bushfire&natural
HAZARDS CRC

PLANNING AND CAPABILITY REQUIREMENTS FOR CATASTROPHIC AND CASCADING DISASTERS

Literature review

Andrew Gissing, Michael Eburn and John McAneney
Risk Frontiers, Macquarie University, Australian National University

RISK FRONTIERS

Australian National University

MACQUARIE University

Version	Release history	Date
1.0	Initial release of document	30/03/2020

Disclaimer:
Risk Frontiers, Macquarie University, the Australian National University and the Bushfire and Natural Hazards CRC advise that the information contained in this publication comprises general statements based on scientific research. The reader is advised and needs to be aware that such information may be incomplete or unable to be used in any specific situation. No reliance or actions must therefore be made on that information without seeking prior expert professional, scientific and technical advice. To the extent permitted by law, Risk Frontiers, Macquarie University, the Australian National University and the Bushfire and Natural Hazards CRC (including its employees and consultants) exclude all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

TABLE OF CONTENTS

ABSTRACT

Catastrophic events pose unique challenges and are inevitable. Previous reviews have highlighted gaps in Australia's preparedness for catastrophic disasters. Australia has no recent experience of a catastrophe, with the Spanish Flu (1918-19) and Cyclone Tracey (1974) being perhaps two historic examples that have overwhelmed systems of management. Catastrophic events require the adoption of a whole community approach. However, this is challenged by the culture of emergency services and wider community apathy. This report provides insights into the preparedness for catastrophic disasters based upon a review of the global literature. Implications for practitioners are discussed to assist in strengthening capability and capacity to reduce the likelihood of becoming overwhelmed.

END-USER STATEMENT

Roger Mentha, *Fire and Rescue, NSW*

A catastrophic disaster though rare, poses the threat of significant consequences if one was to occur. Such consequences would likely overwhelm our traditional methods of doing business, as well as our normal way of living. The management approaches we would need to ake would be different, with the sector needing to embrace alternate sources of capacity existent in the community, non-government and private sector. Our planning needs to consider what the key objectives of an emergency management response to a catastrophic disaster would be and what functions would need to be prioritized such as leadership and the provision of information to communities. But, how much can we do to effectively prepare remains a question. The researchers in this report challenge us to think about our societal level of risk appetite and to consider how this would inform the extent to which the sector prepares for future catastrophic events.

INTRODUCTION

Although Australia is a disaster-prone continent our records of natural disasters go back less than 200 years…Disasters caused by enemy attack are possible but disaster caused by natural phenomena are certain. We must therefore prepare ourselves for this certainty. As part of this preparation we must simply learn from the lessons of the Darwin disaster. We cannot afford to relearn them again during the next disaster, at the expense of more Australian lives.

Major-General Allan Stretton (Stretton, 1979).

In their 2018 report, the World Economic Forum (2018) identified extreme weather events to be the number one global risk. Simple Google searches reveal many catastrophic end-of-the-world scenarios including meteor strikes, solar storm, mega super volcanic eruptions, earthquakes, pandemics, super-storm and tsunami. In 2017, the world experienced a series of deadly hurricanes in the Caribbean and United States; flooding in Bangladesh with over 1200 lives lost; a large earthquake in Mexico and forest fires in Portugal and California. The sum of these events made 2017 the second costliest year in terms of global weather losses as a percentage of global GDP between 1990 and 2017, beaten only by 2005 (Pielke, 2018).

It is often argued that the nature of natural catastrophes is changing (Boin and t Hart, 2010), with their frequency and scale of impacts increasing (Carayannopoulos, 2017). At this juncture no data exists to support this contention (Crompton and McAneney, 2008, Pielke, 2018),but it is true that the modernisation of technology, increased societal complexies, aging infrastructure, growing urbanization, environmental degradation, climate change and globalisation of networks all conspire to grow new vulnerabilities.

Numerous reviews have concluded that Australia is ill prepared to cope with a truly catastrophic disaster, an event of sufficient magnitude to exhaust the combined response capacity of all jurisdictions (Council of Australian Governments, 2002, Smith, 2008, Government of Western Australia, 2017). Though it must be appreciated that such conclusions are not necessarily, helpful, as by definition catastrophes overwhelm plans, capability and capacity. It is better to consider our preparation to avoid becoming overwhelmed and hence less likely to experience catastrophe.

The 2005 review of Australia's preparedness for a catastrophic event concluded that planning has been seen as an extension of existing emergency management arrangements rather than a specific focus in its own right (Catastrophic Disasters Emergency Management Capability Working Group, 2005). It is likely that Australia is not alone in this respect with the official post Hurricane Katrine review concluding:

Government failed because it did not learn from past experiences, or because some lessons thought to be learnt were somehow not implemented. If 9/11 was a failure of imagination, then Katrine was a failure of initiative. It was a failure of leadership (David, 2006).

The Australian Catastrophic Disasters Emergency Management Capability Working Group (2005) identified many specific limitations to he country's preparedness. These included cross jurisdictional planning; interoperability of communications; transportability of professional qualifications; predictive modelling; research and understanding of events; long term community support and recovery; the coordination of international support and aid; and the engagement of the private sector.

In 2016 based upon consultation with jurisdictions, the Australian Government published a capability road map focused on reducing the occurrence of catastrophe through strengthening capability and capacity. Key proposed actions arising from the road map include: development of a national capability and planning framework; review of existing national and jurisdictional plans to ensure adequate consideration of catastrophic events; improvement of information and intelligence systems; development of crisis leadership capabilities; improving catastrophic disaster knowledge; exercising and stress testing of plans and systems; developing a rapid expansion model; developing supply chain partnerships; and enhancing communications and warnings capabilities (Australian Government, 2016).

Given the identified weakness and the need to support ongoing efforts to better prepare to mitigate catastrophic disaster risk, there is an urgent research need to investigate how organisations and communities prepare, respond and recover from catastrophic disaster events, though difficult given Australia's lack of experience. In this report we attempt to discuss the nature of catastrophic disasters, and outline a framework to provide direction to prepare our systems to minimise the occurrence of catastrophe. Case studies are utilised to illustrate key concepts.

METHOD

A search of global literature was conducted between October 2017 and February 2018 using Google Scholar and Google internet search engines for relevant academic and grey literature. The search utilised a combination of keywords including: catastrophic disaster, catastrophe, black swan, grey swan, disaster preparedness, emergency preparedness, emergency management preparedness, disaster planning, emergency planning, emergency management planning, disaster readiness, emergency readiness, critical infrastructure preparedness, capability planning and critical infrastructure protection. As articles were read, other specific authors or concepts were further investigated to ensure key literature were not missed. Specific jurisdictional websites were searched regarding emergency plans and legislation.

DEFINING CATASTROPHE

There has been some confusion about the term catastrophe within the Australian emergency management sector (Crosweller, 2015b). The word catastrophe is widely used and various and varying definitions exist, depending on the context. For example, a car accident may be catastrophic to the individuals involved, but not so for the wider community. In a similar vein, a severe cyclone could be considered catastrophic to an impacted community or region, but not for the nation. An influenza pandemic resulting in significant deaths across the nation might be considered a national catastrophe. This concept has been explored by the Global Challenges Foundation (2017) and is illustrated in Figure 1.

SCOPE

	Imperceptible	Damaging	Catastrophic
Global	Global warming By 0.001 C$^{\circ}$	Depletion of the ozone layer	Nuclear war
Local	Minute increase in regional air pollution	Recession in one country	National genocide
Personal	Loss of one hair	Loss of one arm	Fatal car crash

SEVERITY

FGURE 1 – CONTEXTUAL VIEW OF CATASTROPHE (SOURCE: GLOBAL CHALLENGES FOUNDATION (2017))

Examples of the many definitions of the word *catastrophe* in the context of emergency management have been collated and are presented in Table 1. Common amongst these is that the magnitude of such events is considered overwhelming and extraordinary causing widespread economic, health, social and environmental consequences, and disruption to government functioning. Some attach quantitative measures whilst others provide qualitative descriptions of societies becoming overwhelmed.

Reference	Definition
Australian NATCATDISPLAN (Australian Government, 2010b)	*p.1 An extreme hazard event that affects one or more communities, resulting in widespread, devastating, economic, health, social and environmental consequences, and that exceeds the capability of existing State or Commonwealth Government emergency and disaster management arrangements. An event could be of sudden impact or sustained impact over an extended timeframe. Defining features of a catastrophic natural disaster are that it will not be possible to immediately meet the needs of those requiring assistance within the existing capability of an individual State or nationally; take considerable time from which to recover; and the affected Executive Government is temporarily incapacitated or requests urgent assistance.*
Australian and New Zealand Emergency Management Committee	*A catastrophic disaster is what is beyond our current arrangements, thinking, experience and imagination. (i.e.: that has overwhelmed our technical, non-technical and social systems, resources, and has degraded or disabled governance structures and strategic and operational decision making functions.)*
Australian Government (Australian Government, 2016)	*p.29 An extreme hazard event which impacts on a community, or communities, resulting in widespread, devastating, economic, social, and environmental consequences and which exceeds the capability of existing state/territory emergency/disaster management arrangements.*
United States National Response Framework (Department of Homeland Security, 2013)	*p.1 Any natural or manmade incident, including terrorism, that results in extraordinary levels of mass casualties, damage or disruption severely affecting the population, infrastructure, environment, economy, national morale, or government functions.*
Insurance Council of Australia (Insurance Council of Australia, 2017)	*Large natural or man-made disasters that cause significant number of (insurance) claims in a region.*
Council of Australian Governments (2002)	*p.63 An extreme natural hazard event which impacts on a community, or communities, resulting in widespread, devastating, economic, social and environmental consequences.*
Bissell (2013)	*p.5 Directly or indirectly affects an entire country, requires national or international response, and threatens the welfare of a substantial number of people for an extended period of time.*
Cal OES (Cal OES Governor's Office of Emergency Services, 2017)	*A sudden event, which results in tens of thousands of casualties and tens of thousands of evacuees; responses capabilities and resources of the state and local jurisdictions will be overwhelmed; characteristics of the precipitating event will severely aggravate the response strategy and further tax the capabilities and resources available to the area; lifesaving support from outside the area will be required, and time is of the essence; likely to have long-term impacts within the incident area as well as, to a lesser extent, on the nation.*
Centre for Risk Studies	*An event of this type has occurred in the past 1,000 years, or could occur somewhere in the world with an annual likelihood of [occurrence] greater than 1 in 1,000 (0.1%), with impacts in a single year above at least one of the following minimum thresholds:* • *Human injury: kills more than 1,000 people or injure or make seriously ill more than 5,000 people* • *Disruption: for a major region or nation, or for a particular international business sector, it would cause normal life patterns and commercial productivity to be substantially interrupted for more than one week* • *Cost: physical destruction of property and infrastructure costing $10 billion to replace, or similar level of loss of value of assets*

	• *Economic impact: at least one country loses at least 1% of Gross Domestic Production*
Boin and McConnell (2007)	*p.52 Event that is believed to have a very low probability of materialising but…if it does materialise will produce a harm so great and sudden as to seem discontinuous with the flow of events that preceded it.*

TABLE 1 – DEFINITIONS OF CATASTROPHE

Catastrophe stands in the spectrum of the definitions of other terms such as *emergency* and *disaster*, which are commonly used to define small to medium sized events. This distinction is not just academic as it is argued that catastrophes require different management approaches (Quarantelli, 2006).

Emergencies are seen as unforeseen, but predictable, regularly occurring and narrow in their scope of impact. They may be tragic for the small numbers of people involved, but largely inconsequential to wider society (Boin and McConnell, 2007). Many definitions of disaster have also been offered and are summarised by Perry (2007). Quarantelli (2000a) outlines a disaster as having the following attributes: sudden impact; disruptive; cause the adoption of unplanned actions; and posing danger to valued assets. Qurantelli (2000b) suggests that the key differences between an emergency and disaster are that organisations have to quickly relate to unfamiliar groups; adjust to losing autonomy; modify performance standards; and operate more closely with the community.

Catastrophes are argued to be different from emergencies and disasters. Catastrophes may also be referred to as a major disaster or extreme event (Kapucu and Van Wart, 2006). Quarantelli (2006) developed a list of six criteria to differentiate catastrophes from disaster events:

1. Most or all of the community built structures are heavily impacted

2. Local officials are unable to undertake their usual work role, and this often extends into the recovery period

3. Help from nearby communities cannot be provided

4. Most, if not all, of everyday community functions are sharply and concurrently interrupted

5. The mass media system especially in recent times socially constructs catastrophes even more than they do disasters

6. The political arena becomes even more important (p. 3-6).

HALLMARKS OF CATASTROPHES

The hallmarks of catastrophes are death and destruction, large-scale disruption, displacement of populations and public anxiety. Often these occur with little to no warning (such as earthquakes), although they may also occur slowly, for example in the case of droughts, disease and food shortages, growing in size and duration. Events overwhelm the capacity of institutions and the community to cope, as emergency systems, communications and plans fail to adapt to the complexity and magnitude of the event leaving leaders out of touch with what is happening on the ground. Local emergency response personnel may be directly impacted themselves, and thus unable to perform their roles. Emergency leaders are confronted with overwhelming issues, with complexity and uncertainty on a scale they have never experienced nor imagined. Information about impacts and needs of affected communities may be limited for days after an event, with decisions required in the absence of complete information. The events becomes subject to significant national and international media scrutiny, and inevitably, political involvement.

Catastrophic events may also be cascading in nature, escalating their impacts as interconnected systems fail yielding yet further impacts and making recovery more complex and prolonged. Essential infrastructure – water, gas, sewage, power, healthcare, banking, transport, emergency response and communication – become severely disrupted. Restoration may take months and disease and fires may wreak further havoc. This notion has been evoked by Pescaroli and Alexander (2015) who state:

Cascading disasters are extreme events, in which cascading effects increase in progression over time and generate unexpected secondary events of strong impact. These tend to be at least as serious as the original event, and contribute significantly to the overall duration of the disasters effects. The subsequent and unanticipated crises can be exacerbated by failure of physical structures and the social functions that depend on them, including critical facilities, or by the inadequacy of disaster mitigation strategies, such as evacuation procedures, land use planning and emergency management strategies. Cascading disasters tend to highlight unresolved vulnerabilities in human society. In cascading disasters one or more secondary events can be identified and distinguished from the original source of disaster (p. 65).

Events impact large areas (Barnshaw et al., 2008) and may not respect borders or boundaries resulting in unclear accountabilities amongst responding agencies, and conflicting public messaging. Such disruption and confusion can reach global scales. The recovery of communities may take many years, with the impacted population displaced, some choosing to re-locate to other areas permanently. Many of those affected may suffer long lasting psychological trauma. Economic losses can be severe as industry and agriculture is disrupted, businesses close down or make further demands to Government for recovery support.

Eastern Japan Great Earthquake Disaster 2011

The 2011 Japanese tsunami and earthquake disaster is an example of a catastrophic disaster. The event left over 13,000 people dead and 335,000 people displaced. Some 190,000 buildings were damaged, including 45,700 that were totally destroyed. Power supply was disrupted for some two weeks causing outages for 4.4 million families. The quake affected the transportation system closing ports and shutting down high-speed rail for several weeks. Some 3 to 4% of the annual Japanese rice production was affected. Many automobile manufacturers were disrupted, resulting in a global decline in vehicle production. Damage to nuclear power plants at Fukushima resulted in a nuclear crisis. In total direct losses have been estimated at $171-183 billion USD (Norio et al., 2011).

Local response capacities were overwhelmed. In total some 180,000 Japanese defence force personnel were mobilised. Some 134 countries and regions as well as 39 international organisations offered aid. Twenty three countries provided rescue teams and nuclear safety experts (Norio et al., 2011). Survivors of some evacuated towns are still struggling many years after the event.

//

MANAGEMENT OF CATASTROPHE

The management of catastrophic events should not just be focused on reducing loss of life and poverty, but also sustaining the continuity of affected communities, recovery society and economies and mitigating the risks of future events (Harrald, 2006).

During catastrophic events little may be achieved by attempting more of the same or simply scaling up existing structures (Crossweller, 2015b). Response strategies that routinely work for everyday events will be quickly overwhelmed and rendered ineffective. The role of emergency management agencies becomes focused on providing leadership, facilitation, subject matter expertise, public information, and specialist resources (Gissing, 2016).

Community members become first-responders and mass convergence of groups into the affected area occurs (Tierney, 1993, Whittaker et al., 2015). Often the success of the response is reliant upon the capacities already present in communities. Social research has shown that rather than panic or being shocked and dazed, that communities impacted by catastrophe typically act proactively and work to assist others. Often rather than working as individuals alone community members form into groups often based on pre-disaster ties (Tierney, 1993). Emergent groups typically arise in the aftermath of a catastrophe when the demands of the community are not being met; when existing traditional structures are inadequate; or when the community feels it is necessary to be involved (Drabek and McEntire, 2003).

These groups often have the advantage of real time situational awareness, knowledge of vulnerable persons and can configure their responses to best meet local needs (Whittaker et al., 2015). Rather than embracing existing social structures and volunteering in the aftermath of events it is argued that disaster management systems often ignore this valuable capacity (Whittaker et al., 2015).

Community Capacity

Numerous examples exist to illustrate the role of community groups and volunteers during catastrophic disaster events.

The response to the Christchurch earthquakes (2010 and 2011) saw organised and emergent volunteer groups (such as the Student and Farmy armies) perform vital roles in assisting the most affected communities. The Student Army was reported to have been some 10,000 people strong was coordinated via Facebook. The group has now formalised after the event as an organisation to promote volunteering in the community.

In the aftermath of the Louisiana floods (2016) and Hurricane Harvey (2017) the volunteer based "Cajun Navy" group consisting of citizens with their watercraft emerged to assist with the rescue of people stranded in floodwater. The group arose originally in the aftermath of Hurricane Katrine following a call for help by city officials. The group has reported responding to calls for help posted on social media, though the group has also established a website through which people can request rescue assistance or resupply (www.cajunnavy.com). During the Louisiana floods FEMA search and rescue teams provided just in time training to volunteers to assist with flood rescues and were overwhelmed by the response (Wachtendorf and Kenda, 2017).

Following the September 11 attack on the World Trade Centre the spontaneous convergence

---

Of public and private vessels to lower Manhattan assisted to evacuate people attempting to flee the area (Wachtendorf and Kendra, 2017). Over a period of 6 to 7 hours some 300,000 to 500,000 people were evacuated, an event that some have compared to the evacuation of Dunkirk during the second world war which too saw the convergence of public and private vessels to evacuate large numbers of people. The convergence may have originally commenced based on a call for assistance by the Coast Guard, but it is also likely that many vessels simply observed the activities of others and decided to assist (Wachtendorf and Quarantelli, 2003).

In the Australian context, the aftermath of the Brisbane 2011 floods saw the emergence of the *'Mud Army'*. This group emerged after the Brisbane City Council issued a call for volunteers to assist with the clean-up. Some 25,000 people responded to the call and volunteered (Adams, 2016).

Specific examples exist also of private sector involvement such as Walmart during Hurricane Katrina and Toll Logistics during the Christchurch earthquake. These will be discussed in a later project report.

No one organisation alone is capable of responding to all aspects of a catastrophe (Benini, 1999). In the case of Hurricane Katrina some 535 organisations were involved ranging from government to non-government and private sectors (Comfort and Haase, 2006). There is a need to integrate and coordinate operations of large numbers to disparate organisations (Boin and Bynander, 2015).

A collaborative model of interacting organisations may be able to adapt more appropriately to threats than individual organisations acting alone (Comfort and Kapucu, 2006). Integration will need to happen under time constraints, substantial pressures and contemporaneous and conflicting demands for services (Comfort and Kapucu, 2006). FEMA have adopted this concept in what they term the *'whole of community'* approach.

Efficient cooperation between organisations, however, is not always a certainty. The Australian experience during the *Spanish Flu* outbreak saw jurisdictions attempt to cooperate on border security and quarantine, however, after disputes occurred, cooperation was abandoned with each state imposing its own policies (Curson and McCracken, 2006). During the response to the Christchurch earthquake a pre-existing dysfunctional relationship between Christchurch City Council and Civil Defence Emergency Management Group was blamed for a lack of regional coordination (Mamula-Seadon and McLean, 2015).

Outside resources may be challenged by the absence of relationships with local communities and local knowledge. Tensions between outside and local resources may result in a less efficient response (Barnshaw et al., 2008). Harrald (2006) outlines a staged model (Figure 2) for the response to catastrophic events comprising an initial response by surviving local resources and community members while external resources are being mobilised; an integration phase to structure local and external resources into an organisation capable to identifying needs and providing resources beyond that of just local responders; a

production phase where needed services are delivered; and a phase of demobilisation and transition to recovery. The phases correspond with the organisational psychology theory of team development.
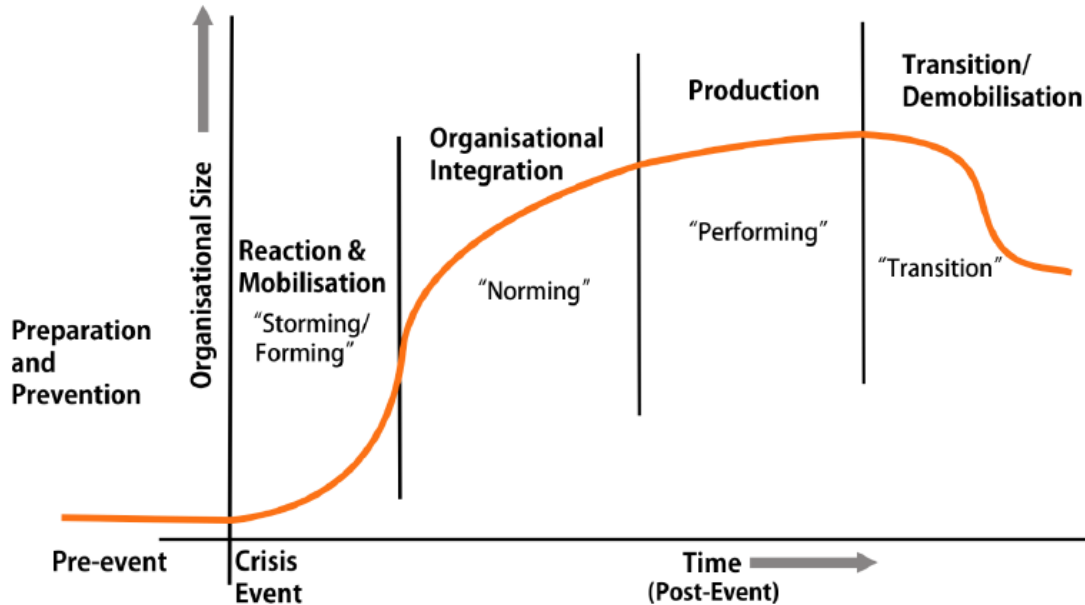
FIGURE 2 – CATASTROPHE RESPONSE PHASES

Catastrophic disaster pose leaders with unique challenges requiring improvisation and flexibility to ensure effective communication and management of scarce resources. t Hart (2014) described the decision making pressures:

> *Leaders need to take highly consequential decisions in a context in which they do not have all the numbers, they can't delegate the issues to a commission, and can't get the experts to study it for a few months. They have to act much faster than governments normally act. And often that acting involves doing quite unpleasant things, or disappointing a lot of people, or making tough decisions about the allocation of scarce resources (p. 172).*

It is argued that successful management of extreme events requires an ability to rapidly assess and adapt (Comfort and Kapucu, 2006), and use flexible decision making rather than relying on bureaucratic systems and procedures (Kapucu and Van Wart, 2006). Management must allow for local innovation, collaboration, trusting relationships and the suspension of rules where necessary (Kapucu and Van Wart, 2006). Often though emergency managers rely on previous experience and training, and fail to adapt their methods of management (Comfort and Kapucu, 2006).

FORESEEABILITY OF CATASTROPHE

Catastrophic disasters are often regarded as unprecendeted surprising forecasters, emergency managers and community alike (Boin and t Hart, 2010). The term "black swan" has been used to describe such events. The "*black swan*" metaphor was a common 16th century term to infer something was impossible. The European explorers in 1697 discovered black swans in Australia. Subsequently the concept grew to mean non only an event that was very rare, but also something that may have been perceived as impossible, until it happens (Aven, 2013). According to Taleb (2007) black swan events have three characteristics: "*First is an outlier, as it lies outside the realm of regular expectations. Second it carries an extreme impact. Third, in spite of its outlier status, human nature leads us to concoct explanations after the fact, making the previously unimaginable event to be both explainable and predictable.*" Aven (2015) suggests that three types of black swan events exist: *unknown unknowns, unknown knowns,* and *events that are judged too improbable and thus are not believed to occur.*

In what follows in this section we provide some discussion and examples of these event types. It may be arguable as to the extent that different elements of examples utilised are consistent with multiple event types.

UNKNOWN UNKNOWNS

The foreseeability of events is dependent upon institutional knowledge of disaster history, scientific modelling and imagination. *Unknown unknowns* are those that challenge existing knowledge and imagination. Without knowledge of a risk it is difficult to put in place specific measures to reduce possible consequences apart from those that are generic in nature. An example of an *unknown unknown* event could be Hurricane Catarina in Brazil during 2004, the first-ever reported hurricane in the South Atlantic)Pezza and Simmonds, 2005). Because of strong wind shear in this part of the world, hurricanes have no history of forming. As a result coastal communities in Brazil were ill prepared for the occurrence of this storm which made landfall as a category 1, and damaged roofs to almost 80% of homes (~30,000), of which 40% were complete failures (McTaggart-Cowan et al., 2006). Given the event had not previously occurred the Brazilian Meteorological authorities struggled to predict its course (Crompton, 2004).

Though such events have been described as unprecedented, often similar phenomena have been observed in the past, albeit at lesser magnitude or with fewer consequences. Another example is the 2003 heatwave in France, which was described as "unprecedented" on the basis of its consequences. Previous deadly heatwaves had not generated much awareness (Lagadec, 2004); it took some 27 years to discover that France's 1976 heatwave had resulted in some 6000 excess deaths (Poumadere et al., 2005). This risk had been mostly ignored with no policies or prevention approaches put in place for a possibly more dangerous heatwave (Poumadere et al., 2005).

Often unforeseen consequences result from unanticipated or unappreciated interconnections between different systems (Masys, 2012, t Hart, 2013, Cavallo and Ireland, 2014, Boin and t Hart, 2010). Cascading consequences occur where loss of one system triggers failure of another (Comfort, 2005). This recognises the

interdependence of many risks and makes prediction of consequences difficult (Cavallo and Ireland, 2014). Such unanticipated impacts can occur in the interaction of hazard events with infrastructure networks such as power grids, water systems, transportation networks and telecommunications that are directly or indirectly linked with other infrastructure components. Interconnections between systems are illustrated in Figure 3.
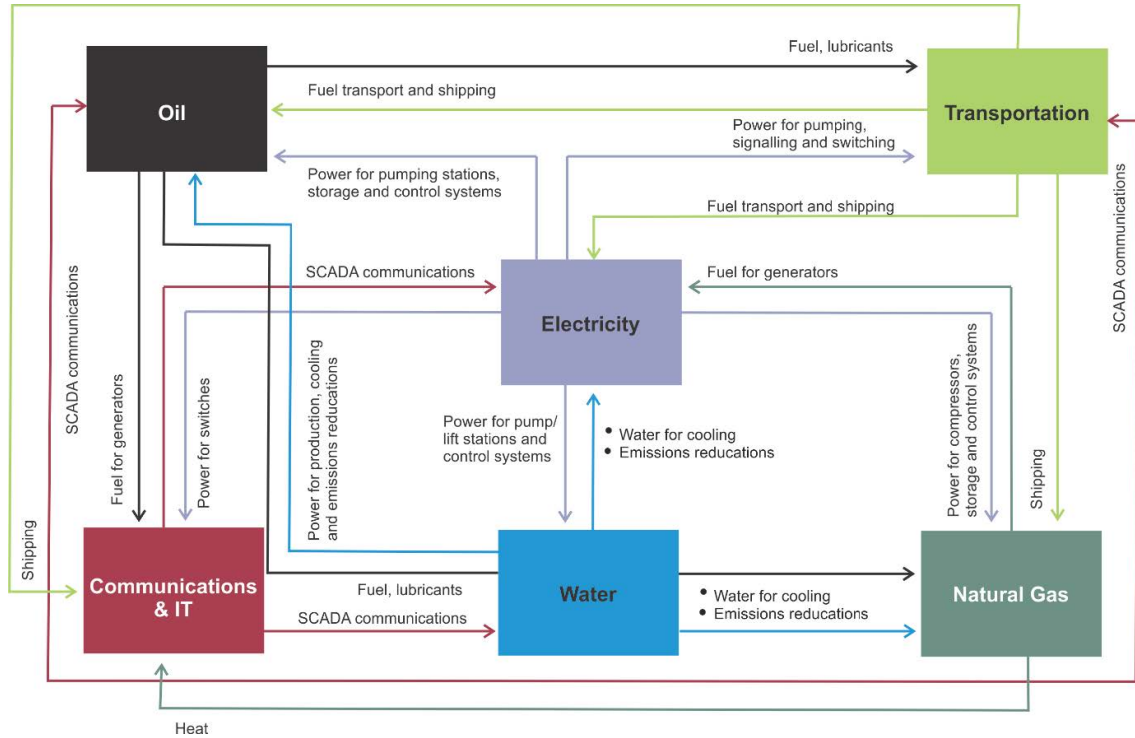

FIGURE 3 – MODEL OF INFRASTRUCTURE INTERCONNECTIONS (SOURCE: NSW CRITICAL INFRASTRUCTURE RESILIENCE STRATEGY DISCUSSION PAPER)

Damage that occurred in Hurricane Katrina highlighted such inter-dependencies, where floodwaters interrupted power supplies, which then shut down communications, traffic lights, water, sewage and gas. The loss of services left New Orleans uninhabitable. The loss of communication systems and transport meant that initial response efforts were also significantly challenged. It took around four days after the impact for minimal communications to be restored (Comfort, 2005).

Disruptions can reach global proportions for example the eruption in 2010 of the Eyjafjallajökull Volcano in Iceland where an ensuing ash cloud caused unprecedented disruption of European air travel costing airlines directly $250 million per day (Gudmundsson et al., 2010) and disrupting businesses and travellers worldwide. Some eight and half million people were stranded during the event, which resulted in severe pressures on other types of transportation and major imbalances in hotel occupancy. Tourism suffered significantly (Pescaroli and Alexander, 2015).

Furthermore, Hurricane Sandy impacted New York and New Jersey in 2012. Winds and storm surge impacted possibly the greatest density of population and essential infrastructure in the United States. Some 8.5 million customers lost power and damage to oil infrastructure resulted in fuel rationing. Impacts extended globally with the closure of the NASDAQ and New York Stock Exchanges (Pescaroli and Alexander, 2015).

Precise modelling of cascading failures is difficult due to the lack of complete information across complex networks (Cavallo and Ireland, 2014, Boin and McConnell, 2007). The danger exists where these are seen as too complex and the risks posed simply ignored (Government Office for Science, 2012). As society continues to modernize and increase in complexity, unexpected risks will likely grow (Boin and t Hart, 2010). For example future automation in the healthcare space could expose vulnerable people to serious life threatening impacts if the infrastructure that technologies rely upon are disrupted.

UNKNOWN KNOWNS

Where knowledge of a risk exists but is not widely appreciated, shared gaps may emerge that result in an event not being foreseen by particular officials or institutions. An example of an event characteristic of an unknown known could include the impact of Tropical Cyclone Nargis. Tropical Cyclone Nargis struck Myanmar in May, 2008, with a similar intensity to Hurricane Katrina. It resulted in the loss of 130,000 lives and the destruction of buildings, farmland, fisheries and livestock. Winter rice crops were destroyed, resulting in food shortages. Despite warnings from neighbouring India being issued to the Myanmar Government these appear not to have been passed on to at-risk communities (Webster, 2008, International Federation of Red Cross and Red Crescent Societies, 2009). Some evidence suggested that Myanmar's media downplayed the warnings that were communicated (Webster, 2008). Levels of community preparedness were also low (International Federation of Red Cross and Red Crescent Societies, 2009). This example highlights the possible consequences of inadequate information sharing to communities at risk to known catastrophe risks.

Further, for many organisations and individuals the deliberate flight of commercial airliners into the World Trade Centre and Pentagon on September 11, 2001 was unimaginable (Comfort and Kapucu, 2006). The 9/11 Commission found that numerous sources of intelligence pointed towards the impending attack and in some cases these were not fully exploited due to information not being adequately shared and an inability to connect the intelligence picture strategically (9/11 Commission, 2004).

In some instances a hazardous event that may have occurred in the distant past recurs with catastrophic consequences in the present. For example the Indian Ocean Tsunami (2004) where Thailand had not experienced a catastrophic tsunami event in recent centuries, hence authorities had no recent historical knowledge of the risk. Though tsunami warning systems had been established for other Ocean basins such as the Pacific nothing was in place for the Indian Ocean. Paleo-tsunami research in Thailand following the event suggested the occurrence of a similar tsunami some 550-700 years prior and at-least three others, with the earliest being some 2150-2350 years prior (Jankaew et al., 2008, Prendergast et al., 2012).

EVENTS THAT ARE JUDGED TOO IMPROBABLE AND THUS ARE NOT BELIEVED TO OCCUR

Often catastrophic disaster risks remain unappreciated due to their rare occurrence and thus a lack of similar events in recent memory (Kapucu and Van

Wart, 2006, t Hart, 2013). In other cases the possible overwhelming magnitude of an event may result in a belief that they are acts of God and little can be done to mitigate them. Some argue that for such reasons disaster risk reduction practices tend to focus on the relatively frequent (routine) hazards with significant impacts (e.g. bushfires in Victoria), while low probability catastrophic events are ignored (McConnell and Drennan, 2006, t Hart, 2013, Crosweller, 2015b). t Hart (2013) suggests that apathy arises from lack of transparency or purposeful misleading framing by risk-producing or risk-regulating entities; or when a collective illusion that a risk no longer exists due to its lack of occurrence in recent memory or over confidence in mitigation measures.

In the context of flooding, the latter has been referred to as the *levee paradox* where following the construction of a flood levee, the community may falsely believe itself to be 'flood free' and, because of the subsequent reduction in flood frequency, awareness of the potential damage from flooding may diminish. This situation is exacerbated where new residents move into the area without ever having experienced flooding before. Collectively these factors can lead to increased development on the floodplain behind the levee and reduced community preparedness, ultimately amplifying flood damages when they inevitably occur (Gissing et al., 2018).

The Fukushima Nuclear Plant accident is a good example of an event judged too improbable to be believed possible. On March 11, 2011, a 9.0 magnitude earthquake occurred with an accompanying tsunami impacting coastal communities. The floodwaters engulfed Fukushima nuclear power plant, triggering a series of failures, explosions, meltdowns and ultimately, the release of radioactive materials (t Hart, 2013). In the aftermath of the event criticism was focused on the lack of preparedness at the plant and that the risk of flooding should have been anticipated based upon previous tsunami knowledge. The plant operator, Tepco, was aware that there was a risk of large tsunami at the site, but had publically dismissed the risk as 'academic' (Funabashi and Kitazawa, 2012). Another contributing factor was the myth of absolute safety promoted by the nuclear energy industry in Japan in an effort to downplay nuclear safety concerns by Japanese residents, who might otherwise have called for the closure of nuclear plants (Funabashi and Kitazawa, 2012).

Events such as Fukushima could also be categorised as "*Grey Swans*" and "*Pear-Shaped Phenomena*". These terms encompass events that may not have happened historically, but are high impact events that are foreseeable utilising physical knowledge (Lin and Emanuel, 2016, Hole and Netland, 2010). Such events are known unknowns in the sense that some know that the event is possible, but do not know when it will occur (Hole and Netland, 2010).

Hurricane Katrina could be considered at the time of its occurrence as a *Grey Swan,* in the sense that the vulnerabilities of the city were well known to authorities including the inadequacy of flood defences that were only designed for a Category 3 hurricane and were not well maintained (Comfort, 2005). In the face of other priorities no group focused its attentions to these problems (Comfort, 2006). Another example may be the L'Aquila earthquake (Italy), where in 2009 308 people died and 67500 were made homeless. Alexander (2010) argues that despite a previous history of large damaging earthquakes and known vulnerability of the construction, the risk had been poorly considered by

the Italian Government. Similarly, the 2010 earthquake in Haiti also exposed ignorance of earthquake risks as local and international experts are said to have warned local officials (The Sunday Times, 25/01/2010). In the absence of an appreciation of the risks, development occurred without proper regulation and when the earthquake happened the collapse of unreinforced masonry buildings contributed to a death toll of some 230,000 people (Bilham, 2010).

Examples of current day *Grey Swan* risks as identified by Blong (2013) in the context of the global insurance industry include cascading infrastructural failure; pandemics; major plant or animal diseases; major heatwaves; solar storms; volcanic mega eruptions; and asteroid or comet impacts. Some of these event categories have not impacted modern society; for example, a volcanic mega eruption similar to the eruption of Mt Tambora in 1815; a solar storm similar to the Carrington event in 1859; or a global flu pandemic similar to the Spanish Flu of 1918. All of these have the possibility of reoccurrence with global implications.

COMPOUNDING EVENTS

Catastrophes may also occur as a consequence of a series of compounding events (Liu and Huang, 2014). Such events occur at around the same time and within the same geographical area or within multiple locations with a specific nation (U.S Global Change Program, 2017). Though the consequences of a single event may not be deemed catastrophic, the sum total of separate events or their interaction can be. An example of such a series of events occurred in the Australian 2011 summer when over January and early February record widespread flooding occurred in Victoria and Queensland, a severe bushfire affected Perth, a category five cyclone struck far north Queensland and heatwave conditions impacted Sydney.

Separate independent hazards can also interact to increase the consequences experienced by a community. For example the eruption of Mount Pinatubo in the Philippines in 1991 coincided with a tropical storm which magnified the consequences of the ash fall (Government Office for Science, 2012). The 2003 heatwave in France occurred within the context of an already saturated crisis landscape comprising drought, out of control wildfires, railway issues, high levels of pollution and epidemics (Lagadec, 2004).

CATASTROPHES IN THE AUSTRALIAN CONTEXT

Australia has not suffered from large catastrophic events in recent times. The types of events that might cause a catastrophe in Australia might include phenomena such as volcanic mega-eruptions in neighbouring nations, solar storms, pandemics, tsunami, meteorites, earthquakes, floods, heatwaves, bushfires, cyclones and dam failures.

While the scale of death attributed to a disaster is just one measure of its impact, the most deadly natural peril events to have occurred in Australia between 1900 and 2015 are shown in Table 2 sourced from the Risk Frontiers *PerilAus* database.

Peril type	Event name	Year	Deaths
Heatwave	Southern heatwave, Jan/Feb 2009 – Victoria/South Australia	2009	432
Heatwave	Heatwave, January 1908 – Victoria/South Australia	1908	215
Bushfire	Black Saturday bushfire, February 2009 – Victoria	2009	173
Tropical cyclone	Unnamed Tropical Cyclone – Port Hedland, March 1912	1912	149
Heatwave	Heatwave, January 1939 – NSW/VIC/SA	1939	145
Tropical cyclone	Unnamed Tropical Cyclone, March 1935 – Broome, WA	1935	140
Heatwave	Heatwave, January 1959 – Melbourne, Victoria	1959	125
Tropical cyclone	The "SS Yongala" Tropical Cyclone, March 1911 – Queensland	1911	120
Tropical cyclone	Unnamed Tropical Cyclone, March 1934 – Queensland	1934	99
Tropical cyclone	TC Tracy, December 1974 – Darwin, NT	1974	71

TABLE 2 – LIST OF TOP TEN DEADLY CLIMATIC AND GEOLOGICAL DISASTERS IN AUSTRALIA (SOURCE: PERILAUS, RISK FRONTIERS)

Case Study: Cyclone Tracey

Cyclone Tracey struck Darwin in the early hours of the 25th of December 1974 with wind gusts estimated at 250km/h. Some 71 fatalities were recorded along with 140 injured. In the hours following the disaster communications between Darwin and the outside world were unreliable, with clear communication of the impacts not arriving at the Natural Disasters Organisation in Canberra for several hours. Initial reports were that 90% of the city was destroyed. The evacuation of Darwin commenced due to concern about the risk of disease, lack of shelter and food supplies on the morning of the 26th of December which saw the population of Darwin reduced from 45,000 to 10,638 by the 31st of December. By this time essential services had been restored (Stretton, 1975).

Key lessons observed by the Natural Disasters Organisation included (Stretton, 1979):

1. Apathy: It's a challenge to get individuals and organisations to take disasters seriously. Despite warning of the Cyclone there was little evidence that emergency headquarters were appropriately manned. Officials responsible for disaster management in Darwin were said to have attended Christmas festivities on the evening before the event. Stretton also concluded that given the warning available that there had been time to evacuate community members to stronger buildings within Darwin.

2. Communication breakdown: Cyclone Tracey resulted in a loss of normal communications. Stretton recommended that communication systems be designed with greater resilience, but observed that loss of communications is a characteristic of major disasters and it should be an immediate priority in the aftermath to restore these.

3. Failure or radio stations: Local radio stations were damaged and went off the air. Priority was given to the restoration of local radio stations so as to enable communication with the population of Darwin.

4. Convergence: The disaster showed that after a disaster occurs there can be an influx of people into the affected area. Stretton recommended legislation to control the movement of people into a disaster area.

5. Legislation: There were activities undertaken that were not covered by legislation.

6. Relief stores: There was a large response by charities, businesses and individuals in the provision of relief stores. However, there was little coordination resulting in waste.

7. Registration and tracing of disaster victims: The disaster presented problems in the registration and tracing of disaster victims.

8. A central pool of relief stores: Following the disaster there was recognition to establish a central pool of relief stores.

9. First aid instruction at secondary schools: in a major disaster there is unlikely to be sufficient trained personnel to attend to the injured. Stretton concluded that there needed to be a wider knowledge of first aid amongst the community.

10. The retirement for centralised control: Stretton concluded that a common feature of disasters are disputes between institutions regarding roles and responsibilities. The appointment of centralised control can overcome disagreements between parties.

The Spanish flu pandemic (1918-19) stands as a significant global disaster and Australia's deadliest event. The number of deaths attributed to this event globally range from 50 to 100 million. In Australia more than 12,000 deaths occurred and possibly more than 2 million were infected. In a short time the health system was overwhelmed, and with so many unable to work normal services were disrupted (Curson and McCracken, 2006).

Australia should not be considered immune from catastrophes and has experienced a number of events that clearly overwhelmed the capacity of institutions and arrangements to effectively respond. Examples are Cyclone Tracey in 1974 (see case study), Victorian Black Saturday Bushfires in 2009 and Victorian floods in 2011. By way of example the Victorian Floods Review concluded:

> *Despite the commitment and professionalism of those who fulfilled various roles for the Victoria State Emergency Service (VICSES) during these floods, it must be said that there is compelling evidence that the VICSES was simply overwhelmed by the size and protracted nature of the floods. VICSES is a relatively small emergency service agency with a limited number of permanent officers and volunteers spread across Victoria. In the absence of the capacity for VICSES to effectively fulfil its legislated role*

////////////////////////////////////

as control agency for these floods, a range of ad hoc arrangements were put in place around the state (Comrie, 2011a; p.4).

Examples of possible catastrophic event scenarios impacting Australia and their estimated probabilities of occurrence are listed in Table 3.

Scenario	Approximate annual probability of occurrence	Reference
Repeat of 1867 Hawkesbury Nepean Flood	1 in 170 years to 1 in 300 years	(NSW Government, 2013)
Repeat of Tunguska (1908) Air Blast	Less frequent than 1 in 100 years	(Blong, 2013)
Major solar storm	Less frequent than 1 in 250 years	(Blong, 2013)
Global pandemic	1 in 100 years	(Blong, 2013)
Tsunami with substantial damage to low-lying communities on the NSW Coast	Between 1 in 72 years and 1 in 475 years	(Risk Frontiers, 2008)
Category 4 Tropical Cyclone with landfall at Townsville	1 in 300 years	Risk Frontiers' CycAus model
Moment Magnitude 6 earthquake impacting an Australian Capital City	1 in 1000 to 1 in 3000 years	(Risk Frontiers, 2015)
Volcanic super-eruption with global impacts	1 in 17,000 years	(Rougier et al., 2018)

TABLE 3 – LIST OF POSSIBLE AUSTRALIAN CATASTROPHIC DISASTER SCENARIOS

Though no specific annual prohibitions of occurrence have been published for catastrophic heatwaves in Australia it must be noted that there have been three events since 1895 where more than 400 fatalities have occurred (Coates et al., 2014). Little is known about the possible scale of a truly catastrophic heatwave in Australia, other than that deadly heatwaves resulting in thousands of deaths have occurred elsewhere, for example the Russian heatwave in 2010 saw an estimated 56,000 deaths (Much re, 2015).

Little has also been written about the possibility of catastrophic bushfires beyond existing Australian experience. A possible scenario may involve the compounding impacts of a series of extreme bushfires over the course of the bushfire season resulting in significant human property, environmental, economic and infrastructure impacts across multiple jurisdictions (Blong, 2017).

///////////////////////////////////////

PREPAREDNESS FOR CATASTROPHE

> *Governments are not good at precautionary management and preparing for the future; they are not good at thinking through and taking the necessary preparations; they are not good at anticipation and planning, and managing for future risk; sometimes they are not even good at collecting or analysing the information necessary to prepare for future events (Fels and Wanna, 2014).*

Many definitions of disaster preparedness exist including those below:

> *Pre-disaster activities that are undertaken within the context of disaster risk management and are based on sound risk analysis. This includes the development/enhancement of an overall preparedness strategy, policy, institutional structure, warning and forecasting capabilities, and plans that define measures geared to helping at-risk communities safeguard their lives and assets by being alert to hazards and taking appropriate action in the face of an imminent threat or actual disaster (United Nations, 2008; p.42).*

> *Disaster preparedness refers to activities and measures taken in advance of a disaster to ensure an effective response to the impact of hazards, including issuing timely and effective early warning and the temporary evacuation of people and property from threatened locations (Australian Institute of Disaster Resilience, 2018).*

Clearly preparedness is an essential component of an emergency management framework in bolstering capability and capacity to reduce the chances of catastrophe occurring. The US Government Accountability Office (2009) stated that the occurrence of Hurricane Katrina dramatically illustrated the adverse consequences that can occur when the nation is unprepared to respond effectively to a major emergency.

In the context of emergency preparedness in Canada the Senate Standing Committee on National Security and Defence stated:

> *They [emergencies] don't happen often and they mostly happen to other people, but sometimes they come to Canada. Some can be pre-empted. Some can't. all can be prepared for – minimising the risk that they will turn into disasters (2008, p.1).*

Communities trust that the emergency management sector is reliable and robust, and is adequately prepared to meet their needs (Sowry, 2017). Though this may not be reasonable in the context of a catastrophe and governments need to be transparent regarding their limitations.

Perhaps, the true measure of successful preparation for a catastrophe is the maintenance of public trust and confidence in the emergency management sector's preparedness and ability to support communities when the need is most (Crosweller, 2015b, Sowry, 2017). Preparedness for catastrophic disaster events must aim to lessen the impacts and speed the recovery of affected communities.

Preparedness efforts should consider all possible consequences of catastrophic events. Often communities focus their preparedness efforts on the last major disaster to occur, rather than those that are likely to occur in the future (Sutton and Tierney, 2006). This is like generals preparing to win the last war.

Some emergency planners believe in the need to consider preparation in the context of worst-case disaster scenarios. This is explicit in the approach termed the *Maximum of Maximums* as described by Fugate (2017b): it's use is not to argue for the resourcing for such events, but rather by considering worst case scenarios, emergency managers can come to understand the possible demands of truly catastrophic events, the gaps that might exist in resources and training; and how such events might be managed.

Limited resources, systems and knowledge mean that it is impossible to mitigate or be prepared for every worst-case scenario. For governments there are few votes when a catastrophe is averted and managed well, while criticism in the face of failure is an ever present risk (McConnell and Drennan, 2006). Therefore, investment in mitigation and preparedness is often post-event, linked to attempts to win back lost public trust. For example there was little effort to prepare for heat waves in France, until after the 2003 heatwave led to 14947 excess deaths resulting in a significant shift in public risk perception along with institutional investment (Poumadere et al., 2005). Some argue that governments can become narrowly focused on a particular threat at the expense of others. For example in the lead up to Hurricane Katrina the United State Government had invested heavily in counter terrorism at the expense of preparedness for natural disasters (McConnell and Drennan, 2006, Boin and McConnell, 2007, Comfort, 2005).

Heide (1989) is not a believer in worst-case scenarios, arguing that these are unrealistic and unlikely to be cost effective. This is supported by Quarantelli (1986) who argued that good planning is based upon realistic rather than worst case scenarios stating that whilst catastrophic disasters cannot be ignored, worst case scenarios will have little credibility with the public and key decision makers. Others argue for an optimal and efficient balance of resources to address catastrophic risks versus other risks (Government Office for Science, 2012). In the view of the authors, however, a clear benefit arising from reflection of worst-case scenarios is to help emergency managers understand the limits of what they can realistically accomplish and the point at which further resources will be needed from the community and private sector.

There is no defined risk appetite to guide emergency managers to determine the appropriate level of risk to resource for. Definitions of societal risk tolerance for disaster events, however, exist in other contexts for example the Australian earthquake building code is based on a 1-in-475 peak ground acceleration; land-use planning polices for floodplains restrict develop for events more frequent than the 1-in-100 year flood; and Australian insurance capital adequacy regulations require financial resilience in the face of losses expected in the 1-in-200 year event. Conclusions of the Queensland Floods Commission of Inquiry also provides insights that suggest that events of the scale the 2011 Queensland floods should be considered beyond the acceptable risk appetite of the State:

> *The disastrous floods which struck south-east Queensland in the week of 10 January 2011 were unprecedented, in many places completely unexpected, and struck at so many points at once that no government could be expected to have the capacity to respond seamlessly and immediately everywhere, and in all ways needed. A great deal can be done to improve readiness to deal with disaster generally, but it is impossible that any government could be permanently ready to come at once to the assistance of everyone needing help in a disaster of that scale and suddenness, unless it were to maintain a standing force of rescue personnel beyond the present capacity of society to fund (Queensland Floods Commission of Inquiry, 2012; p. 30).*

There is some truth to this conclusion, in our view, especially the unrealistic expectation that the government is ready and able to respond immediately after such an event of this size. However it ignores the fact that there had been even larger floods in the 1800s; the extent of flooding in Brisbane in 2011 was not very different that which occurred in 1974; local government had allowed significant development in regions that had been flooded in 1974; and that the operations of the Wivenhoe Dam in respect to the release of flood waters were poorly geared to protecting Brisbane (van den Honert and McAneney, 2011).

Preparation for catastrophic events occurs within a context of rising community expectations regarding the capacity of the emergency management system to mitigate and respond to threats. Often such expectations result in a low tolerance for even minor disruptions, and calls for reviews and change after emergencies occur (Boin and t Hart, 2010). Expectations also do not appear to moderate in the face of large scale events as witnessed in Australia by the reoccurring blame game after events such as the Black Saturday Fires and Queensland Floods.

Building preparedness is a continuous process that involves collaborating across a wide diversity of organisations including non-government, private and all levels of government (US Government Accountability Office, 2006). It is also achieved by working in partnership with communities to enhance their capacities to cope with and reduce the impacts of a disaster (International Federation of Red Cross and Red Crescent Societies, 2000).

The interrelated elements which support the creation of disaster preparedness can be referred to as a preparedness system (US Department of Homeland Security, 2011). In the aftermath of Hurricane Katrina much was written about the elements of disaster preparedness to minimize the occurrence of catastrophic events. The US Government Accountability Office (2006) found that building effective preparedness required effective planning and coordination, robust training and exercising in which capabilities were realistically tested, problems identified, and subsequently addressed in partnership with key stakeholders. In addition integrating an all hazards risk management framework in decision making was central to assessing catastrophic disaster risks and guiding the development of national capabilities to mitigate where possible and respond to such risks.

FEMA has developed a National Preparedness System which encompasses six parts including identifying and assessing risk; estimating capability requirements;

building and sustaining capabilities; planning to deliver capabilities; validating capabilities and reviewing and updating (FEMA, 2017c). Similarly, the US National Incident Management System defines preparedness as a continuous cycle including planning; organizing, training, equipping; exercising; and evaluating and improving (FEMA, 2014b). The research literature supports these elements for effective preparedness noting the importance of: ongoing risk monitoring (Boin and t Hart, 2010, US Government Accountability Office, 2006, Tekeli-Yeşil, 2006); enhancing community resilience and mitigating risk (Boin and t Hart, 2010, Tekeli-Yeşil, 2006); establishing clear governance arrangements (US Government Accountability Office, 2006); preparing plans and developing interagency agreements (Kapucu and Van Wart, 2006, US Government Accountability Office, 2006, der Heide, 2006, Tekeli-Yeşil, 2006); estimating and sustaining required capability (FEMA, 2017c); training personnel (Kapucu and Van Wart, 2006, Boin and t Hart, 2010, Perry and Lindell, 2003, McConnell and Drennan, 2006, US Government Accountability Office, 2006, Tekeli-Yeşil, 2006); embedding crisis management into organisational processes and culture (McConnell and Drennan, 2006); building trust and collaboration between organisations (Boin and t Hart, 2010); exercising (Boin and t Hart, 2010, Perry and Lindell, 2003, McConnell and Drennan, 2006, US Government Accountability Office, 2006, Alexander, 2005, Fugate, 2017a); and promoting a culture of learning and implementing lessons from past events (Kapucu and Van Wart, 2006, McConnell and Drennan, 2006).

Key elements of preparedness are summarised in Figure 4, which illustrates a preparedness framework to guide activities to reduce the consequences of catastrophic events and improve their management based upon key elements identified in the literature. The following sections outline each element in detail in an attempt to define better practice.

FIGURE 4 – PREPAREDNESS FRAMEWORK

///////////////////////////////////

COMMUNITY

> *One consistent theme, which emerged during the community consultations was a strong desire for community involvement in all phases of emergency management: planning, preparation, response and recovery. Concern was often expressed that communities had not been actively engaged in this process and invaluable local knowledge was not adequately considered. There was a prevailing sense that local communities had been disempowered by the state within the emergency management framework (Comrie, 2011b; p.5).*

Ultimately, the ability to withstand a possible catastrophe comes back to the resilience of the impacted community. Where community resilience may be defined as *the ability to adapt to changing conditions and prepare for, withstand, and rapidly recover from disruption* (FEMA, 2013a). However, community awareness of hazards is often low and attitude to preparedness apathetic (FEMA, 2017a). Resilient communities are those that function well under stress; can successfully adapt; are self-reliant and have social capacity (Council of Australian Governments 2011). Communities are at the core of emergency management and it is essential that leaders recognise the capacities of communities who are often the first responders in aiding their communities and integral to recovery efforts. The recent review of the New Zealand disaster management arrangements concluded that:

> *It is clear that local leadership, knowledge and engagement with those affected communities is integral to supporting trust and confidence and to ensuring an effective response (Sowry, 2017; p.2).*

The Australian emergency management sector has long promoted a policy of shared responsibility meaning that disaster resilience is the collective responsibility of all sectors of society including all levels of government, businesses, NGOs and communities (Council of Australian Governments, 2011).

Community participation is vital to building resilience, however, emergency planning and policy in Australia has traditionally been inwardly focused on the accountabilities and strategies of emergency management organisations (Webber et al., 2017). In more recent times there has been a greater acknowledgement of the need to involve communities in emergency planning (Comrie, 2011b) to the point where communities are considered equal partners in decision making. In many cases communities have been recognised as passive participants in emergency management as evidenced by the one way communication techniques often deployed by emergency services when communicating with the public (Webber et al., 2017). Such top-down generic approaches view the community as a uniform group of individuals with the same needs and values (O'Neil, 2004). Communities, however, are heterogeneous in their nature and it is essential that engagement with communities be based upon a thorough knowledge of the community. Without such knowledge engagement may fail to acknowledge the communities capacity, knowledge, interests, concerns, values and priorities (Webber et al., 2017). When communities are not respected as partners they may also question decisions that were made in response to a disaster (Pearce, 2003).

The National Strategy for Disaster Resilience Community Engagement Framework support community participation stating that engagement means:

> *Working in partnership with the community, building on existing networks, resources and strengths, identifying and supporting the development of community leaders and empowering the community to exercise choice and take responsibility (Australian Government, 2013; p. 3).*

The framework acknowledges that community engagement must be central to the business of the emergency management sector, being fully embedded within its culture, vision, policies, procedures, and practice (Australian Government, 2013).

Key principles identified in the research literature for ensuring communities are effectively engaged in the prevention, preparedness, response and recovery in the context of catastrophic events include:

Principle 1: Understand the community – engagement should be based on a thorough understanding of the community including the full diversity of the at-risk populations including their capacity, knowledge, interests, concerns, values and priorities (Webber et al., 2017).

Principle 2: Foster participation – community members must be empowered to particiapate and be acknowledged as equal partners. Participation should be based on two-way dialogue resulting in decision making that is negotiated between stakeholders in a transparent manner (Webber et al., 2017). Though involvement is essential, it does not necessarily mean giving the community control (Kennedy et al., 2008).

Principle 3: Leverage and build social capital – strong social capital is a critical enabler. Engagement should both leverage and foster social capital (Dufty, 2010).

Principle 4: Communicate effectively – information should be tailored to the community and include information about community roles (i.e. what shared responsibility means); risks faced by communities; and practical advice on how to prepare, respond and recover and how effective these measures are (Australian Government – Attorney-General's Department, 2010).

Principle 5: Evaluate, learn and improve – a process to frequently evaluate and learn based upon engagement experiences is essential (Webber et al., 2017).

Principle 6: Govern and embrace – an organisations culture and leadership must embrace community participation for engagement to be effective (Webber et al., 2017).

CULTURE

Effective preparedness for catastrophic events must be embedded in the core values, beliefs and identity of an organisation (Pollock and Coles, 2016). The US National Mitigation Framework states (FEMA, 2013b):

> *Building and sustaining a culture of preparedness and a mitigation mindset will make the Nation more socially, ecologically and economically resilient before, during and after an incident (p.1).*

A key component of organiational culture is leadership and an important role for leaders is to 'institutionalise' emergency preparedness throughout their organisations (Pollock and Coles, 2015). Maintaining preparedness for catastrophic events requires long term political will due to their infrequent occurrence. This means that preparedness systems may not be tested for many years, with benefits of public expenditure not initially realised (Kapucu, 2008).

The culture of emergency management organisations must promote resilient incident management that allows for flexibility and improvisation through promoting the value of decentralised management, local knowledge and deference to experts by management (t Hart, 2013). Successful organisations in the face of catastrophic disasters promote a culture of collaboration and information sharing, and build strong trusting institutional and personal relationships with other organisations and individuals (Waugh and Streib, 2006, Kapucu et al., 2010, Boin and t Hart, 2010, McEntire, 2002). Boin and t Hart (2010) argue that most communication failures are cultural including: a lack of pre-existing communication routines and channels; poor trust between organisations; and narrow definitions of what should be communicated and to whom. Such factors must be addressed to ensure communication is effective and allows for a diversity of collaboration including with non-government, private sector, academic, media and community organisations. Organisational culture and delegations must also empower local emergency managers to make decisions in the absence of fear of punishment by their employers (McConnell and Drennan, 2006). Building cultures of collaboration, however, can be challenging as often such aspirations are afforded low priority; some organisations encourage tribal identities; divides exist between different levels of hierarchies and volunteers and paid staff (Boin and t Hart, 2010); differing organisational priorities; organisational cultures; lines of accountability; and decision-making cycles (Boin and McConnell, 2007).

Emergency management needs to be considered core business, with emergency management expertise embedded and integrated across all parts and levels of Government.

GOVERNANCE

Governance refers to the set of norms -- laws and regulations, frameworks and standards, institutional arrangements and practices -- that exist across the disaster management system (Mamula-Seadon and McLean, 2015). In mitigating against, preparing for, responding to and recovering from catastrophes it is essential to clearly define governance arrangements. These arrangements must be well understood and communicated to enable timely and effective response (US Government Accountability Office, 2006).

Hurricane Katrina demonstrates the impact when governance arrangements lack clarity. The US Government Accountability Office (2006) reported that confusion existed regarding roles and responsibility and when to exercise specific arrangements for a catastrophic event due to confusion regarding the definition of catastrophe.

The United Nations (2008) outlines that it is important that institutional arrangements for preparedness are reflected in legislation. It is argued that such legislation is needed to address the role of Government and community stakeholders throughout all disaster management phases. Legislation should encourage community participation, as well as regular monitoring on emergency preparedness (United Nations, 2008).

Typically emergency management governance structures are created in legislation to oversee preparedness activities. In the Australian context, these governance structures are established in State legislation and consist of committees at State, Regional and Local levels. Some state emergency plans in Australia also clearly define preparedness responsibilities for different hazards, e.g. the Tasmanian Emergency Management Plan.

Legislation should not be restrictive, but foresee that unknown circumstances will occur, hence allowing for adaptation and flexibility. For example the Victoria *Emergency Management Act 1986* in a state of disaster allows the Minister to:

a) *direct any government agency to do or refrain from doing any act, or to exercise or perform or refrain from exercising or performing any function, power, duty or responsibility.*
b) *if it appears to the Minister that compliance by a government agency with an Act or subordinate instrument, which prescribes the functions powers duties and responsibilities of that agency, would inhibit response to or recovery from the disaster, declare that the operation of the whole or any part of that Act or subordinate instrument is suspended.*

Given response to catastrophic events is typified by collaborative efforts (Boin and t Hart, 2010) governance frameworks must allow for a collaborative and networked approach including the incorporation of non-government, private and community organisations, and emergent groups. Frameworks, should, however, also enable independent action in case networks fail.

Boin and t Hart (2010) argue that preparedness frameworks and systems for catastrophic events should be independently audited on a regular basis. Independent review is seen to enhance accountability and allow lessons to be

drawn utilising comparative analysis against different jurisdictions (Boin and t Hart, 2010). Sowry (2017) also suggests that transparency is needed so to provide more clarity about key risks and how they are being managed.

Governance of critical infrastructure is of particular importance as infrastructure is an essential enabler in responding to any catastrophe. The Victorian Floods Review outlined concerns regarding governance of infrastructure:

> *This Review has also revealed serious concerns about the protection of essential service infrastructure that is owned and operated by private industry. The electricity sub-station at Charlton and the Kerang terminal station are constructed on floodplains. Neither is adequately protected from major flooding. This resulting in the extended outage of power at Charlton that, among other things, severely restricted emergency communications. The Kerang terminal station was protected following a concerted effort, including by the local community, to build a sandbag levee as the flood approached (Comrie, 2011b, p.5).*

Several Australian states have developed or are developing critical infrastructure governance frameworks. The Australian Government (2010a) Critical Infrastructure Resilience Strategy takes a resilience approach to build capacity within organisations in order to not just respond to disruptions, but to learn and adapt from incidents. Such an approach encourages organisations to develop capacity to deal with shocks. The strategy outlines that this approach is in preference to more traditional approaches to developing plans to deal with finite scenarios. The strategy specifically states:

> *It is argued that organisations that build organisational resilience through distributed decision making, unified by a strong sense of ownership and purpose over the response priorities, and aided by adaptable tools and techniques, can give those organisations an enhanced ability to deal with both foreseeable and unforeseen events (Australian Government, 2010a, p.13).*

The Victoria State Government (2015) Critical Infrastructure Resilience Strategy outlines a resilience improvement cycle as shown in Figure 4, which comprises of risk management planning, exercising, validation and assurance activities.
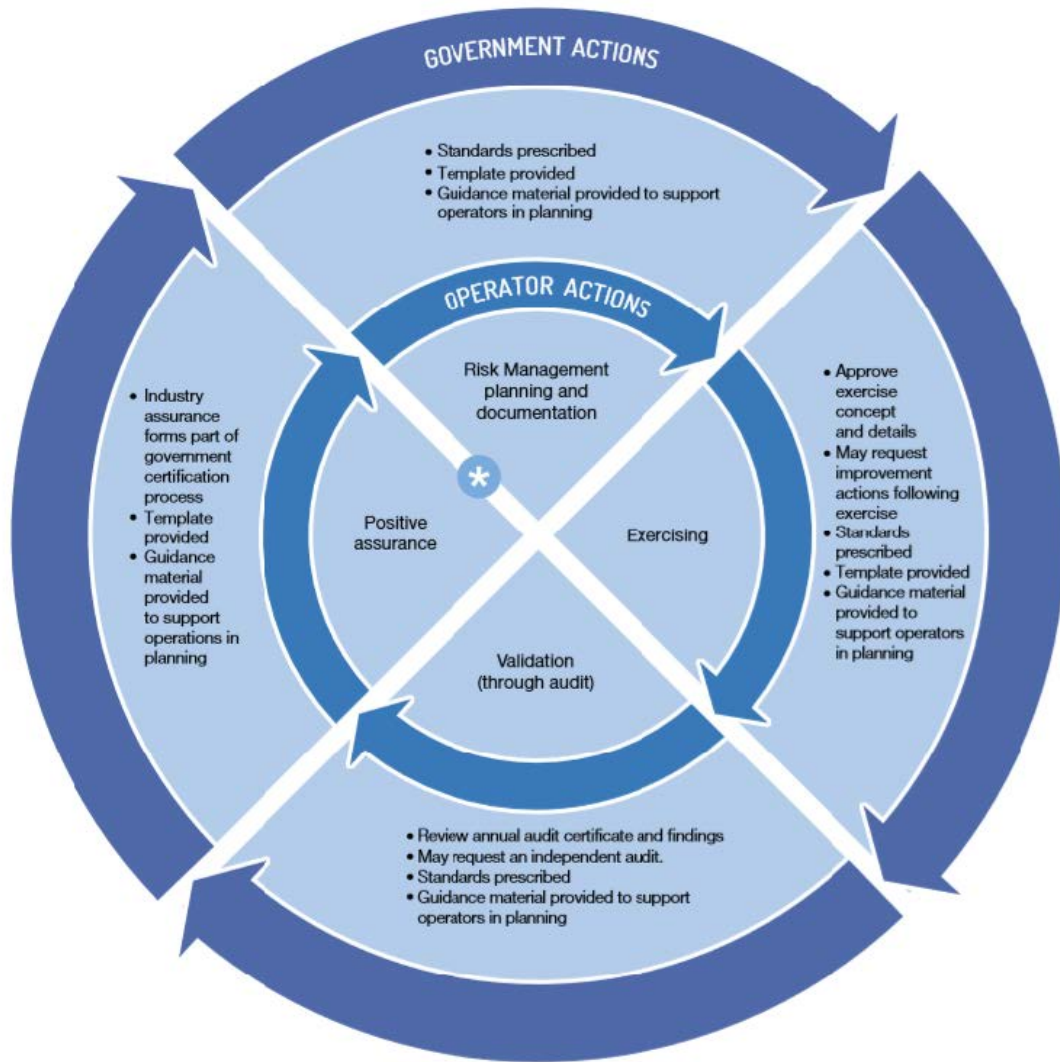
FIGURE 4 – RESILIENCE IMPROVEMENT CYCLE

Further discussion about governance in the context of catastrophic events will be provided separately to this report.

UNDERSTANDING RISK

All preparedness activities must to the extent possible be based upon knowledge of disaster risks (Perry and Lindell, 2003, Sutton and Tierney, 2006). Though preparedness must also be undertaken in the context that not all risks will be known and hence arrangements must be adaptive. In this context we refer to risk as being a function of the hazard, exposure to the hazard, and the vulnerability of exposed elements (Walker et al., 2015).

The importance of understanding risk is recognised in the Sendai Framework:

> *Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and response (United Nations, 2015; p. 14).*

Specific guidelines for the conduct of emergency risk assessments have been produced including the Australian National Emergency Risk Assessment Guidelines. It would be foolish, however, to be confident that our existing knowledge of risk is sufficient. New and emerging technologies, aging infrastructure and changing community exposure may reveal novel risks. The key is to employ the most effective risk identification techniques to minimise the chance of surprise.

Existing Australian approaches to all-hazards risk assessment in practice largely rely on qualitative methods informed by subject matter expert opinion and limited historic and scientific knowledge. Such approaches are subject to bias and assume that subject matter experts are available to contribute. Such approaches lie in contrast with those adopted by the insurance industry which relies heavily on quantitative approaches to understand risk. Some specific lead agencies employ more detailed quantitative modelling, however, assessments provide different outputs that are hard to compare. In the absence of comprehensive integrated evidence-based approaches it is difficult to accurately determine preparedness and mitigation priorities (Gissing, 2017).

The following specific principles are key to ensuring an effective assessment of risk:

Principle 1: Risk assessment should be transparent and evidence-based. Former FEMA Administrator Craig Fugate has said:

> *As part of embracing change, we must be sure to plan for what can happen, rather than what has happened in the past. We must bring science and analysis into our plans. Since we do not yet understand all the challenges that are being created by our expanding population, increased urbanisation and interdependent supply chains, we must look at our models to ensure that we are analysing the right things (Fugate, 2017b; p 6).*

Accurate data and research is fundamental to better understanding disasters and their impacts (Deloitte Access Economics, 2014). A fundamental challenge

in assessing risks of catastrophic events is that they are rare (Plag et al., 2015), meaning data to assist in their study will be scarce. The Australian Government Productivity Commission (2014) identified concerns in the availability of hazard and vulnerability information within Australia. Key issues included data gaps as well as inaccessibility, uncertainty, inconsistency and unwillingness by some stakeholders to disclose data.

Scenario-based risk assessment approaches have been utilised to gain an understanding of catastrophic disaster risks. The Catastrophic Disasters Emergency Management Capability Working Group (2005), for example, used scenarios to review Australia's approach to respond and recover from catastrophic events. Scenarios included a large earthquake in a major Australian City, a large tropical cyclone impact on Northern Queensland, an East coast tsunami and influenza flu pandemic. Realistic disaster scenarios allow emergency managers to conceptualise the impacts of plausible events including estimation of critical planning assumptions such as the number of causalities and damaged buildings and the extent of infrastructure disruption (Bushfire and Natural Hazards CRC, 2015). It is important that scenarios involve some level of imagination in order to appreciate outcomes well beyond what has occurred before and the potential for unique interactions. Rodríguez and Barnshaw (2006) described this as encouraging thinking based upon a possibility rather than a probability.

Case Study: Failure of imagination

The 9/11 Commission concluded that "*imagination is not a gift usually associated with bureaucracies*" (9/11 Commission, 2004, p.344). In its critique of the lack of imagination shown in the lead up to the September 11 catastrophe it references the example of the bombing of Pearl Harbour where intelligence suggested a heightened risk of attack, though preparedness levels remained largely unchanged and the bombing unexpected. A 1996 review of US aviation security did not mention the possible risk of suicide attacks utilising aircraft. However, the Commission did find that some parts of the US Government that had thought about the possibility of such a method of attack and that there was intelligence to suggest that it was plausible, for example in 1994 a private plane crashed into the south lawn of the White House. The North American Aerospace Defence Command imagined the possibility of utilising aircraft as weapons, possibly an overseas hijacked airliner carrying a weapon of mass destruction. The idea, however, was not pursued as it was seen as a distraction to the organisations primary focus and was viewed as unrealistic. Richard Clarke, a senior US counter terrorism official had stated to the Commission that he had been concerned by such a plot but had drawn his awareness from Tom Clancy novels rather than intelligence. The Commission concluded that *it is therefore critical to find a way of routinising, even bureaucratising, the exercise of imagination (9/11 Commission, 2004, p.344)*.

Principle 2: Risk assessment should focus on both direct and indirect impacts, secondary cascading and possible compounding impacts. Specifically analysis of realistic catastrophic disaster scenarios should consider the physical damage to residential and commercial buildings, critical facilities, essential services, schools and hospitals; economic losses including business disruption, repair and reconstruction costs and lost employment; social impacts including estimates of temporary shelter requirements, displaced persons, estimated death and injuries,

and restoration timelines for essential services; and secondary cascading impacts (Government Office for Science, 2012).

Assessment of the risk of cascading impacts should critically analyse vulnerabilities of essential infrastructure to identify likely failure scenarios. Infrastructure vulnerabilities and interdependencies should be mapped to identify risks involving cascading systems collapse (Comfort, 2005) with the Government Office for Science, 2012) advocating a systems based approach (Government Office for Science, 2012).

Principle 3: Risk assessments should include consultation and participation of a diverse range of experts and disciplines from government, community, NGOs, infrastructure, private sector and expert stakeholders (Government Office for Science, 2012). Participation should encourage information sharing between parties both across and within agencies so that a complete picture of risk can be established on an ongoing basis (Australian Government Productivity Commission, 2014). This should include the sharing of information between emergency services and infrastructure operators to achieve an understanding of possible cascading impacts. The community can also be involved in collecting and sharing risk information through crowd-sourcing (Gissing, 2017).

The concept of "Red teaming" can be utilised to assist in challenging pre-existing understanding and assumptions about identified risks (Government Office for Science, 2012). Red teaming is a deliberate process designed to challenge established ideas, concepts and assumptions to enable alternate interpretations and ideas to be expressed (Masys, 2012).

Principle 4: Risk assessments should consider the effectiveness of existing mitigation controls and identify any gaps.

Principle 5: Risk assessments should be ongoing, regularly updated and consider how risks may evolve overtime due to population increases, global climate change, urban growth, technical advances and infrastructure changes.

Principle 6: To ensure effective assessment and management of risks identified each should have a "risk owner" where a risk owner is defined as an agency or body responsible for its assessment and coordination of risk management measures. In the Australian context, though disaster response arrangements are often clear, it is not always possible to identify those responsible for the assessment, preparedness and mitigation of particular risks (Gissing, 2017).

MITIGATION

Australian Government Productivity Commission (2014) define mitigation as:

> *The practice of reducing the probability or extent of losses to people property and the environment resulting from natural hazards by reducing the frequency and magnitude of factors that cause exposure and vulnerability (p. 372).*

Mitigation is preventative measures aimed to reduce risks and enhance resilience. Such measures and governance arrangements are unique to specific hazards and are often introduced post event when institutions attempt to build back better.

Principles to guide effective disaster mitigation include:

Principle 1: Disaster mitigation should be based upon the principle of shared responsibility which leverages efforts across the whole of community including the private and not-for-profit sectors (FEMA, 2017b).

Principle 2: Mitigation investment should be informed by risk (FEMA, 2017b) and should involve consulting broadly with communities and key stakeholders (FEMA, 2013a).

Principle 3: Mitigation investment should be prioritised based upon its cost effectiveness, which in turn needs to consider the life time costs and purported benefits. The Australian Government Productivity Commission (2014) recommended, as a key mechanism to identify and prioritise mitigation, that project proposals should be supported by robust and transparent cost-benefit evaluations that are consistent with state risk assessments. FEMA (2013a) suggests a framework to evaluate mitigation options including life safety and property protection benefits; environmental and social impacts; technical, legal and political feasibility; project management capability to implement and local leadership.

Principle 4: The effectiveness of mitigation must be monitored and evaluated with this information informing future mitigation decision-making.

Principle 5: Mitigation strategies must be maintained if investment benefits are to be fully realised along with periodic revision of mitigation plans (FEMA, 2013a)

The design of mitigation strategies should also consider the key components of resilience. Rodin (2014; p. 14) outlines five characteristics of resilience as described in Table 4.

Principle	Description
Awareness	*The entity has knowledge of its strengths and assets, liabilities and vulnerabilities, and the threats and risks it faces. Being aware includes situational awareness, the ability and willingness to constantly assess, take in new information, and adjust understanding in real time.*
Diversity	*The entity has different sources of capacity so it can successfully operate even when elements of that capacity are challenged: in other words there are redundant elements or assets. The entity possesses or can*

	draw upon a range of capabilities, ideas, information sources, technical elements, people or groups.
Integration	*The entity has coordination of functions and actions across systems, including the ability to bring together disparate ideas and elements, work collaboratively across elements, develop cohesive solutions, and coordinate actions. Information is shared and communication is transparent.*
Self-regulation	*The entity can regulate itself in ways that enable it to deal with anomalous situations and disruptions without extreme malfunction or catastrophic collapse. Cascading disruptions do not result when the entity suffers a severe dysfunction: it can fail safely.*
Adaptive	*The entity has the capacity to adjust to changing circumstances by developing new plans, taking new actions, or modifying behaviours. The entity is flexible: it has the ability to apply existing resources to new purposes or for one element to take on multiple roles.*

TABLE 4 – PRINCIPLE OF RESILIENCE

PLANNING

The basis for planning lies in the principle that effective response and recovery are based on a pre-designed plan that maps the various activities that will be necessary during an emergency (Adini et al., 2006, US Government Accountability Office, 2006). It seeks the most effective use of resources under extreme circumstances (Alexander, 2005). Emergency planning has been described as a systematic and ongoing process, preparing organisations for the response to, and recovery from, emergencies. It evolves as lessons are identified and addressed, and circumstances change (UK Cabinet Office, 2011a). Key objectives of emergency plans should be to facilitate the protection of life; ensure resources are allocated effectively (Alexander, 2005); and to increase multi-agency and community resilience by ensuring that all those responsible for managing the emergency on behalf of the community know their role; are competent to carry out their roles; have access to available resources and facilities; and have confidence that their partners in response and recovery are similarly prepared (UK Cabinet Office, 2011a).

Best practice guidelines have been developed by the Australian, Canadian and UK Governments to guide practitioners in the development of emergency plans (Australian Government, 2004, Public Safety Canada, 2010, UK Cabinet Office, 2011a).

Often in frequent, small events, when uncertainty and time pressures are low, existing plans and procedures are sufficient to guide an adequate response (Boin and t Hart, 2010). However, during catastrophic events additional challenges are presented: essential infrastructure and critical resources may not be available, for example, overwhelming plans and pre-existing approaches (Kapucu, 2008, t Hart, 2013, Boin and t Hart, 2010). Command and control structures may fail if they assume uninterrupted communications (Kapucu and Van Wart, 2006). Quarantelli (1988) argues that there is often a large gap between what is planned and what actually occurs in major disasters.

Timothy Manning of FEMA in comments about disaster planning the United States said that "*FEMA had come to realise that its disaster planning worked well for 'average disasters' but beyond that, it failed catastrophically*" (Lahey, 2013). McConnell and Drennan (2006) make similar findings outlining four key challenges to planning including: catastrophes are low probability events that require large resources, whose provision will often compete with other policy issues for funding. Planning requires ordering and coherence of possible risks, yet catastrophes are unpredictable; planning requires the integration of networks, however, in reality networks are fragmented; and planning requires active preparation through training and exercising, but given the cost of these often only symbolic preparedness is possible. Though researchers note its limitations the utility of planning is argued to be in building networks of collaboration, establishing a starting point (Boin and t Hart, 2010) and building mental preparedness (Boin and Bynander, 2015).

Case Study: Limitations of plans

An American Red Cross Multi-Disciplinary Team (2011) conducted an assessment of emergency preparedness following the Chilean 2010 Earthquake and Tsunami which resulted in at least 521 deaths and $US 30 billion in damages. The report concluded that Chile was not adequately prepared for a disaster of the size experienced. In relation to emergency planning the following was observed:

> *The emergency plans in Chile lacked the necessary detail, scope, redundancy, and flexibility required to effectively and efficiently respond to an event of this magnitude. The Chilean national disaster plan does not specify the roles and responsibilities of the federal agencies in the event of a disaster. The plan implies, but does not state, that the national agencies will act at the direction of the President once information as to the scale and the scope of the disaster is received from the affected regions.*

The national plan outlines in detail the process by which the provinces and regions will report the effects of the disaster to the national government. However, the earthquake severed almost all communication between the capital and the affected areas, and so an "important component of the plan was crippled from the onset of the disaster (American Red Cross Multi-Disciplinary Team, 2011; p.25).

Plans may be essential, but they are only one of the elements underlying preparedness (Heide, 1989, Adini et al., 2006, Sutton and Tierney, 2006, Boin and t Hart, 2010). Plans can be illusory, if other requirements are neglected, creating a false sense of security (Boin and t Hart, 2010). This has been referred to as the 'paper' plan syndrome (Heide, 1989) or the production of 'fantasy documents' (Boin and t Hart, 2010). Heide (1989) argues that disaster planning is an illusion of preparedness unless based on valid assumptions about human behaviour, incorporates an inter-organisational perspective, is tied to resources, and is known and accepted by the participants. Focus should be on the process of planning rather than just the production of a written document (Quarantelli, 1998, Boin and t Hart, 2010, Eriksson and McConnell, 2011).

Traditional methodologies argue that plans should be multi-hazard in their focus, whilst incorporating special considerations associated with individual hazards (Sutton and Tierney, 2006, Quarantelli, 1998). This is based on the principle that the same general tasks will largely need to be planned for regardless of hazard type (Tierney, 1993). Alexander (2005) argues that multiple plans can result in conflicts and ambiguities, while Quarantelli (1991) argues that since societal responses are similar across different hazards, the nature of the specific hazard should not matter.

Though traditional approaches to planning have utilised all-hazard methodologies, it has been suggested in the context of planning for catastrophic events that a specific scenario-based approach may be preferable (Ruback et al.). This approach is recommended due to the complexities and possible geographical size of a major emergency that would not be appropriately covered off by a generic all hazards plan. Scenario based planning uses a specific scenario to establish a framework for modelling the consequences of an event, modelling the possible resources required to respond and evaluate existing emergency management capabilities (Ruback et al.). Boin and t Hart

///////////////////////////////////////

(2010) suggest that good practice involves a mixed approach of combining generic all hazards planning with a suite of specific contingency plans.

Examples of Plans designed for specific catastrophic disaster scenarios include:

- 2015 Hawaii Catastrophic Hurricane Plan (FEMA, 2015a)
- 2013 Hawkesbury Nepean Flood Emergency Sub Plan (NSW Government, 2013)
- 2010 Southern California Catastrophic Earthquake Response Plan (California Emergency Management Agency, 2010)
- 2014 Puget Sound Region Regional Catastrophic

Research has identified numerous elements and criteria for effective planning for catastrophes. These are summaries in the following principles:

Principle 1: Plans should be consistent with relevant legislation, regulations and governance arrangements and their scope clearly articulated (Alexander, 2005). The plans should detail the roles and responsibilities of organisations likely to be involved in all phases of the management of catastrophic events (i.e. prevention, preparedness, response and recovery) and coordination frameworks that will be employed. Planning at a local level is likely to be tactical, whilst planning at a state or national level will be strategic.

It must be respected, however, that despite the intention of plans responses during unforeseen circumstances will need to deviate from previously agreed arrangements. This creates in some instances a possible dilemma if legislation inhibits response. In such cases should Incident Controllers be empowered to ignore legislation?

Principle 2: Plans should to the extent possible be based upon an accurate knowledge of risk (Perry and Lindell, 2003, Quarantelli, 1998, Tierney, 1993, FEMA, 2014a). Plans should not just focus on the behaviour of a hazard but be based upon a thorough understanding of the community and its vulnerabilities including possible secondary hazards, cascading impacts of infrastructure disruption, supply chain gaps and the limitations of the most vulnerable in the community. Plans should avoid optimism bias. Boin and t Hart (2010) argue that plans need to consider worst-case scenarios and avoid selecting a narrow set of well-known risks on which to plan for. This would include ensuring arrangements account for key infrastructure failures in particular communications and that relief plans incorporate the needs of the most vulnerable.

Case Study: Planning for vulnerable persons

A key lesson emerging from numerous events has been that the most vulnerable members of the community (e.g. elderly, sick, very young) are often over represented in disaster fatality statistics. The 2011 Japanese earthquake illustrated that though drills were regularly held and evacuation centres were identified in plans, many older people died because they were unable to access evacuation centres or participate in drills (Norio et al., 2011). Likewise the failure to accommodate the requirements of people with special needs in the evacuation of New Orleans in 2005 resulted in many vulnerable people becoming stranded in the city.

Principle 3: Plans must be based upon realistic assumptions concerning social behaviour during emergencies (Sutton and Tierney, 2006, Quarantelli, 1998, Perry and Lindell, 2003, Tierney, 1993, Crosweller, 2015b). Plans should be based upon how people are likely to act rather than assuming they can be made to fit arrangements detailed in a plan (der Heide, 2006), this includes designing plans to ensure formal responses are integrated with those of volunteers, community groups and organisations (Tierney, 1993).

Case Study: Consideration of human behaviour

Lessons from the response to previous catastrophes illustrate how human behaviour during a disaster may differ from that expected.

Christchurch earthquake, 2011. Behaviour at hospitals during the Christchurch event differed from what would normally be expected including patients arriving by abnormal means without pre-hospital care, patient reluctance to enter hospital buildings and the spontaneous arrival of additional medical resources that had not been planned for (Ardagh et al., 2012).

Nepal earthquake, 2015. Within one week of the Nepal earthquake it is estimated that approximately 100,000 people left Kathmandu for rural areas (Sanderson and Ramalingam, 2015). This mobility had not been expected.

French heatwave, 2003. Typically emergency services would anticipate a call for help to initiate emergency responses, however, during the heatwave, however, in this case many victims did not call for help (Lagadec, 2004).

Principle 4: Planning should anticipate the range of problems that might occur and the possible solutions to them (Quarantelli, 1998) including their timing. Many of these problems can be identified based upon lessons of previous events (der Heide, 2006), however, it is impossible to anticipate everything or accurately predict problems ahead of time (Quarantelli, 1998, Eriksson and McConnell, 2011). McConnell and Drennan (2006) identify a paradox in that the more elaborate and detailed a plan is, the less likely it will be use during an event. Plans should therefore be focused on general principles and not specific details, encouraging flexibility, adaptation and improvisation (Quarantelli, 1998, Perry and Lindell, 2003, Eriksson and McConnell, 2011). In this sense plans should assume that informal responses will emerge rather than espouse management based upon prescriptive formal procedures that maybe utilised for routine emergencies. As stated by Tierney (1993; p. 37) *"if a situation could be handled through routine organisational operations and standard procedures, and if all its details could be planned out beforehand, it would not be a disaster"*.

In the context of catastrophic events the following functions maybe required: situational awareness (US Government Accountability Office, 2006); donation management; mass evacuation; pre-hospital emergency triage and treatment; medical surge operations; patient evacuation and transport; public health issues; sheltering and mass-care operations; traffic management policies; requests for incident management teams; resource reception and deployment; school closure; search and rescue; victim identification; family assistance (Emergency Management Divsion Washington, 2014); property protection; warning and

information dissemination (Boin and t Hart, 2010); integration of emergent groups (Quarantelli, 1994); management of animals (Taylor et al., 2015); coordination of foreign aid (Carafano, 2011); mass fatality management (Scottish Government, 2017); child protection; continuity of governance (Catastrophic Disasters Emergency Management Capability Working Group, 2005); and longer term recovery.

It is essential, however, that plans establish operational objectives and that priorities for emergency management resourcing be based upon these. In this sense it may not be realistic to develop detailed plans for every foreseeable function. Just those that relate to the achievement of operational objectives.

Principle 5: Planning should identify the demands that a major emergency would impose and the resources needed by agencies to undertake their roles and responsibilities including possible timing (Tierney, 1993, Perry and Lindell, 2003, Alexander, 2005). This should then be compared with resources available such that gaps can be identified. This process should include the identification of atypical resources and service providers that might be able to assist (Ardagh et al., 2012).

Resource assessments must be based upon realistic assumptions. For example assuming that 100% of known resources are available twenty-four hours per day, seven days a week is unrealistic. This was illustrated during the French 2003 heatwave where many senior decision makers were on leave at the time the catastrophe was emerging slowing resource mobilisation (Lagadec, 2004).

To accompany the identification of resource requirements, planners must also consider the logistics required to move large amounts of human and physical assets into an affected area.

Principle 6: Consideration should be given to management structures to coordinate resources (Tekeli-Yeşil, 2006) (See later discussion on considerations for command, control and coordination.) Consideration must be given to how organisations will communicate including back-up systems. Communication failures are frequently identified in the aftermath of events and should be avoided (Drabek, 1985).

Where appropriate planning should consider proactive actions in anticipation of a catastrophic event for example the pre-deployment of necessary resources and activation of surge capacity. Fugate (2011) argues that planning for forward leaning responses where proactive deployment of resources occurs based upon possible consequences rather than waiting for later confirmation of actual impacts enables the response to influence outcomes. From his experience awaiting confirmation of impacts meant that initial responses were too slow and by the time resources were established with any critical mass there was little they could do to influence the outcome of an event. This principle was applied during the national response effort to Cyclone Tracey in 1974 when the then National Disaster Organisation in the absence of any detailed impact reports from Darwin deployed resources based upon contingency planning that had been developed based upon a similar scenario of a major cyclone striking Queensland (Stretton, 1975).

Principle 7: Plans must facilitate the involvement of organisations across all tiers of Government, the non-government, the business sector and the community (Kapucu and Van Wart, 2006) and allow for the incorporation of international aid arrangements. Planning by individual organisations must be integrated horizontally and vertically (Quarantelli, 1998, Perry and Lindell, 2003, United Nations, 2008, Mamula-Seadon and McLean, 2015, Hanfling et al., 2012). The FEMA Operational Planning Manual states:

> *FEMA's operational plans must be written not only to guide FEMA operations but also to interlock with the plans of other Federal departments and agencies; likewise plans for other Federal departments and agencies must integrate with FEMA's plans. For this reason, operational planning is generally conducted in partnership with other organisations (FEMA, 2014a, p.8).*

As catastrophes exceed the operating capacity of any single jurisdiction, a collaborative, national approach should be used to plan and prepare for such events (US Department of Homeland Security, 2007).

The Australian Catastrophic Disasters Emergency Management Capability Working Group (2005) recommended that national protocols be developed to manage the integration of overseas workers and international aid into an affected jurisdiction. The need for such a protocol was well illustrated in the aftermath of the Tohoku earthquake and associated tsunami where it was found that accepting foreign aid was a complex and difficult task (Carafano, 2011). It is important to ensure support is provided to local industries and businesses to supply goods and services so as not to place further stress on impacted economies. This is best achieved by planning to work with local businesses to procure relief items where available (Sanderson and Ramalingam, 2015).

Planning is more effective if it involves all stakeholders and hence must involve likely end-users including the community (Boin and t Hart, 2010). The involvement of the community in the development of disaster plans, and supporting communities to develop their own emergency plans is encouraged, so as to enable community members to play an active role in supporting emergency services in the response to, and recovery from emergencies (UK Cabinet Office, 2011a, Perry and Lindell, 2003, Council of Australian Governments, 2011, United Nations, 2008, Webber et al., 2017). Key reasons in involving communities have been identified as allowing individuals to exercise their right to be involved in processes that may affect them; the ability to utilise the knowledge, skills and capacities of local people; and in any case it is likely local communities will be the first responders (McConnell and Drennan, 2006).

Principle 8: Embedding emergency plans within the management culture is vital to ensure effective response on the day of an emergency (UK Cabinet Office, 2011a). Effective planning involves explaining provisions of the plan to personnel of organisations that will be involved in the response to, and recovery from a catastrophe (Perry and Lindell, 2003, Tierney, 1993, United Nations, 2008); and embedding planning into all aspects of organisational structures, policies, practices and culture (McConnell and Drennan, 2006). Planning should be undertaken by personnel with experience and knowledge of the discipline (Alexander, 2005).

Principle 9: Plans should consider business continuity arrangements (United Nations, 2008). This is essential to ensure critical capabilities remain available during an event. During the 2016 South Australian state-wide blackout, numerous agency business continuity plans failed (Burns et al., 2017). Best practice processes for the establishment of business continuity plans and strategies are contained within the Business Continuity Institute (2013) Good Practice Guidelines. The Catastrophic Disasters Emergency Management Capability Working Group (2005) recommended that jurisdictions work to ensure the continuity of key supply chains, for example, those that supply food and water to communities. The emergency management sector also has a role in assisting critical private sector suppliers resume operations

One strategy that might be considered to ensure continued operation and efficient resource usage is to temporally adjust service delivery standards. Such standards of delivery should define the optimal level of service delivery that can be expected during a catastrophic disaster (Hanfling et al., 2012).

To assist essential services plan for the continuity of operation in the United Kingdom, the UK Cabinet Office (2015) developed a set of resilience assumptions that provide guidance regarding how long certain types of infrastructure maybe unavailable for. The assumptions are summarised in the Table 5 below along with some examples of actual infrastructure disruptions.

Nature of disruption	Impact	Secondary impacts	Previous experience
Denial of access/loss of premises	14 days or longer	Essential services, supply chains and local services disrupted	
Financial	Retail banking services, payment systems lasting several days	Reputational damage, social disruption ad contractual implications	
Staff absence	15 to 20% of staff	In the event of a pandemic, overseas borders may close disrupting supply chains. Local services are also likely to be disrupted	
Telecommunications	Disruption to fixed and mobile communications lasting for 3 days	Disruption to cash supply and payments	
Transport: Aviation	Disruption for 15 days in a 3-month period. Under certain circumstances disruption up to 5 months.	Staff may be stranded. International supply chains disrupted	
Transport: Domestic	Road traffic for up to 5 days. Potentially twice in a period of a month. Local roads could be affected for 1 week. Rail network disruption for up to 2 weeks	Staff unable to travel. School closures. Postal and courier services impacted. Key suppliers suffer disruption	
Loss of electricity	Some urban areas without power for up to 5 days and likely longer	Loss of lighting, power to lifts, computing and communications. Other essential services disrupted including the road network, road and rail travel, petrol stations, water supplies, sewage processing, ATM and banking	Following Hurricane Sandy electricity operators restored power to 99% of 1.3 million affected customers within 16 days (Webley, 2012). In the aftermath of Hurricane Maria in Puerto Rico 140 days after impact some 29% of customers (1.3 million people) remained without power (Irfan, 2018)

Water and wastewater services	Localised loss of water for non-industrial customers for up to 2 weeks	Disruption to manufacturing and supply chains	A third of households after the Christchurch earthquake were without water for a week. 800 homes suffered waste water disruption for more than 6 months (Giovinazzi et al. 2011)

TABLE 5 – RESILIENCE PLANNING ASSUMPTIONS

Principle 10: Plans are 'living documents' (Alexander, 2005). They need to be maintained and regularly revised to ensure they remain relevant in the context of the risk profile they have been developed to manage (Boin and t Hart, 2010). Plans should be updated when risks change; lessons are identified from incident debriefs and reviews; lessons are learnt from exercises; changes in organisations occur; and, when changes in key personnel take place (Perry and Lindell, 2003, UK Cabinet Office, 2011a). In short, planning is an ongoing process (Dynes et al., 1972).

CONSIDERATION FOR COMMAND, CONTROL AND COORDINATION

Emergency management has tradition been characterised by command control response models whereby:

- Command: (*authority within an agency) is executed vertically, and includes the internal ownership, administrative responsibility, and detailed supervision of an agency's personnel, tasks and resources (Sowry, 2017, p.26).*
- Control: *(authority across agencies) is executed horizontally, and it is the authority to direct tasks to another agency, and to coordinate that agency's actions so they are integrated with the wider response. Control authority is established in legislation or in an emergency plan. This is control to ask a certain agency towards a certain outcomes. It is not control over the actual resource – personnel and vehicles (Sowry, 2017, p.26).*
- Coordination: *bringing together agencies and resources to ensure unified, consistent and effective response (Sowry, 2017, p.26).*

Command and control approaches have been frequently criticised by social scientists (Quarantelli, 1988, Tierney, 1993) and with Drabek and McEntire (2003) describing it as being "*based on inadequate theory, incomplete evidence and a weak methodology.*" It is argued that command and control approaches are based on false assumptions that society will be chaotic and helpless and responding agencies must take over management (Tierney, 1993, Dynes, 1990); that responses are best directed through centralised decision making (Tierney, 1993, Dynes, 1990); departures from standard operating procedures can be detrimental (Drabek and McEntire, 2003); that emergent groups are unhelpful (Drabek and McEntire, 2003); and that an effective response is achieved through a single individual being in charge and supporting organisations arranged hierarchically (Tierney, 1993). Command and control models may also fail because many responding organisations are autonomous without hierarchical relationships between them (Boin and Bynander, 2015).

It is argued that plans should allow for decentralised decision making (Kapucu and Van Wart, 2006, Boin and McConnell, 2007), allowing for more flexible, improvised and networked responses that the centralisation of decision-making

inhibits (Boin and t Hart, 2010, Tierney, 1993). Decentralised models recognise emergent group behaviours, and local response capacity, and that preparedness is built on existing social structures and support networks (Dynes, 1990). Thus planning should focus on identifying existing groups and networks that are capable of undertaking leadership roles and building their capacity to do so (Tierney, 1993, Wachtendorf and Quarantelli, 2003, Dynes, 1990).

According to these authors, excessive reliance on rigid, centralised and top-down decision-making in response to catastrophes is liable to be fraught as centralised decision makers are unlikely to hold sufficient knowledge that maybe available only at local levels, especially in the early phases when information maybe scare or unreliable (Kapucu and Van Wart, 2006, Boin and t Hart, 2010); leaders may be missing or unavailable (Comfort and Kapucu, 2006); and decision makers likely overwhelmed by competing priorities and complexity of the event.

Communication chains between different hierarchal levels are vulnerable to disruption due to technology, demands on them during a crisis and the lack of existing channels to communicate with emergent organisations making central coordination even more difficult (Boin and t Hart, 2010). Only in the long run once the 'fog' has cleared may strategic decision-makers make a tangible on the ground impact (Boin and McConnell, 2007). Time can also often be lost attempting to communicate through the chain of command and waiting for decisions to be communicated back down (Boin and t Hart, 2010).

During Hurricane Katrina the hierarchical design of the Department of Homeland Security exercising top down control was inconsistent with the requirements of the rapidly changing environment (Comfort, 2005). Centralised decision making processes and strict processes were said to have caused delays in providing disaster assistance and complicated communication between local, state and federal officials resulted in poor situational awareness (Waugh and Streib, 2006).

The US Coast Guard was praised for its successes in rescuing survivors in the aftermath of Katrina. The US Government Accountability Office (2006) in their review concluded that the US Coast Guard's successful response was underpinned by the agency's operational principles that promoted leadership, accountability, and enabled personnel to take responsibility and action, based on relevant authorities and guidance. The Coast Guard was able to mitigate some of the communication failures that were experienced because it had embraced a planning assumption that communications systems could be disrupted, prompting approaches that allowed personnel to act independently or with limited direction from commanding officers based upon a prior knowledge of their mission.

The centralisation of decision-making has been criticised in the context of 2011 Japanese earthquake and tsunami. The Government appeared to lack the power that was expected of it with critical information not shared immediately after the disaster resulting in inefficient decision making (Norio et al., 2011). Similar criticism was made after the 1995 Kobe earthquake in which delays by the Governor to request assistance were blamed on the time taken to gain accurate information. The Japanese culture of collective decision making was also

///

criticised as it was likely to create time delays compared with more individualist decision making (Heath, 1995).

Centralisation and bureaucracy were also blamed for hampering response efforts during the French 2003 heatwave. Lagadec (2004; p. 5) described the situation as:

> *Before making any public move, organisations want a thorough, zero-risk scientific understanding of the alleged event; they then consult their hierarchy; a policy decision is taken, and – ideally – once everything is back under control, information may be released to the general public to 'reassure' lay people.*

The decentralised approach to the management of evacuation of hundreds of thousands of people from lower Manhattan following the September 11 attacks was praised for its success (Wachtendorf and Quarantelli, 2003). Instead of adopting a top down command and control model the Coast Guard supported a group of supporting vessels through the provision of information and relaxing normal day safety regulations (Wachtendorf and Quarantelli, 2003).

Most recently, centralised decision-making was found to delay the notification of residents following the false warning of an imminent ballistic missile attack on Hawaii. In this case local officials believed that they needed to gain approval from FEMA before issuing a cancellation text message (McAvoy and Jones, 17/1/2018).

In a recovery context, the experience of establishing a centralised national government department to coordinate recovery efforts following the Christchurch earthquakes was seen to have strengthened coordination between national agencies, and quickened decision-making at a national level. However, at a local level there appeared to be weaknesses in coordination between national and local levels and ensuring meaningful public engagement throughout the recovery process. Mamula-Seadon and McLean (2015) argue that to enable effective recovery, structures must allow for broad community participation, transparency and accountability.

In the context of the overall research debate regarding command and control approaches questions have been raised regarding the adequacy of Incident Control Systems (ICS) and their derivatives, for example, the Australasian Interagency Incident Management System in the context of catastrophic events. ICS aims to establish model incident management structures to foster interoperability between agencies. Arguments have been made that ICS is only a partial solution better suited to routine, smaller scale events (Harrald, 2006). Its application, however, in catastrophic events is limited as activities of emergent groups cannot be structured beforehand (Wachtendorf and Kendra, 2017). In this context Wachtendorf and Kendra (2017) state that the concept is essentially "a tool for agencies to manage themselves". Suggestions of its use in coordinating recovery operations has been criticised in that ICS models ignore that recovery is an intensely social process (Buck et al., 2006).

In a review of the Christchurch 2010 and 2011 earthquakes, Ellis and MacCarter (2016) concluded that ICS models did not integrate emergent groups well with

formal emergency coordination frameworks and that incident management structures need to provide for liaison and coordination with such groups.

Quarantelli (1988) emphasised the role of coordination over control, believing that coordination was key. Dynes (1990) also outlined an alternate model that reinforced the existing strengths of social units and was referred to as the "*problem solving model*". The model consists of: respecting the continuity of community capacity and existing social structures; promotion of coordination and common decision-making in a decentralised context rather than authority relationships and centralised decision-making; and recognition of emergent behaviours to support response and recovery efforts and the need for cooperation with emergent groups and volunteers and to promote their mobilisation.

Decentralised decision making maybe supported by higher level of coordination (Carayannopoulos, 2017). This model allows decision makers to focus on coordinating resources to support and integrate local efforts. In this sense decision makers spend more time asking than telling; requesting as opposed to ordering; and delegating and decentralising rather than centralising (Quarantelli, 1988). Similarly, Lagadec (2004) suggests the need for shared leadership and networked decision making, believing that command and control approaches are only suitable for small scale events. Comrie (2011b) argued for some degree of central coordination of agencies to avoid agencies acting in a siloed and uncoordinated fashion that would be quickly overwhelmed in a large scale event. Similarly, Stretton (1979) argued for centralised control based upon his experiences in directing relief efforts following Cyclone Tracey. Such contrasting views may reflect the need for disciplined hierarchical models to mobilise centrally controlled resources, but decentralised networked approaches to integrate and coordinate the efforts of many diverse organisations (Harrald, 2006). Whittaker et al. (2015) argues that this model should be based upon integrating official emergency response frameworks with social structures rather than attempting to impose an artificial command and control structures on the community.

Coordination can occur at all levels. There is merit for more strategic level coordination where the resource demands or consequences of an event extend well outside the impacted area requiring wider strategy and prioritization to support local decision makers. Where impacts are specific to a single locality or region there may be opportunities to support local coordination through deployment of expertise from high levels. For example during the Christchurch, 2011, earthquake response, the Director of New Zealand Civil Defence was forward deployed as the National Controller to Christchurch in anticipation that local resources would be overwhelmed and with acknowledgment of local dysfunctions to bring about a locally coordinated effort with national assistance (Mamula-Seadon and McLean, 2015). A similar model was utilised in the 1974 response to Cyclone Tracey when the then Director-General of the Natural Disasters Organisation was forward deployed to Darwin to coordinate the immediate relief operation (Stretton, 1975). A recent New Zealand Government review has recommended extending the concept of forward deployment by developing a group of professionals that could be deployed when needed (Sowry, 2017).

Higher levels of governance may also assist to streamline processes and make changes to assist response and recovery efforts. For example the New Zealand Government passed specific legislation after the Christchurch, 2011 earthquake to assist in streamlining recovery efforts (Mamula-Seadon and McLean, 2015).

Despite its popularity, decentralised decision-making and process flexibility must be well thought out. Given the large numbers of resources involved in responding to a catastrophic event lack of control and process can result in significant resource wastage. In the context of Hurricane Katrina it was found that adherence to strict business-as-usual processes delayed in some instances the ability to expedite the delivery of vital supplies and other assistance. However, in other cases it was identified that suspension or lack of controls resulted in waste or mismanagement. There is a key conflict between ensuring resources are deployed quickly, but also that internal controls are appropriate to avoid waste and mismanagement (US Government Accountability Office, 2006). The answer maybe to consider where flexibility in critical processes is required and when within the planning process.

///

ASSESSING AND DEVELOPING CAPABILITY

Planning activities are of little use unless resources are available to support required response and recovery activities (Sutton and Tierney, 2006). The US Government Accountability Office (2006) review of Hurricane Katrina stated:

> *Substantial resources and capabilities marshalled by state local and federal governments and non-government organisations were insufficient to meet the immediate challenges posed by the unprecedented degree of damage and resulting number of hurricane victims caused by Hurricane Katrina and Rita. Developing the capabilities needed for catastrophic disasters should be part of the overall national preparedness effort that is designed to integrate and define what needs to be done, where, based on what standards, how it should be done, and how well it should be done. (p. 7)*

Capability and capacity are frequently used terms in the emergency management sector. Capability can be defined as the *degree of competency and skill, knowledge and attributes*, whilst capacity refers to *the quantity of resources (Sowry, 2017; p.20).*

The US National Incident Management System (FEMA, 2015b) states that assessing and developing capability provides the human and technical capital stock necessary to build capabilities, and address modernisation and sustainability requirements. Emergency Management Victoria (2016) define five capability elements of:

- *People – all people involved in undertaking emergency management activities from community, government, agencies and business*
- *Resources – infrastructure, fleet, IT equipment, radios, communications equipment's, consumables and personal protective clothing and equipment*
- *Governance – legislation, funding, authorising environment, emergency management arrangements, doctrine and policy*
- *Systems – learning and development, information technology, financial, infrastructure and assets management, workforce management, workplace health and safety, quality control, data and AIIMS*
- *Processes – capacity planning, risk management, continuous improvement, information flow and planning*

An understanding of risk and required strategies allows planners to identify what capability and capacity challenges exist, including sustainment gaps. Assessing capability and capacity gaps necessitates an assessment of current resources (human and physical), systems and infrastructure available against a knowledge of risk, strategies outlined in Plans and known resource requirements (Crosweller, 2015a, US Department of Homeland Security, 2007). Such an assessment can reveal hidden capabilities, identify how capabilities may be better utilised and major gaps that may exist in relation to implementing plans for major emergencies. The assessment should also consider the application of capabilities across all of the emergency management phases and the capabilities of all stakeholders (United Nations, 2008). The outcomes of such a process is illustrated in Figure 5 (US Government Accountability Office, 2006).
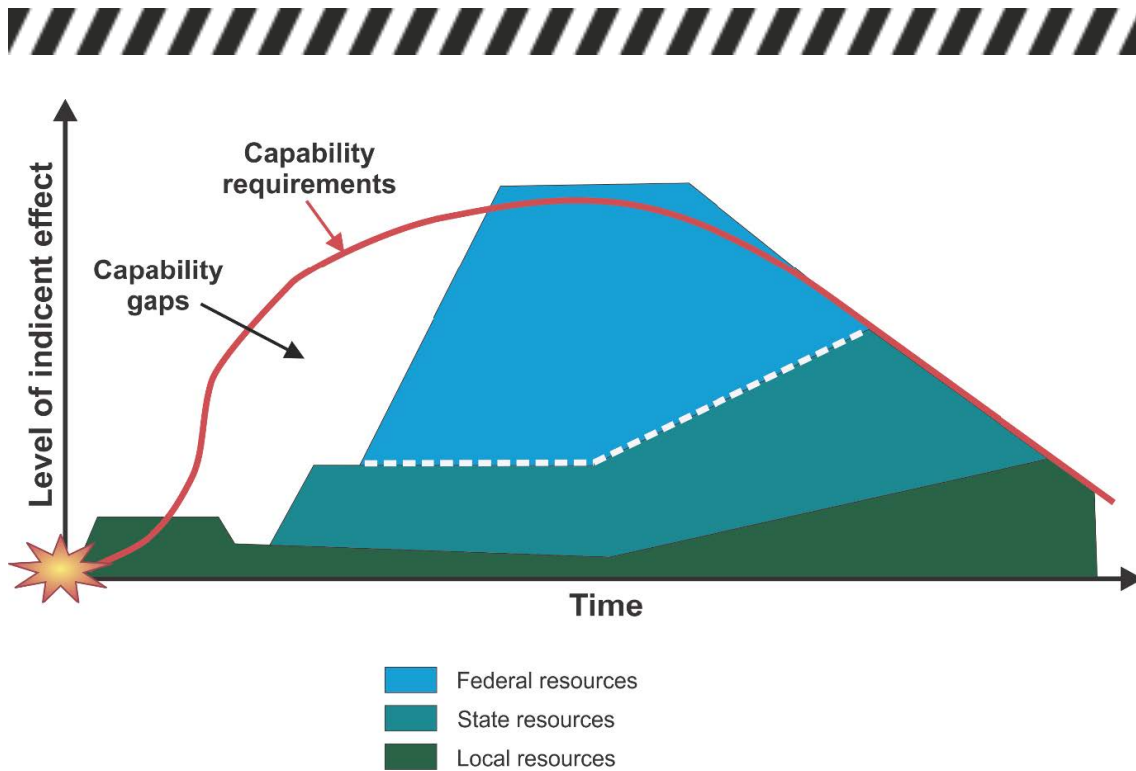
FIGURE 5 – CAPABILITY ASSESSMENT

The United States utilises the Threat and Hazard Identification and Risk Assessment Guide (US Department of Homeland Security, 2013) process to help communities identify capability targets and resource requirements necessary to address anticipated and unanticipated risks. The Guide outlines a four step process:

1. Identify the threats and hazards of primary concern to the community
2. Give the threats and hazards context. Describe the hazards of concern, illustrating how they may impact the community
3. Establish capability targets. Assess each hazard in context to develop a specific capability target for each core capability
4. Apply the results. For each core capability, estimate the resources required to achieve the capability targets, while also considering preparedness strategies, including mitigation opportunities.

The outcome of a capability assessment process can result in a capability framework; forward planning for the development of new capabilities; and possible adjustments to emergency plans including the re-ordering of strategic, operational and/or tactical priorities (Crosweller, 2015a). Resulting capability needs should be prioritised based upon risk, and will be specific to individual communities and jurisdictions as risk profiles differ (US Government Accountability Office, 2006). Where gaps continue to exist this information should be shared within organisations and external partners to ensure realistic expectations are maintained of an organisation's capability. Hurricane Katrina exposed the fact that decision makers at different jurisdictional levels did not understand of the limits and capacities of other jurisdictions (Comfort, 2005).

It is important to acknowledge that emergency management capacity is ultimately built from the community level (Waugh and Streib, 2006), as it is the community that will often provide first responders when emergency management agencies are overwhelmed. It is therefore essential to consider wider community capabilities in any capability analysis.

The US Department of Homeland Security (2015) has developed a list of core capabilities that represent critical tasks required during a disaster in order to develop capability targets. It should be noted that these capabilities are not exclusive to any single government or agency, but rather require the combined efforts of the whole community including NGOs, the private sector and the community (US Department of Homeland Security, 2015). Emergency Management Victoria and the Western Australian Government have developed a similar list of core capabilities. In addition the Australian Capability Roadmap suggests 20 national capabilities (Australian Government, 2016). These capabilities are collectively mapped and summarised in Table 6. Comparison between the different frameworks identifies that the US approach also incorporates counter terrorism capabilities and that the Victorian and US frameworks do not assign capabilities within the same disaster phases.

Prevention	Preparedness	Response	Recovery
Planning			
Public information and warning			
Operational coordination			
Intelligence and information sharing			
Public order and community safety			
Building community resilience			
Leadership			
Innovation			
Governance			
Supply chain integrity and security	Community resilience	Infrastructure systems	
Physical protective measures	Long-term vulnerability reduction	Logistics and supply chain management	
Risk management for protection programs and activities	Risk and disaster resilience assessment	Fatality management services	
	Fire management and suppression		Natural and cultural recovery
	Threats and hazards identification	Mass care services	Housing/built recovery
	Planning for catastrophic events	Mass search and rescue operations	Social recovery
	Threshold testing	Operational communications	Economic recovery
		Public health, healthcare and emergency medical services	Health and social services
		Situational assessment/impact assessment	Learning and analysis
		Critical transportation	
		Relief assistance	

		Environmental response/health and safety	
		Evacuation and support	
		Civil disaster expansion	
		Responder protection and sustainment	

TABLE 6 – SUMMARY OF COMBINED EMERGENCY MANAGEMENT CORE CAPABILITIES

INTEROPERABILITY

Interoperability is key to enabling effective collaboration between agencies. Interoperability is defined as the ability for resources from different agencies to work with each other (Kapucu et al., 2010). Pollock and Coles (2015) outline that due to the dynamic, complex and inter-organisational nature of emergency management operations, effectively managing knowledge sharing across organisations in a rapid fashion has become a critical emergency management success factor. Those agencies involved in the collaborative process must achieve interoperability in order to achieve their objectives. The UK Joint Emergency Services Interoperability Program (2016) has developed an interoperability framework illustrated in Figure 6 to identify key conditions to the achievement of interoperability.

Co-locate
Co-locate with commanders as soon as practicably possible at a single, safe and easily identified location near to the scene.

Communicate
Communicate clearly using plain English.

Co-ordinate
Co-ordinate by agreeing the lead service. Identify priorities, resources and capabilities for an effective response, including the timing of further meetings.

Jointly understand risk
Jointly understand risk by sharing information about the likelihood and potential impact of threats and hazards to agree potential control measures.

Shared situation awareness
Shared Situational Awareness established by using METHANE and the Joint Decision Model.

FIGURE 6 – CAPABILITY ASSESSMENT

Lack of coordination and communication between agencies was well illustrated by the experiences of emergency first responders to the World Trade Centre 9/11

terrorist attacks. Command posts were located in different locations and information that was critical to inform decision-making was not shared between responding agencies. The 9/11 Commission Report concluded that for New York and other major cities to be prepared for future terrorist attacks, different responding agencies must be fully coordinated (9/11 Commission, 2004).

In Australia, the Catastrophic Disasters Emergency Management Capability Working Group (2005) recommended that national discussions between jurisdictions be held to ensure collaborative systems and inter-jurisdictional interoperability existed, with a focus on the areas of communications equipment; landline and mobile telephones; response equipment; national registration of professionals; legal consistency between jurisdictional emergency management legislation that may impact upon the delivery of national response; national resource sharing arrangements; and integration of international resources.

TRAINING

Ellis and MacCarter (2016) reflecting on observations from the Christchurch, 2011, found few people involved in the management of the event had either the training or the capability to lead during a major disaster. This problem is compounded by the fact that catastrophic incidents are rare and decision makers do not get sufficient real experience in dealing with them.

All stakeholders involved in emergency management must not only be trained to a high level of proficiency in their given expertise, but must also possess awareness of the other responders' roles. Therefore, training should include all aspects of leadership, crisis planning, response, recovery, and mitigation including how these elements are applied in the context of catastrophic events. Effective training must also have clear goals, be relevant, reflect current practice and incorporate critical self-reflection (Pollock and Coles, 2015). Organisations should make training decisions based on information derived from the assessments, strategies, and plans established within previous phases of the preparedness system (FEMA, 2015b).

Before an emergency occurs, members of all relevant agencies must work together, building relationships and trust. Joint training through exercises and simulations, reaching across organisations, are useful in developing a culture of interoperability (Pollock and Coles, 2015). To achieve this, the Victorian State Fire and Emergency Services Training Framework (Fire Services Commissioner, 2012) outlines a unified approach with an expressed objective to:

> *maximise interoperability, capacity, capability, resilience and sustainability through training that harnesses synergies and improves consistency of practice* (Fire Services Commissioner, 2012, p.8).

The structuring of learning and development has been well summarised by the concept of the training cycle (Alliance Sector Skills Council, 2010) and involves four key action areas:

- Research learning and development needs
- Plan and develop learning and development opportunities
- Facilitate learner achievement
- Maintain and improve quality standards

In Australia, there is a nationally endorsed Public Safety Training Package which provides units of competency, qualifications frameworks and assessment guidelines required to perform functions across the spectrum of emergency management.

US Department of Homeland Security (2007) states that jurisdictions should develop multi-year Training and Exercise Plans to build and assess capabilities. Our search of the literature revealed that several jurisdictions including Victoria and Queensland in Australia and the State of Washington (US) have developed training plans or strategies. These documents typically outline available training, key stakeholders, roles and responsibilities, and training required by different emergency management functions (Queensland Government, 2015a, Washington State Military Department, 2015, Fire Services Commissioner, 2012).

To ensure that training strategies and requirements are understood and meet local needs, stakeholders should be consulted and included in training governance arrangements (Queensland Government, 2015b).

Training should include a focus on building the capability of local leaders to establish collaborative coordination models with emergent groups.

EXERCISING

Exercises are "*activities that consider or simulate a real life situation so that an agency is able to review or test procedures and practice participants in defined roles*" (Ministry of Civil Defence & Emergency Management, 2009). Regular exercises assist to build awareness and knowledge; improve decision-making skills, enhance relationships between collaborative partners (Boin and t Hart, 2010) and test plans (Perry, 2004). Short of actual events, these offer the best opportunity to test plans and to ensure they are understood (US Government Accountability Office, 2010).

In the aftermath of Hurricane Katrina, the US Government Accountability Office (2006) concluded that inadequate exercising before the event had created a lack of understanding as to the types of assistance that would be necessary, the required timing for assistance and the contributions organisations might provide. Perry (2004) in evaluating an emergency exercise found that exercising enhanced participants teamwork and perceptions of response knowledge. In a similar evaluation Alim et al. (2015) found that training and drills improved knowledge and ability regarding disaster preparedness. Fugate (2017b), however, challenged the way emergency managers exercise arguing that exercises are focused on scenarios in which emergency management agencies are capable of handling rather than considering truly catastrophic events. In other words there is no stretch involved.

Effective exercise programs focus on continuous improvement (Commonwealth of Australia, 2012). Exercises should be evaluated to identify improvements needed in an agency, process or function and establish whether the exercise achieved its objectives (Ministry of Civil Defence & Emergency Management, 2009). The lessons identified should be integrated into updated plans and procedures (Ministry of Civil Defence & Emergency Management, 2009). Multi-year exercise plans build preparedness by using a step-by-step approach, where planning and training are linked to the exercise program (Ministry of Civil Defence & Emergency Management, 2009).

Governments of Australia, UK and New Zealand have produced best practice guidelines that provide practical advice regarding the design, planning, execution and evaluation of exercises (Ministry of Civil Defence & Emergency Management, 2009, Commonwealth of Australia, 2012, UK Cabinet Office, 2011a).

EVALUATING, MONITORING AND IMPROVING

Three main methods of evaluating and monitoring preparedness performance identified in the literature area:

- Post exercise/incident evaluations
- Preparedness reporting
- Strategic preparedness reviews/auditing

POST EXERCISE/INCIDENT EVALUATIONS

Real world events and exercises provide opportunities to validate emergency plans and preparedness elements (US Department of Homeland Security, 2011). Recent Australian examples of major post incident reviews include the 2011 Queensland Floods Commission of Inquiry, 2009 Victorian Bushfires Royal Commission, 2010 Victorian Floods Review, 2016 South Australian Blackout Review, and 2016 review of the Melbourne Thunderstorm Asthma Outbreak. Such reports are characterised by analysis and recommendations to improve emergency management preparedness for future emergencies.

An example of a review after a major exercise is the 2011 UK 'Watermark' exercise which involved some 20,000 individual participants. The exercise was undertaken to validate the effectiveness of measures implemented to improve the management of flooding following recommendations by the Pitt Review after flooding in England in 2007. The exercise was evaluated utilising feedback from participants and resulted in a report to the UK and Welsh Governments making recommendations to improve preparedness for major incidents (Exercise Watermark Team, 2011).

PREPAREDNESS REPORTING

Attempts have been made to evaluate, measure, monitor and report on emergency preparedness outside the occurrence of an emergency event or exercise. Examples of such reporting in the emergency management context were identified in the US, New Zealand and Australia.

The development of clear and well-defined indicators is a vital component of such evaluations. Indicators should be aimed at identifying the level of performance against each criteria. Assessment against the defined indicators assists to provide focus and direction to help identify strengths and weaknesses in emergency preparedness levels and facilitate targeted improvement (Adini et al., 2014). The United Nations (2008) has developed a guidance package which outlines a series of indicators in which to benchmark emergency preparedness activities against better practice.

The Western Australia State Emergency Management Committee develops an annual report detailing the emergency management sector's progress concerning building, enhancing and improving capability across the full range of hazards and potential impacts. The report specifically assesses preparedness against the State's emergency management capability framework (State Emergency Management Committee Western Australia, 2014). A similar series of

reports are prepared in the US and are analysed to produce a national preparedness report (see latter discussion). These reports are based upon self-assessments aligned to the core capabilities identified in the US National Preparedness Goal. A similar report is also produced by the New Zealand Government.

Case Study: United States National Preparedness Report

The United States National Preparedness Report (US Department of Homeland Security, 2015b) summarises progress in building, sustaining, and delivering the core capabilities described in the 2011 National Preparedness Goal (the Goal). Each year, the report presents an opportunity to assess improvements that that whole community have made in preparedness, and to identify where gaps remain. The National Preparedness Report is informed by State Preparedness Reports completed by States and Territories.

State Preparedness Reports are an annual self-assessment of state level preparedness submitted by the 56 States and Territories to FEMA. The Post-Katrina Emergency Management Reform Act of 2006 requires a State Preparedness Report to be completed by a State or Territory receiving Federal preparedness assistance. The reports support the National Preparedness System by helping to identify State and Territory preparedness gaps. States, Territories and the Federal Government use this information to help make decisions to build and sustain capabilities, plan to deliver capabilities, and validate capabilities (US Department of Homeland Security, 2015b).

States and Territories begin by setting capability targets identified in the Threat and Hazard Identification and Risk Assessment Process. They then assess their current preparedness levels for achieving their capability targets according to the core capabilities defined in the National Preparedness Goal. For each core capability, jurisdictions assess their preparedness levels in each of the solution areas of planning, organisation, equipment, training and exercises. In cases where their current preparedness levels are deficient, States and Territories explain the improvements they would need to address the gaps in their jurisdictions (US Department of Homeland Security, 2015b).

An example of another preparedness assessment process is the SOPAC Member Countries National Capacity Assessments that were led by the Australian Government (2010c) to assess tsunami warning and mitigation system capacities. The assessment process utilised a panel of experts to asses each country's capability using an assessment questionnaire that detailed key elements of a preparedness framework. The assessments assisted countries to prioritise funding to address identified gaps.

STRATEGIC PREPAREDNESS REVIEWS/AUDITING

Our research identified that external governance bodies such as Auditor-Generals, Inspector-Generals and Parliamentary Committees have conducted strategic reviews/audits of emergency preparedness in the US, Australia and Canada. For example the Victoria Auditor-General (2014) undertook a review of heatwave management in Victoria, the Australian National Audit Office (2000) reviewed Commonwealth Emergency Management Arrangements and the US

Government Accountability Office (2014) undertook a review of Federal Government emergency preparedness.

The Canadian Senate Standing Committee on National Security and Defence (2008) provides an example of a comprehensive sector wide review by a Parliamentary Committee that examined the Canadian Government's efforts to improve disaster preparedness and disaster response capacity in the following areas:

- continuity of essential government services during emergencies
- the capacity of the Canadian Armed Forces to offer assistance during emergencies
- the usefulness of emergency caches scattered around the country
- funding municipalities for emergency equipment and training
- collaboration among federal, provincial, territorial and municipal governments
- achieving lessons learnt and best practices
- emergency public communications
- policing during emergencies.

In Victoria, the *Victorian Emergency Management Act (2013)* establishes the function of the Inspector-General for Emergency Management. The primary role of the Inspector-General is to provide assurance to government and the community regarding the emergency management arrangements in Victoria and fostering their continuous improvement. A similar function exists under the *Queensland Disaster Management Act (2003),* which establishes the function of the Queensland Inspector-General Emergency Management.

IMPLEMENTING LESSONS LEARNT

A supporting culture and effective governance is key to effective lessons management (Emergency Management Victoria, 2015). Each organisation involved in emergency management should have a defined responsibility to implement accepted lessons learnt where resources are available. For example, the UK lessons identified from exercises and operations policy framework (UK Cabinet Office, 2011b) states:

> *Each individual Department and Agency has responsibility for defined areas of policy, plans and procedures falling within their area of work, including maintenance, review and revision of these in response to lessons identified (UK Cabinet Office, 2011b; p.1).*

It is important that lessons be shared broadly on a systematic basis amongst a range of different stakeholders to enable opportunities for wider learning (Alexander, 2010). Emergency Management Victoria (2015) outlines a lessons management process including capturing observations; analyzing insights; identifying lessons; assessing actions; implementation and dissemination; measuring and monitoring; and lessons learned.

Within the emergency management sector there is a habit of ignoring lessons from previous events resulting in the repeat of past mistakes (Alexander, 2010, der Heide, 2006). By way of example, Redlener and Reilly (2012) concluded that there must be more effort in applying lessons from previous events; for example,

virtually all the health problems experienced after Hurricane Katrina in the US were again witnesses during Hurricane Sandy in 2012. A further example is illustrated in a 2009 audit of Public Safety Canada which concluded that while action reports following exercises were completed, the observations and recommendations from these reports had not been systematically collected and used to improve emergency plans and operations (Office of the Auditor General of Canada 2009). Scanlon (2001) went further to say that the Canadian experience is one of lessons learnt and promptly forgotten.

When Brian A. Jackson of the RAND Corporation testified to the US Committee on Homeland Security he spoke about key lessons applicable to strengthening national preparedness. Areas identified for further attention included: developing better ways to assess and measure preparedness to maintain confidence in the national preparedness system; and, improving the ability and agility of the national response system to more effectively learn lessons from preparedness exercises (Jackson, 2014).

On the other hand, there are examples where lessons have been implemented. For example, the Tasmanian Audit Office concluded that there had been a high level of implementation of the learnings from the 2013 Tasmanian Bushfires Inquiry and its recommendations (Tasmanian Audit Office, 2015). However, the Tasmanian Audit Office also stressed that the maintenance of many measures will require ongoing attention to ensure they are effective into the future.

In some cases independent monitors have been appointed to provide assurance that recommendations of reviews and evaluations have been implemented, or Government independent assurance bodies have conducted audits. For example, independent monitoring of the implementation of recommendations occurred for the Victorian Bushfires Royal Commission and the UK Pitt Review. The Tasmanian Audit Office also audited the implementation of recommendations from the 2013 Tasmanian Bushfires Inquiry. The US Government Accountability Office (2014) recommends that the status of recommendations implementation be tracked and reported.

//

REFERENCES

1   9/11 COMMISSION 2004. Final report of the national commission on terrorist attacks upon the United States. *Washington, DC: US Government*.

2   ADAMS, K. 2016. Queensland floods 2011: Mud Army shows city spirit. *Brisbane Times* [Online]. Available: https://www.brisbanetimes.com.au/national/queensland/queensland-floods-2011-mud-army-shows-city-spirit-20160113-gm4q0r.html [Accessed 18/2/2018].

3   ADINI, B., GOLDBERG, A., LAOR, D., COHEN, R., ZADOK, R. & BAR-DAYAN, Y. 2006. Assessing Levels of Hospital Emergency Preparedness. *Prehospital and Disaster Medicine,* 21**,** 451-457.

4   ADINI, B., VERBEEK, L., TRAPP, S., SCHILLING, S., SASSE, J., PIENTKA, K., BÖDDINGHAUS, B., SCHAEFER, H., SCHEMPF, J. & BRODT, R. 2014. Continued vigilance–development of an online evaluation tool for assessing preparedness of medical facilities for biological events. *Frontiers in Public Health,* 2**,** 1-8.

5   ALEXANDER, D. 2005. Towards the development of a standard in emergency planning. *Disaster Prevention and Management: An International Journal,* 14**,** 158-175.

6   ALEXANDER, D. E. 2010. The L'Aquila earthquake of 6 April 2009 and Italian Government policy on disaster response. *Journal of Natural Resources Policy Research,* 2**,** 325-342.

7   ALIM, S., KAWABATA, M. & NAKAZAWA, M. 2015. Evaluation of disaster preparedness training and disaster drill for nursing students. *Nurse education today,* 35**,** 25-31.

8   ALLIANCE SECTOR SKILLS COUNCIL 2010. National Occupational Standards for Learning and Development. UK: Alliance Sector Skills Council.

9   AMERICAN RED CROSS MULTI-DISCIPLINARY TEAM 2011. Report on the 2010 Chilean Earthquake and Tsunami Response. Virginia: USGS.

10 ARDAGH, M. W., RICHARDSON, S. K., ROBINSON, V., THAN, M., GEE, P., HENDERSON, S., KHODAVERDI, L., MCKIE, J., ROBERTSON, G. & SCHROEDER, P. P. 2012. The initial health-system response to the earthquake in Christchurch, New Zealand, in February, 2011. *The Lancet,* 379**,** 2109-2115.

11 AUSTRALIAN GOVERNMENT - ATTORNEY-GENERAL'S DEPARTMENT 2010. Guidelines for the Development of Community Education, Awareness & Engagement Programs. Canberra.

12 AUSTRALIAN GOVERNMENT 2004. Emergency Planning. *In:* AUSTRALIAN GOVERNMENT ATTORNEY-GENERAL'S DEPARTMENT (ed.). Canberra: Australian Government.

13 AUSTRALIAN GOVERNMENT 2010a. Critical Infrastructure Resilience Strategy. Canberra: Attorney General's Department.

14 AUSTRALIAN GOVERNMENT 2010b. NATCATDISPLAN Version 1.0. Canberra: Attorney-General's Department Emergency Management Australia.

15 AUSTRALIAN GOVERNMENT 2010c. SOPAC Member Countries National Capacity Assessments. *In:* BUREAU OF METEOROLOGY (ed.). Canberra: Australian Government.

16 AUSTRALIAN GOVERNMENT 2013. National Strategy for Disaster Resilience Community Engagement Framework. *In:* DEPARTMENT, C. A.-G. S. (ed.). Canberra.

17 AUSTRALIAN GOVERNMENT 2016. A capability roadmap: enhancing emergency management in Australia 2016. Canberra: Attorney-General's Department.

18 AUSTRALIAN GOVERNMENT PRODUCTIVITY COMMISSION 2014. Natural Disaster Funding Arrangements. Canberra, Australia: Australian Government Productivity Commission.

19   AUSTRALIAN INSTITUTE OF DISASTER RESILIENCE. 2018. Glossary. Available: https://knowledge.aidr.org.au/glossary/?wordOfTheDayId=&keywords=preparedness&alpha=&page=1 &results=50&order=AZ [Accessed 18/2/2018].

20   AUSTRALIAN NATIONAL AUDIT OFFICE 2000. Commonwealth Emergency Management Arrangements. Canberra: Australian National Audit Office.

21   AVEN, T. 2013. On the meaning of a black swan in a risk context. *Safety science*, 57, 44-51.

22   AVEN, T. 2015. Implications of black swans to the foundations and practice of risk assessment and management. *Reliability Engineering & System Safety*, 134, 83-91.

23   BARNSHAW, J., QUARANTELLI, E. & LETUKAS, L. 2008. The characteristics of catastrophes and their social evolution: An exploratory analysis of implications for crisis policies and emergency management procedures.

24   BENINI, A. A. 1999. Network without centre? A case study of an organizational network responding to an earthquake. *Journal of Contingencies and Crisis Management*, 7, 38-47.

25   BILHAM, R. 2010. Lessons from the Haiti earthquake. *Nature*, 463, 878-879.

26   BISSELL, R. 2013. *Preparedness and response for catastrophic disasters*, CRC Press.

27   BLONG, R. 2013. Pear-Shaped Phenomena. *13th AON Benfield Hazards Conference, 2013*.

28   BLONG, R. 2017. RE: *Discussion of catastrophic bushfires*. Type to GISSING, A.

29   BOIN, A. & BYNANDER, F. 2015. Explaining success and failure in crisis coordination. *Geografiska Annaler: Series A, Physical Geography*, 97, 123-135.

30   BOIN, A. & MCCONNELL, A. 2007. Preparing for critical infrastructure breakdowns: the limits of crisis management and the need for resilience. *Journal of Contingencies and Crisis Management*, 15, 50-59.

31   BOIN, A. & T HART, P. 2010. Organising for effective emergency management: lessons from Research. *Australian Journal of Public Administration*, 69, 357-371.

32   BUCK, D. A., TRAINOR, J. E. & AGUIRRE, B. E. 2006. A critical evaluation of the incident command system and NIMS. *Journal of Homeland Security and Emergency Management,* 3.

33   BURNS, G., ADAMS, L. & BUCKLEY, G. 2017. Independent Review of the Extreme Weather Event South Australia 28 September - 5 October 2016.

34   BUSHFIRE AND NATURAL HAZARDS CRC 2015. Learning from the past, planning for the future. *Hazard Note*, 1-2.

35   BUSINESS CONTINUITY INSTITUTE 2013. Good Practice Guidelines. London, UK: Business Continuity Institute.

36   CAL OES GOVERNOR'S OFFICE OF EMERGENCY SERVICES 2017. Catastrophic Planning.

37   CALIFORNIA EMERGENCY MANAGEMENT AGENCY. 2010. Southern Califorina Earthquake Response Plan. Available: http://www.caloes.ca.gov/cal-oes-divisions/planning-preparedness/catastrophic-planning [Accessed 1 March 2018].

38   CARAFANO, J. 2011. The Great Eastern Japan Earthquake: Assessing Disaster Response and Lessons for the U.S. Available: www.heritage.org [Accessed 19 October 2015].

39   CARAYANNOPOULOS, G. 2017. Whole of Government: the Solution to Managing Crises? *Australian Journal of Public Administration*, 76, 251-265.

40 CATASTROPHIC DISASTERS EMERGENCY MANAGEMENT CAPABILITY WORKING GROUP 2005. Review of Australia's Ability to Respond to and Recover From Catastrophic Disasters. Canberra: Australian Emergency Management Committee.

41 CAVALLO, A. & IRELAND, V. 2014. Preparing for complex interdependent risks: a system of systems approach to building disaster resilience. *International journal of disaster risk reduction*, 9, 181-193.

42 COATES, L., HAYNES, K., O'BRIEN, J., MCANENEY, J. & DE OLIVEIRA, F. D. 2014. Exploring 167 years of vulnerability: an examination of extreme heat events in Australia 1844–2010. *Environmental Science & Policy*, 42, 33-44.

43 COMFORT, L. K. Fragility in disaster response: Hurricane Katrina, 29 August 2005. The forum, 2005.

44 COMFORT, L. K. 2006. Cities at risk: Hurricane Katrina and the drowning of New Orleans. *Urban Affairs Review*, 41, 501-516.

45 COMFORT, L. K. & HAASE, T. W. 2006. Communication, coherence, and collective action: The impact of Hurricane Katrina on communications infrastructure. *Public Works management & policy*, 10, 328-343.

46 COMFORT, L. K. & KAPUCU, N. 2006. Inter-organizational coordination in extreme events: The World Trade Center attacks, September 11, 2001. *Natural hazards*, 39, 309-327.

47 COMMONWEALTH OF AUSTRALIA 2012. Australian Emergency Management Handbook Series: Managing Exercises Handbook 3. Canberra: Commonwealth of Australia.

48 COMRIE, N. 2011a. Review of the 2010-11 Flood Warnings & Response Interim Report. Melbourne.

49 COMRIE, N. 2011b. Review of the 2010-11 Flood Warnings and Response. In: STATE GOVERNMENT VICTORIA (ed.). Melbourne: State Government Victoria.

50 COUNCIL OF AUSTRALIAN GOVERNMENTS 2002. Natural Disasters in Australia. Canberra, Australia.

51 COUNCIL OF AUSTRALIAN GOVERNMENTS 2011. National Strategy for Disaster Resilience. Canberra: Commonwealth of Australia.

52 CROMPTON, R. 2004. South Atlantic Hurricane puts Brazil in a Spin. *Risk Frontiers Briefing Note*, No. 64.

53 CROMPTON, R. P. & MCANENEY, K. J. 2008. Normalised Australian insured losses from meteorological hazards: 1967–2006. *Environmental Science & Policy*, 11, 371-378.

54 CROSWELLER, M. 2015a. How a change in thinking might change the inevitability in disasters. *Australian Journal of Emergency Management*, 30.

55 CROSWELLER, M. 2015b. Improving our capability to better plan for, respond to, and recover from severe-to-catastrophic level disasters. *Australian Journal of Emergency Management*, 30, 41.

56 CURSON, P. & MCCRACKEN, K. 2006. An Australian perspective of the 1918–1919 influenza pandemic. *New South Wales public health bulletin*, 17, 103-107.

57 DAVIS, T. 2006. Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina. Final Report. *US House of Representatives*, February, 15.

58 DELOITTE ACCESS ECONOMICS 2014. Building an open platform for natural disaster resilience decisions. In: DELOITTE (ed.). Australia: Deloitte.

59 DEPARTMENT OF HOMELAND SECURITY 2013. National Response Framework.

60 DER HEIDE, E. A. 2006. The importance of evidence-based disaster planning. *Annals of emergency medicine*, 47, 34-49.

61   DRABEK, T. E. 1985. Managing the emergency response. *Public Administration Review*, 45, 85-92.

62   DRABEK, T. E. & MCENTIRE, D. A. 2003. Emergent phenomena and the sociology of disaster: lessons, trends and opportunities from the research literature. *Disaster Prevention and Management: An International Journal,* 12, 97-112.

63   DUFTY, N. 2010. A new approach to Community Flood Education. Available: http://www.academia.edu/14315357/A_New_Approach_to_Community_Flood_Education [Accessed 1 March 2016].

64   DYNES, R. R. 1990. Community emergency planning: false assumption and inappropriate analogies.

65   DYNES, R. R., QUARANTELLI, E. L. & KREPS, G. A. 1972. A perspective on disaster planning. DTIC Document.

66   ELLIS, S. & MACCARTER, K. 2016. *Incident Management in Australasia*, Melbourne, CSIRO Publishing.

67   EMERGENCY MANAGEMENT DIVSION WASHINGTON 2014. Puget Sound Region Regional Catastrophic Disaster Coordination Plan. United States: Emergency Management Division Washington.

68   EMERGENCY MANAGEMENT VICTORIA. 2015. EM-Learn Framework. Available: https://files-em.em.vic.gov.au/public/EMV-web/EM-LEARN_Framework.pdf [Accessed 24/2/2018].

69   EMERGENCY MANAGEMENT VICTORIA. 2016. Victorian Preparedness Goal. Available: https://www.emv.vic.gov.au/our-work/victorian%20-preparedness-goal/ [Accessed 17 August 2016].

70   ERIKSSON, K. & MCCONNELL, A. 2011. Contingency planning for crisis management: Recipe for success or political fantasy? *Policy and Society*, 30, 89-99.

71   EXERCISE WATERMARK TEAM 2011. Exercise Watermark Final Report. London: DEFRA.

72   FELS, A. & WANNA, J. 2014. Foreword. *In*: BOSTON, J., WANNA, J., LIPSKI, V. & PRITCHARD, J. (eds.) *Future-Proofing the State*. Canberra: ANU Press.

73   FEMA. 2013a. Local Mitigation Planning Handbook. Available: https://www.fema.gov/media-library/assets/documents/31598.

74   FEMA. 2013b. National Mitigation Framework. Available: https://www.fema.gov/national-mitigation-framework.

75   FEMA 2014a. FEMA Operational Planning Manual. Washington, United States: U.S. Department of Homeland Security.

76   FEMA. 2014b. Unit 3: NIMS Preparedness. Available: https://training.fema.gov/emiweb/is/is700a/student%20manual/is0700a_studentmanual_l3.pdf [Accessed 28 November 2017].

77   FEMA 2015a. 2015 Hawaii Catastrophic Hurricane Plan. Hawaii: FEMA.

78   FEMA. 2015b. *National Preparedness Cycle* [Online]. Available: https://www.fema.gov/national-preparedness-cycle [Accessed 5 October 2015].

79   FEMA. 2017a. 2017 National Preparedness Report. Available: https://www.fema.gov/media-library/assets/documents/134253.

80   FEMA. 2017b. Draft National Mitigation Investment Strategy. Available: https://www.fema.gov/news-release/2018/01/11/fema-releases-draft-national-mitigation-investment-strategy-public-comment.

81   FEMA. 2017c. National Preparedness System [Online]. Available: http://www.fema.gov/national-preparedness-system [Accessed 29 November 2017 2017].

82   FIRE SERVICES COMMISSIONER 2012. State Fire and Emergency Services Training Framework. Melbounre, Victoria: Fire Services Commissioner.

83   *Craig Fugate Remarks on Disasters*, 2011. Directed by FUGATE, C.

84   FUGATE, C. 2017a. Building an Emergency Management Baseline: Four Non-Negotiables. *IAEM Bulletin* [Online]. Available: http://www.cadmusgroup.com/wp-content/uploads/2017/09/IAEM-Bulletin-Craig-Fugate-August-2017.pdf?hsCtaTracking=99c3908a-bb09-48dc-a079-6a88e88f0712%7C40836b9a-a8f0-4225-9aa5-3d38e1030e7c [Accessed 25/2/2018].

85   FUGATE, C. 2017b. New approaches to response, recovery and resilience. *Australian Journal of Emergency Management*, The, 32, 6.

86   GIOVINAZZI, S., WILSON, T., DAVIS, C., BRISTOW, D., GALLAGHER, M., SCHOFIELD, A., VILLEMURE, M., EIDINGER, J. & TANG, A. 2011. Lifelines performance and management following the 22 February 2011 Christchurch earthquake, New Zealand: highlights of resilience.

87   GISSING, A. 2016. Planning for Catastrophic Disaster in Australia. *Asia Pacific Fire Magazine*, April 2016

88   GISSING, A. 2017. Disaster Risk Management: Australian Challenges. *Asia Pacific Fire Magazine*, 34-39.

89   GISSING, A., VAN LEEUWEN, J., HAYNES, K. & TOFA, M. 2018. Flood levee influences on community preparedness – a paradox? *Australian Journal of Emergency Management*, In Press.

90   GLOBAL CHALLENGES FOUNDATION. 2017. Global Catastrophic Risk 2016. Available: http://globalprioritiesproject.org/wp-content/uploads/2016/04/Global-Catastrophic-Risk-Annual-Report-2016-FINAL.pdf.

91   GOVERNMENT OF WESTERN AUSTRALIA. 2017. Emergency Preparedness Report 2017. Available: https://www.oem.wa.gov.au/Documents/Publications/PreparednessReports/2017SEMCEmergencyPreparednessReport.pdf.

92   GOVERNMENT OFFICE FOR SCIENCE 2012. High impact low probability risks: Blackett review. Government Office for Science.

93   GUDMUNDSSON, M. T., PEDERSEN, R., VOGFJÖRD, K., THORBJARNARDÓTTIR, B., JAKOBSDÓTTIR, S. & ROBERTS, M. J. 2010. Eruptions of Eyjafjallajökull Volcano, Iceland. Eos, *Transactions American Geophysical Union*, 91, 190-191.

94   HANFLING, D., ALTEVOGT, B. M. & GOSTIN, L. O. 2012. A framework for catastrophic disaster response. *Jama*, 308, 675-676.

95   HARRALD, J. R. 2006. Agility and discipline: Critical success factors for disaster response. *The annals of the American Academy of political and Social Science*, 604, 256-272.

96   HEATH, R. 1995. The Kobe earthquake: Some realities of strategic management of crises and disasters. *Disaster Prevention and Management: An International Journal*, 4, 11-24.

97   HEIDE, E. A. 1989. *Disaster Response: Principles of Preperation and Coordiantion*, USA, C.V Mosby Company.

98   HOLE, K. & NETLAND, L.-H. 2010. Toward risk assessment of large-impact and rare events. *IEEE Security & Privacy*, 8, 21-27.

99   INSURANCE COUNCIL OF AUSTRALIA. 2017. Catastrophe events and the community. Available: http://www.insurancecouncil.com.au/issues-submissions/issues/catastrophe-events.

100   INTERNATIONAL FEDERATION OF RED CROSS AND RED CRESCENT SOCIETIES 2000. Introduction to Disaster Preparedness. International Federation of Red Cross and Red Crescent Societies.

101 INTERNATIONAL FEDERATION OF RED CROSS AND RED CRESCENT SOCIETIES 2009. World Disaster Report 2009 - Focus on early warning, early action.

102 IRFAN, U. 2018. Puerto Rico's blackout, the largest in American history, explained. Vox [Online]. Available: https://www.vox.com/2018/2/8/16986408/puerto-rico-blackout-power-hurricane [Accessed 14/2/2018].

103 JACKSON, B. 2014. Applying Lessons Learned from Past Response Operations to Strengthening National Preparedness. Santa Monica CA: Rand Corporation.

104 KAPUCU, N. 2008. Collaborative emergency management: better community organising, better public preparedness and response. *Disasters*, 32, 239-262.

105 KAPUCU, N., ARSLAN, T. & DEMIROZ, F. 2010. Collaborative emergency management and national emergency management network. *Disaster Prevention and Management: An International Journal*, 19, 452-468.

106 KAPUCU, N. & VAN WART, M. 2006. The evolving role of the public sector in managing catastrophic disasters: Lessons learned. *Administration & Society*, 38, 279-308.

107 KENNEDY, J., ASHMORE, J., BABISTER, E. & KELMAN, I. 2008. The meaning of 'build back better': evidence from post-tsunami Aceh and Sri Lanka. *Journal of contingencies and crisis management*, 16, 24-36.

108 LAGADEC, P. 2004. Understanding the French 2003 Heat Wave Experience: Beyond the heat, a Multi-Layered Challenge. *Journal of contingencies and crisis management*, 12, 160-169.

109 LAHEY, K. 2013. Maximum of Maximums. *Australian Journal of Emergency Management*, 28, 5.

110 LIN, N. & EMANUEL, K. 2016. Grey swan tropical cyclones. *Nature Climate Change*, 6, 106-111.

111 LIU, M. & HUANG, M. 2014. Compound Disasters and Compounding Processes Implications for Disaster Risk Management. Available: https://www.unisdr.org/we/inform/publications/50226 [Accessed 27 November 2017].

112 MAMULA-SEADON, L. & MCLEAN, I. 2015. Response and early recovery following 4 September 2010 and 22 February 2011 Canterbury earthquakes: Societal resilience and the role of governance. *International Journal of Disaster Risk Reduction*, 14, 82-95.

113 MASYS, A. 2012. Black swans to grey swans: revealing the uncertainty. *Disaster Prevention and Management: An International Journal,* 21, 320-335.

114 MCAVOY, A. & JONES, C. 17/1/2018. FEMA: Hawaii didn't need approval to retract missile alert. *KSL.com* [Online]. Available: https://www.ksl.com/?nid=157&sid=46238607&title=fema-hawaii-didnt-need-approval-to-retract-missile-alert [Accessed 28/1/2018].

115 MCCONNELL, A. & DRENNAN, L. 2006. Mission impossible? Planning and preparing for crisis. *Journal of Contingencies and Crisis management*, 14, 59-70.

116 MCENTIRE, D. A. 2002. Coordinating multi-organisational responses to disaster: lessons from the March 28, 2000, Fort Worth tornado. *Disaster Prevention and Management: An International Journal*, 11, 369-379.

117 MCTAGGART-COWAN, R., BOSART, L. F., DAVIS, C. A., ATALLAH, E. H., GYAKUM, J. R. & EMANUEL, K. A. 2006. Analysis of hurricane Catarina (2004). *Monthly Weather Review*, 134, 3029-3053.

118 MINISTRY OF CIVIL DEFENCE & EMERGENCY MANAGEMENT 2009. CDEM Exercises - Director's Guidleines for Civil Defence Emergency Management (CDEM) Groups [DGL 10/09]. Wellington, New Zealand: Ministry of Civil Defence & Emergency Management.

119 MUNICH RE. 2015. Heat wave, drought, wildfires in Russia. Available: https://www.munichre.com/site/touch-naturalhazards/get/documents_E-132629599/mr/assetpool.shared/Documents/5_Touch/_NatCatService/Catastrophe_portraits/event-report-hw-dr-wf-russia-touch-en-update.pdf [Accessed 16/2/2018].

120 NORIO, O., YE, T., KAJITANI, Y., SHI, P. & TATANO, H. 2011. The 2011 eastern Japan great earthquake disaster: Overview and comments. *International Journal of Disaster Risk Science*, 2, 34-42.

121 NSW GOVERNMENT 2013. Hawkesbury Nepean Flood Emergency Sub Plan. In: NSW STATE EMERGENCY SERVICE (ed.). Sydney: NSW Government.

122 O'NEIL, P. 2004. Developing a Risk Communication Model to Encourage Community Safety from Natural Hazards.

123 PEARCE, L. 2003. Disaster management and community planning, and public participation: how to achieve sustainable hazard mitigation. *Natural hazards*, 28, 211-228.

124 PERRY, R. W. 2004. Disaster exercise outcomes for professional emergency personnel and citizen volunteers. *Journal of Contingencies and Crisis Management*, 12, 64-75.

125 PERRY, R. W. 2007. What is a Disaster? *Handbook of disaster research*. Springer.

126 PERRY, R. W. & LINDELL, M. K. 2003. Preparedness for emergency response: guidelines for the emergency planning process. *Disasters*, 27, 336-350.

127 PESCAROLI, G. & ALEXANDER, D. 2015. A definition of cascading disasters and cascading effects: Going beyond the "toppling dominos" metaphor. *Planet@ Risk*, 3.

128 PEZZA, A. B. & SIMMONDS, I. 2005. The first South Atlantic hurricane: Unprecedented blocking, low shear and climate change. *Geophysical Research Letters*, 32.

129 PIELKE, R. 2018. Weather-related natural disasters 2017: was this a reversion to the mean. Available: https://riskfrontiers.com/newsletter-volume-17-issue-2/ [Accessed 20/2/2018].

130 PLAG, H., BROCKLEBANK, S., BROSNAN, D., CAMPUS, P., CLOETINGH, S., JULES-PLAG, S. & STEIN, S. 2015. Extreme Geohazards: Reducing the Disaster Risk and Increasing Resilience.

131 POLLOCK, K. & COLES, E. 2015. Theory & Practice in UK Emergency Management. UK: Emergency Planning College.

132 POUMADERE, M., MAYS, C., LE MER, S. & BLONG, R. 2005. The 2003 heat wave in France: dangerous climate change here and now. *Risk analysis*, 25, 1483-1494.

133 PUBLIC SAFETY CANADA 2010. Emergency Management Planning Guide. In: PUBLIC SAFETY CANADA (ed.). Canada: Public Safety Canada.

134 QUARANTELLI, E. 1994. Emergent behaviours and groups in the crisis time period of disasters. Available: dspace.udel.edu/bitstream/handle/19716/591/PP206.pdf?sequence=1 [Accessed 22 September 2015].

135 QUARANTELLI, E. 1998. Major Criteria for Judging Disaster Planning and Managing Their Applicability in Developing Countries. *University of Delaware Disaster Research Center* [Online].

136 QUARANTELLI, E. 2000a. Disaster research. In: BORGATTA, E. & MONTGOMERY, R. (eds.) *Encyclopedia of sociology*. New York: Macmillan.

137 QUARANTELLI, E. 2000b. Emergencies, disaster and catastrophes are different phenomena. Available: http://udspace.udel.edu/bitstream/handle/19716/674/PP304.pdf?sequence=1&isAllowed=y [Accessed 17/2/2018].

138 QUARANTELLI, E. 2006. *Catastrophes are different from disasters: Some implications for crisis planning and managing drawn from Katrina*. 11 June 2006. Social Sciences Research Council [Online]. Available: www.understandingkatrina.ssrc.org/Quarantelli [Accessed 15 October 2015].

139 QUARANTELLI, E. L. 1986. Planning and management for the prevention and mitigation of natural disasters, especially in a metropolitan context: Initial questions and issues which need to be addressed.

140 QUARANTELLI, E. L. 1988. Disaster crisis management: A summary of research findings. *Journal of management studies*, 25, 373-385.

141 QUARANTELLI, E. L. 1991. Different types of disasters and planning implications.

142 QUEENSLAND FLOODS COMMISSION OF INQUIRY 2012. Queensland floods commission of inquiry: final report. Brisbane, Australia.

143 QUEENSLAND GOVERNMENT 2015a. Disaster Management Training Handbook. In: PUBLIC SAFETY BUSINESS AGENCY (ed.). Brisbane: Queensland Government.

144 QUEENSLAND GOVERNMENT 2015b. Evaluation of Emergency Management Training and Exercise Arrangements. In: INSPECTOR-GENERAL EMERGENCY MANAGEMENT (ed.). Brisbane: Queensland Government.

145 REDLENER, I. & REILLY, M. J. 2012. Lessons from Sandy—preparing health systems for future disasters. *New England Journal of Medicine*, 367, 2269-2271.

146 RISK FRONTIERS 2008. *Development of information for a tsunami risk assessment for the NSW coast*, Wollongong, NSW State Emergency Service.

147 RISK FRONTIERS 2015. *Earthquake Scenario*, Bushfire and Natural Hazards Cooperative Research Centre, South Melbourne.

148 RODIN, J. 2014. *The Resilience Dividend*, United States, PublicAffairs.

149 RODRÍGUEZ, H. & BARNSHAW, J. 2006. The social construction of disasters: From heat waves to worst-case scenarios. SAGE Publications Sage CA: Los Angeles, CA.

150 ROUGIER, J., SPARKS, R. S. J., CASHMAN, K. V. & BROWN, S. K. 2018. The global magnitude–frequency relationship for large explosive volcanic eruptions. *Earth and Planetary Science Letters*, 482, 621-629.

151 RUBACK, J., WELLS, S. & BISSELL, R. *Instructor Notes for Catastrophe Readiness and Response* [Online]. Washington DC: FEMA. Available: https://training.fema.gov [Accessed 20 October 2015].

152 SANDERSON, D. & RAMALINGAM, B. 2015. NEPAL EARTHQUAKE RESPONSE: Lessons for operational agencies. *The active learning network for accountability and performance in Humanitarian action ALNAP*.

153 SCANLON, J. 2001. Lessons Learned and Lessons Forgotten: The Canadian Disaster Experience. Available: http://www.iclr.org/listofpublicpolicypap.html [Accessed 12 October 2015].

154 SCOTTISH GOVERNMENT 2017. Preparing Scotland: Guidance on dealing with mass fatalities in Scotland.

155 SENATE STANDING COMMITTEE ON NATIONAL SECURITY AND DEFENCE 2008. Emergency Preparedness in Canada. Canada: Senate Standing Committee on National Security and Defence.

156 SMITH, R. 2008. Summary and Conclusions: Report of the Review of Homeland Security and Border Security.

157 SOWRY, R. 2017. Better Responses to Natural Disasters and Other Emergencies.

158 STATE EMERGENCY MANAGEMENT COMMITTEE WESTERN AUSTRALIA 2014. Emergency Preparedness Report 2014. Perth: State Emergency Management Committee Western Australia.

159 STRETTON, A. 1975. Darwin Disaster: Cyclone Tracey. Canberra: Natural Disasters Organisation.

160 STRETTON, A. 1979. Ten lessons from the Darwin Disaster: In Natural Hazards in Australia. Canberra: Australian Academy of Science.

161 SUTTON, J. & TIERNEY, K. 2006. Disaster Preparedness: Concepts, Guidance, and Research. *Fritz Institute Assessing Disaster Preparedness Conference*. Sebastopol, California.

162 T HART, P. 2013. After Fukushima: reflections on risk and institutional learning in an era of mega-crises. *Public Administration*, 91, 101-113.

163 T HART, P. 2014. Managing Crises Long Term: The challenges of preparedness and response. In: BOSTON, J., WANNA, J., LIPSKI, V. & PRITCHARD, J. (eds.) *Future-Proofing the State*. Canberra: ANU Press.

164 TALEB, N. 2007. The black swan: the impact of the highly improbable. NY: Random House.

165 TASMANIAN AUDIT OFFICE 2015. Report of the Auditor-General 2015-16. Follow up reports published since June 2011. Hobart, Tasmania: Tasmanian Audit Office.

166 TAYLOR, M., MCCARTHY, M., BURNS, P., THOMPSON, K., SMITH, B. & EUSTACE, G. 2015. The challenges of managing animals and their owners in disasters: Perspectives of Australian response organisations and stakeholders. *Australian Journal of Emergency Management*, 30, 31-37.

167 TEKELI-YEŞIL, S. 2006. Public health and natural disasters: disaster preparedness and response in health systems. *Journal of Public Health*, 14, 317-324.

168 THE SUNDAY TIMES. 25/01/2010. Officials ignored Haiti earthquake warnings. *The Australian* [Online]. Available: http://www.theaustralian.com.au/news/world/officials-ignored-haiti-earthquake-warnings/news-story/a16503378b5289950fbfc160eb928b0b?sv=a429f4c8c83dee47cf5ac2f4b5141191 [Accessed 11 December 2017].

169 TIERNEY, K. J. 1993. Disaster preparedness and response: Research findings and guidance from the social science literature. Disaster Research Center, University of Delaware.

170 U.S GLOBAL CHANGE PROGRAM. 2017. Climate Science Special Report. Available: https://science2017.globalchange.gov/ [Accessed 7/3/2018].

171 UK CABINET OFFICE 2011a. Emergency Preparedness. London: UK Cabinet Office.

172 UK CABINET OFFICE. 2011b. *Lessons identified from UK exercises and operations: a policy framework* [Online]. Available: https://www.gov.uk/government/publications/lessons-identified-from-uk-exercises-and-operations-a-policy-framework [Accessed 12 October 2015].

173 UK CABINET OFFICE. 2015. National business resilience planning assumptions. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/475773/NBRPA2015.pdf [Accessed 28/1/2018].

174 UK JOINT EMERGENCY SERVICES INTEROPERABILITY PROGRAM. 2016. Joint Doctrine: The Interoperability Framework Edition 2. Available: http://www.jesip.org.uk/uploads/media/pdf/JESIP_Joint_Doctrine-The_Interoperability_Framework_%5bedition_2-July-2016%5d.pdf [Accessed 28/1/2018].

175 UNITED NATIONS 2008. Disaster Preparedness for Effective Response. *In*: UNISDR (ed.). Geneva, Switzerland,: United Nations.

176 UNITED NATIONS 2015. Sendai Framework for Disaster Risk Reduction 2015-2030. Geneva, Switzerland: UNISDR.

177 US DEPARTMENT OF HOMELAND SECURITY 2007. Target capabilities list. Washington D.C: US Department of Homeland Security.

178 US DEPARTMENT OF HOMELAND SECURITY 2011. National Preparedness System. Washington DC: US Department of Homeland Security.

179 US DEPARTMENT OF HOMELAND SECURITY 2013. Threat and Hazard Identification and Risk Assessment Guide. Washington DC: US Department of Homeland Security.

180 US DEPARTMENT OF HOMELAND SECURITY 2015. National Preparedness Goal, Second Edition September 2015. Washington DC: US Department of Homeland Security.

181 US GOVERNMENT ACCOUNTABILITY OFFICE 2006. Catastrophic Disasters. Washington DC: US Government Accountability Office.

182 US GOVERNMENT ACCOUNTABILITY OFFICE 2009. National Preparedness. Washington DC: US Government Accountability Office.

183 US GOVERNMENT ACCOUNTABILITY OFFICE 2010. Criteria for developing and validating effective response plans.

184 US GOVERNMENT ACCOUNTABILITY OFFICE 2014. Emergency Preparedness. Washington D.C: US Government Accountability Office.

185 VAN DEN HONERT, R. C. & MCANENEY, J. 2011. The 2011 Brisbane floods: causes, impacts and implications. Water, 3, 1149-1173.

186 VICTORIA AUDITOR-GENERAL 2014. Heatwave Management: Reducing the Risk to Public Health. Melbourne: Victorian Auditor-General.

187 VICTORIA STATE GOVERNMENT 2015. Critical Infrastructure Resilience Strategy. In: EMERGENCY MANAGEMENT VICTORIA (ed.). Melbourne, Victoria: Victoria State Government.

188 WACHTENDORF, K. & QUARANTELLI, E. L. 2003. The evacuation of lower manhattan by water transport on september 11: An unplanned 'success.'. *Joint Commission Journal on Quality and Patient Safety*, 29, 316-318.

189 WACHTENDORF, T. & KENDRA, J. 2017. 'Cajun Navy' rescuers in Hurricane Harvey show vital role of volunteer boats. Available: https://theconversation.com/cajun-navy-rescuers-in-hurricane-harvey-show-vital-role-of-volunteer-boats-83200 [Accessed 1/2/2018].

190 WALKER, G. R., MASON, M. S., CROMPTON, R. P. & MUSULIN, R. T. 2015. Application of insurance modelling tools to climate change adaptation decision-making relating to the built environment. *Structure and Infrastructure Engineering*, 1-13.

191 WASHINGTON STATE MILITARY DEPARTMENT 2015. State of Washington Training and Exercise Plan. Washington State: Washington State Military Department.

192 WAUGH, W. L. & STREIB, G. 2006. Collaboration and leadership for effective emergency management. *Public administration review*, 66, 131-140.

193 WEBBER, D., GISSING, A., DUFTY, N. & BIRD, D. 2017. Community participation in emergency planning: NSW state emergency service case study. *Australian Journal of Emergency Management*, The, 32, 28.

194 WEBLEY, K. 2012. Hurricane Sandy By the Number: A Superstorm's Statistics, One Month Later. *Time Magazine* [Online]. Available: http://nation.time.com/2012/11/26/hurricane-sandy-one-month-later/ [Accessed 14/2/2018].

195 WEBSTER, P. J. 2008. Myanmar's deadly daffodil. *Nature Geoscience*, 1, 488-490.

196 WHITTAKER, J., MCLENNAN, B. & HANDMER, J. 2015. A review of informal volunteerism in emergencies and disasters: Definition, opportunities and challenges. *International journal of disaster risk reduction*, 13, 358-368.

197 WORLD ECONOMIC FORUM. 2018. The Global Risk Report 2018 - 13th Edition. Available: http://www3.weforum.org/docs/WEF_GRR18_Report.pdf.