from the Climate Change in Australia report and State of the Climate 2016 report by CSIRO and BoM, and the Climate Council of Australia.

The Climate Change in Australia report, as well as accompanying interactive materials can be found at: www.climatechangeinaustralia.gov.au

The State of the Climate 2016 report can be found at: www.bom.gov.au/state-of-the-climate

The Climate Council of Australia's website is at: www.climatecouncil.org.au

Additional information about Queensland's natural climate influencers can be found at: www.bom.gov.au

C

The Queensland State Natural Hazard Risk Assessment

Scope

This is the first State level assessment using the Queensland Emergency Risk Management Framework.

While the framework can accommodate all hazards, this initial assessment has been limited to the natural hazards that have the most significant impact to the State of Queensland, as shown in Figure 23.

Future iterations of State-level risk assessments will mature toward encompassing all disaster events identified within the *Disaster Management Act 2003*.

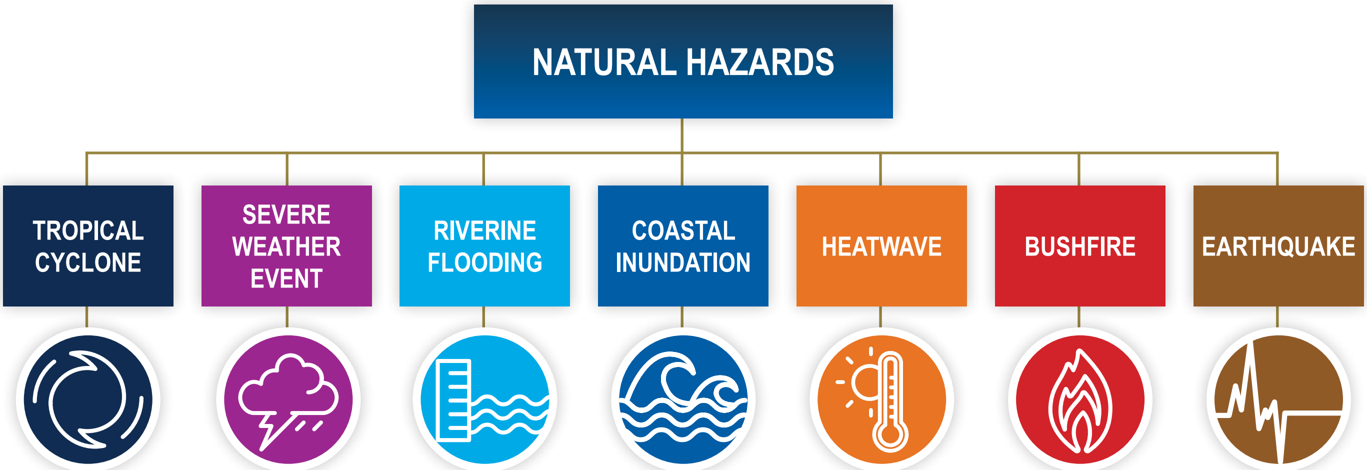


Figure 23

Seven natural hazards are addressed in the scope of this assessment document.

Source: Icons supplied by Bureau of Meteorology and adapted by Queensland Fire and Emergency Services

Figure 24

Boats litter the foreshore of Port Hinchinbrook Marina as a result of the winds and storm surge from Severe Tropical Cyclone Yasi in February 2011.

Source: Torsten Blackwood

Risk assessment process: snapshot

This risk assessment approach includes two key processes to identify the risk and then to assign the level of risk.

The outcomes of these two processes are used to populate multiple risk management documents including the Risk Assessment Table, Risk Register and Decision Log. The process is outlined in Figure 25.

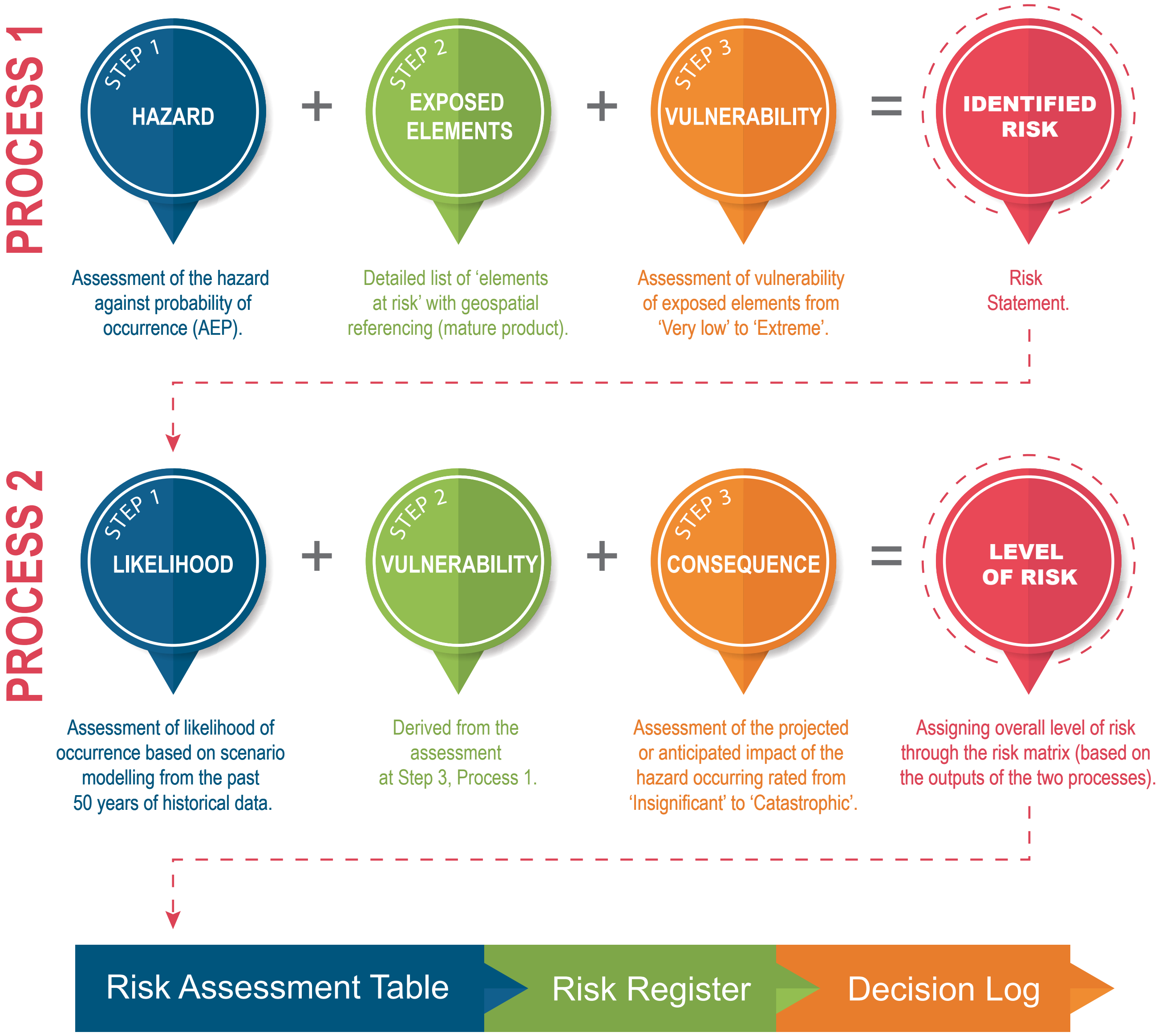


Figure 25

The risk assessment process underpins the identification and assessment of risk.

Source: Queensland Fire and Emergency Services

Developing the State Natural Hazard Risk Assessment

As depicted in Figure 9 on page 17 in Part B, Queensland's Disaster Management Arrangements commence at the Local level, with the 77 Local Government groups having primacy in managing disaster events within their area. This includes conducting risk assessments and the development of disaster management plans.

The 22 Disaster Districts review the Local assessments and plans within their district boundaries to identify any resources and support requirements through the development of a District level risk assessment and disaster management plans appropriate to their context.

A key element of this approach is the identification of residual risk which then informs where additional support may be required. The State Natural Hazard Risk Assessment comprises macro-level, hazard-specific risk information.

Each profile refers to potential exposures which at the operational level involves analysing the societal elements within a given area that have been or could be subject to the impact of the particular hazard. **Exposed elements** considered include:

- Essential Infrastructure
- Access/resupply
- Community & Social
- Medical
- Significant Industries
- Environment.

Once exposed elements are identified, geospatial referencing to map the locations and the interdependencies of these elements is conducted. This is an essential step in assessing the impact of hazards upon the elements – and in particular the networks and systems relevant to their effective and efficient functioning – across broad areas.

A key determinant used in the development of the risk analysis is the assessment of the vulnerability of exposed elements. In this process, **vulnerability** is assessed by reviewing the level of exposure and susceptibility, the ability to sustain a community during and post an event, and the effectiveness of current control and mitigation measures. The assessment includes consideration of:

- loss of essential infrastructure and recovery timeframes
- repair/rebuild timeframes of essential infrastructure
- access/resupply to, or evacuation from, the area/community/site
- topographic features of the area/community/site that exacerbate the impact of a hazard
- demographic features of the area/community/site that typify the population as vulnerable
- health support services available in the area/community/site
- effectiveness of current control or mitigation measures.

Figure 26

The effects of Severe Tropical Cyclone Debbie on Daydream Island in March 2017.

Source: Department of Natural Resources and Mines

The analysis of vulnerability is a direct precursor to identifying risk. Including vulnerability in the methodology allows for the analysis of individual characteristics of a community and ensures all risk management planning is 'fit for purpose' for that particular area.

Conversely, risks to a particular community can be reduced by directly addressing these identified vulnerabilities.

The level of risk is determined through an assessment of consequence which is a product of the severity of exposure, the level of vulnerability and the coping capabilities and capacities of the communities involved.

Consequences of an event are derived from analysing the effects on communities based on the severity of exposure and the level of vulnerability.

The level of consequence is an assessment of what the projected or anticipated impact would be, either directly or indirectly, of the hazard manifesting on Local, District and State assets. These may be both short term and longer term impacts (i.e. weeks, months, years) depending on the severity of the impact.

In assessing exposure and vulnerability, the level of impact of a hazard manifesting can be determined by identifying key features of a community that include:

- **People (casualties) – the number of casualties and fatalities**
- **Financial & Economic – impacts to the Queensland economy, which may include a decline of both micro or Local level and macro or State and National level economic activity (over months or years).**
- **Community & Social – destruction or damage to objects or places of cultural and religious significance and community cohesion.**
- **Public Administration – governing bodies' ability to cope within response and recovery phases and the resulting level of public confidence and media.**
- **Environmental – damage or destruction to natural resources, ecosystems and or species.**

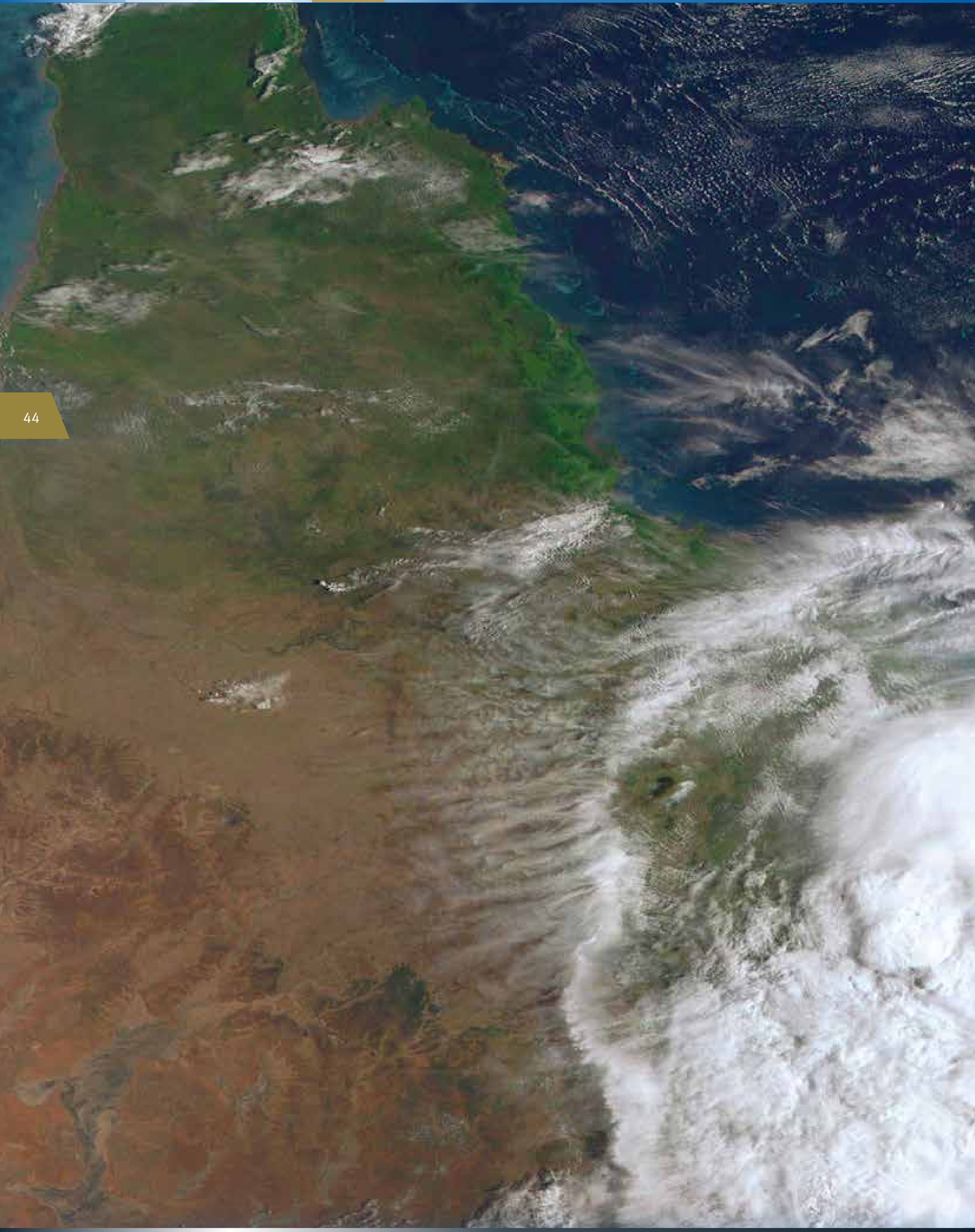
While the consequence criteria and levels provided are derived from the National Emergency Risk Assessment Guidelines 2015, some aspects of the criteria such as 'People (casualties)' and 'Financial & Economic' assessments have been developed based on the Australasian Triage Scale and advice from Queensland Treasury.

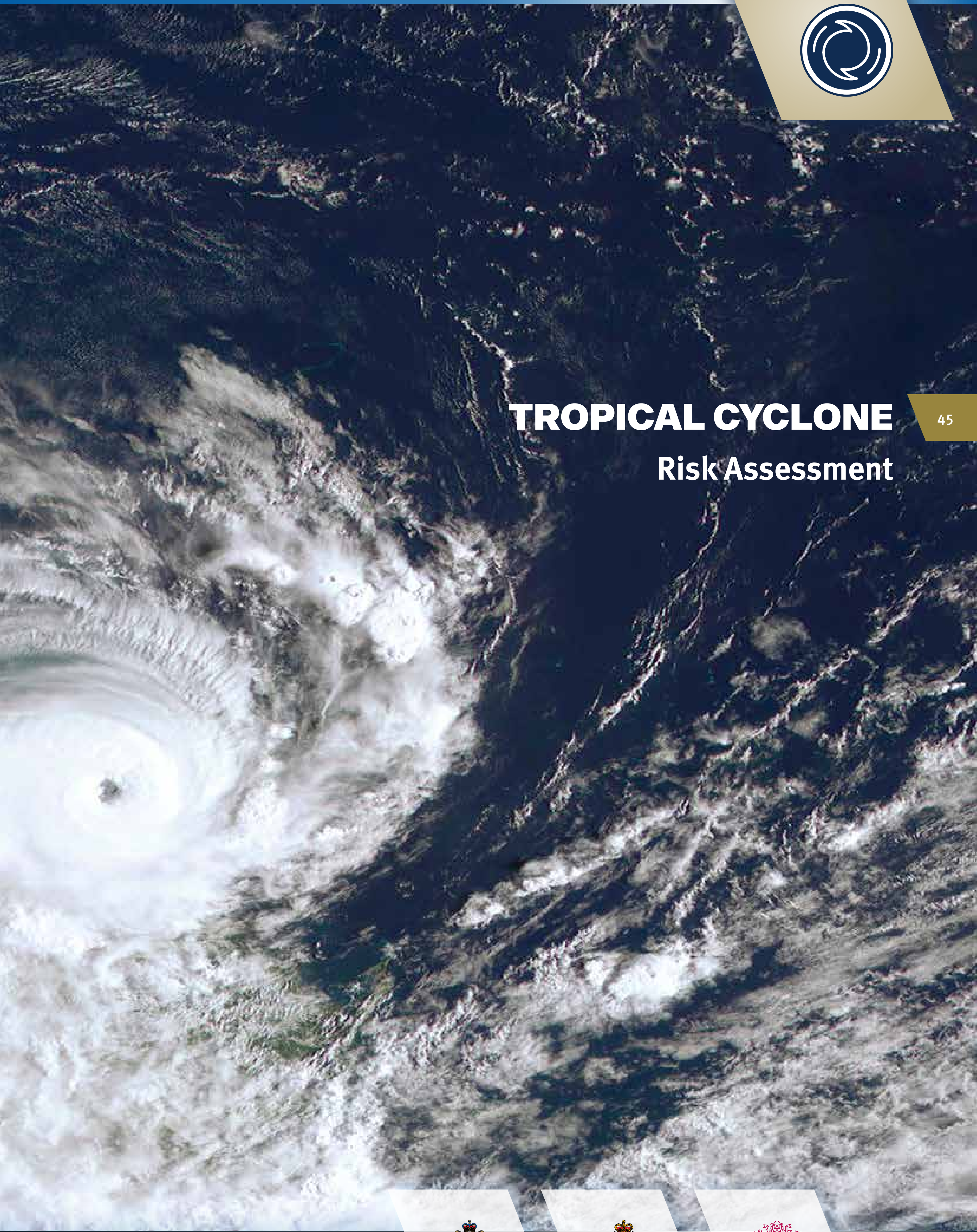
The hazard-specific risk profiles presented in the following pages together comprise the State Natural Hazard Risk Register.

Risk profiles have been chosen over a more traditional register format as they afford more risk information for readers. The hazard-specific risk profiles are a product of reviewing the operational detail within the District and Local risk assessments and disaster management plans as well as conducting further State level analysis.

Each hazard-specific risk profile includes the following sections:

- **Definition and explanation of the hazard phenomenon**
- **Queensland context**
- **Multi-hazard interaction (if relevant to that hazard)**
- **Potential exposures**
- **Risk analysis and risk statement**
- **Treatments**
- **Other useful information sources.**





TROPICAL CYCLONE

Risk Assessment

Tropical Cyclone

Definition

Tropical cyclones are low pressure systems that form over warm tropical waters and have gale force winds (sustained winds of 63 km/h or greater and gusts in excess of 90 km/h) near the centre. Technically they are defined as a non-frontal low pressure system of synoptic scale developing over warm waters having organised convection and a maximum mean wind speed of 34 knots or greater extending more than half-way around near the centre and persisting for at least six hours.

The gale force winds can extend hundreds of kilometres from the cyclone centre. If the sustained winds around the centre reach 118 km/h (gusts in excess 165 km/h), the system is called a Severe Tropical Cyclone. These are referred to as hurricanes or typhoons in other countries. The circular eye or centre of a tropical cyclone is an area characterised by light winds and often clear skies. Eye diameters are typically 40 km but can range from under 10 km to over 100 km. The eye is surrounded by a dense ring of cloud about 16 km high known as the eye wall which marks the belt of strongest winds and heaviest rainfall.

Tropical cyclones derive their energy from the warm tropical oceans and do not form unless the sea-surface temperature is above 26.5°C, although once formed, they can persist over lower sea-surface temperatures. Tropical cyclones can persist for many days and may follow quite erratic paths. They usually dissipate over land or colder oceans. Every cyclone is unique, varying according to a number of factors including life cycle, intensity, movement, size and impact (wind, storm surge and flooding), as shown in the table below.

Category	Strongest gust (km/h)	Typical effects
1 Tropical Cyclone	Less than 125 km/h Gales	Minimal house damage. Damage to some crops, trees and caravans. Boats may drag moorings.
2 Tropical Cyclone	125 - 164 km/h Destructive winds	Minor house damage. Significant damage to signs, trees and caravans. Heavy damage to some crops. Risk of power failure. Small boats may break moorings.
3 Severe Tropical Cyclone	165 - 224 km/h Very destructive winds	Some roof and structural damage. Some caravans destroyed. Power failure likely.
4 Severe Tropical Cyclone	225 - 279 km/h Very destructive winds	Significant roofing and structural damage. Many caravans destroyed and blown away. Dangerous airborne debris. Widespread power failures.
5 Severe Tropical Cyclone	More than 280 km/h Extremely destructive winds	Extremely dangerous with widespread destruction.

Figure 27

The severity of a tropical cyclone is described as categories ranging from 1 to 5.

Source: Bureau of Meteorology

The Queensland context

When assessing the potential for the effect of cyclonic event, a 200 km buffer is applied to the geographical boundary of Queensland to take into consideration indirect effects of tropical cyclones that do not make landfall. Since 1 January 1967 Queensland has experienced the direct and indirect effects of 146 cyclones of varying strength, duration and intensity (Category 1 to Category 5).

This is inclusive of those cyclones that have developed outside Queensland but make landfall as a tropical low.

While satellite tracking of cyclones began in 1970, 1967 represented a significant year in Queensland's cyclone history with 4 tropical cyclones and 5 east coast lows impacting on South East Queensland between January and July alone.

Consideration of these events within a 50 year timeframe also allows us to observe changes in frequency and intensity of cyclones due to climate change.

Whereas the cyclone season officially runs from 1 November to 30 April, the breakdown of occurrences (shown below) shows a greater propensity for cyclones to impact Queensland from January through to April.

Month	November	December	January	February	March	April	May
Number of Events	2	17	43	33	34	16	1
Percentage of Total Events	1%	12%	29%	23%	23%	11%	1%

Figure 28

Queensland has experienced the effects of 146 cyclones since 1967. Note that these figures represent the date the cyclone was initially designated by the Bureau of Meteorology (not the total span of the event).

Source: Bureau of Meteorology

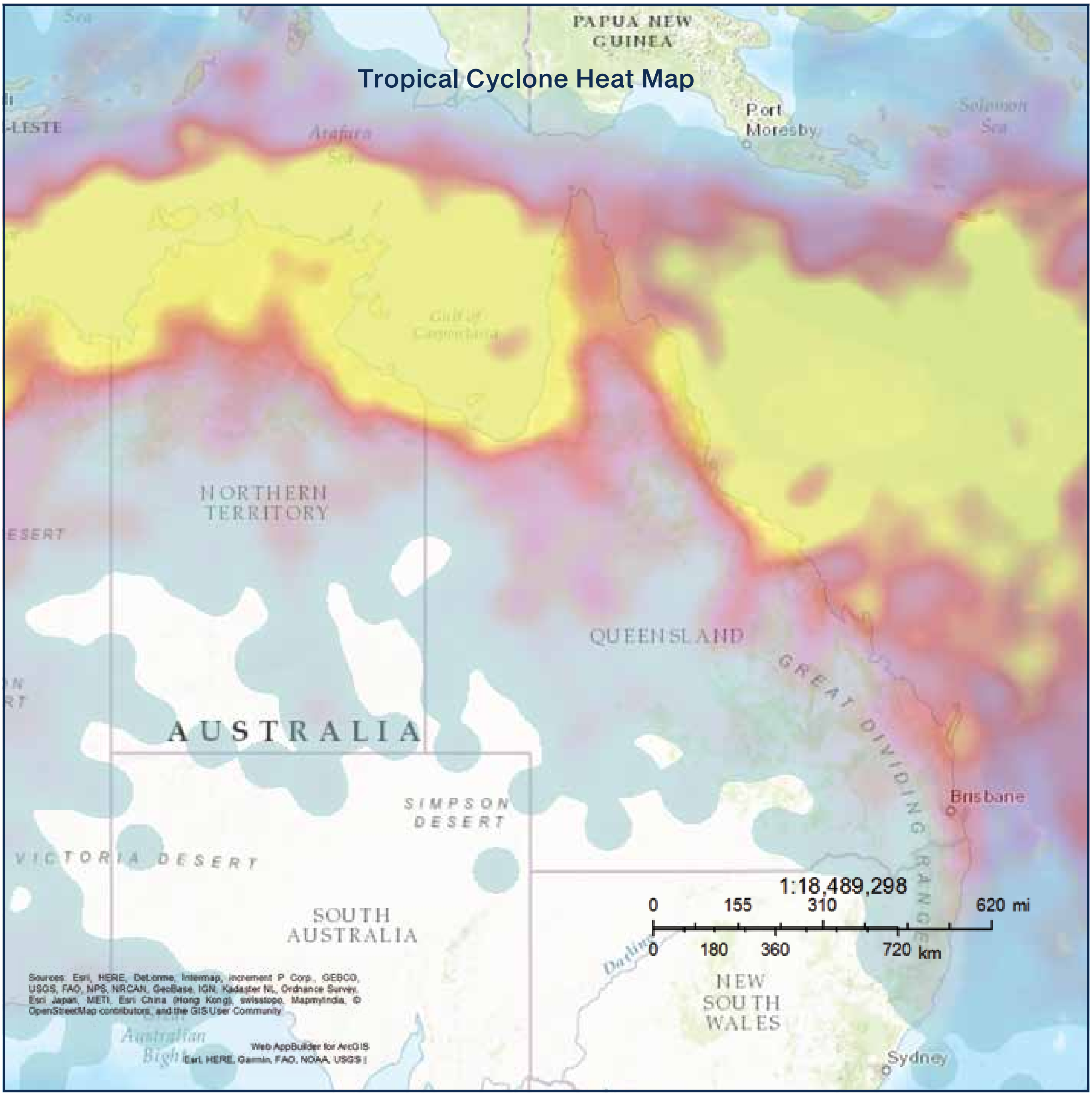
Geographically, tropical cyclones are observed to effect the areas of the Gulf of Carpentaria and Cape York Peninsula to the north of the State and the eastern coastline extending from the north tip of Queensland to central coastal regions.

There are instances where tropical cyclones have moved inland from the north and east of Queensland and pushed south, however the priority risk area for Queensland is as depicted by the historical cyclone heat map in Figure 29.

Figure 29

Heat map reflecting the historical occurrences of tropical cyclones (of varying strength, intensity and duration) from 1967 to 2017. The red to yellow hue overland highlights areas that have sustained the greatest number of cyclone landfalls.

Source: Data from Bureau of Meteorology, map created by Queensland Fire and Emergency Services



Multi-hazard interaction

When analysing the potential impacts of cyclone manifestation, understanding hazard characteristics in detail has shown secondary hazards will occur from the primary event. Therefore the interaction of the primary and secondary hazards and their cascading effects need to be considered. Primary and secondary hazard characteristics relating to tropical cyclones are:

- damage from sustained high wind speeds
- rapid delivery of concentrated rainfall leading to flash flooding
- increased risk of storm surge, creating higher risk of coastal inundation
- onset of riverine flooding due to prolonged and sustained deluges.

Potential exposures

Assessing the hazard interaction and the impact of the characteristics of those hazards upon exposed elements provides a clearer understanding of vulnerabilities.

The 2017 risk assessment highlighted elements susceptible to hazard interaction. Some key observations for communities across Queensland are impacts to:

Essential Infrastructure

Power & communications – direct effect of wind on power lines and communications infrastructure coupled with the cumulative effect of flooding on key network nodes has led to prolonged periods of disruption. Additionally the interdependency of communications networks and other key community infrastructure (including services such as water and governance infrastructure) on power has led to protracted disruption issues.

Transport – short term disruption to air, road, rail and maritime systems due to the impacts of the event (e.g. high winds disrupting air and rail travel). Impact from possible associated inundation (flash or riverine) across major road and rail networks has historically led to short to medium term disruptions. Return of essential services to communities and industry highly-dependent on the level of disruption across access and resupply. Recovery efforts also likely to be complicated depending on the magnitude and duration of the event.

Access/resupply

Areas within the Gulf of Carpentaria, the Cape York Peninsula and west of the Great Dividing Range have been susceptible to short to long term isolation due to flooding events brought on by the effects of a cyclonic or severe weather event.

In most cases there is a reasonable degree of resilience as most people in those areas live in isolation generally and have redundancy plans in place. Towards the east coast, where typically the greater density of Queensland's population inhabits, extreme and prolonged flood events have caused substantial impact to major road and rail networks, airports and maritime infrastructure.

Community & Social

Direct impact from wind and inundation to shelter and housing leading to widespread displacement across the community. Social infrastructure (e.g. schools, hospitals, community centres) also directly and indirectly affected through infrastructure damage, loss of power, water and communications.

Remote Indigenous communities and townships comprised of a mix of ethnically, culturally and socio-economically diverse groups who are generally reliant on social media and word-of-mouth for emergency alerts, are vulnerable to loss of communications across the District and/or Local Government area (linked to loss of power) as a result of impact from a tropical cyclone.

Exposure to repetitive events of varying magnitude, duration and impact has led to a decrease in resilience of people and communities across Queensland.

Significant Industry

Agriculture – considerable increase in stock and crop losses have historically been observed as a result of tropical cyclone events. Removal of fertile soil due to flood impact brought on by a cyclonic event has caused significant impact to the agriculture industry which adds to the loss of the direct stock or crop loss. In addition, there has been considerable loss of equipment, residential and equipment storage areas, which has added to the disruption period.

Industry – disruption to industry has occurred as a result of direct impact from an event. The dependency on power and communications for industry has also led to a considerable decrease in productivity creating loss of stock, income and employment. In some areas across Queensland, there has been a permanent loss of local business as a result of tropical cyclone events.

Environment

Due to the nature of a tropical cyclone, environmental impacts can be widespread or concentrated. Observations include severe impacts upon sections of the Great Barrier Reef including damage to and loss of Areas of Ecological Significance.

Risk analysis

The level of risk is determined through an assessment of the severity of exposure, the level of vulnerability, the coping capabilities and capacities of the communities involved and the overall potential consequences:

People

- A number of fatalities and critical injuries occurring as a direct result of an event.
- Increased hardship due to financial pressures and short- to long term displacement (evacuations and/or loss of habitable dwellings) impacts upon the emotional capacity of individuals. This can lead to increases in mental health issues and impacts upon domestic cohesion.

Financial & Economic

- Decline in economic activity as a result of direct and indirect impacts to major regional and State projects as well as to Queensland's agricultural, resources, construction and tourism sectors and local businesses.
- Damage to or loss of residential and essential civic infrastructure (e.g. hospitals and schools) as well as short to medium term disruption to transport network infrastructure and services (roads, rail, air and maritime).

Community & Social

- Decrease in social connectedness which requires external resources to return the community to functioning effectively.
- Damage to elements of cultural and religious significance to the community intensifies the decrease in social connectedness.

Public Administration

- Increased demand on emergency services, frontline services and community and social services managing the event with extended hours of operation and some impact to normal servicing provisions. This is likely to cause delays in service during the period of immediate effect of the event and add to financial impacts beyond normal budgeted operations for responding agencies.
- Sustained and frequent media coverage (both positive and negative) by national and international media outlets.
- Rise in spontaneous volunteerism or incidences of self-help due to strain on the provision of response from governing bodies and emergency services.

Environment

- Damage to ecosystems and species recognised at a Local, District and/or State level.
- Significant short to medium term impacts to tourism due to environmental damage sustained as a result of an event.

Risk statement

The manifestation of a tropical cyclone, especially a severe tropical cyclone leads to disruption of power and communication networks and the closure of transport hubs including highways, major roads, ports and local airports across the affected area in Queensland. This will severely impact access/resupply in the affected area for short to the long term. Several isolated areas and small towns may require evacuation and/or resupply due to level of exposure to the hazard.

The isolation of some communities means any evacuation or recovery efforts would be complex due to potential impact on access/resupply. Presence of highly vulnerable persons across the affected area will further compound evacuation planning.

Some hospitals and medical/care facilities are highly vulnerable to the effects of a tropical cyclone (e.g. high winds, flooding and storm surge leading to structural damage to buildings) which may require a need for State-level assistance with evacuation.

Short to medium term reduction of services coupled with strain on frontline services across all government sectors are felt due to increased demand in response to event consequences with impacts felt to the wider community while post event recovery efforts continue.

Agriculture and industry sustain financial losses as a result of the direct event impact and indirect disruption of essential services. A short term decline in tourism for areas affected by severe damage is coupled with local business decline and displacement of people.

Secondary hazards such as riverine flooding, flash flooding and storm surge further compound periods of disruption, delaying the issues of response and recovery efforts.

Treatments

The operational risks and their specific treatment plans are addressed within the District and Local level risk registers and disaster management plans.
The following list is indicative of the range of committees, groups and plans through which the risks associated with this hazard are addressed at the State level. This list is not exhaustive as the multiple and multifaceted issues arising at a State level are often addressed as part of business-as-usual strategies and activities by Commonwealth, State and Local Governments, as well as relevant private-sector service providers and community organisations, and typically respond to more than one hazard. Some informative links are also included.

Committees/groups

- Queensland Disaster Management Committee
- State Disaster Coordination Group
- Disaster Management Interdepartmental Committee
- District Disaster Management Groups
- Local Disaster Management Groups
- Queensland Tropical Cyclone Coordination Committee
- Climate Change Advisory Group
- Local Recovery Groups
- District Recovery Groups
- State Human & Social Recovery Committee
- Functional Recovery Groups (Human and Social Recovery Group; Economic Recovery Group; Building Recovery Group; Environmental Recovery Group; Roads Recovery Group)

Organisations

- CSIRO – www.csiro.au
- Bureau of Meteorology – www.bom.gov.au
- James Cook University Cyclone Testing Station – www.jcu.edu.au/cyclone-testing-station
- The Climate Council – www.climatecouncil.org.au
- Climate Change Authority – www.climatechangeauthority.gov.au/about-cca/authority-members
- Department of Infrastructure, Local Government and Planning – www.dilgp.qld.gov.au/planning/state-planning-instruments/state-planning-policy.html
- Queensland Reconstruction Authority – www.qldreconstruction.org.au

Reports/publications/plans

- Queensland Government Disaster Management Plans – www.disaster.qld.gov.au/Disaster-Resources/cdmp/Pages default.aspx
- Bureau of Meteorology – Tropical Cyclone History – www.bom.gov.au/cyclone/history/
- The Climate Council –
  › Cranking Up the Intensity: Climate Change and Extreme Weather Events. 2017
  › Tropical Cyclones and Climate Change: Factsheet. 2017.

References and sources of additional information

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SEVERE WEATHER EVENT

Risk Assessment

Severe Weather Event

Definition

A severe weather event is defined by Bureau of Meteorology as associated with one or more of the following phenomena:

- 'Damaging' wind gusts of 90 km/h (48 knots) or destructive wind gusts of 125 km/h (67 knots) or more at 10 metres above the ground.
- Heavy rain which may lead to flash flooding, generally defined as the rainfall amount which has a 10% probability of being exceeded in a year over a given duration (1 to 6 hours). This is often referred to as the rainfall with a 10-year Average Recurrence Interval (ARI).
- 'Very large' hail, greater than 4cm in diameter (corresponding to greater than golf ball size).
- Dangerous surf with deep water wave heights of 4 metres or more from an onshore direction, which will generally put lives at risk and potentially lead to significant beach erosion.
- Abnormally high tides generally of greater than 0.5 metres above the Highest Astronomical Tide (HAT).
- Tornado/es.

The Queensland context

Since 1 January 1917, Queensland has experienced 3,584 recorded severe weather events defined as such by the Bureau of Meteorology. While there is no defined season or period throughout the year when severe weather events are more likely to occur, intense storms and especially electrical thunderstorms have a greater tendency to manifest during summer months (October to April) and periods of heatwave.

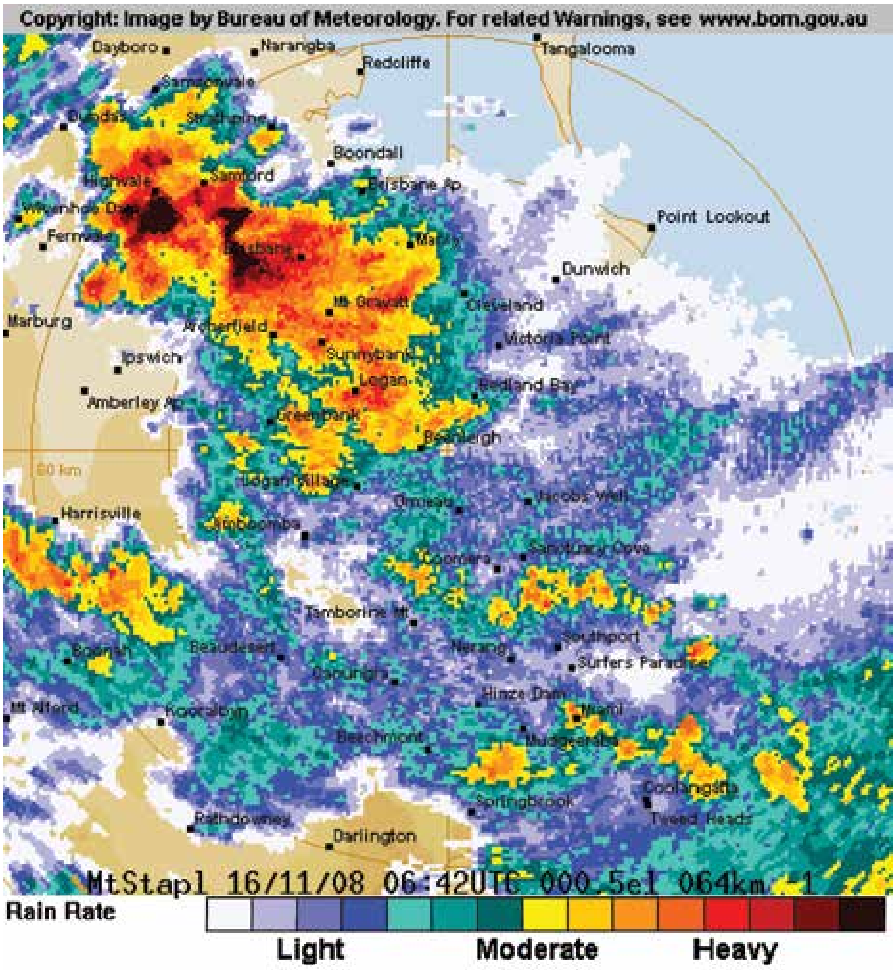

Figure 30

Weather radar showing heavy rainfall during a severe weather event over Brisbane, heavily impacting The Gap in November 2008.

Source: Bureau of Meteorology

	Severe Storm Archive - BOM				
Date Range	**Rain**	**Wind**	**Hail**	**Lightning**	**Tornado**
1917 - 1966	25	208	146	12	19
1967 - 2000	109	200	342	5	45
2001 - 2006	213	378	216	6	22
2007 - 2010	556	187	117	1	10
2011 - 2016	367	167	220	2	11
Totals	**1270**	**1140**	**1041**	**26**	**107**

Figure 31

This table shows the number and type of severe weather events recorded in Queensland during the past 100 years.

Source: Bureau of Meteorology

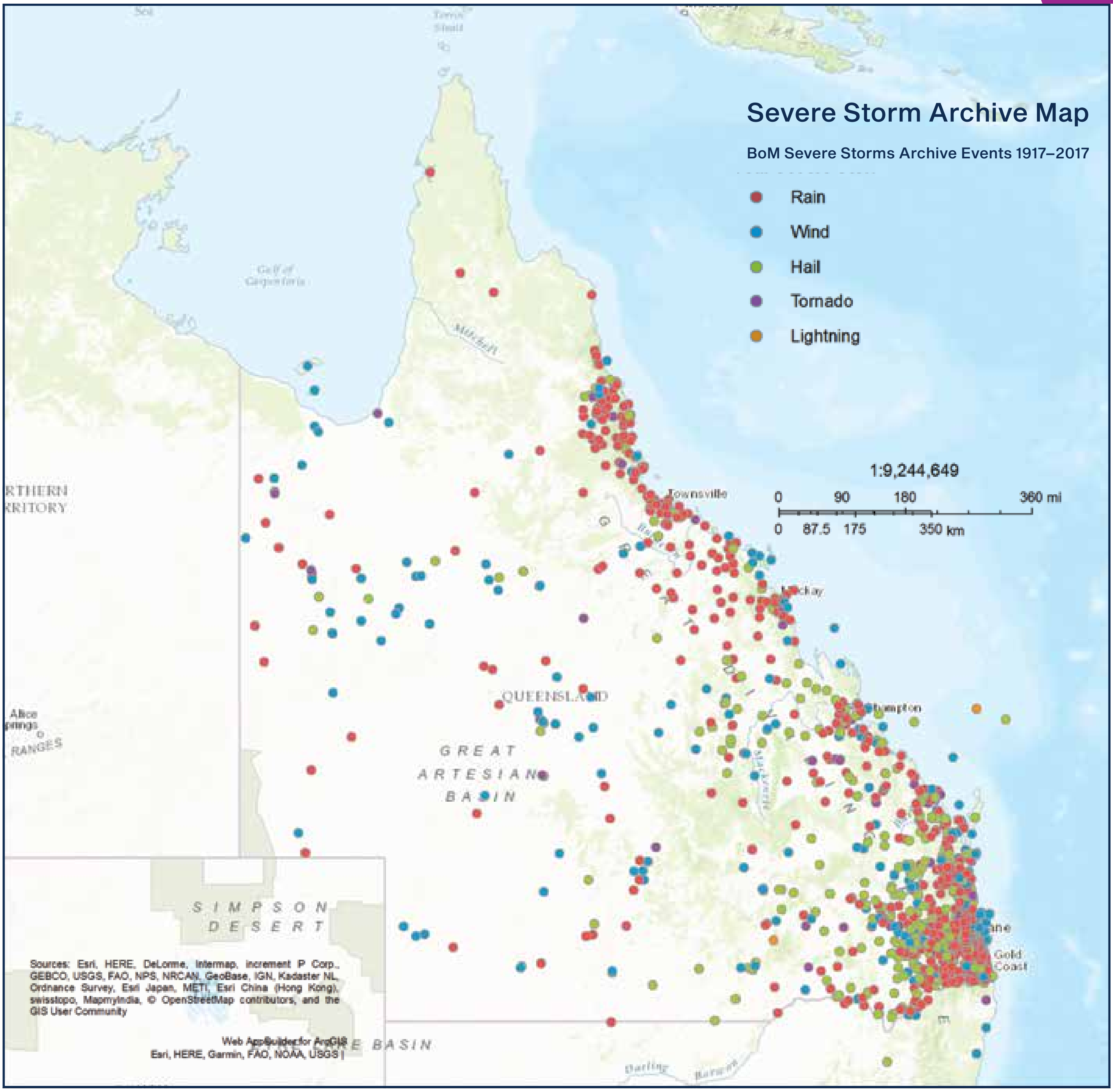

Figure 32

The above map shows the number and type of severe weather events in Queensland since 1917 as detailed in Figure 31.

Source: Data from Bureau of Meteorology, map created by Queensland Fire and Emergency Services

The above map is a database of all recorded severe local storm events since 1917. Not all storms are recorded; indeed it can be common for a storm not to be recorded because:

- it impacted an unpopulated area
- nobody saw it
- nobody reported it
- it was not detected by any observation systems (e.g. radar, Automatic Weather Systems).

This will cause two types of bias to be imposed on the database:

- there is an artificial increase in observed events over time
- the observed distribution of severe thunderstorms across the country is influenced by population density.

Multi-hazard interaction

When analysing the potential impacts of a severe weather event, understanding hazard characteristics in detail has shown secondary hazards can occur from the primary event.

The interaction of the primary and secondary hazards and their cascading effects need to be considered.

Primary and secondary hazard characteristics relating to severe weather events are:

- flash and riverine flooding
- damaging wind gusts and hail leading to damage to infrastructure
- storm surge causing erosion and localised flooding through coastal inundation
- lightning strikes leading to ignition of bushfires.

Potential exposures

Assessing the hazard interaction and the impact of the characteristics of those hazards upon exposed elements provides a clearer understanding of vulnerabilities.

The 2017 risk assessment highlighted elements susceptible to hazard interaction. Some key observations for communities across Queensland are impacts to:

Essential Infrastructure

Power & Communications – widespread effect to the power network through direct impact from storm events. Power disruption is observed across the short to medium term. Communication networks are similarly affected via direct impact and indirectly due to the loss of power. Increased occurrences of landslips during severe weather events have also caused disruption across these networks.

Transport – short term disruption to air, road, rail and maritime systems due to the impacts of the event (e.g. high winds disrupting air and rail travel). Impact from possible associated inundation (flash or riverine) across major road and rail networks have historically led to short to medium term disruptions. Return of essential services to communities and industry highly dependent on the level of disruption across access and resupply. Recovery efforts also likely to be complicated depending on the magnitude and duration of the event.

Access/resupply

Areas within the Gulf of Carpentaria, the Cape York Peninsula and west of the Great Dividing Range have been susceptible to short to long term isolation due to flooding events brought on by the effects of a cyclonic or severe weather event. In most cases there is a reasonable degree of resilience as most people in those areas live in isolation generally and have redundancy plans in place. Toward the east coast where typically the greater density of Queensland's population inhabits, extreme and prolonged flood events have caused substantial impact to major road and rail networks, airports and maritime infrastructure.

Community & Social

Direct impact from wind and inundation to shelter and housing leading to widespread displacement across the community. Social infrastructure (schools, hospitals and community centres) also directly and indirectly affected through infrastructure damage, loss of power, water and communications.

Exposure to repetitive events of varying magnitude, duration, impact and therefore consequence has led to a decrease in resilience of people and communities across Queensland.

Significant Industries

Agriculture – considerable increase in crop and stock losses have historically been observed due to severe wind gusts, flooding (flash and riverine) and hail.

Industry – direct impact as a result of wind, hail and inundation damage. Indirect disruption due to a loss of essential services such as power, communications and water.

Environment

Direct impact from lightning strikes, wind gusts and storm surge causing damage to national parks, State forests and coastal areas. Landslip susceptibility increased due to wind and rain.

Risk analysis

The level of risk is determined through an assessment of the severity of exposure, the level of vulnerability, the coping capabilities and capacities of the communities involved and the overall potential consequences:

People

- A number of fatalities and critical injuries may occur as a direct result of an event.
- Short term displacement of persons due to damage to residential properties or isolation from flash flooding.
- Increase in personal financial pressure due to losses sustained during the event. For example, as reported by the Insurance Council of Australia, approximately 50,000 insured vehicles were damaged during the 2014 Brisbane hail storm, many of which were personal vehicles written off by insurance companies.

Financial & Economic

- Residential and essential civic infrastructure (e.g. hospitals and schools) as well as short to medium term disruption to transport network infrastructure and services (roads, rail, air and maritime).
- Businesses may be affected due to staff shortages caused by access issues and disruption of essential services.
- Economic loss due to disruption caused by an event. Recovery costs for damage to infrastructure and non-supply periods. Potential widespread personal finance impacts seeing an increase in insurance claims and associated costs.

Community & Social

- Prolonged disruption to social infrastructure (schools, hospitals, aged care facilities) likely to compound response and recovery issues.
- Damage to elements of cultural and religious significance to the community can impact on social connectedness.

Public Administration

- Increased demand on emergency services, frontline services and community and social services managing the event with extended hours of operation and some impact to normal servicing provisions.
- This is likely to cause delays in service during the period of immediate effect of the event and add to financial impacts beyond normal budgeted operations for responding agencies.

Environment

- Damage to ecosystems and species recognised at a Local, District or State level.
- Impacts to tourism due to environmental damage sustained as a result of an event.

Risk statement

The manifestation of a severe weather event, can lead to localised and widespread outages of the power network from direct impact of the event across the short to medium term.

Communication networks are likely to be indirectly affected due to the loss of power with additional disruption via direct impact to the communications network.

Short term disruption to major air, road and rail systems due to the impacts of the event are likely to lead to major congestion and significant transport related incidents. Access is likely to be a disruption concern due to flash flooding across affected areas potentially impacting on responding agencies and adding to traffic congestion and incidents.

A number of fatalities and critical injuries may occur as a direct result of the event including short term displacement of persons due to damage of residential properties or isolation from flash flooding at a local level. This has the potential to increase demand on emergency services at times, requiring specialist emergency services support to assist front line officers while responding to calls for service.

Immediate effects on agriculture and industry is likely to be observed in the short term, with financial losses as a result of the direct event impact and indirect disruption of essential services.

Environmental impact from lightning strikes, wind gusts and storm surge causing damage to national parks, State forests and coastal areas, including an increase of susceptibility of landslips, can potentially lead to a short term decline in tourism and indirect damage or destruction of property or ecosystems and species recognised at a Local, District or State level.

Recovery costs for damage to infrastructure and non-supply periods to government is likely to cause strain on budgets with the potential for widespread personal finance impacts due to insurance claims and associated costs related to the event impacts.

Secondary hazards such as flash flooding and storm surge further compound periods of disruption delaying the issues of response and recovery efforts.

Treatments

The operational risks and their specific treatment plans are addressed within the District and Local level risk registers and disaster management plans. The following list is indicative of the range of committees, groups and plans through which the risks associated with this hazard are addressed at the State level. This list is not exhaustive as the multiple and multifaceted issues arising at a State level are often addressed as part of business-as-usual strategies and activities by Commonwealth, State and Local Governments, as well as relevant private-sector service providers and community organisations, and typically respond to more than one hazard. Some informative links are also included.

Committees/groups

- Queensland Disaster Management Committee
- State Disaster Coordination Group
- Disaster Management Interdepartmental Committee
- District Disaster Management Groups
- Local Disaster Management Groups
- Climate Change Advisory Group
- Local Recovery Groups
- District Recovery Groups
- State Human & Social Recovery Committee
- Functional Recovery Groups (Human and Social Recovery Group; Economic Recovery Group; Building Recovery Group; Environmental Recovery Group; Roads Recovery Group)

Organisations

- CSIRO – www.csiro.au
- Bureau of Meteorology – www.bom.gov.au
- James Cook University Cyclone Testing Station – www.jcu.edu.au/cyclone-testing-station
- The Climate Council – www.climatecouncil.org.au
- Climate Change Authority – www.climatechangeauthority.gov.au/about-cca/authority-members
- Department of Infrastructure, Local Government and Planning – www.dilgp.qld.gov.au/planning/state-planning-instruments/state-planning-policy.html
- Queensland Reconstruction Authority – www.qldreconstruction.org.au

Reports/publications/plans

- Queensland Government Disaster Management Plans – www.disaster.qld.gov.au/Disaster-Resources/cdmp/Pages default.aspx
- Bureau of Meteorology Severe Storm Archive – www.bom.gov.au/australia/stormarchive
- The Climate Council –
  › Cranking Up the Intensity: Climate Change and Extreme Weather Events. 2017
  › Intense Rainfall and Flooding: The Influence of Climate Change. 2017.
- Queensland Government Disaster Management Plans – www.disaster.qld.gov.au/Disaster-Resources/cdmp/Pages default.aspx

References and sources of additional information

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- The Climate Council. The Influence of Climate Change. 2017. Climate Council of Australia Limited.
- Green Cross Australia – Harden Up, Protecting Queensland - hardenup.org/
- Coates, L., et al (2017). An Analysis of Human Fatalities from Cyclones, Earthquakes and Severe Storms in Australia. Report for the Bushfire and Natural Hazard Cooperative Research Centre.

RIVERINE FLOODING

Risk Assessment

Queensland Government

Riverine Flooding

Definition

Riverine flooding is defined as a covering of normally dry land by water that has escaped or been released from the normal confines of any lake, river, creek or other natural watercourse, whether or not altered or modified; or any reservoir, canal, or dam.

Rainfall is the key component in creating a flood however there are many other contributing factors. When rain falls on a catchment, the amount of rainwater that reaches the waterways depends on the characteristics of the catchment, particularly its size, shape and land use. Some rainfall is 'captured' by soil and vegetation, and the remainder enters waterways as flow. River characteristics such as size and shape, the vegetation in and around the river, and the presence of structures in and adjacent to the waterway all affect the level of water in the waterway.

When rain falls over an area of land, some is absorbed by the soil, while the rest becomes runoff and flows downhill. The area of land that contributes runoff to a particular point is called the catchment.

The amount of rainfall, the intensity of the rainfall over time (the temporal pattern) and the distribution of the rainfall over an area of land (the spatial pattern) can all vary widely. The floods that are produced by this rainfall are therefore equally variable, that is, every flood is different.

Heavy, intense rainfall can occur suddenly, and the quickly rising floods caused by this in the minutes or hours after the rainfall are known as flash floods. Flash floods are typically associated with relatively small catchment areas where there may be little or no permanent flow of water.

As there is little time to react, flash floods are particularly difficult to predict and manage in real time. Floods can occur slowly in larger catchment areas, rainfall can build up over hours, days or weeks.

The runoff from this rainfall flows across land and then down gutters, drains, gullies, creeks and rivers and may create significant floods that inundate large areas of land for days, weeks or months.

The Queensland context

Since 2011, and in response to the Queensland Floods Commission of Inquiry, the Queensland Government has supported councils and disaster management entities by delivering flood projects, and producing flood maps and information at town and catchment scales. Flood risk includes both the chance of an event taking place and its potential impact.

Land use planning informed by floodplain management plans can reduce risk for new development areas. Flood risk is harder to manage in existing developed areas however modification measures such as dams or levees can change the behaviour of floodwaters. Similarly, property modification measures can protect against harm caused by floods to individual buildings, and response modification measures help communities deal with floods.

Australia's growing population and changing climate patterns imply that the characteristics of the floods we experience will change in the future. Better future land use planning and floodplain management can mitigate the impacts of flooding. Appropriate urban design can reduce the severity of flood impacts. Catchment and waterway revegetation can reduce the impact of flooding. Emerging technologies can improve our ability to predict and manage floods.

Responsibility for flood risk management in Queensland generally rests with Local Governments because they are the major service provider to communities and are responsible for managing local development. Responsibility for floodplain management is more complex.

Governance of floodplain management in Queensland is dispersed across various State-level agencies, including:

- Queensland Reconstruction Authority
- Department of Infrastructure, Local Government and Planning
- Department of Natural Resources and Mines
- Department of Energy and Water Supply
- Department of Science, Information Technology and Innovation
- Queensland Fire and Emergency Services.

Potential exposures

Assessing the hazard interaction and the impact of the characteristics of those hazards upon exposed elements provides a clearer understanding of vulnerabilities.

The 2017 risk assessment highlighted elements susceptible to hazard interaction. Some key observations for communities across Queensland are impacts to:

Essential Infrastructure

Power & Communications – direct effect of flooding on power and communications infrastructure including key network nodes has led to prolonged periods of disruption. Additionally, the interdependency of communications networks and infrastructure on power can result in prolonged disruption issues. The equipment which has been affected by recent flood events include: bulk and zone substations, C&I substations, overhead lines, pad mount and ground transformers, underground pillars and streetlights.

Water Infrastructure – water treatment plants and sewerage treatment plants located close to waterways are exposed to flooding.

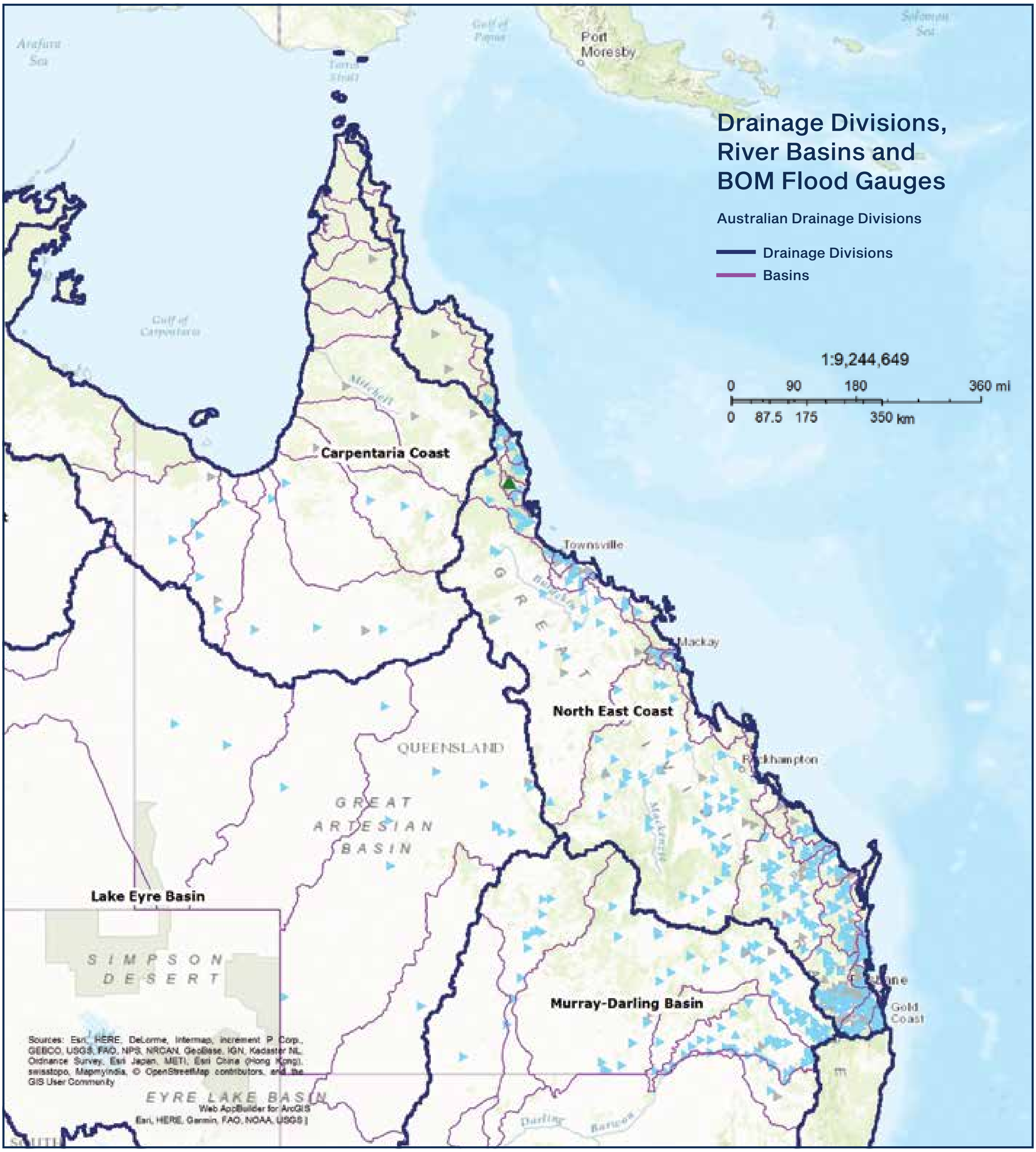

Figure 33

Geospatial map of Queensland indicating river basins and river gauge network used to identify Minor, Moderate and Major flood heights.

Source: Data from Bureau of Meteorology, map created by Queensland Fire and Emergency Services

Transport – impact from inundation across major road and rail networks have historically led to short to medium term disruptions. Return of essential services to communities and industry is highly dependent on the level of disruption across access and resupply. Recovery efforts are also likely to be complicated depending on the magnitude and duration of the event.

Access/resupply

Areas within the Gulf of Carpentaria, the Cape York Peninsula and west of the Great Dividing Range have been susceptible to short to long term isolation due to flooding events brought on by the effects of a cyclonic or severe weather event. In most cases there is a reasonable degree of resilience as most people in those areas live in isolation generally and have redundancy plans in place. Toward the east coast where typically the greater density of Queensland's population inhabits, extreme and prolonged flood events have caused substantial impact to major road and rail networks, airports and maritime infrastructure.

Community & Social

Prolonged disruption to social infrastructure (e.g schools, hospitals, aged care facilities) is likely to compound response and recovery issues.

Damage to elements of cultural and religious significance to the community can impact on social connectedness.

The community's social connectedness is damaged, such that the community requires external resources to return the community to functioning effectively, with no permanent dispersal.

Significant Industries

Agriculture – considerable increase in stock and crop losses have historically been observed as a result of riverine flooding events. Removal of fertile soil as a result of flood impact has caused significant impact to the agriculture industry which adds to the loss of the direct stock or crop loss. In addition, there has been considerable loss of equipment, residential and equipment storage areas, which has added to the disruption period.

Significant Industry – disruption to industry has occurred as a result of direct impact from an event. The dependency on power and communications for industry has also led to a considerable decrease in productivity creating loss of stock, income and employment. Some areas across Queensland have experienced permanent loss of local business as a result of riverine flood events.

Environment

Due to the nature of a riverine flooding event, environmental impacts can be widespread or concentrated. Severe impacts have occurred upon sections of essential agricultural areas (as noted above), the Great Barrier Reef through sediment transfer, and damage to and loss of Areas of Ecological Significance as a result of habitats experiencing inundation.

Risk analysis

The level of risk is determined through an assessment of the severity of exposure, the level of vulnerability, the coping capabilities and capacities of the communities involved and the overall potential consequences:

People

- A number of fatalities and critical injuries may occur as a direct result of an event.
- Increased hardship due to financial pressures and short to long term displacement (evacuations and/or loss of habitable dwellings) impacts upon the emotional capacity of individuals. This can lead to increases in mental health issues and impacts upon domestic cohesion.

Financial & Economic

- Decline in economic activity as a result of direct and indirect impacts to major regional and State projects as well as Queensland's agricultural, resources, construction and tourism sectors and local businesses.
- Residential and essential civic infrastructure (e.g. hospitals and schools) as well as short to medium term disruption to transport network infrastructure and services (roads, rail, air and maritime).
- Permanent loss of small to medium local businesses as a result of repeat events causing significant loss and disruption of local economy and turnover.

Community & Social

- Decrease in social connectedness which requires external resources to return the community to functioning effectively.
- Damage to elements of cultural and religious significance can compound the decrease in social connectedness.

Public Administration

- Increased demand on emergency services requiring specialist emergency services support to assist front line officers in restoring basic services and public order while responding to calls for service.
- Sustained and frequent media coverage (both positive and negative) by national and international media outlets.
- Significant strain on governing bodies delivering core functions as a result of responding to the consequences of an event.

Environment

- Damage to ecosystems and species recognised at a Local, District or State level.
- Impacts to tourism due to environmental damage sustained as a result of an event.

Risk statement

The manifestation of a tropical cyclone or severe weather event in Queensland which delivers a significant amount of rainfall in a particular catchment area may potentially lead to a riverine flooding event.

This may have a cumulative effect of impact to exposed elements as a result of the multi-hazard interaction in the affected area, or alternatively observe only the effect from riverine flooding due to the primary event not directly impacting the flooded location.

The riverine flooding event can range in duration depending on the amount of rainfall and current ground and climatic conditions.

Exposed elements such as power and communication nodes, roads, rail, air and maritime networks and hubs are likely to observe short to medium term disruption periods.

Damage from the cumulative effect of events can potentially cause network outages over the affected area, destruction of road infrastructure, and temporary cessation of rail, maritime and air services.

Communities situated in the direct forecast impact areas may require coordinated evacuations placing strain on frontline services across all government sectors due to increased demands for response to the event.

Additionally, short to medium term disruption to road and rail networks may potentially impact access, resupply and response efforts within the affected communities.

Financial loss to the agriculture, industry and transport sectors are expected to be significant and require additional funding considerations to support the impacted sectors or locations.

A short to medium term decline in tourism for significantly impacted areas may couple with local business decline and displacement of the local population. Significant environmental damage and impacts to Areas of Ecological Significance are to be expected.

Figure 34

Flooding in Rockhampton due to rainfall from Severe Tropical Cyclone Debbie in March 2017.

Source: Department of Natural Resources and Mines

Treatments

The operational risks and their specific treatment plans are addressed within the District and Local level risk registers and disaster management plans. The following list is indicative of the range of committees, groups and plans through which the risks associated with this hazard are addressed at the State level. This list is not exhaustive as the multiple and multifaceted issues arising at a State level are often addressed as part of business-as-usual strategies and activities by Commonwealth, State and Local Governments, as well as relevant private-sector service providers and community organisations, and typically respond to more than one hazard. Some informative links are also included.

Committees/groups

- The Queensland Government is represented on:
  - › the Bureau of Meteorology Hazard Services Forum
  - › the National Flood Risk Advisory Group
  - › the National Flood Warning Infrastructure Working Group
- Queensland Flood Warning Consultative Committee
- Queensland Disaster Management Committee
- State Disaster Coordination Group
- Queensland Flood Resilience Coordination Committee
- Disaster Management Interdepartmental Committee
- District Disaster Management Groups
- Local Disaster Management Groups
- Climate Change Advisory Group
- Local Recovery Groups
- District Recovery Groups
- State Human & Social Recovery Committee
- Functional Recovery Groups (Human and Social Recovery Group; Economic Recovery Group; Building Recovery Group; Environmental Recovery Group; Roads Recovery Group)

Organisations

- Geoscience Australia – www.ga.gov.au/scientific-topics/hazards/flood/nfrip
- Department of Natural Resources and Mines – www.dnrm.qld.gov.au/
- Department of National Parks, Sport and Racing – www.npsr.qld.gov.au
- Department of Infrastructure, Local Government and Planning – www.dilgp.qld.gov.au/planning/state-planning-instruments/state-planning-policy.html
- Queensland Reconstruction Authority – www.qldreconstruction.org.au

Reports/publications/plans

- Queensland Government Disaster Management Plans – www.disaster.qld.gov.au/Disaster-Resources/cdmp/Pages/default.aspx
- Department of Natural Resources and Mines –
  - › Flood Check – www.dnrm.qld.gov.au/mapping-data/maps/flood-mapping-program/floodcheck-map
  - › Flood Mapping Implementation Kit – www.dnrm.qld.gov.au/__data/assets/pdf_file/0009/230778/flood-mapping-kit.pdf
  - › Guide for Flood Studies and Mapping in Queensland – www.dnrm.qld.gov.au/__data/assets/pdf_file/0010/332695/guide-flood-studies-mapping-qld.pdf
- Queensland Reconstruction Authority – Flood Warning Gauge Review – www.qldreconstruction.org.au/u/lib/cms2/QLD%20Flood%20Warning%20Gauge%20Network%20fact%20sheet.pdf
- Queensland Reconstruction Authority - Strategic Policy Framework for Riverine Flood Risk Management 2017 – www.qldreconstruction.org.au/u/lib/cms2/Strategic%20Policy%20Framework%20for%20Riverine%20Flood%20Risk%20Management.pdf

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- Office of the Queensland Chief Scientist – Understanding Floods.
- The Climate Council. Intense Rainfall and Flooding: The Influence of Climate Change. 2017. Climate Council of Australia Limited.
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COASTAL INUNDATION

Risk Assessment

Coastal Inundation

Definition

Coastal erosion and storm tide inundation are naturally occurring coastal processes that are referred to as coastal hazards as they have the potential to impact on public safety and development along the coast. They are quite different processes and the scope of this assessment is restricted to storm tide inundation.

A storm tide is the combination of astronomical tide + storm surge + wave set-up. A storm surge is an increase (or decrease) in water level associated with some significant meteorological event (for example, a high onshore wind associated with a tropical cyclone or severe weather event).

Combined with a normal astronomical tide, this can result in a recorded water level higher than the predicted tide. The magnitude of the storm tide is dependent on the severity and duration of the meteorological event, the seabed shape and the proximity of bays, headlands and islands.

Large waves can also be generated by winds associated with the meteorological event, increasing the risk of the storm tide in coastal areas. In some situations, such as when winds blow offshore, the actual tide level can be lower than that predicted.

Figure 35

The effects of storm surge at Tully Heads from Severe Tropical Cyclone Yasi in February 2011.
Source: Photo courtesy of ABC News, Kerrin Binnie

The Queensland context

The implications of projected sea level rise and an increase in cyclone intensity for Queensland's coast include a progressive worsening of coastal hazards including:

- increased water levels will accelerate coastal erosion
- sediment transport patterns may be altered by shifts in wave direction triggering changes to the form and location of shorelines
- low-lying land may be permanently inundated
- increased cyclone and storm activity will escalate the severity of coastal erosion events.

In northern Queensland, large storm tide events are generally associated with cyclones. However, in southern Queensland, storm tide events can also be caused by severe storms and east coast lows.

A storm surge is a constituent of storm tide and astronomical tide. Every cyclone that affects the coast produces a storm surge. But not all storm tides rise to dangerous levels. The height of the surge depends on:

- The coinciding time of the surge with the astronomical tide – at low astronomical tide it may not cause an overall exceedance of the highest astronomical tide (HAT) reducing the threat, whereas coinciding with high astronomical tide can increase the threat of storm surge.
- The intensity of the cyclone – as the winds increase, the sea water is piled higher and the waves on top of the surge are taller.
- The forward speed of the cyclone – the faster the cyclone crosses the coast, the more quickly the surge builds up and the more powerfully it strikes.
- The angle at which the cyclone crosses the coast – in general, the more head on the angle the higher the surge. However other angles can lead to local zones of enhanced surge in areas such as narrow inlets and bays.
- The shape of the sea floor – the surge builds up more strongly if the slope of the sea bed at the coast is shallow. If the sea bed slopes steeply, or if fringing reefs are present, then the surge will be less.
- Local topography – bays, headlands and offshore islands can funnel and amplify the storm surge.

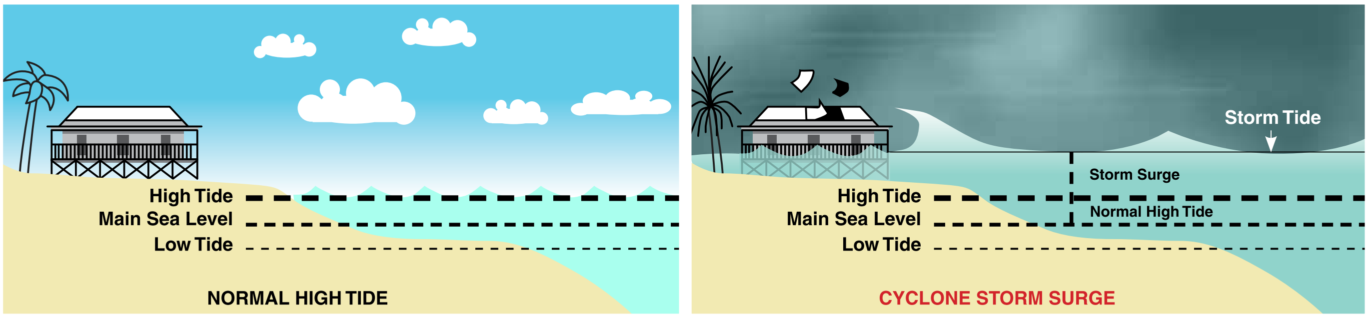

Figure 36

Depiction of 'normal' high tide and storm tide.

Source: Queensland Fire and Emergency Services based on an original illustration by Bureau of Meteorology

Multi-hazard interaction

A primary hazard such as a tropical cyclone or severe weather event often leads to the consequence hazard of coastal inundation. The interaction of the primary and secondary hazard can have a cascading effect which needs to be considered. Primary and secondary hazard characteristics relating to coastal inundation are:

- damage from sustained high wind speeds (brought on by the primary event of a severe tropical cyclone)
- rapid delivery of concentrated rainfall leading to flash flooding or riverine flooding (brought on by the primary event of a severe tropical cyclone or severe weather event).

Potential exposures

Assessing the hazard interaction and the impact of the characteristics of those hazards upon exposed elements provides a clearer understanding of vulnerabilities.

The 2017 risk assessment highlighted elements susceptible to hazard interaction. Some key observations for communities across Queensland are impacts to:

Essential Infrastructure

Power & Communications – power and communication nodes situated in low-lying coastline areas have been exposed to coastal inundation. Disruption to services have been compounded by damage to the infrastructure by storm tide in addition to inundation.

Transport – barge and ferry terminals across Queensland have been exposed to storm tide. Disruption periods vary from short to long term rated against the severity of the event.

Access/resupply

Road networks paralleling the coastline at sea level have experienced a range of moderate to severe levels of storm tide damage. Short to medium term disruption has been observed due to impacts of storm tide and inundation. Rail and air assets are generally located inland from the coast, however instances of flash flooding to regional airports due to inland penetration caused by storm tide have occurred.

Maritime industry and recreational users are exposed to impacts from storm tide which have caused considerable loss to the industry from direct impact to boats and associated marine assets. Considerable damage has been observed to seawalls along the impact areas, which leads to further exposure of those areas normally protected by seawalls (such as marinas and seaside residential properties).

Community & Social

Communities along the coastline have suffered major damage from storm tide. Loss of residential dwellings, businesses and community infrastructure has occurred as a result of impact from coastal inundation and storm tide.

Significant Industry

Agriculture – industry situated in low-lying coastal areas are exposed to inundation. Considerable loss of crops and fertile soil caused by being exposed to saltwater inundation has caused long term disruption to productivity.

Heavy Industry – situated in ports and coastal areas that rely on maritime services to export or import product are directly affected by storm tide and flooding caused by coastal inundation. In addition, being cut-off by cascading effects of access disruption due to road or rail networks being affected adds to the loss of production resulting in economic impacts.

Tourism – regions affected by storm tide and inundation have seen prolonged periods of downturn in tourism numbers. This has led to a strain on businesses, the local economy and at times permanent loss of the transient workforce.

Local Industry/Business – situated in seaside communities are exposed to considerable losses caused by the direct impact of coastal inundation and storm surge.

Environment

Local species and Areas of Ecological Significance are affected due to damage to foreshore reserves and coastal ecosystems. Storm tide penetration inland has also led to damage of these areas and permanent loss due to landslips along estuaries and inlets.

Risk analysis

The level of risk is determined through an assessment of the severity of exposure, the level of vulnerability, the coping capabilities and capacities of the communities involved and the overall potential consequences:

People

- A fatality or several critical injuries may occur that require immediate medical treatment and could be potentially life threatening requiring hospitalisation.

Financial & Economic

- Medium term decline of economic activity (12 months or more) or government revenues from industries impacted (e.g. mining, agriculture and tourism). Impairment of an industry and/or damage to an asset that requires State Government financial assistance. The recovery from loss of essential infrastructure requires financial assistance beyond the allocated budget.

Community & Social

- The community's social connectedness is damaged, such that the community requires external resources to return the community to functioning effectively, with no permanent dispersal.

Public Administration

- Governing bodies encounter limited reduction in delivery of core functions. Emergency services, frontline services and community and social services manage the event with extended hours of operation and some impact to normal servicing provisions. Infrequent critical media coverage with isolated incidents of the public being critical.

Environment

- Minor damage to ecosystems and species recognised at a State level and/or significant loss or impairment of an ecosystem or species recognised at the Local or District level. Significant damage to environmental values of interest.

Figure 37

Satellite imagery showing the effect of storm surge on Mission Beach by Severe Tropical Cyclone Yasi in February 2011.

Source: Department of Natural Resources and Mines

Risk statement

The manifestation of a tropical cyclone or severe weather event along the coastline of Queensland, sufficient enough to create a storm surge leading to coastal inundation, is likely to have a cumulative effect of impact to exposed areas.

Exposed elements such as power and communication nodes, roads, rail, air and maritime networks and hubs are likely to observe short to medium term disruption periods. Damage from the cumulative effect of events can potentially cause network outages over the affected area, destruction of road infrastructure and temporary cessation of rail, maritime and air services.

Communities situated in the direct forecast impact areas may require coordinated evacuations placing strain on frontline services across all government sectors due to increased demands for response to the event. Additionally, short term disruption to road and rail networks may potentially impact access, resupply and response efforts within the affected communities.

Financial loss to the agriculture, industry and transport sector are expected to be significant and require additional funding considerations to support the impacted sectors or locations.

Short to medium term decline in tourism for significantly impacted areas may couple with local business decline and displacement of the local population. Significant environmental damage and impacts to Areas of Ecological Significance are to be expected.

Treatments

The operational risks and their specific treatment plans are addressed within the District and Local level risk registers and disaster management plans. The following list is indicative of the range of committees, groups and plans through which the risks associated with this hazard are addressed at the State level. This list is not exhaustive as the multiple and multifaceted issues arising at a State level are often addressed as part of business-as-usual strategies and activities by Commonwealth, State and Local Governments, as well as relevant private-sector service providers and community organisations, and typically respond to more than one hazard. Some informative links are also included.

Committees/groups

- Queensland Disaster Management Committee
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- Disaster Management Interdepartmental Committee
- District Disaster Management Groups
- Local Disaster Management Groups
- Climate Change Advisory Group
- Local Recovery Groups
- District Recovery Groups
- State Human & Social Recovery Committee
- Functional Recovery Groups (Human and Social Recovery Group; Economic Recovery Group; Building Recovery Group; Environmental Recovery Group; Roads Recovery Group)

Organisations

- Geoscience Australia – www.ga.gov.au
- James Cook University Cyclone Testing Station – www.jcu.edu.au cyclone-testing-station
- Department of Science, Information Technology and Innovation – www.qld.gov.au/dsiti/about-us/business-areas/science-precincts-projects/environment-nature
- Department of Environment and Heritage Protection – www.ehp.qld.gov.au/coastal
- Department of Infrastructure, Local Government and Planning – www.dilgp.qld.gov.au/planning state-planning-instruments/state-planning-policy.htm
- Queensland Reconstruction Authority – www.qldreconstruction.org.au

Reports/publications/plans

- Queensland Government Disaster Management Plans – www.disaster.qld.gov.au/Disaster-Resources/cdmp/Pages/default.aspx
- Queensland Local Government Coastal Hazard Adaptation Program – QCoast2100 – www.qcoast2100.com.au
- Department of Environment and Heritage Protection – Coastal Hazard Mapping – www.ehp.qld.gov.au/coastal/management/coastal_plan_maps.php
- Queensland Government – Coastal Hazards, Incidents and Events – www.qld.gov.au/environment/coasts-waterways/coast-hazards/
- Department of Environment and Heritage Protection Coastal Management Plan – www.ehp.qld.gov.au/coastal/management/coastal_plan_maps.php
- Department of Environment and Heritage Protection – Coastal Hazard Mapping

References and sources of additional information

- The Climate Council – www.climatecouncil.org.au
- Climate Change Authority – www.climatechangeauthority.gov.au/about-cca/authority-members
- Australian Research Council's Centre of Excellence for Climate System Science – www.climatescience.org.au/about

HEATWAVE

Risk Assessment

Heatwave

Definition

A heatwave is defined as “three (3) days or more of high maximum and minimum temperatures that are unusual for that location.”

Heatwaves are calculated using the forecast maximum and minimum temperatures for the next three days, compared to both actual temperatures over the previous 30 days and to the ‘normal’ temperatures expected for that location.

The Queensland context

Violent weather events, such as floods and cyclones, tend to create a lot of media attention, with a focus on related deaths and injuries, and economic impacts. Heatwaves are not associated with these relatively rapid onset events, and therefore tend to not be reported to the same extent.

However, heatwaves can result in significant health stress on vulnerable people. This stress may result in death during the heat event and, in many cases, well after the heatwave has passed. Often the cause of death during a heatwave is difficult to determine as many people who die due to this extreme heat have a pre-existing or contributing health condition.

Climate projections show that extreme heat events are expected to occur more often and with greater intensity in the future. There has been an increased occurrence of heatwaves and severe heatwaves across Queensland. This change in heatwave climatology correlates with an increase in demand for heatwave services experienced over the last decade. This has culminated in the release of the Heatwave Response Plan by Queensland Health, which incorporates the Bureau of Meteorology’s heatwave service.

Across Queensland, over the 30 years 1986 to 2015, a substantial fraction of the State has experienced an average of three such events per year.

Heatwave Intensity	Colour Code	Potential Community Impact
Low intensity heatwave	Yellow	Most people expected to have adequate capacity to cope with this level of heat, but begin to see health effects. Increased risk to vulnerable groups.
Severe heatwave	Orange	Increased morbidity and mortality for vulnerable groups, such as those over 65, pregnant women, babies and young children, and those with chronic illness (e.g. renal disease, ischaemic heart disease).
Extreme heatwave	Red	May impact normally reliable infrastructure, such as power and transport. Health risk for anyone who does not take precautions to keep cool, even those who are healthy.

Figure 38

Recognised level of heatwave intensity used in the provision of heatwave services.

Source: Bureau of Meteorology

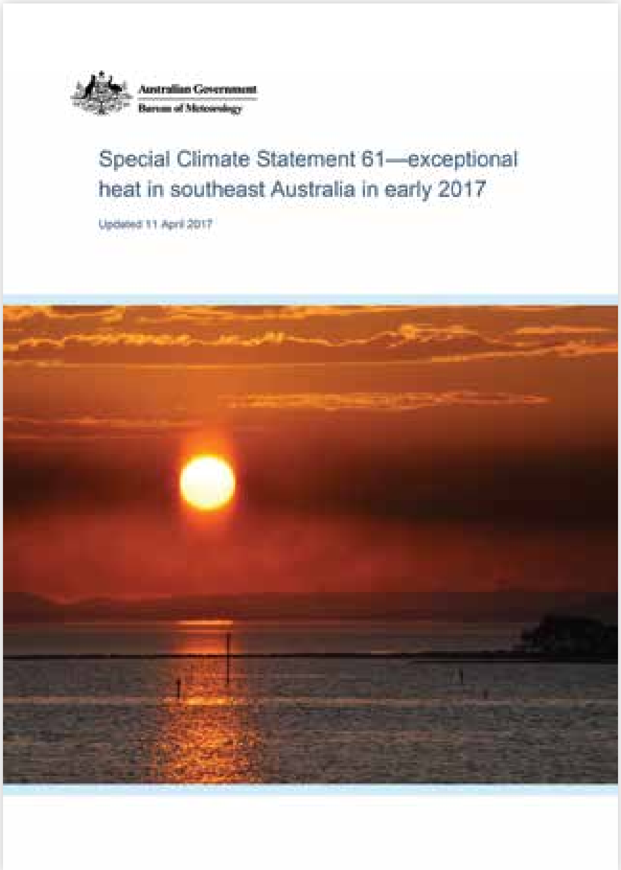


Figure 39

One of the most notable features of summer 2016–17 was the prolonged period of above average temperatures. On average, January and February 2017 ranked among the hottest months on record for large parts of southeast Australia and up into central Queensland. At least 20 sites across Queensland and New South Wales, with 40 or more years of data, set new records for the total number of summer days with maximum temperatures of at least 40°C. More details are contained within ‘Special Climate Statement 61—exceptional heat in southeast Australia in early 2017’.

Source: Bureau of Meteorology

Multi-hazard interaction

When analysing the potential impacts of a heatwave event, understanding hazard characteristics in detail has shown secondary hazards can occur from the primary event. The interaction of the primary and secondary hazards and their cascading effects need to be considered. Primary and secondary hazard characteristics relating to a heatwave event are:

- increased heat risk leading to the ignition of bushfires
- increase in propensity for electrical storms due to climatic conditions.

Potential exposures

Assessing the hazard interaction and the impact of the characteristics of those hazards upon exposed elements provides a clearer understanding of vulnerabilities.

The 2017 risk assessment highlighted elements susceptible to hazard interaction. Some key observations for communities across Queensland are impacts to:

Essential Infrastructure

Power – power infrastructure across Queensland has been vulnerable due to high levels of peak demand leading to failure across some areas of the service. Infrastructure is susceptible to damage or outages related to sustained high temperatures and the increased risk of bushfire during heatwave conditions.

Water – extra demand on the service is to be expected. Sustained high temperatures may damage some elements of the infrastructure (e.g. increased likelihood of water mains failure; increased risk for contamination through bacterial growth).

Transport Infrastructure – sustained periods of intense heat has caused damage to rail networks and roadways. The increased risk of bushfire during heatwave conditions has seen a disruption of services and some cases of damage to infrastructure.

Access/resupply

Increased movement of people in built up centres or moving towards coastal areas seeking respite has caused significant traffic issues and subsequent traffic incidents impacting on responding agencies.

Community & Social

Centres of governance – vulnerabilities across Districts related to the increased risk of bushfire during heatwave conditions. School closures across Queensland are likely to be expected during severe and extreme heatwaves. Reduction in availability of key emergency service personnel as a result.

Demographics & vulnerable populations – due to perceived high costs, low-socio economic persons may not utilise air conditioning or have limited access to air conditioning or redundancy in supply of power and water.

Medical – those with pre-existing renal, respiratory and/or heart conditions, aged populations living outside care facilities or in retirement communities, people with disabilities or mental health disorders are noted as being extremely vulnerable during severe and extreme heatwaves. Hospitals and clinics, aged care facilities and retirement communities also are highly vulnerable during heatwaves to power outages. Failure in older, less well maintained air-conditioning systems is highly likely.

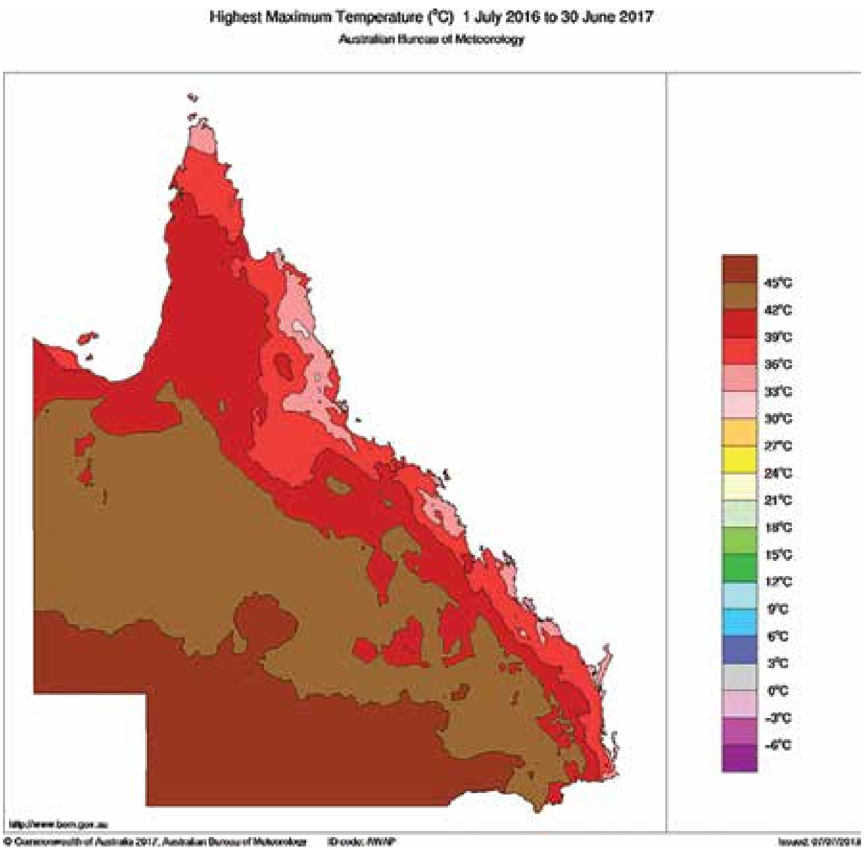


Figure 40

This map depicts the highest maximum temperatures experienced within Queensland from 1 July 2016 to 30 June 2017. Temperatures during the summer of 2016/17 broke 205 weather records in 90 days.

Source: Bureau of Meteorology

Significant Industries

Agriculture – livestock is increasingly susceptible during severe and extreme heatwaves. Expect increase in livestock mortality and therefore increase in numbers of stock loss. Substantial impacts on agriculture will be due to exacerbation of pre-existing drought conditions and moisture loss to the soil.

Environment

Vulnerabilities across Queensland exist for Areas of Ecological Significance (e.g. national parks, wildlife reserves and conservation areas) related to the increased risk of bushfire during heatwave conditions. Wildlife populations are also highly vulnerable in heatwaves.

Risk analysis

The level of risk is determined through an assessment of the severity of exposure, the level of vulnerability, the coping capabilities and capacities of the communities involved and the overall potential consequences:

People

- Increased mortality rates to be expected among aged populations and those medically dependent persons with pre-existing conditions (e.g. people on life support, people with heart disease or renal failure). Aboriginal and Torres Strait Islander communities highly vulnerable during heatwaves due to general lower state of health compared to the wider community.

Financial & Economic

- Short term isolated areas of economic loss due to disruption caused by an event. Recovery costs for damage to infrastructure and non-supply periods.

Community & Social

- Increased pressure on community and social services response to those highly susceptible to the effects of prolonged heatwave conditions.

Public Administration

- Increased demand on emergency services, frontline services and community and social services managing the event with extended hours of operation and some impact to normal servicing provisions. This is likely to cause delays in service during the period of immediate effect of the event and add to financial impacts beyond normal budgeted operations for responding agencies.

Environmental

- Large scale bush and wildfires across areas of national parks, State forests and Areas of Ecological Significance have been observed as a result of exacerbated bushfire conditions.

Figure 41

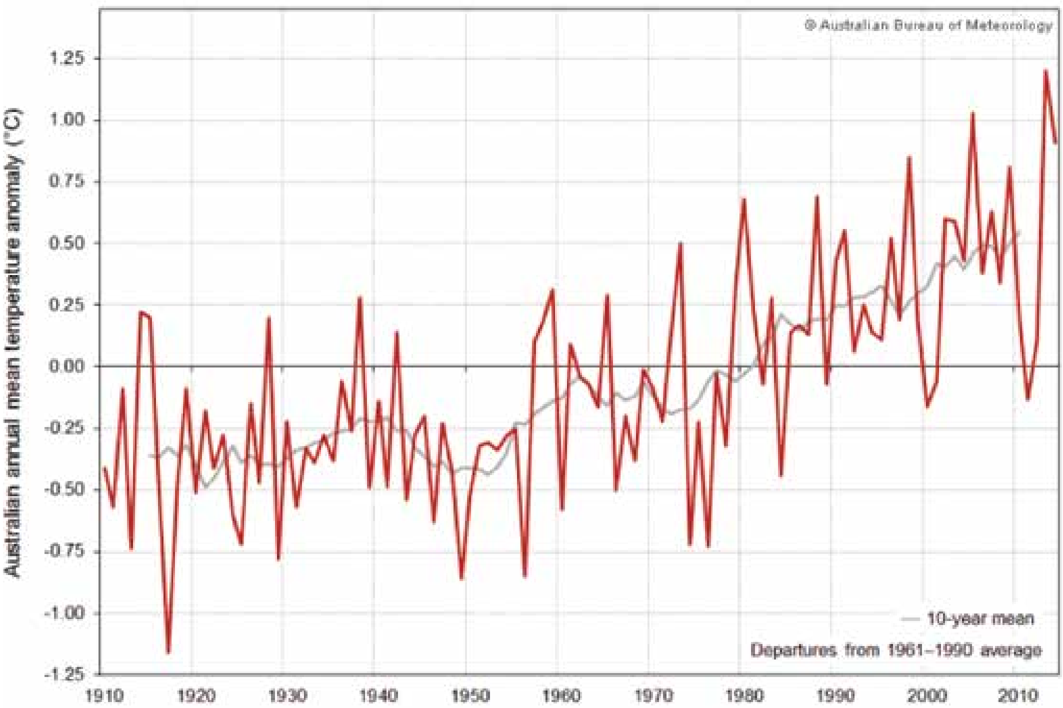
This photo, taken during the drought of 2006, shows a water depth indicator at the empty Longway Dam, near Longreach, Western Queensland.

Source: William West Photography

Figure 42

The warming depicted in the dataset used for this graph is very similar to that shown in international analyses of Australian temperature data and very closely matches satellite data and warming of sea surface temperatures around Australia. This agreement provides added confidence for decision makers, and reinforces our understanding of the changing climate.

Source: Bureau of Meteorology



Risk statement

The manifestation of a heatwave event can lead to localised and widespread outages of the power network due to high levels of peak demand, leading to failure across some areas of the service. Infrastructure is susceptible to damage or outages, related to direct impact from sustained high temperatures and the increased risk of bushfire during heatwave conditions.

Sustained high temperatures coupled with increased demand on the service may damage some elements of the water infrastructure, increasing the likelihood of water mains failure. Increased risk for contamination through bacterial growth can occur leading to impacts on the demand of the service.

A number of fatalities and critical injuries may occur in those with pre-existing renal, respiratory and/or heart conditions, and in elderly populations (65+) who are a demographic noted as being extremely vulnerable during severe and extreme heatwaves. Additionally areas which have limited access to air conditioning or redundancy in supply of power and water can add to the criticality of this risk.

Short term disruption to major, road and rail systems due to the impacts of the event are likely to lead to major congestion and significant transport related incidents. Increased movement of people in built up centres or moving towards coastal areas seeking respite can potentially add significantly to traffic issues and subsequent traffic incidents. This is likely to lead to a reduction in the availability of key emergency service personnel due to the increases in calls to responding agencies.

Substantial impacts on agriculture due to exacerbation of pre-existing drought conditions and moisture loss to the soil is likely to lead to livestock mortality during severe and extreme heatwaves

Recovery costs for damage to infrastructure and business interruption due to non-supply periods is likely. This can lead to instances of economic assistance being required from Local or State funding.

National parks, wildlife reserves, conservation areas and wildlife populations are highly vulnerable to heatwaves and additionally to the increased risk of the secondary hazard of bushfire.

Treatments

The operational risks and their specific treatment plans are addressed within the District and Local level risk registers and disaster management plans. The following list is indicative of the range of committees, groups and plans through which the risks associated with this hazard are addressed at the State level. This list is not exhaustive as the multiple and multifaceted issues arising at a State level are often addressed as part of business-as-usual strategies and activities by Commonwealth, State and Local Governments, as well as relevant private-sector service providers and community organisations, and typically respond to more than one hazard. Some informative links are also included.

Committees/groups

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- Local Disaster Management Groups
- Climate Change Advisory Group
- Local Recovery Groups
- District Recovery Groups
- State Human & Social Recovery Committee
- Functional Recovery Groups (Human and Social Recovery Group; Economic Recovery Group; Building Recovery Group; Environmental Recovery Group; Roads Recovery Group)

Organisations

- Bureau of Meteorology – www.bom.gov.au/australia/heatwave
- Queensland Health – www.health.qld.gov.au/public-health/disaster
- Department of Communities, Child Safety and Disability Services – www.qld.gov.au/community/disasters-emergencies
- Queensland Ambulance Service – www.ambulance.qld.gov.au/services.html
- School of Public Health and Social Work (Environmental Health and Emergency Care) – Queensland University of Technology – www.qut.edu.au/health/research/research-areas/environmental-health
- Queensland Reconstruction Authority – www.qldreconstruction.org.au

Reports/publications/plans

- Queensland Government Disaster Management Plans – www.disaster.qld.gov.au/Disaster-Resources/cdmp/Pages/default.aspx
- Queensland Health - Dealing with Disasters – Heatwave – www.qld.gov.au/emergency/dealing-disasters/heatwave.html
- Bureau of Meteorology - Heatwave Service – www.bom.gov.au/australia/heatwave
- The Climate Council – Super-Charged Storms in Australia: The Influence of Climate Change. 2016. Climate Council of Australia Limited.

References and sources of additional information

- PriceWaterhouseCoopers. Protecting Human Health and Safety during Severe and Extreme Heat Events A National Framework. 2011.
- Turner, L. et al. The Effect of Heat Waves on Ambulance Attendances in Brisbane, Australia. 2013. Griffith Research Online.
- Toloo, G. et al. The Impact of Heatwaves on Emergency Department Visits in Brisbane, Australia: A Time Series Study. 2014. Critical Care Forum, BioMed Central.
- Toloo, G. et al. Socio-demographic Vulnerability to Heatwave Impacts in Brisbane, Australia: A Time Series Analysis. 2014. Australian and New Zealand Journal of Public Health.
- Nairn, J. Fawcett, R. Heatwaves in Queensland. Australian Journal of Emergency Management. 2017.

BUSHFIRE

Risk Assessment

Bushfire

Definition

Bushfire hazard is the potential fire behaviour characterised by the weather, fuels and topography. A Bushfire Prone Area is land that could support a significant bushfire or be subject to significant bushfire attack. This area includes potentially hazardous vegetation with a Medium, High or Very High Potential Bushfire Intensity.

The Queensland context

Bushfire Prone Area (BPA) mapping is used by multiple Local Governments when preparing planning schemes, and to underpin the planning of bushfire mitigation activities. BPA mapping is also an input to Local disaster management planning and land use planning in accordance with Queensland's State Planning Policy 2016.

Land use planning provisions are required to work in conjunction with other risk management measures including building controls, mitigation infrastructure, early warning systems, community awareness and disaster management. Land use planning provisions are one component of an integrated disaster management strategy.

The approach used to map BPAs combines spatial information on potential fire weather severity, landscape slope and potential fuel load. Bushfires in these areas have the potential for high to extreme levels of flame, ember and wind attack, radiant and convective heat exposure and smoke hazard as a result of high potential fuel loads, slope and severe fire weather. Bushfire impacts in a BPA are potentially harmful to people and property.

Of these impact mechanisms, flame attack, radiant heat exposure and ember attack are most relevant to land use planning and building decisions that seek to reduce the risks to life and property in new developments. Land that could be subject to significant bushfire attack from embers, flames or radiant heat is included in a Potential Impact Buffer with a default width of 100m from all areas of Medium, High or Very High Potential.

National best practice in the assessment of bushfire hazard is characterised by:

- A suitably defined planning level of representative fire weather relevant to the time period being assessed. For example, a representative weather stream at the required planning level for the coming year should be used.
- Fuels state represented to sufficient levels of detail so as to produce generally representative fire behaviour (intensities, flame heights, spotting and other characteristics). The representation of previous fires and treatments such as fire breaks, and the re-accumulation of fuels since time of prior burn is important. Fuels should also include both grass and forest fuels.

Potential exposures

There are key area interface zones (I-Zones) where natural bushland interacts with urban areas that creates a vulnerability to people, domestic dwellings and industrial areas. This is also a priority management area for QFES and Local disaster management groups within their fire mitigation strategies.

Assessing the hazard interaction and the impact of the characteristics of those hazards upon exposed elements provides a clearer understanding of vulnerabilities.

The 2017 risk assessment highlighted elements susceptible to hazard interaction. Some key observations for communities across Queensland are impacts to:

Essential Infrastructure

Power – State power infrastructure is vulnerable to bushfire threat. Some areas have seen short term periods of disruption to the network due to direct impact from fire to power poles, substations and indirect impact from rising ash and embers causing powerlines to spark and short at key nodes across the network. Generally, fire mitigation strategies employed by infrastructure owners in conjunction with QFES and local council fire mitigation plans, reduces the vulnerability of the network to this hazard.

Communications – there are multiple key communication assets across Queensland located within topographically high areas. This facilitates greater coverage of service for communications providers, however leaves the infrastructure vulnerable to exposure from bushfire hazard (which is also exacerbated by the topography) as the majority of the locations are in natural bushland.

This heightens the vulnerability for direct impact disruption as well as indirect disruption due to communications reliability on power supply which, when affected, has led to short term interruption of service through loss of power.

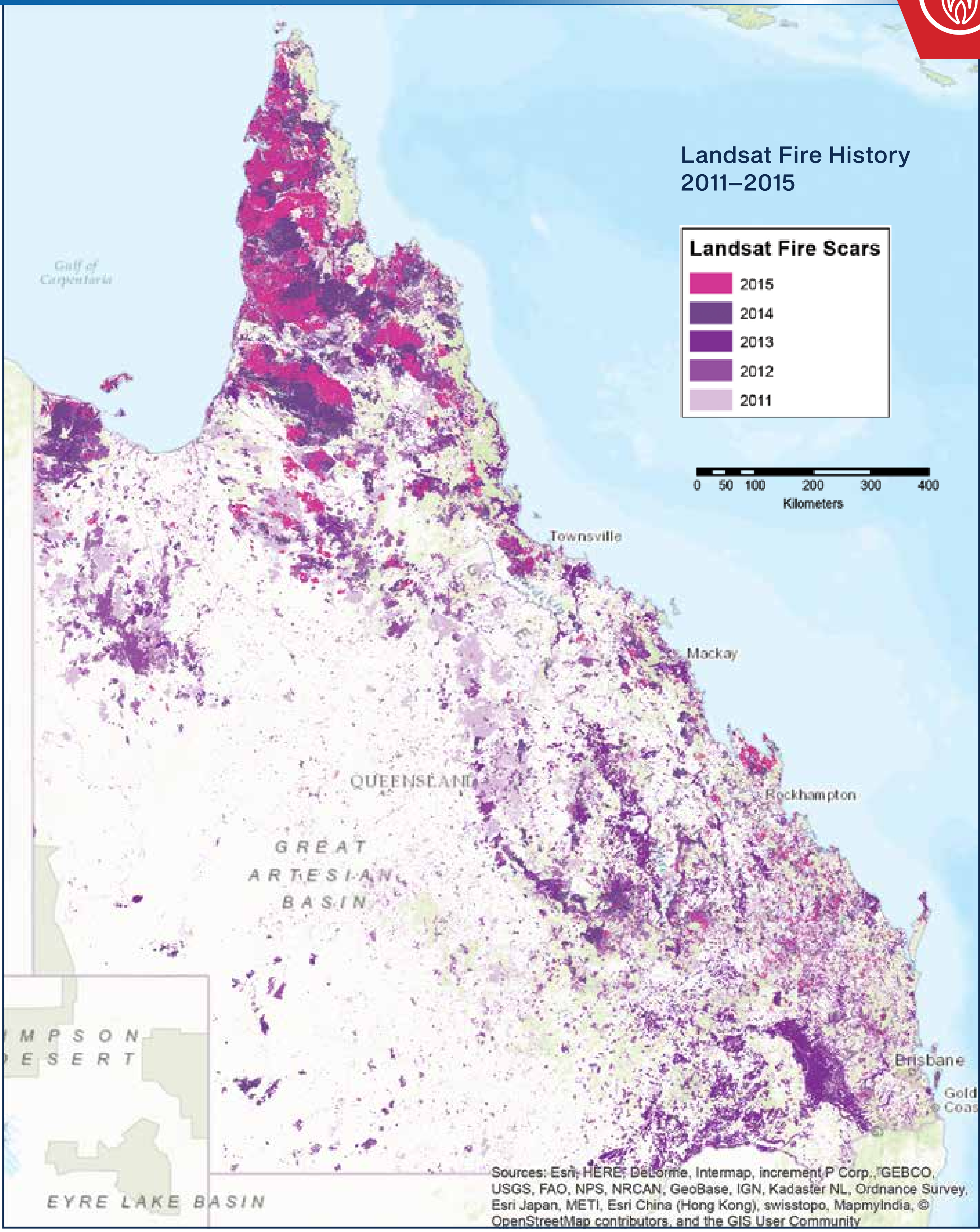

Figure 43

Queensland's Landsat Fire scar imagery showing the location where fires occurred between 2011 and 2015. A 'fire scar' is the visibly blackened land surface left after bushfires burn vegetation and leaf litter.

Source: Data from Department of Science, Information Technology and Innovation, map created by Queensland Fire and Emergency Services

Water – recent assessments have identified water infrastructure exposure to be minor. Most infrastructure operators employ effective mitigation strategies to ensure assets are as safe from the hazard as possible. Indirect disruption has been observed in the short term when power has been affected, however the majority of water operators have redundancy plans to maintain operations over the short to medium term.

Transport infrastructure – some isolated transport infrastructure is vulnerable to bushfire exposure where it is situated in I-Zone locations. These areas are noted at a Local level and managed in conjunction with infrastructure owners. Some roadways and road structures (e.g. bridges, overpasses and signage) across Queensland are exposed to severe bushfire conditions. Disruption periods associated with these assets are normally short term with alternate routes or traffic management plans enacted.

Access/resupply

Short term disruption periods have been observed during periods of large scale bushfires. There have been instances of damage to road and rail networks from extreme heat exposure caused by bushfire, which has led to disruption of access or use of services in the short term leading to transport delays at times and significant costs for repair or return of services.

Community & Social

There are some communities in isolated areas which are highly vulnerable to exposure from a bushfire hazard. These small, populated locations are at times off the grid and located in densely vegetated areas. Built up areas established in areas surrounded by national parkland (e.g. mountain suburban areas) also are highly vulnerable to exposure of bushfire hazard. These types of I-Zone areas are significant focus areas for QFES and Local Disaster Management Groups due to their restricted access and egress routes and proximity to high fire risk areas.

Demographics & vulnerable populations – I-Zone areas within remote Indigenous communities and townships comprised of a mix of ethnically, culturally and socio-economically diverse groups – who at times are reliant on social media and word-of-mouth for emergency alerts – are vulnerable to loss of communications across the District (linked to loss of power) as a result of impact from a bushfire hazard.

Medical – built up and remote urban towns along I-Zone areas have a minor vulnerability to their medical assets and infrastructure being exposed to a bushfire hazard.

Significant Industries

Agriculture – rural areas across Queensland have sustained stock and crop losses from direct exposure to a bushfire hazard. Additionally, some bulk storage areas (such as grain silos, cotton stores and, in some locations, cattle yards) are vulnerable to exposure from a bushfire hazard. The significant impacts of bushfire to these locations have had and are likely to experience medium to long term disruption periods.

Mining – underground mining locations across Queensland rely on surface air vents to supply clean air to workers who are at times located at significant depths below-ground. Air intakes are vulnerable to impact from exposure of smoke in air vents produced in a bushfire hazard. This has and can cause short term disruption to production of those mines due to essential evacuations of the underground workers.

Open cut mines across Queensland are also vulnerable to exposure from a bushfire hazard. If directly impacted, this can cause significant disruption to the mines and loss of major mining equipment. The mining industry works reasonably well with local authorities to mitigate fire exposure hazard and at times assists with response resources.

Forestry – Queensland's forestry industry is highly vulnerable to exposure from bushfire hazard due to the nature of the industry. Loss of timber at a significant scale can cause long term disruption to industry equipment and infrastructure located in these areas.

Environment

National parks and areas of dense vegetation have shown consistency in being the high exposure areas across the State to bushfire hazard. Uncontrolled burns in these areas have led to significant natural bushland areas being impacted by bushfire. Native vegetation and fauna are highly vulnerable to the manifestation of bushfire hazard during an event in these locations in addition to State or Local infrastructure that traverses those locations.

Risk analysis

The level of risk is determined through an assessment of the severity of exposure, the level of vulnerability, the coping capabilities and capacities of the communities involved and the overall potential consequences:

People

- A fatality or critical injuries in vulnerable persons with pre-existing respiratory conditions is likely. Remote, isolated communities may also expect fatalities or several critical injuries due to limited communications and their access restrictions. Evacuation of these areas is likely and would require significant resources to facilitate.

Financial & Economic

- Disruption risk to significant industry could see impairment of an industry or damage to an asset that requires State Government financial assistance. The recovery from loss of essential infrastructure is simple but requires financial assistance beyond allocated budgets. Economic downturn may cause significant impact to a local business sector, seeing the need for Local or State funding assistance in the short term.

Community & Social

- The community's social connectedness is disrupted, due to disruption of essential services linked to the community, which may require reprioritisation or reallocation of existing resources to return the community to functioning effectively, with no permanent dispersal.

Public Administration

- Increased demand on emergency services, frontline services and community and social services managing the event with extended hours of operation and some impact to normal servicing provisions. This is likely to cause delays in service during the period of immediate effect of the event and add to financial impacts beyond normal budgeted operations for responding agencies.

Environmental

- Potential for moderate damage to ecosystems and species recognised at the State level and/or significant loss of an ecosystem or species recognised at the Local or District level. Significant damage to environmental values of interest are also possible.

Figure 44

Grassfire prone areas may be subject to relatively frequent vegetation fires that are often fast moving and may result in high levels of smoke, flame and ember hazard.

Source: Queensland Fire and Emergency Services

Risk statement

The manifestation of bushfire is mostly observed in natural bushland areas across Queensland. There are areas of interaction with urban landscapes and essential infrastructure where bushfire has manifested. The severity of impact to essential services is reflective of the mitigation strategies that are existing in the particular area of a bushfire event.

Exposed elements such as power and communication nodes, roads and rail networks and air services are likely to observe short to medium term disruption periods. Damage from the cumulative effect of fire and smoke can potentially cause network outages over the affected area, destruction of infrastructure, and temporary cessation of rail and air services.

Communities situated in the direct forecast impact areas may require coordinated evacuations, placing strain on frontline services across all government sectors due to increased demands for response to the event. Additionally, short term disruption to road and rail networks may potentially impact access, resupply and response efforts within the affected communities. Disruption and loss to industry may occur and impact will be dependent on the severity of the event.

National parks and areas of dense vegetation exposed to this hazard may see significant loss due to impact by bushfire. Native vegetation and fauna are highly vulnerable to the manifestation of bushfire hazard during an event in these locations in addition to State or Local infrastructure that traverses those locations.

Treatments

The operational risks and their specific treatment plans are addressed within the District and Local level risk registers and disaster management plans.
This list is not exhaustive as the multiple and multifaceted issues arising at a State level are often addressed as part of business-as-usual strategies and activities by Commonwealth, State and Local Governments, as well as relevant private-sector service providers and community organisations, and typically respond to more than one hazard. Some informative links are also included.

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- Local Disaster Management Groups
- Climate Change Advisory Group
- Local Recovery Groups
- District Recovery Groups
- State Human & Social Recovery Committee
- Functional Recovery Groups (Human and Social Recovery Group; Economic Recovery Group; Building Recovery Group; Environmental Recovery Group; Roads Recovery Group)
- Area Fire Management Groups
- State Inter-Departmental Committee (SIDC) on Bushfires

Organisations

- Queensland Fire and Emergency Services – www.qfes.qld.gov.au/Pages/default.aspx
- Queensland Rural Fire Service – ruralfire.qld.gov.au/Pages/Home.aspx
- Department of National Parks, Sports and Racing – www.npsr.qld.gov.au
- Department of Natural Resources and Mines – www.dnrm.qld.gov.au
- Australasian Fire and Emergency Service Authorities Council – www.afac.com.au
- Queensland Reconstruction Authority – www.qldreconstruction.org.au

Reports/publications/plans

- Department of Infrastructure, Local Government and Planning – www.dilgp.qld.gov.au/planning/state-planning-instruments/state-planning-policy.html
- Climatic Change – Natural Hazards in Australia: Extreme Bushfire. Climatic Change (2016) 139: 85.
- Queensland Rural Fire Service – Operation Cool Burn – ruralfire.qld.gov.au/BushFire_Safety/Pages/Operation-Cool-Burn.aspx
- BNHCRC – Fire Surveillance and Hazard Mapping – www.bnhcrc.com.au/research/understanding-mitigating-hazards/256
- BNHCRC - Bushfire Predictive Services – www.bnhcrc.com.au/research/cluster/bushfire-predictive-services
- Queensland Government Disaster Management Plans – www.disaster.qld.gov.au/Disaster-Resources/cdmp/Pages/default.aspx

References and sources of additional information

- Bushfire & Natural Hazard Cooperative Research Centre – www.bnhcrc.com.au
- South East Queensland Fire and Biodiversity Consortium – www.fireandbiodiversity.org.au
- Terrestrial Ecosystem Research Network – www.tern.org.au
- Climatic Change – Sharples, J.J. et al. Natural Hazards in Australia: Extreme Bushfire. (2016) 139: 85.

EARTHQUAKE

Risk Assessment

Earthquake

Definition

Earthquakes are the vibrations caused by rocks breaking under stress. The underground surface along which the rock breaks and moves is called a fault plane. Earthquakes in Australia are usually caused by movements along faults as a result of compression in the Earth's crust.

While earthquake magnitude was traditionally measured on the Richter scale, Australia's earthquakes are relatively small and infrequent. Therefore it is now calculated using the "local magnitude" scale, which is derived from the Richter scale but has been adapted to local conditions.

The size or magnitude of earthquakes is determined by measuring the amplitude of the seismic waves recorded on a seismograph and the distance of the seismograph from the earthquake. These are put into a formula which converts them to a "moment magnitude", which is a measure of the energy released by the earthquake. For every unit increase in magnitude, there is roughly a thirty-fold increase in the energy released. A magnitude 7.5 (the likely maximum magnitude for Australia) earthquake releases energy equivalent to about 50 times the impact of the Hiroshima bomb. Fortunately, smaller earthquakes occur much more frequently than large ones and most cause little or no damage.

Earthquake effects are rated using the Modified Mercalli intensity scale, which ranges from I (imperceptible) up to X (destruction of most masonry structures). The intensity felt at a particular location depends on many factors such as distance from focus, nature of the local strata overlying bedrock, local topography and an observer's level of alertness and activity at the time of an earthquake.

For the very shallow earthquakes common in many parts of Australia, with a focal depth of less than 10 km, people who are near the epicentre and on average ground will usually experience the maximum MM intensities in the table in Figure 46.

Earthquake Building Damage - Examples

MMI V	MMI VI	MMI VII	MMI VIII
Kalgoorlie CBD, 20 April, 2010	Boulder CBD, 20 April, 2010	Greater Newcastle, 27 December, 1989	Central Newcastle and Christchurch, 22 February, 2011
Cracking of vulnerable masonry (e.g. parapets & chimneys with minor falls). Minor cracking to masonry houses.	Collapse of vulnerable masonry and severe cracking to other masonry structures.	Severe damage to unreinforced masonry (URM) buildings, some damage to low ductility framed buildings, particularly irregular buildings.	Heavy damage to URM buildings, severe damage to irregular low ductility buildings.
			

GEOSCIENCE AUSTRALIA

Figure 45

Examples of Australian earthquakes using the Modified Mercalli (MM) intensity scale.

Source: Geoscience Australia

Moment Magnitude (Indicative only)	MM Intensity (Likely maximum)	Definition
1.2	II	MII - felt by a few persons at rest indoors, especially by those on upper floors or otherwise favorably placed.
2.0	III	MIII - felt indoors, but not identified as an earthquake by everyone. Vibrations may be likened to the passing of light traffic. It may be possible to estimate the duration, but not the direction. Hanging objects may swing slightly. Standing motorcars may rock slightly.
3.0	IV	MMIV - generally noticed indoors, but not outside. Very light sleepers may be awakened. Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building. Walls and frame of building are heard to creak. Doors and windows rattle. Glassware and crockery rattle. Liquids in open vessels may be slightly disturbed. Standing motorcars may rock, and the shock can be felt by their occupants.
4.0	V-VI	MMV - generally felt outside and by almost everyone indoors. Most sleepers awakened. A few people frightened. Direction of motion can be estimated. Small unstable objects are displaced or upset. Some glassware and crockery may be broken. Some windows crack. A few earthenware toilet fixtures crack. Hanging pictures move. Doors and shutters swing. Pendulum clocks stop, start or change rate. MMVI - felt by all. People and animals alarmed. Many run outside. Difficulty experienced in walking steadily. Slight damage to masonry D. Some plaster cracks or falls. Isolated cases of chimney damage. Windows and crockery broken. Objects fall from shelves and pictures from walls. Heavy furniture moves. Unstable furniture overturns. Small school bells ring. Trees and bushes shake or are heard to rustle. Material may be dislodged from existing slips, talus slopes, or slides.
5.0	VI-VII	MMVII - general alarm. Difficulty experienced in standing. Noticed by drivers of motorcars. Trees and bushes strongly shaken. Large bells ring. Masonry D cracked and damaged. A few instances of damage to Masonry C. Loose brickwork and tiles dislodged. Unbraced parapets and architectural ornaments may fall. Stone walls crack. Weak chimneys break, usually at the roof-line. Domestic water tanks burst. Concrete irrigation ditches damaged. Waves seen on ponds and lakes. Water made turbid by stirred-up mud. Small slips, and caving-in of sand and gravel banks.
6.0	VII-VIII	MMVIII - alarm may approach panic. Steering of motor cars affected. Masonry C damaged, with partial collapse. Masonry B damaged in some cases. Masonry A undamaged. Chimneys, factory stacks, monuments, towers, and elevated tanks twisted or brought down. Panel walls thrown out of frame structures. Some brick veneers damaged. Decayed wooden piles break. Frame houses not secured to the foundation may move. Cracks appear on steep slopes and in wet ground. Landslips in roadside cuttings and unsupported excavations. Some tree branches may be broken off.
7.0	VIII-IX	MMIX - general panic. Masonry D destroyed. Masonry C heavily damaged, sometimes collapsing completely. Masonry B seriously damaged. Frame structures racked and distorted. Damage to foundations general. Frame houses not secured to the foundations shift off. Brick veneers fall and expose frames. Cracking of the ground conspicuous. Minor damage to paths and roadways. Sand and mud ejected in alluviated areas, with the formation of earthquake fountains and sand craters. Underground pipes broken. Serious damage to reservoirs.

Figure 46

Earthquake effects can be rated using the Modified Mercalli (MM) intensity scale. For an explanation of Masonry categories, refer to Geoscience Australia at: www.ga.gov.au/scientific-topics/hazards/earthquake/basics/what/modified-mercalli-scale.

Source: Information from Geoscience Australia, table created by Queensland Fire and Emergency Services

In Australia, earthquakes with magnitudes of less than 3.5 seldom cause damage. The smallest magnitude earthquake known to have caused fatalities is the moment magnitude 5.6 Newcastle earthquake in 1989 as shown Figure 45.

However, magnitude 4.0 earthquakes occasionally topple chimneys or result in other damage which may cause harm.

Apart from shaking, earthquakes of magnitude 5.0 or greater may also trigger landslides. The larger the magnitude of the earthquake, the bigger the area over which landslides may occur.

In areas underlain by water-saturated loose granular sediments, large earthquakes (usually magnitude 5.0 or greater) may cause liquefaction. The shaking causes the wet sediment to lose its strength and stiffness and begin to flow.

Subsidence from liquefaction may cause buildings to topple.

Large undersea earthquakes that cause permanent displacement on the ocean floor can cause a tsunami, or a series of waves, which can cross an ocean and cause extensive damage to coastal regions. Earthquakes can also create underwater landslides that in turn can trigger more localised tsunami.

The Queensland context

Australia does not typically experience large earthquakes, with, on average, a single magnitude 5 (or greater) event occurring each year. This is because Australia does not sit on the edge of a tectonic plate, unlike New Zealand that experiences far greater earthquake activity as a result. Notable Queensland earthquakes of 5.0 or greater have occurred in the locations shown in Figure 47.

Potential exposures

For the purposes of this report, impact will be assessed against a Newcastle-type event with an MMVI-VII range of intensity. This assessment is not definitive for the whole of Queensland, however areas of susceptibility identified throughout this assessment have been referred to Geoscience Australia for further potential evaluation.

Assessing the hazard interaction and the impact of the characteristics of those hazards upon exposed elements provides a clearer understanding of vulnerabilities. The 2017 risk assessment highlighted elements susceptible to hazard interaction. Some key observations for communities across Queensland are impacts to:

Essential Infrastructure

Power & Communications – direct effect of intense ground shaking on power infrastructure (generators, switchyards, poles and lines) and communications infrastructure (towers and exchanges) triggering widespread local outages may lead to prolonged periods of disruption. Additionally the interdependency of communications networks and other key community infrastructure (including services such as water and governance infrastructure) on power may lead to protracted disruption issues.

Water – mains water pipelines, some of which have high levels of asbestos, may be damaged or ruptured from intense ground shaking. Disruptions to mains water supply should be expected across the medium to long term where replacement of the pipeline is protracted. Asbestos contamination within water across a broad area would be likely and of concern at the State level. Some referable dam infrastructure built prior to 1994 (when the AS 1170 Earthquake Loading Code was published) may also be vulnerable.

Access/resupply

Major road and rail networks across the State may be susceptible to shaking and settlement leading to considerable surface damage. Sections of State highways and older bridges may also be vulnerable to intense shaking causing disruption.

Community & Social

Building Code – a large number of pre-1994 masonry buildings exist within the central business districts of regional towns and cities (especially within historical quarters) whose structural materials and architectural form makes them vulnerable to intense shaking. A significant number of regional schools, hospitals and centres of governance are situated in buildings built prior to 1994.

Essential Community and Government Services – these services are likely to be significantly disrupted across the medium to long term as a result of damage to buildings that house these services and/or are dependent on power, communications and other infrastructure.

Significant Industries

Gas & Oil Infrastructure such as pipelines, storage tanks, wells and other infrastructure may be vulnerable to intense ground shaking leading to potential ruptures. Ruptures may lead to disruption to services and/or environmental damage.

Wide disruption to industry as a result of direct impact from an event with the addition of consequential impact from the dependency on power, communications and water may lead to considerable decrease in productivity.

Environment

The risk of liquefaction is linked to the geomorphology of an area. Areas with a built environment that may be affected by an earthquake may result in subsidence or collapse of buildings.

Earthquakes which occur in areas of the Great Barrier Reef (for example the 2016 5.8 magnitude earthquake off shore from Bowen, Queensland) may cause significant damage to the reef's structure.

Intense shaking may precipitate landslips in prone areas. This may have further effects on power & communications infrastructure and populated areas located within these regions.

Possible asbestos contamination of a size and scale exceeding local capacity to manage.

Figure 47

Notable earthquakes in Queensland.

Source: Data from Geoscience Australia, map created by Queensland Fire and Emergency Services

Date	Location	Magnitude	Depth
August 2016	Offshore north east of Bowen	5.8	7km
August 2015	Offshore east of Fraser Island	5.3	13km
July 2015	Offshore east of Fraser Island	5.4	13km
February 2015	Eidsvold, Bundaberg	5.2	13km
July 2011	Bowen, Mackay	5.3	7km
November 1978	Heron Island, Yeppoon	5.2	12km
December 1974	Offshore of Mackay	5.1	6km
June 1965	Tarewinnabar, Warwick	5.3	28km
June 1918	Lady Elliot Island, Gladstone	6.0	15km

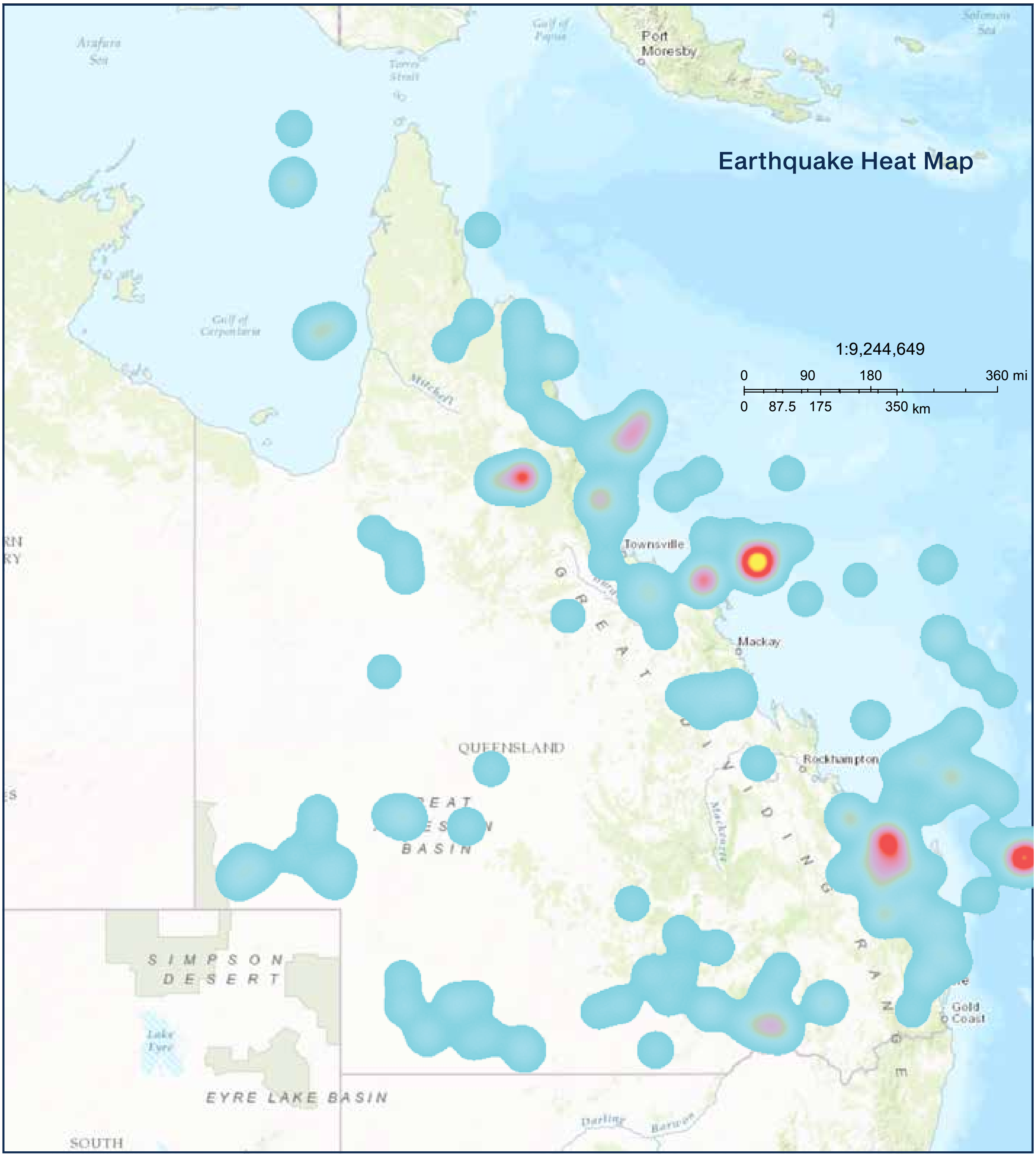


Figure 48

Heat map depicting location and intensity of earthquakes above a magnitude of 3.0 in Queensland between 1967 and 2017. Areas of red to yellow indicate a concentration of earthquakes over time within an area.

Source: Data from Geoscience Australia, map created by Queensland Fire and Emergency Services

Risk analysis

The level of risk is determined through an assessment of the severity of exposure, the level of vulnerability, the coping capabilities and capacities of the communities involved and the overall potential consequences:

People

- A significant number of fatalities and critical injuries occurring as a direct result of an event (highly dependent on time of occurrence and location).
- Increased hardship due to financial pressures and medium term displacement (evacuations and/or loss of habitable dwellings) impacts upon the emotional capacity of individuals. This can lead to increases in mental health issues and impacts upon domestic cohesion.

Financial & Economic

- Sharp decline in regional economic activity, possibly impacting at a State level, as a result of direct impact to major regional projects as well as local businesses.
- Damage to or loss of residential and essential civic infrastructure (e.g. hospitals and schools) as well as short to medium term disruption to transport network infrastructure and services (roads, rail, air and maritime).

Community & Social

- Loss of essential services (e.g. power and water) and government services will significantly impact the community for the short to medium term. Recovery may be protracted dependent on levels of damage and loss.
- Longer term decrease in social connectedness which requires external resources to return the community to functioning effectively.
- Damage to elements of cultural and religious significance to the community intensifies the decrease in social connectedness.

Public Administration

- Vulnerability of buildings and dependency on essential services may cause significant strain on governing bodies and emergency services delivering core functions. Pressure will be exacerbated as a result of responding to the consequences of an event and will likely require State support.
- Increased demand on emergency services, frontline services and community and social services managing the event with extended hours of operation and some impact to normal servicing provisions. This is likely to cause delays in service during the period of immediate effect of the event and add to financial impacts beyond normal budgeted operations for responding agencies.
- Sustained and frequent media coverage (both positive and negative) by national and international media outlets.

Environmental

- Damage to ecosystems such as the Great Barrier Reef recognised at a Local, District and/or State level.

Risk statement

The sudden onset of an earthquake, especially an earthquake with an intensity of shaking of moment magnitude rating of MMVI to MMVIII, will likely lead to widespread power, water and communication outages, closure of transport hubs including highways, major roads, local airports and ports through extensive infrastructure damage within the affected area of Queensland.

Such disruptions will severely impact access/resupply in the affected area across the short term. Disruption to essential services (e.g. mains gas and water) may be significant, protracted and require substantial assistance to enable full return of service.

A number of fatalities and critical injuries may be expected depending on magnitude and intensity, duration, location and time of event.

Short to medium term reduction of services coupled with strain on frontline services across all government sectors are likely due to increased demand, potentialy enduring across the wider community while post event recovery efforts continue.

Presence of any vulnerable persons within the affected area may lead to an increase in number of injuries sustained adding pressure on frontline services during response and recovery phases.

Building damage, especially concerning those buildings built prior to 1995, is likely to be extensive and may further impact upon provision of essential and governance services across the medium to long term. Presence of asbestos within buildings and elements of infrastructure such as pipelines is likely to result in contamination and may exceed local capacity to manage.

Secondary hazards such as liquefaction may occur or be exacerbated by the geomorphology of the affected area and intense shaking may precipitate landslips in prone areas. Offshore earthquakes of significant magnitude located near or under the Great Barrier Reef may lead to structural damage of the reef. The potential for coastal inundation as a secondary hazard exists.

Treatments

The operational risks and their specific treatment plans are addressed within the District and Local level risk registers and disaster management plans. The following list is indicative of the range of committees, groups and plans through which the risks associated with this hazard are addressed at the State level. This list is not exhaustive as the multiple and multifaceted issues arising at a State level are often addressed as part of business-as-usual strategies and activities by Commonwealth, State and Local Governments, as well as relevant private-sector service providers and community organisations, and typically respond to more than one hazard. Some informative links are also included.

Committees/groups

- Queensland Disaster Management Committee
- State Disaster Coordination Group
- Disaster Management Interdepartmental Committee
- District Disaster Management Groups
- Local Disaster Management Groups
- Local Recovery Groups
- District Recovery Groups
- State Human & Social Recovery Committee
- Functional Recovery Groups (Human and Social Recovery Group; Economic Recovery Group; Building Recovery Group; Environmental Recovery Group; Roads Recovery Group)

Organisations

- Geoscience Australia – www.ga.gov.au/
- Department of Natural Resources and Mines & Business Queensland – www.business.qld.gov.au/industries/mining-energy-water/resources/geoscience-information
- Australian Earthquake Engineering Society – www.aees.org.au
- Seismology Research Centre – www.src.com.au/earthquakes
- Queensland Reconstruction Authority – www.qldreconstruction.org.au

Reports/publications/plans

- Geoscience Australia – Historic Earthquakes of Australia and their Significance
- University of Queensland – Seismological Observatory – http://www.quakes.uq.edu.au
- Queensland Government Disaster Management Plans – www.disaster.qld.gov.au/Disaster-Resources/cdmp/Pages/default.aspx

References and sources of additional information

- Australian Disaster Resilience Knowledge Hub – www.knowledge.aidr.org.au/disasters
- Ministry of Civil Defence and Emergency Management – www.civildefence.govt.nz
- Coates, L., et al (2017). An Analysis of Human Fatalities from Cyclones, Earthquakes and Severe Storms in Australia. Report for the Bushfire and Natural Hazard Cooperative Research Centre.

Summary and priorities

This assessment has identified tropical cyclone as equally the most disruptive and damaging natural hazard within Queensland with the potential to pose the most risk to life due to limitations to disaster operations during impact. **Tropical cyclones are accorded the highest priority for Queensland.**

Historically, of all natural hazards, tropical cyclones have claimed the most lives in Queensland although not in recent years. As depicted within this assessment, tropical cyclones can reasonably be expected to manifest to varying degrees of severity each year due to Queensland's geography and climate.

The cascading and coincident effects of a tropical cyclone described in the risk profile can pose complex issues such as:

- damage from sustained high wind speeds
- rapid delivery of concentrated rainfall leading to flash flooding
- increased risk of storm surge creating higher risk of coastal inundation
- onset of riverine flooding due to prolonged and sustained deluges.

While Queensland is very well placed with regard to mitigation efforts, including the capability to prepare for, respond to and recover from tropical cyclones, the reasonably rapid onset and violence of tropical cyclones – over broad scale geography involving numerous Local Government areas and multiple Disaster Districts – can render the management of disaster operations challenging. This is particularly the case with large severe tropical cyclones such as Severe Tropical Cyclone Yasi in 2011 and Severe Tropical Cyclone Debbie in 2017.

The impacts to Queensland's and indeed the national economy can be very significant, with long term recovery efforts required. This assessment also takes into account the climate projections that indicate tropical cyclones may reduce in frequency yet be more intense when they do manifest.

Figure 49

The extent of rising flood waters from the Fitzroy River can be seen across vast tracts of agricultural and pastoral land near Rockhampton on 5 January 2011.

Source: Torsten Blackwood

This assessment has identified riverine flooding as equal to tropical cyclone as the most disruptive and damaging natural hazard within Queensland. These two phenomena are often coincident, with riverine flooding frequently occurring as a result of a tropical cyclone.

Riverine flooding is of equal highest priority for Queensland. However a range of climate influences, as indicated within this report, may give rise to riverine flooding, thereby making it a more frequently manifesting hazard. Previous risk assessments have nominated riverine flooding as the most destructive natural hazard in Queensland with very significant disruption to business and damage to property and the environment, such as the recorded impacts during the flooding events of 2010/11.

While the most immediate impacts of tropical cyclones are coastal, the extent of land mass potentially exposed to riverine flooding covers a significant portion of the State. The river basins and catchments of Queensland cover very large geographic areas and pose many challenges with regards to logistics, access/resupply and evacuation if required. Significant work has been and continues to be undertaken in the identification and management of flood risk by both the Queensland and Federal Governments.

Severe weather events have historically been one of Queensland's most damaging natural hazards. The cascading and coincident effects of severe weather can pose complex issues such as:

- lightning strikes leading to bushfires
- rapid delivery of concentrated rainfall leading to flash flooding and riverine flooding
- damaging wind gusts and hail leading to significant damage to infrastructure
- storm surge causing erosion and localised flooding through coastal inundation.

The Bureau of Meteorology provides world class weather forecast services and warning advice to Queensland. However the sometimes unpredictable nature of the phenomenon does at times relegate the identification and warning of impact location and intensity or severity to relatively short time frames across dispersed communities.

As a result, when conditions are conducive to severe weather events, rapid onset can pose risk to life such as the creation of hazardous road conditions. Further, significant economic impacts have been recorded by severe weather events destroying agriculture and or damaging built up areas. **The management of risk associated with severe weather events is the second highest priority for Queensland.**

Coastal inundation cannot be considered in isolation and storm surges in particular are a consequence of a tropical cyclone or a severe weather event.

The profile of this hazard is increased when considering climate change projections of a rising sea level, and an increase in the severity of tropical cyclones and severe weather events.

Significant planning and mitigation is undertaken by coastal Local Governments coupled with support from State Government however there are multiple developed coastal areas that could face significant risk if a severe tropical cyclone impacts in or near to an exposed or vulnerable location and aligns with high tides. The aforementioned compounding issues related to tropical cyclones, associated with such an event raise the profile of the risks associated with coastal inundation. **Coastal inundation is Queensland's equal third priority.**

Heatwaves, arguably due to their less violent, slower onset and less publicised nature, have only more recently begun to be recognised at a true level of risk. Climate projections indicate generally hotter conditions, with the Bureau of Meteorology and Queensland Health working collaboratively on the Heatwave Service to align service response with weather forecasts.

Heatwaves have a broad range of potential health effects impacting mortality rates for vulnerable persons as well as potential impacts on essential services. Heatwaves are also one contributing factor, from a multi-hazard perspective, in the increased hazard of bushfire. **Managing the risk associated with heatwaves is Queensland's equal third priority.**

Bushfire is a frequently occurring event in Queensland however is generally very well managed and often occurs in areas less densely populated. While this can reduce the risk to life there is still the potential for a range of significant economic impacts to Queensland agriculture, industry and tourism. Bushfire Prone Area mapping is used within land use planning and mitigation operations along with predictive analytics and fire weather forecasts to proactively manage this hazard before risks manifest. **Bushfire risk is Queensland's fourth priority.**

Earthquakes are a frequently occurring phenomenon in Queensland with some geographic areas registering clusters of events. However, the magnitude is often less than 3.5 with the effects seldom felt.

While not relevant to all of Queensland, some areas have experienced an earthquake with a magnitude over 5 on the Richter scale. This occurred most recently offshore, north east of Bowen in August 2016, with a magnitude of 5.8.

An earthquake of this magnitude occurring within the vicinity of a built environment is likely to cause significant damage to structures, particular underground services and piping, with potential risk to life due to the collapse of structures. The accurate assessment of earthquake susceptibility is a highly specialised discipline with this assessment team referring areas with potential susceptibility to Geoscience Australia. **Earthquakes are Queensland's fifth natural hazard risk priority.**

Figure 50

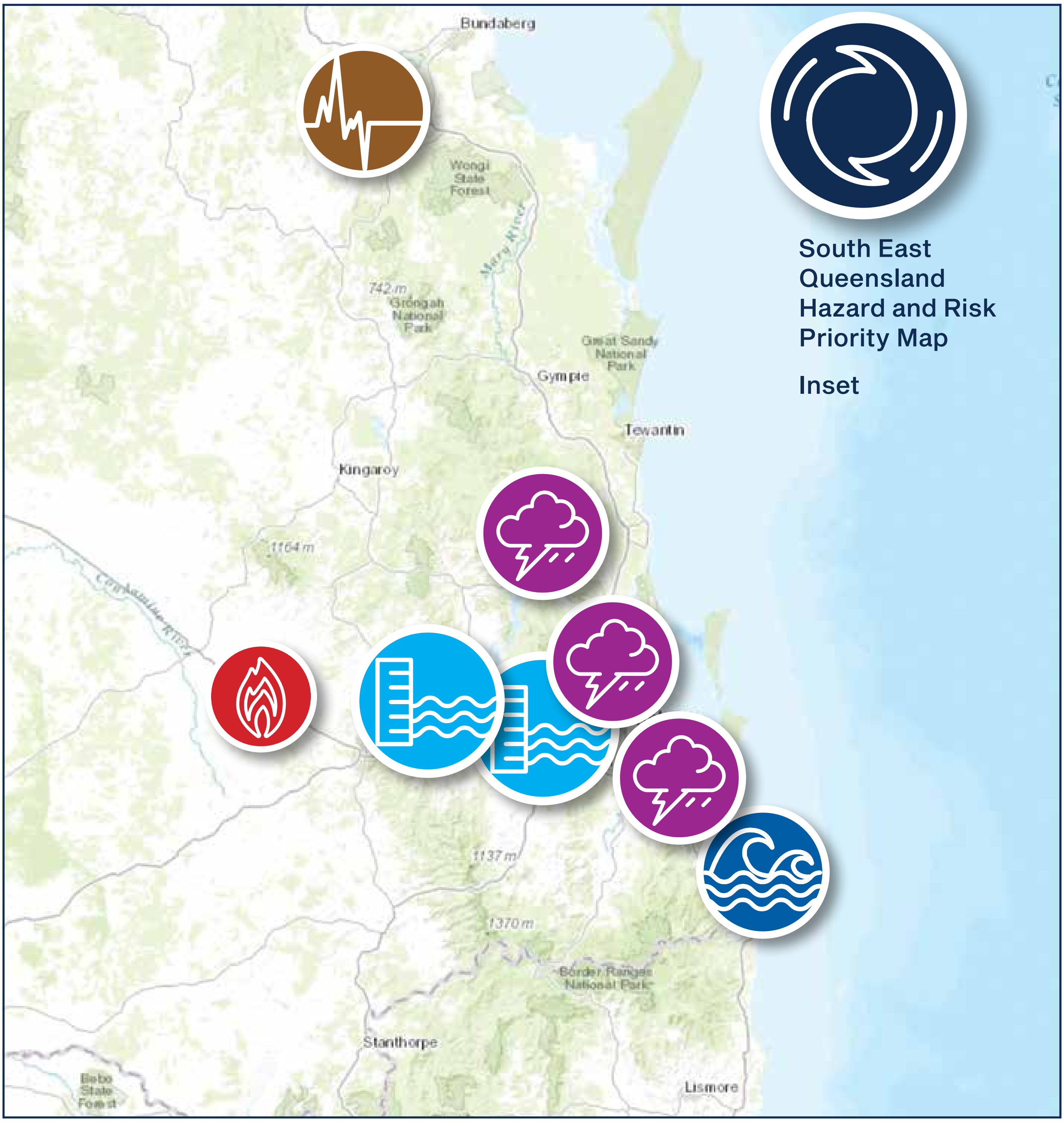
Hazard icons, sized in proportion to risk priority and grouped indicatively of coincident effect.

Source: Queensland Fire and Emergency Services

Figure 51

Hazard icons positioned and sized to represent the indicative location and macro level priority of natural hazard risk across Queensland. Local Government Area and Disaster District risk assessments and plans contain more specific and operational level risk information. Icons are an indicative representation of the potential impact areas of natural hazards. Heat maps and assessments in the publication are a more accurate representation.

Source: Queensland Fire and Emergency Services


South East Queensland Hazard and Risk Priority Map
Inset
Bundaberg
Wongi State Forest
Mary River
742 m
Grongah National Park
Great Sandy National Park
Gympie
Tewantin
Kingaroy
1164 m
Condamine River
1137 m
1370 m
Border Ranges National Park
Stanthorpe
Lismore

Queensland Government