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TOWNSVILLE CITY NATURAL DISASTER RISK MANAGEMENT STUDY STAGE 1: REPORT SUMMARY

Storm clouds gather over Townsville

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DOTARS
DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES
Queensland Government
Department of Emergency Services
Emergency Management Queensland
THE NEW TOWNSVILLE CITY
1 CITY COMMUNITY COUNCIL DIRECTION

TOWNSVILLE CITY NATURAL DISASTER RISK MANAGEMENT STUDY STAGE 1: REPORT SUMMARY

1. THE STUDY CONTEXT

This report is a summary of a longer and more technical study prepared for Townsville City Council by the Institute for International Development Ltd (IID), disaster risk management consultants. It summarises the key outcomes of the multi-hazard Disaster Risk Management Study undertaken under the Commonwealth Government's Natural Disaster Mitigation Program. The study follows the methods for disaster risk assessment contained in the Australian & New Zealand standard AS/NZS 4360-2004 *Risk management* (SA & SNZ, 2004) and the disaster risk management process employed by the Department of Emergency Services and described in Zamecka and Buchanan (1999).

1.1 The Study Area

Townsville City was amalgamated with neighbouring Thuringowa City in March 2008, however, this study is confined, by its Terms of Reference (TOR), to the area administered prior to the amalgamation by Townsville City Council (TCC). It extends over a land area of approximately 1870 square kilometres.

At the national census held in September 2006 the study area had a total population of 95,464, the great majority of it concentrated in the Townsville urban area. The Department of Local Government and Planning (DLGP) in 2004 produced a series of projections of resident population using high, medium and low growth assumptions. The medium range projections forecast the resident population of the study area to reach 118,653 by June 2026.

1.2 Legislation and Standards

A range of legislation and standards have an influence on disaster risk management within the study area. These range from Commonwealth legislation and national standards to the Townsville City local disaster plan. The key piece of legislation is the Queensland *Disaster Management Act* 2003.

One of the more significant features of this Act is its clear statement of the responsibilities of local governments. The Act states that each local government is 'to ensure it has a disaster response capability'. This capability is defined in the Act as:

> ***"disaster response capability",*** *for a local government, means the ability to provide equipment and a suitable number of persons, using the resources available to local government, to effectively deal with, or help another entity to deal with, an emergency situation or a disaster in the local government area.*

1.3 Previous Studies and Mitigation Activity

The former TCC had commissioned a range of single hazard studies, largely aimed at providing information on which to structure its works program and to inform its planning process and disaster management planning. Those studies provide the technical background for this multi-hazard study. The most recent hazard studies undertaken for TCC are:

- Bushfire hazard mapping: analysis of bushfire susceptibility based on vegetation type and slope (Trinity Software, 1999);
- Development of a cyclone wind damage model for use in Cairns, Townsville and Mackay – Part 4 of the project 'Queensland climate change and community vulnerability to tropical cyclones: Cyclone hazards assessment' (CTS and SEA, 2003);
- Townsville landslide hazard zonation study (Coffey Geoscience, 2001) and Townsville steep slope risk assessment (Coffey Geoscience and Landmarc, 2004);
- Ross River hydraulics study: downstream flood assessment (Maunsell McIntyre, 2001);
- Ross River Dam upgrade risk analysis and consequence analysis (GHD, 2005a and b);
- Townsville flood hazard assessment (Maunsell, 2005a and b);
- Earthquake risk assessment of Townsville City (CERA, 2006); and,
- Townsville-Thuringowa storm tide study (GHD and SEA, 2007).

TCC responded to the findings of these studies by undertaking several major risk reduction projects including the $15 million flood mitigation capital works program based on the flood study recommendations; $1.5 million stabilisation works to reduce landslide risks in the Castle Hill area following the steep slope study; the installation of a rainfall station on Castle Hill to provide alerts of potentially hazardous landslide conditions; and implementation of a sophisticated storm tide warning system based on the storm tide study. NQ Water (now part of the New Townsville City Council) has also completed the $115 million upgrading of the Ross River Dam to bring it up to international dam safety standards.

The combined councils have operated a joint Local Disaster Management Group (LDMG) with a fulltime professional disaster manager as executive officer for several years.

The range of studies undertaken and the engineering-focused risk reduction action that has been implemented demonstrate a clear commitment by TCC to managing the major natural hazards that confront the Townsville community. This study draws on those studies and identifies a range of risk treatment options that emphasise non-structural risk treatment strategies.

1.4 Risk Management Methodology

The risk management Standard AS/NZS 4360-2004 (SA/SNZ, 2004) defines 'risk' as:

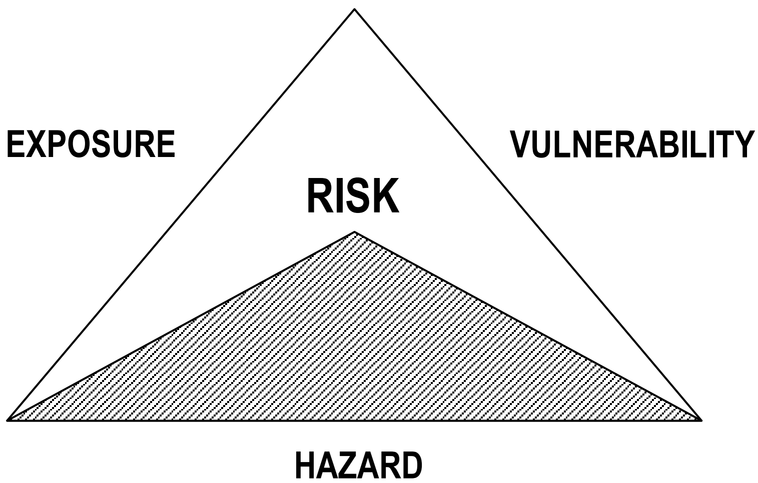
> *the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.*

This definition is quite adequate for analysing the risks posed by a single hazard impact to a single element e.g. a single building or business.

The definition adopted by the Department of Emergency Services, by contrast, goes a little way to broaden the objective to cover multiple hazards or a range of different types of impact by the one hazard to whole communities. Their definition is:

> *A concept used to describe the likelihood of harmful consequences arising from the interaction of hazards, community and the environment.* (Zamecka and Buchanan, 1999)

The 'likelihood' component is derived largely from consideration of the hazard phenomena involved, i.e. the probability that a hazard of a given magnitude will impact on a given place within a certain timeframe. It can also include measures of the 'likelihood' that those elements exposed to the hazard will be harmed, i.e. their degree of vulnerability. 'Consequences' are usually measured in terms of lives lost, people injured, damage to property, disruption to economic activity and the impact on the environment. Risk can thus be assessed in terms of the interaction between three key elements – the hazard, the community elements exposed to that hazard and their vulnerability. The relationship between these three elements is shown in the following figure.



The risk-hazard-exposure-vulnerability relationship (after Crichton, 1999)

In the figure, the large triangle portrays each of the variables as making an equal contribution. The magnitude of the resulting risk is represented by the area of the triangle. The amount of risk may be diminished by reducing the size of any one or more of the three contributing components. In the smaller (hachured) triangle the risk has been reduced by mitigating the exposure and vulnerability components. The reduction of any of the factors to zero (e.g. by eliminating floodplain development) would consequently eliminate the risk. Conversely, an increase in any one of the elements (e.g. an increase in poorly designed development in high hazard areas) would increase the risk.

1.5 Evaluation Criteria

The degree to which risk is accepted or tolerated, by both individuals and the community, is very much dependant on the frequency, magnitude and controllability of the hazards involved. It is also influenced by the length of time that has elapsed since the last significant hazard impact – the more recent that event, the lower the threshold of acceptance or tolerance is likely to be. For regulators such as TCC this poses a significant (if not impossible) challenge – that is, to determine the ultimate 'comfort levels' of an informed public and to satisfy their concerns over the inevitable trade-offs affecting their safety.

There is no definition of what constitutes an 'acceptable' level of community risk. There are, however, thresholds of exposure or structural resilience established in the Townsville City planning scheme, State Government policies (e.g. State Planning Policy 1/03 *Mitigating the adverse effects of flood, bushfire and landslide* – known as SPP 1/03) and the construction standards established under the Building Code of Australia (BCA) that establish *de facto* thresholds. For hazards including destructive winds, inundation and earthquake these documents establish an event probability (known as the *average recurrence interval* or ARI) above which it has been deemed impractical or uneconomical to reduce the risks further. For bushfire and landslide the restrictions are based on boundaries within which development may take place. Those thresholds, at they apply in the study area, are summarised in the following table.

HAZARD	THRESHOLD	COMMENTS
Destructive wind	500 year ARI	Established in the wind loading standard of the BCA since about 1981.
Flood	50 year ARI	This has been the threshold for development in the planning scheme for many years, but it has been increased to the 100 year ARI level in the past few years.
Storm tide	100 year ARI	Established under the State Coastal Management Plan and implemented since 2005.
Landslide	Planning boundary only	Established under SPP 1/03 and implemented since 2004.
Bushfire	Planning boundary only	Established under SPP 1/03 and implemented since 2004.
Earthquake	500 year ARI	Established in the earthquake loading standard under the BCA since about 1985.

It is important to note that these thresholds **apply only to development that has taken place since they were introduced** – they have no retrospective force. This means that development that took place before these thresholds came into force will not necessarily meet the currently desired standard of safety.

To provide a consistency of analysis across all six hazards, this study has adopted an event frequency in the 50 to 100 year average recurrence interval (ARI) range (i.e. an event that might occur only once in a lifetime) against which to assess the current level of natural hazards risk posed and to provide a benchmark against which to the develop risk reduction strategies. Those strategies can thus be measured against the following criteria, in priority order, <u>for events up to and including the 100 year ARI level</u>:

1. reduce, and preferably eliminate, the risk of death or injury to emergency workers engaged in responding to any hazard impact;
2. reduce, and preferably eliminate, the risk of death or injury to the general population;
3. reduce, to an acceptable level, the risk of destruction or damage to public infrastructure and facilities;
4. reduce, to an acceptable level, the risk of destruction or damage to private property;
5. manage the impact of natural hazard impacts on cultural heritage and the natural environment to the extent that loss of heritage is minimised and the biodiversity of flora and fauna is maintained;
6. minimise the long-term impact on the local economy.

2. THE HAZARDS

This study has been confined by its TOR to considering only six natural hazards: severe storms (cyclones and thunderstorms); floods; storm tide; landslide; bushfire; and earthquake.

2.1 Natural Hazards

Natural hazards have been defined by Fournier d'Albe (1986) as:

> ***Natural hazard*** *means the probability of occurrence, within a specified period of time in a given area, of a potentially damaging natural phenomenon.*

There is a statistical relationship between the frequency with which a natural hazard impact occurs in a given place and its severity. Low intensity events are experienced with some frequency whereas very severe events tend to be very rare. Understanding the relationship between recurrence and severity is one of the more important aspects of analysing the risks posed by natural hazards. They differ in that regard from anthropogenic hazards (such as workplace accidents, dam failure or terrorism) in that such 'man made' hazards rarely happen more than once in a given place.

Most 'damaging natural phenomena' are very complex and can be associated with a range of harm-producing elements. A tropical cyclone, for example, may be seen as the main hazard, but it is its attendant 'damaging natural phenomena' of storm tide, coastal erosion, destructive winds, widespread rainfall, riverine flooding and numerous widespread landslides that actually produce the damage.

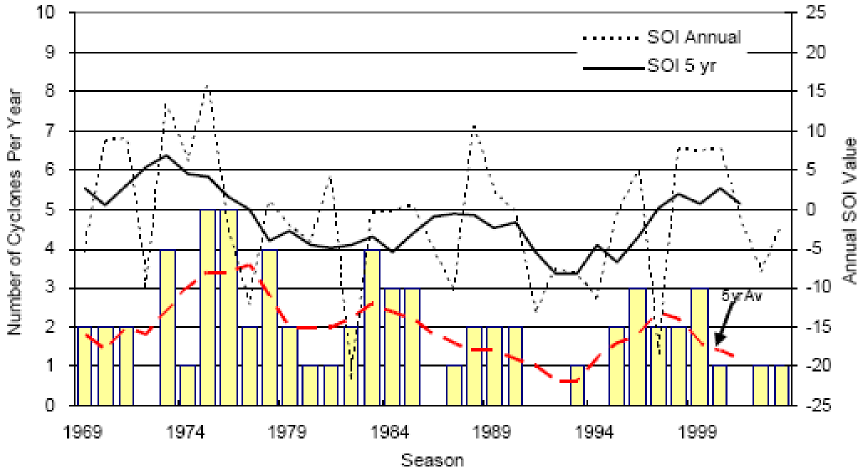
Similarly, some hazards are regional in nature (i.e. they are mega-hazards that have a widespread and usually simultaneous impact) whilst others are smaller in scale and have an impact on a relatively small area. In a similar vein, hazards such as flood and storm tide inundation, landslides and (to some extent) bushfires are confined in their extent by factors such as terrain. Earthquakes and severe winds, by comparison, have no such spatial constraints. Others, such as hail and lightning, tend to have a localised impact, but they can have an impact anywhere.

These are key factors to be considered in developing risk management strategies for natural hazards.

2.2 Tropical Cyclones and Severe Thunderstorms

Tropical cyclones and severe thunderstorms each bring with them potentially destructive winds and intense rainfall. Thunderstorms also bring with them the potential for damaging hail and lightning strike. Both of these forms of severe weather have had damaging impacts within the study area.

On average, around two cyclones come within 500 km of Townsville in each season. The record from 1900 to 2004 (which is certainly incomplete for earlier and more distant storms) shows that of the 150 events recorded as having approached to within 500 km of Townsville, around 20% came to within 100 km and a further 25% to between 100 and 250 km. Around 55% of all storms were classed as severe cyclones (i.e. Category 3 or higher) with one event (TC *Aivu*) now classed as a Category 5 storm. Category 4 TC *Althea* in 1971 was the most destructive recent tropical cyclone in the Townsville region.



Record of tropical cyclones that have come within 500km of Townsville since 1969 (GHD & SEA, 2007)

Cyclones are very large-scale systems and their impact is experienced over a very wide area. Their effects can last for days and weeks. In Queensland they cause an annual average loss of $89.8 million (in 1999 dollars) - the second greatest level of loss after floods (BTE, 2001).

Thunderstorms are produced by relatively small-scale convective processes which can occur when the atmosphere is moist and unstable. Many thunderstorms are typically short-lived (up to an hour) and limited in size (up to 10 km in diameter) but can traverse large distances during that time and are capable of inflicting significant damage. Individual storm impacts can vary greatly both in space and time.

Between 1967 and 1999 in Queensland severe thunderstorms caused an annual average loss of $37.3 million (again in 1999 dollars). On average the Townsville area experiences between 15 and 20 thunderstorm days every year.

Most of the damage done by both tropical cyclones and severe thunderstorms is caused by their strong winds. The most severe winds, however, are associated with the tornadoes that both systems may spawn. Severe winds can destroy buildings, topple trees, flatten standing crops, bring down power lines and block roads with fallen vegetation. People are most at risk of injury or death from wind driven projectiles such as roofing iron and tree branches, especially if they are caught in the open.

Almost all storms produce some lightning and associated thunder. Lightning strike can cause significant damage to property, especially electrical and electronic equipment and can also start wildfires. Fatalities from lightning strike are not particularly rare - during the period 1803–1991 some 650 people were killed by lightning strike in Australia (i.e. an average of 3.4 per year).

The approach of tropical cyclones is well tracked by satellite and radar systems for several days before they are within destructive range so warnings are good. Modern weather radar systems are also proving to be invaluable for detecting and tracking severe thunderstorms. This information is used by the

Bureau of Meteorology (BoM) to provide as long a warning time as possible. There are instances, however, when storms form very rapidly and practical warnings are not possible. Townsville City is well covered by the dedicated weather watch radar installed on Mt Stuart.

2.3 Floods

Flood is defined in SPP 1/03 as:

> *A temporary inundation of land by expanses of water that overtop the natural or artificial banks of a watercourse i.e. a stream, creek, river, estuary, lake or dam.*

To put it more simply, floods are *water where and when it is not wanted*. Floods account for the largest amount of loss caused by natural hazards in Queensland with an average annual loss of $111.7 million (BTE, 2001).

Riverine (i.e. main stream) flooding is the most commonly analysed form of flood hazard, but in the study area it is the flash flooding in smaller streams and sub-catchments and stormwater surcharge that have been demonstrated in recent years to be the principal problems. Riverine and flash floods are associated with the natural drainage systems, but stormwater surcharge is more correctly associated with the engineered drainage network of urban areas. Dambreak flooding is also a potential concern in the study area.

The study area contains about half of the catchment of the Ross River and a much smaller proportion of the Haughton River catchment. Flooding in the Ross River has been modified (but not controlled) by construction of the Ross River Dam in the 1970s. The numerous local catchments and sub-catchments within the urban area and on Magnetic Island are essentially uncontrolled. Detailed records of floods in the Ross River are sketchy, but major floods are known to have occurred in 1941, 1946 and 1960.

The recent history of flash flooding and stormwater surcharge, by contrast, has been quite dramatic. In recent years, major flash flood and stormwater surcharge events were experienced in 1990, 1998, 2002 and 2008. The 1998 flooding, produced by very intense rainfall from ex-TC *Sid*, was by far the most serious. The rainfall intensities experienced in that episode have been assessed as having an ARI of around 500 years.

The flood study undertaken by consultants Maunsell Australia P/L in 2005 modelled the flood hazard within the Townsville urban area and on Magnetic Island, to establish the likely inundation extents and depths for a range of flood events up to an including the probable maximum flood (PMF) level. The more frequently occurring 50 and 100 year ARI events are used for urban planning, engineering design and emergency response planning. The extremely rare PMF event is modelled for disaster response planning purposes to indicate the 'worst case' type of event. There is little difference in the horizontal extent of inundation between the 50 year and 100 year events although water depths will be greater in the less frequent event. The extent of PMF flooding is considerably greater.

Modelled flood inundation extent for 50 to 100 year ARI events

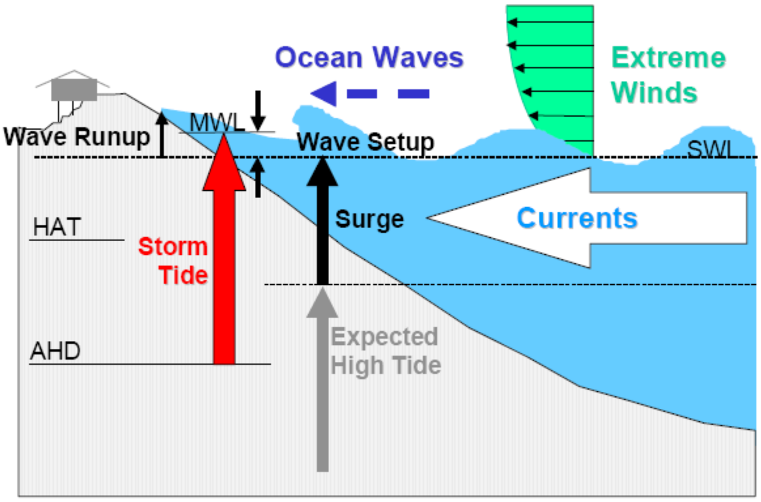
Townsville is probably the only major urban centre in Australia that has had a large earth and rock embankment-type dam constructed immediately upstream of it. The risk of a catastrophic failure of the dam has been recognised for many years. As a result, the dam has recently undergone a major upgrade, in part to reduce its storage capacity and in part to bring it into compliance with the safety standards of the Australian National Committee on Large Dams (ANCOLD). The installation of flood gates undertaken as part of this upgrade will also enhance the flood control capabilities of the dam.

The BoM, in conjunction with TCC, provides warnings of potential flooding in identified catchments based on data from a network of automatic weather stations (AWS) and river stream gauges. These are linked to flood behaviour models and form an Alert System. There are at least 22 flood warning stations within the Ross River basin operated by various agencies. The Alert system is designed to provide flood height estimates and warnings of main stream flooding. It is not designed to provide flash flood or stormwater surcharge warnings within the smaller urban catchments.

The very short flood response time experienced in these local catchments makes it very difficult to provide meaningful warnings. Good local knowledge of the flood behaviour in those catchments remains the best defence.

2.4 Storm Tide

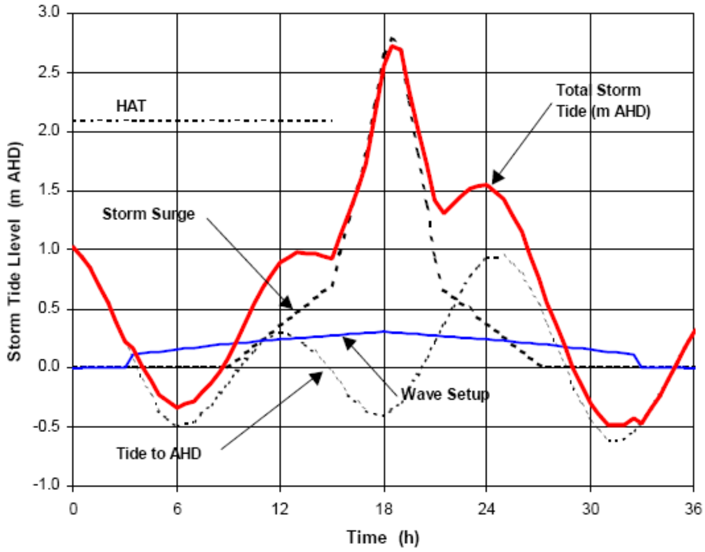
All tropical cyclones are capable of producing a storm surge. The potential magnitude of the surge is affected by many factors; principally the intensity of the cyclone, its size and its forward speed. As the cyclone approaches the coast, the local shape of the coastline and the slope of the undersea bathymetry contribute significantly to the resulting surge height. When the storm surge is combined with the daily tidal variation and the degree of wave setup, the absolute combined water level reached is called the storm tide.



Components of a storm tide (GHD & SEA, 2007)

Records of only three (of 23) cyclones affecting Townsville explicitly mention storm tide impacts. They were TC *Sigma* in 1896, an unnamed cyclone in 1940 and TC *Althea* in 1971. It is likely that several other cyclones also produced elevated sea levels in the Townsville area, however, they do not appear to have been sufficiently significant to have been worthy of note.

The TC *Althea* storm tide event is the best documented. *Althea* had a central pressure of 950 hPa and produced a storm surge of 2.9 m. The surge reached the coast very close to low tide so the height of the storm tide was almost 1.5 m lower than it would have been had it crossed the coast at the top of the tide around 6 hours later.



Storm tide associated with Tropical Cyclone *Althea* (GHD & SEA, 2007)

Townsville faces a potentially significant storm tide threat, though it would require a very rare event to cause major problems.

The BoM, in conjunction with the EPA, produces warnings of storm tide generated by tropical cyclones as part of their overall cyclone warning process. This capability has been enhanced as a result of the Townsville-Thuringowa Storm Tide Study where Council, in association with Systems Engineering Australia, has developed a highly accurate storm tide warning application known as *SEAtide*.

2.5 Landslides

The presence of well developed debris fans at the base of hills such as Mt Stuart and Castle Hill are clear evidence of a long and ongoing history of landslides in the study area. Two recent events illustrate the type of risks posed by landslide.

In January 1998 ex-TC *Sid* produced the most intense rainfall on record for Townsville. That rainfall caused two significant debris flows in the Nelly Bay area of Magnetic Island. The larger debris flow caused significant damage to the Magnetic Island International Resort. A very large boulder transported by the debris flow was left perched in the gully above the resort and had to be broken up by engineers to remove the further threat.

In April 2000 TC *Tessi* produced over 420 mm in a 24 hour period over Townsville. That rainfall produced coalescing debris flows off the north-eastern slopes of Castle Hill that entered the swimming pools and basements of houses and left a very large boulder perched up-slope from some of the City's most expensive residential properties. Engineering activity was again required to stabilise that boulder. A debris flow was also triggered from the northern slopes of Castle Hill and its runout entered houses at the foot of the slope. Since then, a gabion wall has been constructed on the hill side above the houses on the north-east slope to protect them from debris flows and boulder movements.

Magnetic Island debris flow damage 1998

Castle Hill debris flows 2000 (Townsville Bulletin photo)

The landslide process is complex and involves a range of factors including the underlying geology and soils, slopes, geomorphology, drainage and vegetation status (cleared or uncleared) – and the nature of human modification of the slope. Rainfall is clearly the most common trigger for landslides and the more widespread the rainfall, as with a tropical cyclone, the more widespread will be the occurrence of landslides. Conversely, the more localised the rainfall, the more localised will be the landslide occurrence. On steep slopes of weathered rock, such as Castle Hill, there is a small probability that a very close earthquake of at least M_L 4.0 could trigger a rock fall. As unlikely as such an event may be it should not be entirely ruled out as a threat.

The study area overall has a small landslide hazard. In a few well identified zones of steeper slopes, the runout areas beneath them and slip-prone soils, however, the hazard is very significant. The Castle Hill steep slope issue requires constant review and monitoring given the potential risk to life and property from boulder falls. A four-year steep slope stabilisation program, jointly funded by Council and the State Government, is to be completed in 2008/09.

There are no systems or procedures designed to provide warnings of landslide in Australia. Since 2001, however, the BoM has included statements relating to the possibility of landslide in their severe weather warnings when they anticipate intense rainfall. To provide locally relevant data, TCC has installed an automated rain gauge on Castle Hill specifically to provide alerts of falls of rain that could lead to landslides occurring.

2.6 Bushfires

The recorded history of bushfires in the study area is rather scant though it is clear that significant fire seasons occur perhaps as frequently as every five years on average. The most widespread vegetation types in the area are grasslands, pasture or sparse woodlands with a grassy ground cover. These grass-dominated vegetation types produce a relatively low level of bushfire fuels – rarely more than 10 or 12 tonnes per hectare (t//ha) following a good wet season, such as that in 2007-08. During a long and hard drought, by contrast, fuel levels can be reduced to almost zero. This compares with fuel loads of 50 t/ha and more that can be experienced in the forests of south-east Queensland. Given these relatively low fuel levels, bushfires close to development in the study area pose only a limited threat and are relatively easy to manage.


Typical fuel conditions following the 2007-08 wet season


The same area following a fire in mid 2008

Over past millennia the most common sources of bushfire ignition have been lightning strike or the 'firestick farming' practices followed by the Aboriginal people of the area. Unfortunately, in more recent years, these sources of ignition have been overtaken by:

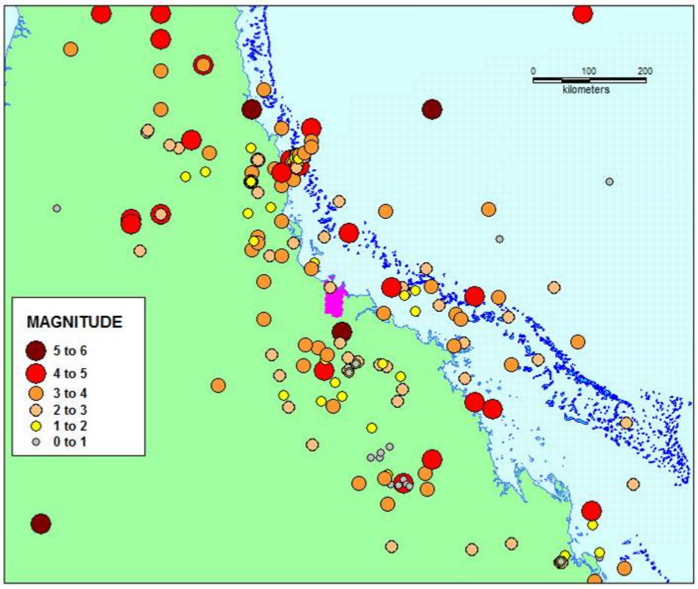
- power line failure (e.g. caused by power lines coming in contact with vegetation or being brought down by high winds or falling vegetation);
- human carelessness (e.g. a poorly supervised burn-off), stupidity (e.g. a discarded cigarette butt, or fires lit by bored and unsupervised children); or,
- criminality (e.g. by outright arson, or by car thieves disposing of stolen cars by setting them alight in bushland).

There are sections of the study area that do have a significant potential bushfire hazard, especially on Magnetic Island and on the steeper forested country on Mt Elliot. Much of the threat is to public land such as National Parks and Defence training areas, however, agricultural land and some residential properties are potentially exposed in areas with medium or low levels of potential hazard.

The BoM issues fire weather warnings which typically lead to the QFRS imposing restrictions or bans on the lighting of fires in the open. During active fires warnings and advice are broadcast over the ABC.

2.7 Earthquakes

Earthquakes are regional hazards. Their effect is not influenced or constrained by topography in the way that floods, for example, are contained in a floodplain. It is therefore necessary to look at a wide region when considering the earthquake risk to the study area. Within a radius of approximately 500 km from Townsville, the National Earthquake Database maintained by Geoscience Australia contains records of some 327 earthquakes. The earliest of these was on 11 November 1875; a Richter magnitude (M_L) 4.5 event located in the Moranbah area approximately 350 km south-south-west of Townsville, whilst the largest was the M_L 5.7 'Ravenswood' event located just 80 km south of the City, on 18 December 1913. Shaking from the Ravenswood earthquake rattled windows and crockery in Townsville. The closest recorded earthquake to Townsville was a M_L 2.2 event on 9 May 1900 with an epicentre immediately south of the City's CBD.



Earthquake epicentres within 500km of Townsville

By both global and national standards the earthquake hazard is low across the study area. That said, no point in the study area is immune from earthquake impact. On the basis of the historic record, it seems safe to assume that the risk of damage to buildings, and death or injury to people, throughout the study area, is relatively low.

It is not possible to predict the occurrence of earthquakes and provide warnings other than broad, regional assessments of the likelihood of occurrence over time somewhere within that region.

2.8 Climate Change

There is broad consensus that global mean temperatures have risen over the past century and that they will continue to rise as the result of Greenhouse-influenced climate change. Whilst there is still debate about the degree to which human activity is responsible, it is prudent to adopt the 'precautionary principle' and take them into account in planning for future disaster risks.

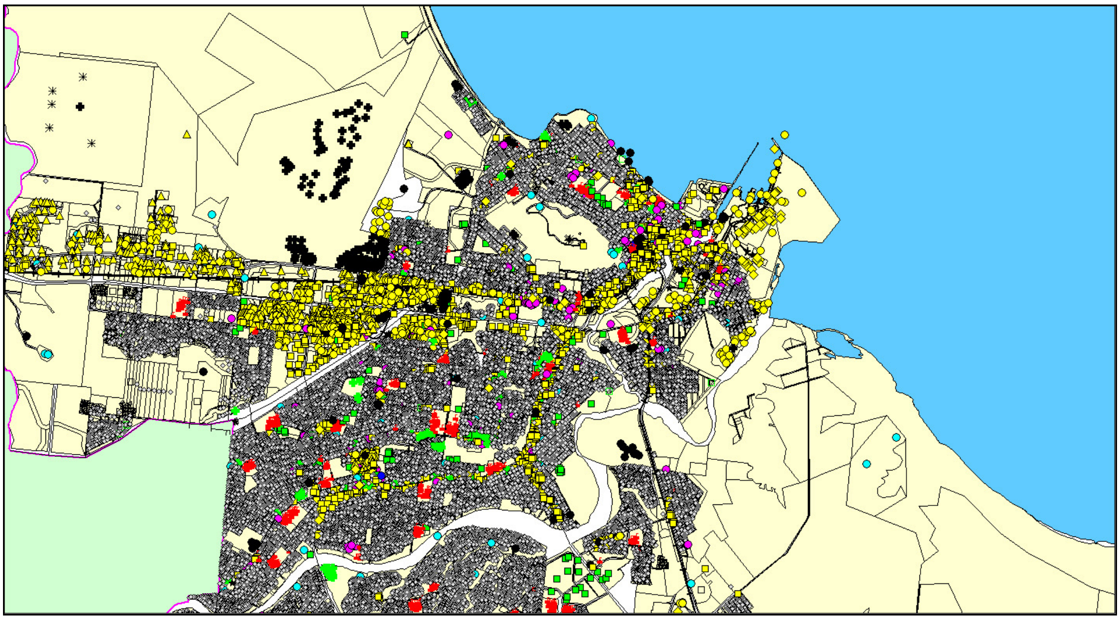
Amongst the predicted impacts of climate change is the increased incidence of more intense rainfall episodes. These will certainly increase the likelihood of flash floods, stormwater surcharge and landslides. Warmer and dryer conditions will clearly increase the likely incidence and severity of bushfires, though extended droughts will greatly reduce fire hazards because of the absence of grass fuels. A forecast increase in tropical cyclone intensity may also be significant to this Region. Any rise in sea level will have a potential influence on inundation hazards including floods and storm tide.

3. THE ELEMENTS AT RISK AND THEIR VULNERABILITY

The other ingredients required in the process of identifying the risks posed by natural hazards are an understanding of the things that are potentially exposed to hazard impacts and the degree to which those elements are susceptible to such an impact. Five main groups of element have been considered: buildings and property; people; lifeline infrastructure; economic activity; and the environment.

3.1 Developed Properties

Data interpreted from Council's rates and other administrative databases have been linked to the December 2007 version of the digital cadastral database (DCDB) to characterise each land parcel as to its actual use. These data have been further edited using recent aerial photography and satellite imagery to produce mapping that shows the distribution of 'developed properties', that is, properties on which buildings, especially dwellings and commercial premises, are established. There are 36,560 individual buildings included in the data set. Of these, 31,896 (or 87.5%) are dwellings, 2548 are commercial or industrial and 1099 are community facilities (including schools).



Developed property mapping shows the pattern of urban land use (residential is grey; commercial is yellow, government is black, schools are red, recreation is green, and so on)

A wide range of facilities, important to community safety and wellbeing before, during and after any emergency, exist throughout the study area. The loss or dislocation of these critical facilities such as hospitals, telephone exchanges and power supply infrastructure would greatly exacerbate the impact on the community, both within the study area and beyond. A further range of facilities exist at which people, especially children or the elderly, may congregate or be concentrated. These are regarded as sensitive facilities.

Telephone exchanges are critical infrastructure

Retirement villages are sensitive facilities

3.2 Population Distribution

Figures from the National Census show that in September 2006 the population of the study area was 95,464. This population is concentrated in the urban parts of the study area. Across the whole study area the average population density is 51 persons per square kilometre. The most densely populated location is a neighbourhood in Heatley which had a population density of 3680 people per sq km.

3.3 Lifeline Infrastructures

The wellbeing and safety of the community is also dependant on a range of lifeline infrastructure networks. These include:

- the road network;
- the rail network;
- power reticulation services;
- water reticulation services;
- sewerage reticulation services;
- telecommunications services;
- logistic support facilities (e.g. fuel and food supply).

3.4 Economy

Townsville is a major transport hub and service centre with road, rail, port and air transport services providing critical links to the inland mining centres of Mt Isa and Charters Towers, as well as to centres both north and south. The transport infrastructure has attracted the establishment of heavy industry and facilitated the development of mineral processing industries, major Defence Force facilities, as well as educational, research and medical facilities of national and international significance. The largest employer industries are public administration and safety (including Defence Force); health care and social assistance services; and retail trades.

3.5 Environment

European occupation of the study area has seen much of the native vegetation removed or greatly modified. Significant areas of largely undisturbed vegetation are preserved in the National Parks on Magnetic Island, Cape Cleveland and Mt Elliot.

The study area retains a wide range of terrestrial and marine fauna. They range from the larger mammals such as kangaroo, dolphin and dugong; to medium mammals such as koala and possum; and small mammals such as gliders, bandicoots and bats. There are at least 300 species of birds recorded as being found in the study area, many of them are migratory.

3.6 Vulnerability of Buildings

Buildings are the most common form of protection for people and house much of the economic and community activities. The characteristics of buildings that make them more or less susceptible to damage or destruction deserves particular attention. As a general rule the older the building the more susceptible it is likely to be. This is in part because of the steady upgrading of standards designed to make buildings more resilient to hazards such as destructive winds and earthquakes; and in part because of changes in the style and materials used in construction.

Several construction standards under the Building Code of Australia introduced since the early 1980s are aimed at making all buildings more resilient to both strong winds and earthquakes. Another standard guides the design and siting of buildings in bushfire-prone areas. An analysis of historical aerial photography shows that about 65% of the study area's buildings were constructed before 1982.

This early post-war house has a fibro roof that is susceptible to wind and debris damage but its small windows make it more resilient to severe wind damage; its timber frame makes it quite resilient to earthquake shaking; and its high set construction makes it resilient to inundation. The fibro roof could become a significant environmental hazard if it were damaged in a storm or earthquake.

These modern houses by contrast have tiled roofs that are largely resilient to wind and debris damage; they have large areas of glass that make them susceptible to wind damage; their timber frames (under the brick veneer cladding) give them a degree of resilience to earthquake shaking; and their slab-on-ground construction could make them susceptible to inundation hazards.

Buildings, especially houses, are most susceptible to damage by strong winds. A survey of damage caused by Category 4 TC *Larry* in Innisfail in 2006 showed that around 40% of pre-1985 and 22% of contemporary houses suffered some degree of wind damage. Roof damage invariably led to further contents damage because it allowed rain to enter the dwellings (Henderson & Ginger, 2008).

3.7 Vulnerability of Lifeline Infrastructure

A wide range of engineering standards also apply to the construction and design of infrastructure elements such as drainage, water supply, sewerage and so on. These standards are applied within the study area. As with buildings, the older the infrastructure the more likely it is to suffer damage under the more extreme conditions of a disaster. Older fibro water mains, for example, can be easily broken under earthquake loads or if displaced by a landslide.

3.8 Vulnerability of People

The degree to which people are likely to be harmed by exposure to hazards depends on a wide range of factors. The very young and the elderly, for example, are groups that are likely to be physically more susceptible to disaster impact than older children or more youthful adults. At the 2006 National Census there were 5836 children under 5 years of age, and 10,442 people 65 years of age and older in the study area. The elderly who are living alone are especially vulnerable and may have a heightened degree of vulnerability to most hazards because of their isolation. There were 2742 elderly in that situation.

The capacity to recover from the impact of any disaster is closely related to socio-economic well being. Less advantaged households will tend to be in rented accommodation; have no, or inadequate, insurance; and have difficulty replacing any losses. They will be more susceptible to unemployment should the businesses in which they work be impacted by the event. Families with low income (taken as less than $400 per week) are particularly susceptible to disaster impact.

People who do not have their own transport are dependent on public transport, which is not widely or evenly available, or on that provided by others. There were 3040 households in the study area that did not have access to their own vehicle in 2006. This makes them particularly susceptible in situations where evacuations may be required in the face of a rapidly evolving severe flood or storm tide situation.

It is something of a truism that '***an aware community is a prepared community'***. People who are new to the area tend to have a lower level of awareness of the hazard environment or have less well established community links than those who have lived there for a long time. Townsville has a very mobile population. Some 44,851 of the study area's total population (or 47%) had lived at their 2006 census night address for less than five years.

There are numerous intangible factors that can influence a community's relative vulnerability. Observations by experienced disaster managers suggest that a potentially critical factor is community cohesion and that participation in volunteer organisations is a strong indicator of community cohesion. At the 2006 census, of the total population over 14 in the study area, a surprisingly large proportion (70%) had not done any voluntary work in the previous 12 months.

There is strong anecdotal evidence that the self reliance and independence that has traditionally been attributed to Australian communities appears to be giving way to an increasing dependence on outside assistance during emergencies. Anecdotal evidence from recent disasters in the study area and elsewhere in Queensland indicate that there is a wide-spread expectation (if not demand) that assistance will be provided by disaster workers, such as the SES placing tarpaulins on damaged roofs, when needed, rather than people taking a greater degree of responsibility for their own welfare and sustenance. Such attitudes, if they become entrenched, can only reduce community resilience.

3.9 Institutional Vulnerabilities

The process of local government amalgamation contains many factors that may unintentionally increase community vulnerability until such time as the new Council and its many systems are truly integrated and operating as a cohesive unit. Of the key factors identified during this study, the lack of a well integrated information infrastructure suitable to support emergency risk management has been most notable.

The Townsville-Thuringowa LDMG has not been activated for an extended period to cope with a major disaster in the past decade, though it has been activated for short periods for less severe events. The periodic changeover of staff in the police, emergency services and Council who staff the LDMG can reduce the cohesion of that group unless it is activated or exercised on a regular basis.

3.10 Building and Infrastructure Exposure to Wind

The wind loading standard under the BCA recognises that the landscape in which a building is located will have an influence on its exposure to strong winds. Buildings close to the coast or along the tops of ridges, for example, are more likely to be directly exposed to strong winds than buildings within an urban environment where neighbouring buildings provide a degree of screening. This study has assessed that there are approximately 6000 dwellings in the study area (or 19% of the total) that are located within areas of heightened exposure to wind hazards.

All above-ground infrastructure elements such as power supply and nodes such as microwave repeater towers are exposed to wind damage or damage by wind-blown debris. The road network is indirectly exposed through its potential dislocation by fallen trees and other wind-blown debris.

It is important to note that the most extensive exposure will only be experienced in the more severe cyclones. Exposure to destructive winds in severe thunderstorms will cover a much smaller area.

3.11 Building and Infrastructure Exposure to Floods

The inundation extent mapping indicates that for a 50 year ARI flood (the ‘design’ event for most of the study area) around 1700 residential properties would at least have water in the yard. Modelling undertaken by TCC for the same flood scenario using building data that included the estimated floor height indicates that of those properties not more than 150 dwellings would have over-floor flooding. For a 100 year ARI flood the modelling indicates that at least 2100 residential properties would have water in the yard with perhaps 200 having above-floor flooding.

In the event of an extreme flood event approaching PMF, or in a catastrophic failure of the Ross River Dam, as many as 14,250 residential properties would have water in the yard, with perhaps half having water over floor-level.

The main infrastructure element exposed to flood is the road network. For a 50 year ARI flood around 130 km of road would have some water over the pavement, however, the available data does not permit identification of road segments that would have a depth of water and/or flow velocity that would require them to be closed. The more obvious of such segments are already marked by flood depth markers.

3.12 Building and Infrastructure Exposure to Storm Tide

The inundation extent mapping for a 100 year ARI storm tide indicates that around 500 residential properties would have some level of storm tide inundation. It is unlikely that more than 100 of them would have over-floor flooding to the extent that the building was at risk of significant damage. Inundation by storm tide does not persist for more than six or seven hours (i.e. until the tide goes out).

The road network close to the coast would suffer some level of inundation and possible deposition of sand and rubble. Less than 40 km of road lie within the area that would be inundated by a 100 year ARI storm tide.

3.13 Building and Infrastructure Exposure to Landslide

Landslides are typically singular events with only a small area affected by any one landslide. There are, however, at least 59 dwellings located within the area assessed as having a potential exposure to debris flows (the most dangerous form of landslide) and around 1000 dwellings that are within the area assessed as having a high landslide risk. The majority of these are located around the slopes of Castle Hill and TCC has already implemented a program of works to minimise that exposure.

The road network can be blocked by landslides. Around 30 km of the road network falls within either a debris flow or high landslide hazard zone, but it is highly unlikely that more than a hundred metres of road would be affected by any given landslide. In-ground infrastructure such as water supply and sewerage pipe networks and telecommunications cable networks are also exposed to dislocation by landslide impact.

3.14 Building and Infrastructure Exposure to Bushfire

The bushfire hazard mapping that is currently available is not suitable for undertaking a detailed exposure analysis. It is likely, however, that the numbers of dwellings potentially exposed to bushfire impact is very small and then confined to either rural areas or around the lower slopes of Mt Stuart where fuel accumulation is likely to be greatest.

Some above-ground infrastructure elements such as wooden power poles may be directly exposed to fire in rural areas. It is also possible for high voltage power lines to arc to the ground through very dense fire smoke, causing the network supply to be interrupted. Telecommunications may also be hampered by dense fire smoke. Poor visibility caused by dense smoke may also lead to some roads and possibly even the airport being closed for short periods.

3.15 Building and Infrastructure Exposure to Earthquake

Exposure to earthquake shaking is dependent on a wide range of factors including the magnitude and depth of the earthquake, its duration, the distance from the event epicentre and the depth and nature of the regolith on which the structure stands. Whilst no part of the study area is immune from earthquake shaking, it is possible to differentiate exposure by the distribution of deeper and softer sediments and alluvial soils that tend to amplify shaking. There are around 1450 dwellings located on the softest soils (deep sandy alluvium) and 14,700 on the next weaker soil (riverine alluvium).

In-ground infrastructure elements such as the water supply and sewerage pipe networks are exposed, particularly where they are located in the weaker soils. Approximately 50% of the study area's water supply and sewerage networks lie in the two weaker soil classes.

4. ASSESSING AND ANALYSING THE RISKS

The Australia and New Zealand *Risk management* standard (AS/NZS 4360:2004) suggests that risk is best assessed by combining the likelihood of an event of a given strength or magnitude happening with the consequences of its outcome. Likelihood is essentially the same as frequency, the measure that best suits natural hazard studies. The levels of likelihood used are set out in the following table and the definitions of consequences are detailed in Appendix A.

DESCRIPTOR	DESCRIPTION	FREQUENCY
Almost certain	will happen numerous times during a person's lifetime	ARI up to 5 years
Likely	likely to happen up to three times in a lifetime (once in a generation)	ARI in the range 15 to 25 years
Possibly	likely to happen only once in a lifetime	ARI in the range 50 to 100 years
Unlikely	known to have happened only once in the recorded history of Australia and similar regions	ARI in the range 200 to 500 years
Rare	some evidence that such an event may have happened in pre-historic times or deemed to be theoretically possible	ARI in excess of 1000 years

The following tables outline the relationship between likelihood, consequences and the resulting level of risk for each of the hazards included. The risk ratings used are based on the relationships employed by the Australian Greenhouse Office (AGO, 2006) for assessing risks posed by climate change[1].

LIKELIHOOD	CONSEQUENCES				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possibly	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Low	Medium

[1] It should be noted that this approach gives equal weight to both likelihood and consequence hence the reduction of risk level as the likelihood diminishes.

4.1 Destructive Wind Risk

The risks posed by destructive winds are summarised in the following table.

LIKELIHOOD	CONSEQUENCES	RISK LEVEL
Almost certain	**Insignificant**: Low levels of wind damage reached in small areas – up to a few tens of buildings with minor damage. Roads and power supply may be affected for a short time by fallen trees.	**Medium**
Likely	**Minor**: Moderate levels of wind damage reached in small areas. Some older buildings may have major roof damage and up to 100 buildings with some damage. Roads, power supply and telecommunications infrastructure may be affected for a few hours by fallen trees or blown debris. Injuries likely.	**Medium**
Possibly	**Major**: Significant levels of wind damage reached in extended areas. Some buildings likely to lose roofs or suffer serious debris damage, with a few tens of buildings possibly destroyed and more than 100 severely damaged. Roads, power supply and telecommunications infrastructure will be affected for more than a day by fallen trees and blown debris. Widespread crop losses. Serious economic impact. Numerous injuries likely and loss of life possible.	**High**
Unlikely	**Catastrophic**: Severe wind damage over extensive areas. Many tens of buildings destroyed and several hundred more severely damaged. Roads, telecommunications and power supply infrastructure will be affected for up to a week by fallen trees and blown debris. Widespread crop losses. Major economic losses and long-term impact. Many injuries and loss of life likely.	**Medium**

The benchmark likelihood for which the risks posed by each hazard are to be assessed is the once-in-a-lifetime ('rare') event. That gives destructive wind from either tropical cyclones or severe thunderstorms a risk rating of HIGH.

4.2 Flood Risk

The risks posed by river floods are summarised in the following table.

The 'design' flood level for the study area falls into the once-in-a-lifetime category (possibly likelihood) so the level of risk posed by flood can be classed as being MEDIUM.

The risk posed by a catastrophic failure of the Ross River Dam, whilst extremely unlikely, must be classed as posing a MEDIUM level of risk.

LIKELIHOOD	CONSEQUENCES	RISK LEVEL
Almost certain	**Insignificant**: Nuisance flood levels reached in smaller urban catchments. Some minor roads cut and a few tens of properties isolated for hours. Minimal risk to urban communities.	**Medium**
Likely	**Minor**: Moderate flood levels reached in most urban catchments. Some roads cut for a few hours. Few if any urban properties with above-floor inundation but several hundred properties with water in the yard.	**Medium**
Possibly	**Moderate**: Major flood levels reached in all urban catchments and the Ross River. Up to 140 km of roads inundated, some cut for up to 24 hours and damaged. Power cuts certain and damage to infrastructure likely. Some evacuations likely. Up to 150 low-lying dwellings and 20 other buildings likely to be flooded over floor level. Loss of life possible but unlikely.	**Medium**
Unlikely	**Major**: Widespread road and infrastructure damage. Urban communities isolated for several days with virtually the entire population of the study area directly or indirectly affected. Evacuations will be required. Major economic losses. Loss of life likely.	**Medium**
Rare	**Catastrophic**: Floods approaching PMF or a catastrophic dam failure. Many hundred dwellings with over-floor flooding. Extensive and long-lasting economic harm. Fatalities certain. Large scale and long-term evacuations will be required.	**Medium**

4.3 Storm Tide Risk

The risks posed by storm tide are summarised in the following table.

LIKELIHOOD	CONSEQUENCES	RISK LEVEL
Almost certain	**Nil**: No damage likely.	**No risk**
Likely	**Insignificant:** Environmental impact only. Foreshore erosion likely.	**Low**
Possibly	**Minor**: Serious foreshore erosion likely. Inundation of fewer than 20 dwellings likely. Almost 20 km of roads will be affected for up to six hours. Few if any casualties.	**Medium**
Unlikely	**Major**: Major foreshore erosion certain. Up to 200 dwellings with some level of inundation. Prior evacuations warranted. Up to 40 km of roads likely to be affected by inundation for up to six hours.	**Medium**
Rare	**Major to Catastrophic**: Widespread and serious foreshore erosion. Around two thousand dwellings with significant inundation. Mass evacuations ahead of the cyclone mandatory to reduce the risk of fatalities.	**Medium**

The 'design' level event is in the once-in-a-lifetime (unlikely) category consequently the risk of storm tide is classed as being MEDIUM.

4.4 Landslide Risk

The risks posed by landslide are summarised in the following table.

There is no 'design' level for landslides, however, if an intense rainfall episode with an ARI of 100 years (possibly likelihood) is taken as a reasonable recurrence interval for landslide the risk posed is MEDIUM. That risk is also confined generally to the slopes of Castle Hill and areas around Mt Stuart, Mt Louisa and on Magnetic Island. It is not a widespread risk.

If the spatial constraint is taken into account the level of risk to the whole study area could reasonably be discounted to LOW.

LIKELIHOOD	CONSEQUENCES	RISK LEVEL
Almost certain	**Nil**: No damage of significance likely.	**No risk**
Likely	**Insignificant**: A few small batter failures and localised slides.	**Low**
Possibly	**Minor**: A few medium size batter failures which cause minor road blockage. Small number of localised slides causing minor damage.	**Medium**
Unlikely	**Moderate**: Numerous batter failures causing extensive road blockage. Widespread slides, some of which will cause damage to in-ground infrastructure and some buildings. Small debris flows and rock falls possible. Injuries and fatalities possible.	**Medium**
Rare	**Major**: Numerous widespread batter failures blocking some roads for more than 24 hours. Widespread slides causing damage to roads, in-ground infrastructure and buildings. Damaging debris flows and rock falls likely. Injuries likely and fatalities possible.	**Low**

4.5 Bushfire Risk

The risks posed by bushfire are summarised in the following table.

LIKELIHOOD	CONSEQUENCES	RISK LEVEL
Annual	**Nil**: Low intensity localised fires with limited spread. Limited threat to property. Easily controlled with small resources.	**No risk**
Almost certain	**Insignificant**: Small to medium intensity localised fires with some spread potential. Some property threat. Easily controlled with small resources.	**Medium**
Likely	**Minor**: Medium intensity, and possibly multiple, fires with some spread potential. Property likely to be damaged. Manageable by conventional methods.	**Medium**
Possibly	**Moderate**: Multiple severe intensity fires with significant spread potential. Property loss and injuries likely. Difficult to manage by conventional methods.	**Medium**
Unlikely	**Major**: Extreme fire intensity and major spread potential over an extended period. Property loss certain, fatalities likely. Very difficult to manage by conventional methods.	**Medium**

There is no ‘design’ level established for bushfire however a weather event with an ARI of around 50 to 100 years (possibly likelihood) would produce a risk posed by bushfire classed as MEDIUM.

As with landslide, the threat would never involve the whole study area at any one time and would be confined to rural areas and those developments on the urban fringe. That level of risk, if taken across the study area could be realistically discounted to LOW.

4.6 Earthquake Risk

The risks posed by earthquake are summarised in the following table.

An earthquake with an intensity likely to be experienced in the 100 year ARI range (possibly likelihood) would produce a risk level of LOW.

LIKELIHOOD	CONSEQUENCES	RISK LEVEL
Likely	**Nil**: Small intensity shaking to MM IV. Little if any damage.	**No risk**
Possibly	**Insignificant:** Small intensity shaking to MM V. Little if any damage.	**Low**
Unlikely	**Minor**: Moderate intensity shaking to MM VI. Minor damage to poorly constructed buildings possible. Injuries unlikely. Some damage to the more fragile in-ground infrastructure possible.	**Low**
Rare	**Major**: Strong intensity shaking to MM VII. Damage to older masonry and poorly constructed buildings likely. Some serious injuries likely and some fatalities possible. Some dislocation of in-ground infrastructure likely. Secondary hazards such as fire possible.	**Low**

Assessment: By this comparative assessment of hazards with a common level of likelihood of impact the risk posed by destructive winds represents the greatest risk to the study area, with flood and storm tide posing the next greatest level of risk. Landslides, bushfires and earthquakes pose a relatively low level of risk.

4.7 Beyond the Likelihood and Consequences Model

Whilst this approach provides an assessment of risks posed by a single event scenario, it does not take account of the wider range of issues that can be significant to the analysis of the risks posed by complex natural hazards. To arrive at a more complete appreciation of the total risk posed by each hazard it is necessary to take into account more than just likelihood and consequences. Five further factors have been considered, namely:

- **Manageability** – those hazards that are difficult to control or manage by existing techniques, resources and warning systems pose an inherently greater risk than those that are easier to manage. For example, bushfires are relatively easily managed whilst mega hazards such as cyclones and earthquakes are very difficult to manage;
- **Awareness** – hazards for which community understanding and awareness before the event have not led to active steps being taken to reduce those risks pose an inherently greater risk than those for which risk reduction efforts have already been made. For example, prior to the devastating Indian Ocean tsunami of 2006 there was little appreciation by the community of the potential devastation that such a hazard could bring;
- **Urgency** – hazards that need to be addressed with some urgency because of a lack of preparedness, for example, pose an inherently greater risk than those that do not demand the implementation of risk reduction action so rapidly;
- **Growth** – hazards for which the risk is likely to grow either because the hazard could become more frequent or severe; or there is likely to be an increase in the number of community elements exposed; or there will be an increase in the vulnerability of those elements, pose an inherently greater risk than those hazards that pose a more constant level of risk. Implementation of planning policies to limit development in hazard-prone areas, for example will greatly limit the growth of risk, however, climate change and an aging population might increase the risk;

- **Outrage** –the political dimension of risk is important because after the impact of an emergency, community outrage at what is perceived to have been a lack of preparedness or an inadequate response can generate unrealistic and unreasonable political demands rather than addressing the reality of community safety needs. Such hazards pose an inherently greater risk than those that tend to be seen as either voluntary risks or as being 'acts of God'.

IID has applied a semi-quantitative approach to arrive at a comparative assessment of each hazard and their various sub-sets (e.g. flash flood as well as riverine flood). This approach allocates scores out of 5 for each element with the highest score going where that element contributes significantly to the total risk. The scenario-specific risk score is the sum score of likelihood and consequences. Whilst subjective they are based on our knowledge of the hazards and the Townsville community. The results of this analysis are as follows:

HAZARD	SCENARIO RISK	MANAGE.	AWARE	URGENCY	GROWTH	OUTRAGE	TOTAL RISK
Severe storm	6	3	2	2	3	3	19
River flood	5	3	2	3	2	4	19
Storm tide	5	3	3	3	3	4	21
Landslide	5	2	3	2	2	3	17
Bushfire	5	1	2	1	2	2	13
Earthquake	4	4	4	2	2	1	17

On this assessment of total risk IID considers storm tide to pose the greatest threat to the Townsville community, with destructive winds and riverine flood a close second. Bushfire poses the lowest overall level of risk.

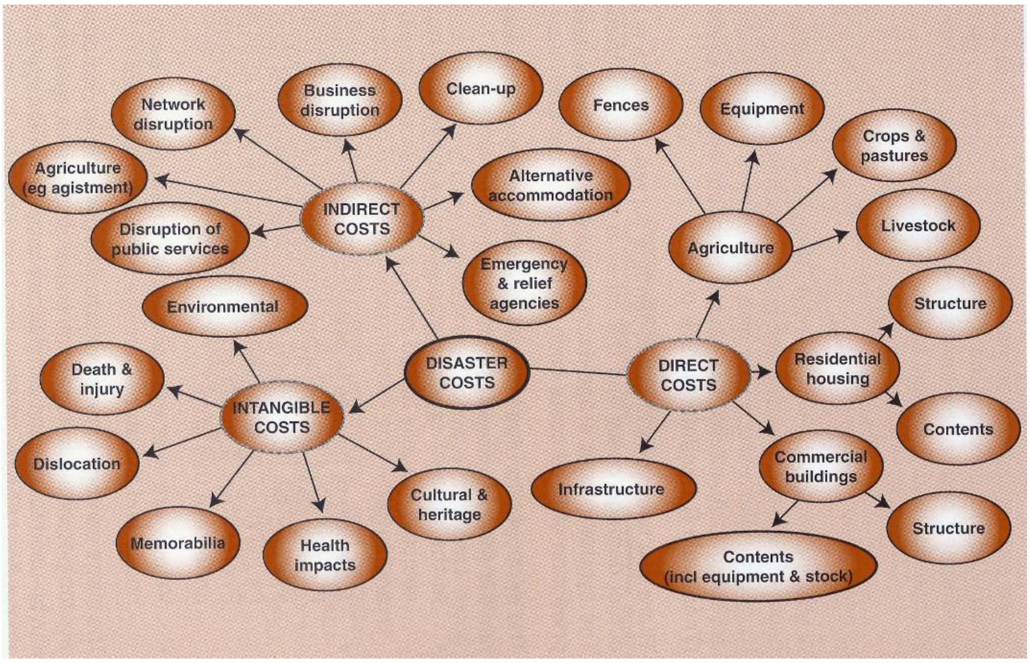
4.8 Economic Risk

Statistics compiled by Bureau of Transport Economics in their 2001 report *Economic costs of natural disasters in Australia* (BTE (2001) show that for Queensland as a whole the most costly natural hazard for the period 1967 to 1999 (on an annual average cost basis) was flood ($111.7 million), followed by cyclones ($89.9 million) and severe storms ($37.3 million), with bushfires occupying a distant fourth place ($0.4 million).

The complete analysis of the economic cost of disasters is extremely complex as the model proposed by the BTE demonstrates.

It is unusual for this full model to be applied to the study of disasters. Most frequently the only costs addressed are the direct costs, and then they are typically confined to the insured losses to private property. This inevitably understates the true costs of disaster. Certainly the most thorough economic analysis of a disaster event in Queensland to date has been that undertaken for DES of the flooding associated with ex-TC *Sid* (DES, 2002). Most of the losses were confined to the former Townsville and Thuringowa City areas. This study calculated the direct losses to total $234.24 million; indirect losses totalled at least $6 million (with issues such as the indirect cost to tourism and agriculture unquantified); the intangible losses at $4.86 million; giving a total loss of at least $245.1 million. Against these costs recompense from insurance payouts ($69.35 million), Natural Disaster Relief Arrangement ($54.37 million) provided $121.91 million in ‘benefits’ giving a net loss of $123.19 million.

It is clear that any expenditure aimed at reducing the economic impact of any natural hazard on the community can be seen as an investment, rather than as a cost.



Disaster cost outline framework (BTE, 2001)

5. TREATING THE RISKS

5.1 Guiding Principles

There is broad agreement that the protection of life and property will take precedence over environmental protection. This is consistent with the objective of all emergency risk management, namely **to provide safe and sustainable communities**. Furthermore, there is no single point of responsibility for emergency risk mitigation – **it is a total community responsibility**.

The more general strategies that are applicable to all hazards are dealt with first and are followed by strategies that relate to the specific hazards.

There are three principal areas in which disaster risk treatment is concentrated:

- engineering actions – the development or modification of structural defences is typically the most costly of all risk treatments, especially where they are required to rectify past engineering or planning decisions. Such decisions may well have been made on the best information available at the time, but subsequent events, or improved knowledge, have shown them to be flawed. Engineering standards can play a significant role in limiting the growth of risk into the future by ensuring that buildings and infrastructure elements are resistant to damage in future events. Such pro-active action is essentially cost-neutral.

- land use planning actions – control of the location and the nature of development through the land use planning process can have a significant impact on the future growth of risk - it cannot, however, have any impact on development that is already established. It is largely cost-neutral. In Queensland SPP 1/03 requires the potential impact of flood, landslide and bushfire to be taken into account in land use planning decisions. The Coastal Management Plan also plays a similar role in requiring storm tide hazards to taken into account.
- emergency management actions – these are generally the most cost effective measures to address both current risks and to limit future risks. They are predominantly non-structural strategies, i.e. they mainly involve people or organisations doing things. Those strategies can be applied to maximise one or more of the key elements of emergency management, namely:

  - research, information and analysis
  - risk modification
  - readiness
  - response
  - recovery.

In the following sections the strategies identified as being appropriate to enhancing community safety and sustainability within the study area are prioritised using the following categories:

- ongoing - activities that are already established as an operational requirement
- high – should be commenced within six months
- medium – should be commenced within twelve months
- low – should be commenced within 18 to 24 months.

5.2 Generic Risk Reduction Strategies

There are many strategies that can be applied to reduce the risks posed by any or all hazards. These generic risk reduction strategies are listed here.

In the first instance there are strategies that need to be implemented as a response to the administrative changes brought about by the amalgamation of Townsville and Thuringowa City Councils in March 2008.

Generic strategy 1: When establishing its new Vision Statement and Corporate Plan the New Townsville City Council consider the inclusion of a clear commitment to maintain a safe and sustainable community, especially in relation to the potential impact of natural hazards. (High priority)

Generic strategy 2: At an early stage in the life of each Council the LDMG arrange a briefing for all elected councillors and senior executives on their roles and responsibilities for emergency risk management. An information package to support such a briefing should contain material such as the LGAQ/DES resource *Elected member's guide to disaster management*. (High priority)

Generic strategy 3: Council, through the LGAQ, request DES to task its legal advisors to compile and disseminate a statement of the legal, administrative and common law responsibilities of Queensland local governments for emergency risk management. (Medium priority)

Generic strategy 4: In the process of re-designing the functional arrangements for its amalgamated structure Council review the subordination of the LDMG to maximise its effectiveness as a risk management body. (High priority)

Generic strategy 5: At an early stage in the amalgamation process the New Townsville City Council promotes a policy that facilitates public access to details of potential hazard impact zones, especially those involving inundation hazards. (High priority)

Generic strategy 6: Council commission a follow-up multi-hazard risk assessment, as Stage 2 of this study, to produce a disaster risk management strategy for the New Townsville City Council. That study should be based on updated City-wide hazard-specific studies for bushfire and earthquake (and possibly flood). (High priority)

Generic strategy 7: Council review its vegetation management strategies to manage remnant native trees and street tree planting to minimise their potential to do damage if brought down during storms or to provide bushfire fuel close to residences. (Ongoing priority)

The second group of generic strategies relate to the scope of the study. This has been limited to consideration of those natural hazards that are covered under the Commonwealth Government's Natural Disaster Response and Recovery Arrangements (NDRRA).

Generic strategy 8: Council, through LGAQ, request DES and EMA to review the limitation of NDMP projects to those hazards covered under the NDRRA so that Queensland local governments can more effectively develop a genuine all-hazards approach to emergency risk management. (Low priority)

Generic strategy 9: Council seek future external funding to extend its multi-hazard risk assessment studies to address the full span of hazards, including heatwave, epidemics and anthropogenic hazards. (Low priority)

The next group of generic strategies relate to the accumulation and recording of disaster information.

Generic strategy 10: The LDMG initiate discussions with the Townsville City Library, the Museum of North Queensland and local history groups to document the community's experience of and response to emergencies. (Medium priority)

Generic strategy 11: The LDMG incorporate into its Local Disaster Management Plan the requirement to undertake and/or fund post-event surveys and studies from which to accurately assess the consequences (physical, economic, personal) of all significant hazard impacts. (Ongoing priority)

***Generic strategy 12*:** The LDMG recommend to DES that guidelines be developed to standardise the conduct of post-event surveys and studies and incorporate those guidelines into the State Disaster Management Plan. (Low priority)

***Generic strategy 13*:** The LDMG develop procedures and protocols by which to manage and coordinate post-event research by outside agencies following a major disaster. (Low priority)

***Generic strategy 14*:** Council, through the LGAQ, recommend to DES that guidelines be developed and circulated to the scientific community relating to the conduct of post-event studies. (Low priority)

***Generic strategy 15*:** The LDMG recommend to Council that as part of the amalgamation of the two council information systems that it commissions a review of its amalgamated information infrastructure and its capacity to fully support the planning for and response to a major emergency. (Ongoing priority)

Generic strategy 16: Council enter into discussions with the BoM to upgrade the Mt Stuart weather watch radar to a Doppler radar and to review the effectiveness of the current flood warning system. (Medium priority)

The next group of generic strategies are aimed at improving community resilience and awareness through improving risk communication.

***Generic strategy 17*:** The LDMG recommend to Council the development of a comprehensive emergency risk communications strategy, in association with the response agencies, including the production of a comprehensive guide to the development of household emergency management plans. That guide should be included in the 'welcome' information pack provided to new residents. (Ongoing priority)

***Generic strategy 18*:** The LDMG, in conjunction with Council and response agencies engage with the local electronic media outlets to establish procedures to manage communications with the community, including messages in languages other than English, to provide authoritative information ahead of, during and after an emergency. (Ongoing priority)

***Generic strategy 19*:** The LDMG and Council establish a program of community awareness as to the importance of SEWS ahead of the annual bushfire and cyclone seasons. (Ongoing priority)

***Generic strategy 20*:** Council use the current high degree of media interest in issues relating to climate change to promote messages of the linkage of climate and natural hazards both now and into the future. (Ongoing priority)

Generic strategy 21: Before the start of each cyclone season Council run a community education program aimed at building community resilience and self reliance. To provide focus to that campaign Council could consider adopting a slogan along the lines of 'your safety is our concern, but your responsibility'. (Ongoing priority)

The final group of generic strategies are aimed at improving the response and recovery activities that will be required following the impact of a major hazard.

Generic strategy 22: The LDMG consider activating the local LDCC in response to the more frequently occurring lower-level emergency situations to expand the experience of members and their agencies. (Ongoing priority)

Generic strategy 23: The LDMG recommend to DES that model sub-plans be developed to provide guidance on planning for infrastructure recovery, business recovery and community welfare activities during and following an emergency. (Medium priority)

Generic strategy 24: Council, through the LGAQ recommend to DES that it publish guidelines for the establishing, coordination and administration of public disaster appeals. (Low priority)

Generic strategy 25: Before the onset of each cyclone season the LDMG should review and update the evacuation sub-plan of the Local Disaster Management Plan to take account of the risks identified in this study and to take account of best-practice evacuation planning methods. (Ongoing priority)

Generic strategy 26: Townsville SES Unit investigate the development of a retirement village emergency and evacuation plan based on that operated by the Maroochy (Sunshine Coast Region) SES Unit. (Ongoing priority)

Generic strategy 27: Council and the LDMG Welfare Committee examine the need and suitability of using 'off the shelf' software to support the registration and tracking of evacuees. (Medium priority)

Generic strategy 28: Council establish a dialogue with the public and private proprietors and operators of critical infrastructure to ensure that they understand their role in the local disaster management process and to encourage their support for the work of the LDMG. (Medium priority)

Generic strategy 29: The LDMG and DES commission specific research and analysis of the full range of critical infrastructure, especially in areas identified as information gaps in this study. Liaise with Geoscience Australia to ensure that this research is modelled on the approach employed in Commonwealth-led Critical Infrastructure Protection, Management and Analysis (CIPMA) program so that the information developed could be exchanged between the two systems. (Medium priority)

Generic strategy 30: The LDMG establish an arrangement with the local members of Wireless Institute Civil Emergency Network (WICEN) to provide communications support in the event of extended outages of telephone and other communications systems. (Ongoing priority)

5.3 Severe Storm Risk Treatment

The treatment of the risks posed by destructive winds associated with severe storms relies heavily on the resilience of the buildings that provide shelter and on the infrastructures that support community activity. The Building Code of Australia and the standards that support it is the key.

Storm strategy 1: Council maximise the likelihood that all new buildings conform to wind loading standards under the BCA by incorporating into the Townsville City Plan wind loading and corrosion line mapping based on the provisions of AS 1170.2-2002, AS 4550-2006 and BCA Table 3.3.3.1. (Ongoing priority)

Storm strategy 2: Council encourage owners and builders to ensure that renovations and/or repairs to houses built before 1989 are upgraded to meet current wind code conditions in line with SAA HB1321 (*Structural upgrading of older houses part 2: cyclone areas)*. (Ongoing priority)

Storm strategy 3: Council run annual information sessions for private certifiers, builders and architects on the requirements of AS 1170.2 and the desirability of applying the retrofit strategies of HB1321. (Medium priority)

Storm strategy 4: Council require operators of caravan parks to install tie down points for caravans and provide information to all caravan owners on caravan safety in high winds. (High priority)

Storm strategy 5: Council maintain a plan for the management of broken fibro and other asbestos-based products following storm damage. Identify appropriate disposal sites. (Ongoing priority)

Storm strategy 6: Council continue to ensure that power supply in all new subdivisions is placed underground and establish a program with Ergon of placing power supply underground in areas of high exposure and/or frequent damage. (Medium priority)

5.4 Flood Risk Treatment

Council has established in its works program a range of structural treatments including upgrading sections of the stormwater infrastructure to cope more effectively with intense rainfall. A flood warning system on the Ross River catchment is established and warning signs have been placed on some road sections that are especially prone to dangerous flooding. The upgrade of the Ross River Dam has also reduced the risk of dambreak flooding.

Flood strategy 1: Council to review the detailed flood risk treatment strategies identified by consultants Maunsell Australia in their 2005 report for inclusion in a new City floodplain management strategy. (Ongoing priority)

Flood strategy 2: Council establish a rolling program to review and update flood modelling at ten or preferably five-year intervals, in urban areas and rural areas where significant development is planned to take place. Continue research and computerised flood impact modelling to support emergency management planning and operations. (Ongoing priority)

Flood strategy3: Council investigate the need to undertake an updated flood management study to take account of the upgrade of the Ross River Dam and to incorporate the NQ Water operational procedures for managing flows through the dam into the local disaster management plan. (Medium priority)

Flood strategy 4: If indicated by the outcomes of *Flood strategy 3* Council investigate the installation of a siren warning system for properties immediately downstream of the dam to be used when flood waters are to be released from the dam. (Medium priority)

Flood strategy 5: LDMG ensure that local SES and QPS staffs are made familiar with management arrangements for local flood issues, conduct on-site briefings on the management of the flood threat at identified flash flooding hotspots, especially where road closures are required. (Ongoing priority)

Flood strategy 6: Council records flood inundation information from major events in order to build up a database of records that can be used in responding to future flood events in flood prone areas. (Ongoing priority)

Flood strategy 7: Recommend to LGAQ that they negotiate with DES and DLGP a review of SPP 1/03 guidelines relating to flood with the particular suggestion that guidance be included on an appropriate resolution for DEM used in flood modelling. (Low priority)

5.5 Storm Tide Risk Treatment

The management of storm tide is similar to that for other inundation hazards.

Storm tide strategy 1: Council establish a rolling program to review and update storm tide modelling at ten or preferably five-year intervals. Continue research and computerised inundation impact modelling to support emergency management planning and operations. (Ongoing priority)

Storm tide strategy 2: The LDMG establish a program to encourage residents in potentially exposed locations to develop household emergency response plans for storm tide based on the existing modelling and storm tide warning system. (High priority)

Storm tide strategy 3: LDMG to maintain specific evacuation plans for communities in storm tide-prone areas such as Cungulla and parts of South Townsville based on scenarios developed from the modelling. (Ongoing priority)

5.6 Landslide Risk Treatment

Council has implemented a program aimed at limiting the risks of damage from landslides originating from Castle Hill, for example the gabion wall to protect houses along Stanton Terrace.

Landslide strategy 1: Stabilise potentially problematic batters or slopes on Council-controlled roads, or erect protective structures (such as mesh fences or bunds) and encourage DMR to undertake similar work on State-controlled roads. (Ongoing priority)

Landslide strategy 2: Given the uncertainty that exists regarding the potential risks posed by rock falls from Castle Hill being initiated by a close earthquake of moderate or greater magnitude, Council, in conjunction with relevant State agencies, commission specific research to establish an appropriate management strategy. (Low priority)

Landslide strategy 3: Council maintain an ongoing community education program warning about rock falls from Castle Hill and landslides from other steep slope areas such as Mount Louisa. (Ongoing priority)

Landslide strategy 4: Recommend to LGAQ that they negotiate with DES and DLGP to review the SPP 1/03 guidelines relating to landslide with the particular suggestion that the 'default' landslide threat zonation of 15% slope be revised to require specific reference to the lithology. (Medium priority)

Landslide strategy 5: Council investigate technical options for monitoring areas of Castle Hill that have been identified as posing a particular threat from rock falls from steep rock cliffs. (Ongoing priority)

Landslide strategy 6: Council establish a MOU with the State government as to their potential liability should major damage or injury result from a rock fall or landslide from Council-managed State land on Castle Hill. (High priority)

Landslide strategy 7: Council commission City-wide landslide hazard potential mapping to SPP 1/03 standard. Council's GIS staff could undertake most of the work with guidance from an external consultant. (High priority)

Landslide strategy 8: Incorporate the updated landslide potential hazard mapping done to SPP 1/03 standard into the new Townsville City Plan. (High priority)

5.7 Bushfire Risk Treatment

Bushfire is unique amongst the hazards considered in this study in that action can be taken to reduce the hazard component of the risk. The most effective such action is to manage the fuels that are available.

Fire strategy 1: Council commission an updated bushfire hazard mapping program to cover the New Townsville City area. Council's GIS staff has the necessary technical skills to undertake this work under the supervision of an external consultant that is skilled in bushfire hazard mapping. (High priority)

Fire strategy 2: Incorporate the updated bushfire hazard potential mapping, done to SPP 1/03 standards, into the new Townsville City Plan. (High priority)

Fire strategy 3: Council consider the immediate appointment of a Fire Management Officer to undertake the duties suggested by the 1994 State Bushfire Audit and to oversee the implementation of the bushfire management strategy for the study area. (Medium priority)

Fire strategy 4: Council adopt as policy for managing fuel on Council-controlled land:

- the fire management principles and practices identified by the FABC and QPWS which seek to strike a balance between community safety and preserving biodiversity;
- recognition of the principle that the need for fuel reduction to improve community safety will take precedence over consideration of smoke pollution from prescribed burning. (Medium priority)

Fire strategy 5: Conduct an annual audit of fuel conditions on Council-controlled land. (Ongoing priority)

Fire strategy 6: Based on the results of those audits, allocate adequate human and equipment resources, including QFRS support, to initiate a sustainable program of fuel management on Council-controlled land, with the land with the greatest level of hazard being treated as soon as possible. (Ongoing priority)

Fire strategy 7: Council, QPWS and Department of Defence, in consultation with QFRS, adopt a maximum desirable fuel loading in bushland interface areas within the study area (e.g. 12 t/ha). Develop strategies to monitor and maintain that loading level, especially in areas adjacent to critical infrastructure and the urban interface. (Medium priority)

Fire strategy 8: Consider formation of the Townsville City Fire Management Committee with representation from QFRS, QPWS, Defence, Powerlink and Ergon as a sub-committee of the LDMG. (Medium priority)

Fire strategy 9: Draw to the attention of building certifiers and developers operating in the City the existence of the *natural hazard management area (bushfire)* mapping and the responsibility they bear to ensure that the provisions of AS 3959 with regard to design and construction standards within those areas designated as being fire-prone, together with appropriate subdivisional design and siting principles identified by CSIRO and others, are complied with. (Low priority)

Fire strategy 10: QFRS promote bushfire safety program in study area suburbs and localities with an identified fire threat. Households in those areas are to be encouraged to develop household fire plans. (Ongoing priority)

Fire strategy 11: QFRS consider installing and maintaining prominent 'fire danger' signage in urban interface areas to improve community awareness in periods of elevated fire danger. (Medium priority)

Fire strategy 12: Recommend to LGAQ that they negotiate with DES and DLGP to review the SPP 1/03 guidelines relating to bushfire with the particular suggestion that guidance be included on an appropriate resolution for modelling in interface area. It would also be advantageous to publish more appropriate weights for aspect to reflect wind direction in local fire weather events and a more comprehensive list of hazard potential scores vegetation or ecosystem types than is currently available. (Low priority)

5.8 Earthquake Risk Treatment

Damaging earthquakes are not a common hazard in Australia in general. There is no science yet available to provide warnings of where and when such an event will happen. The greatest risk to people in an earthquake is from poorly constructed buildings failing under earthquake loads. The Building Code of Australia provides good design and construction standards.

Earthquake strategy 1: Commission a detailed site class study of the urbanised area to improve the resolution and accuracy of the class zones suggested in this study. From that analysis identify specific building types that may be exposed to amplified earthquake shaking. (Low priority)

Earthquake strategy 2: Ensure all new buildings comply with the BCA earthquake loading code (AS1170.4) as modified by the revised acceleration factors. Encourage owners of existing buildings to upgrade their properties to current standards when undertaking structural renovations or extensions. (Low priority)

Earthquake strategy 3: Conduct an audit of all Council buildings and where appropriate retrofit all those deemed to be potentially unsafe in an earthquake of Richter magnitude 5.0 or greater. (Low priority)

Earthquake strategy 4: Educate the public about what to do in an earthquake. (Medium priority)

6. CONCLUSIONS

The overall risks posed to the population of the study area are relatively small and experienced infrequently. The threat to life is generally low if people take notice of warnings and respond in an appropriate manner. Most fatalities tend to occur when people do not take notice of warnings or engage in inappropriate behaviour. Flash flood and stormwater surcharge and destructive winds associated with severe storms represent the most significant threats to urban property and bushfire remains a threat to rural property.

Many of these risks were recognised by the two former Councils and each took steps to reduce those risks, mainly through structural activities. By adopting the non-structural strategies identified in this study the New Townsville City Council will go a long way to further reducing the risks posed by natural hazards to a level that is as low as reasonably practicable in all but the most extreme events. Their adoption will make Townsville City a safer and more sustainable community.

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APPENDIX A: DEFININTIONS OF CONSEQUENCES

DESCRIPTOR	PEOPLE	PROPERTY, ENVIRONMENT, ECONOMY
Insignificant	No injuries or fatalities*; **and** Few if any people are displaced** and then only for short duration; **and** Little or no personal support required (support not monetary or material).	Inconsequential or no damage; **and** Little or no disruption to community; **and** No measurable impact on environment; **and** Little or no financial loss.
Minor	Small number of injuries but no fatalities*. First aid treatment required; **or** Some displacement** of people within the community (less than 24 hrs); **or** Some personal support required.	Some damage that is easily repaired with some disruptions (less than 24 hours); **or** Small impact on the environment but with no lasting effects; **or** Some financial loss.
Moderate	A small number of fatalities* possible, medical treatment required with some hospitalisations; **or** Localised displacement** of people within the community who return within 48 hours; **and** Personal support satisfied through local arrangements.	Localised damage that is rectified by routine arrangements. Normal community functioning with some inconvenience; **or** Some impact on the environment with no long-term effect or small impact on environment with long-term effect; **or** Significant financial loss leading to a small number of business failures and unemployment.
Major	Fatalities; **and/or** Extensive injuries, significant numbers hospitalised; **or** Large numbers of people displaced** within the community for up to a week; **and** External resources required for personal support.	Significant damage that is beyond the capacity of local resources and community only partially functioning; some services unavailable for a t least a week; **or** Some impact on environment with long-term effects including localised habitat destruction and possible extinctions; **or** Significant financial loss – some financial assistance required. Many business failures and much unemployment.
Catastrophic	Significant fatalities; **and/or** Large numbers of severe injuries and large numbers requiring hospitalisation for an extended period; **or** General and widespread displacement** of people to locations outside the community for an extended period.	Extensive damage requiring lengthy restoration; **or** Major impact on environment and/or permanent damage including local species extinctions; **or** Long term serious damage done to the local economy including business closures and extensive unemployment. Community unable to function without significant and lengthy external welfare support.

* does not include avoidable fatalities such as people who disregard warnings and place themselves in flood waters or other dangerous situations.
** displacement is taken to mean that people are not able to return to their normal place of residence until that place is made habitable.