November 2012

ERSA

Environmental Risk Science and Audit

SUMMARY REPORT

NATURAL HAZARD RISK ASSESSMENT FOR LOGAN CITY COUNCIL

for the Local Government Association of Queensland

ERSA 1023-3

INTRODUCTION

The Local Government Association of Queensland (LGAQ) commissioned Environmental Risk Science and Audit Pty Ltd (ERSA) to undertake a multi-hazard risk assessment of Logan City. This Summary Report has been prepared to explain the key assessment conclusions and strategies for improved disaster risk management.

Conclusions

Our assessment concludes that:

- the overall risks to the population are relatively small and infrequent
- heatwaves and bushfires pose the greatest threat to life
- floods and storms pose the most significant threats to property; and
- landslides, earthquakes and tsunami pose very little risk.

In reaching these conclusions, ERSA specialists worked with Logan City Council disaster managers, to identify the natural disaster hazards that are relevant to Logan City, and to consider the City's exposure and vulnerability to those hazards. A high degree of consensus was achieved in assessing and ranking the identified disaster risks.

The top four places in rank order alternate between bushfire, flood and heatwave. It is clear however that severe heatwave is a much more frequently occurring hazard than severe flood. Earthquakes clearly pose the lowest risk across all likely levels of severity while tsunamis pose virtually no risk because there is effectively no exposure.

Recommended strategies

ERSA identified 27 strategies that we consider will go a long way to eliminating the risks posed by all hazards throughout Logan City in all but the most extreme events. Adoption of the identified strategies will contribute to making Logan City a safer and more resilient community.

Contents of this Summary Report

This Summary Report contains:

- an explanation of the study approach an examination of the City and its natural hazards
- a review of the City's community elements that are potentially exposed and vulnerable to disaster impacts
- a summary of our assessment of risk; and
- recommendations for disaster risk management strategies for Logan City Council.

Further detail is provided in the full ERSA *Natural Hazard Risk Assessment for Logan City Council*.

OUR STUDY APPROACH

The approach adopted for this study follows the risk management process established in *AS/NZS ISO 31000-2009 Risk management - principles and guideline* (SA/SNZ, 2009).

Risk, Hazard, Exposure and Vulnerability

In particular, our approach adopts the idea that risk may be measured in terms of *consequences* and *likelihood*. 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.

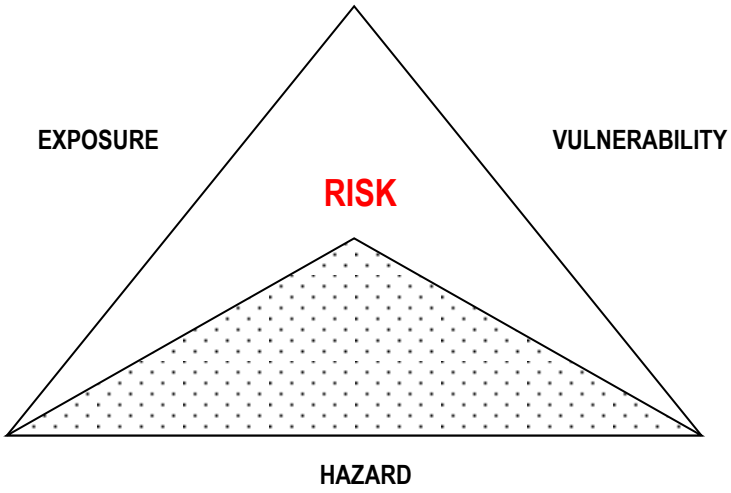

Figure 1: The risk-hazard-exposure-vulnerability relationship (after Crichton, 1999)

In Figure 1, the large triangle portrays each of the variables as making an equal contribution. The area of the triangle represents the magnitude of the resulting risk. Reducing the size of any one or more of the three contributing components may diminish the amount of risk.

In the smaller (shaded) triangle the risk has 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.

In order to ascertain relative risk, ERSA adopted a finer set of risk dimensions, described as follows:

- Frequency – (the same as 'likelihood') events that occur frequently are scored more highly than those that rarely occur.
- Seriousness – (essentially the same as 'consequences') events that have the potential for causing significant numbers of casualties and/or significant economic loss are scored more highly than those that produce few casualties or little loss.
- Manageability – those hazards that are difficult to control or manage by existing techniques, resources and warning systems are scored more highly than those that are more easy to manage.
- Awareness – hazards for which community understanding and awareness before the event have not led to active steps taken to reduce those risks are scored more highly than those for which risk reduction efforts have already been made. There are elements of voluntary versus involuntary risks in this assessment as well.
- Urgency – hazards that need to be addressed with some urgency because of a lack of preparedness, for example, are scored more highly 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 are scored more highly than those hazards that pose a more constant level of 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 are scored more highly than those that tend to be seen as either voluntary risks or as being 'acts of God'.

The Analysis

Application this approach allowed ERSA to:

- identify of the range of natural hazards that have the potential to impact on the Logan City and the analysis of the potential consequences of such impacts
- analyse of the complex nature of the Logan City built environment and the infrastructures that support the community together with their susceptibility to hazard impacts
- analyse the potential exposure of the Logan City population to the range of hazard impacts and their susceptibility to such exposure; and
- analyse the complex (and at times competing) jurisdictional relationships that exist in the administration of emergency/disaster management in Logan City.

Evaluation Criteria Adopted

To help develop strategies for improvement, ERSA needed to set 'desirable' performance thresholds.

While these thresholds were influenced by the 'design level' thresholds established in policies including SPP 1/03 and the Standard Building Code, practical performance thresholds, for all but the most extreme events, were set to:

- reduce, to an acceptable level, the risk of death or injury to emergency workers engaged in responding to any hazard impact
- reduce, to an acceptable level, the risk of death or injury to the general population
- reduce, to an acceptable level, the risk of destruction or damage to public infrastructure and facilities
- reduce, to an acceptable level, the risk of destruction or damage to private property
- minimise the long-term impact on the local economy; and
- manage the impact of natural hazards 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.

Other Considerations

This study has also considered the effect of the relevant legislative framework influencing disaster risk management and the significant work of others involved in disaster risk assessment and management in Logan City.

Disaster Response Capability

A range of legislation and standards has an influence on disaster risk management within the study area. 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'.

Previous Studies and Mitigation Action

The South East Queensland (SEQ) region has been the subject of numerous studies into a range of natural hazards, particularly tropical cyclones and their associated storm tide, destructive wind and flood hazards.

The most recent hazard studies undertaken for Logan City Council provide the foundation for this multi-hazard risk study. They are:

- *Natural hazards and the risks they pose to South-East Queensland* (Granger and Hayne, 2001) which covers Logan City and its neighbours (except Scenic Rim Region)
- *Logan City natural disaster risk management study draft report* (Landmarc, 2005)
- *Beaudesert Shire disaster risk management study* (Landmarc, 2004); *Beaudesert Shire bushfire risk management study* (IID, 2005)
- *Logan-Albert River food modelling and mapping study 2011* (Engeny Water Management, 2011); and
- *Logan City Bushfire Risk Management study draft* (Logan City Council, 2012).

LOGAN CITY AND ITS DISASTER HAZARDS

Logan City

The current boundaries of Logan City were established in 2008 as part of the State-wide series of council amalgamations and boundary adjustments (Figure 2). These amalgamations fundamentally changed the nature of Logan City from being an urban extension to Brisbane to being a future major growth centre with an extensive rural base. They enclose a total land area of approximately 960 square kilometres.

Logan City is bordered by Scenic Rim Regional in the south and south-west, Ipswich City in the north-west, Brisbane City in the north, Redland City in the north-east and Gold Coast City in the south-east.

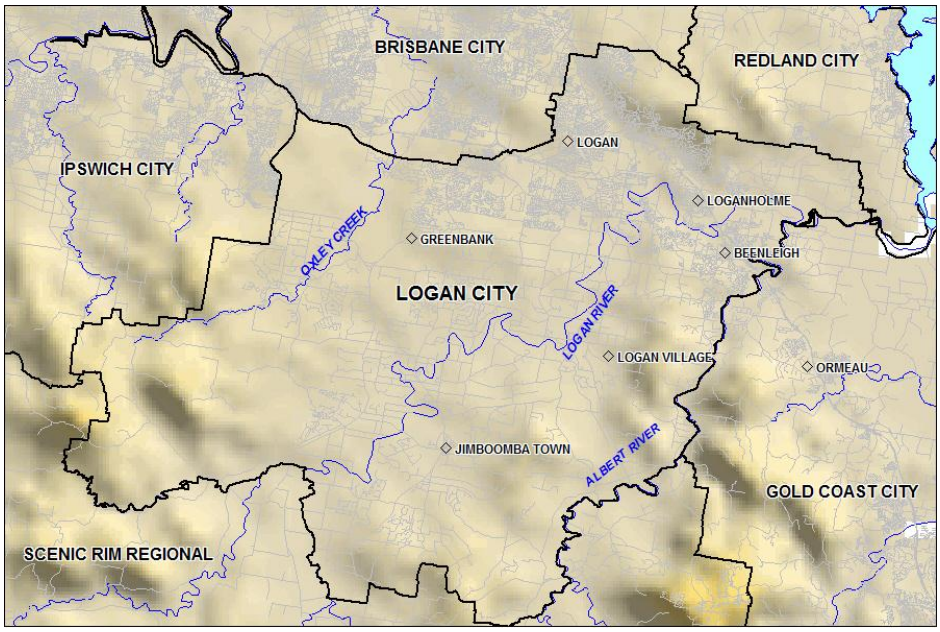

Figure 2: Logan City locality

Disaster Hazards Considered

In line with the LGAQ Terms of Reference and *Natural Disaster Response and Recovery Arrangements* (*NDRRA) Determination 2007*, this study considered the risks posed by the following natural hazards:

- tropical cyclones and severe storms (and their attendant phenomena of destructive winds, and torrential rain)
- floods
- bushfire
- landslide
- earthquake; and
- tsunami.

ERSA has also undertaken to analyse the risks posed to the Logan City community by heatwave, the most lethal of all natural hazards in Australia.

In addition, the likely effects of climate change on the frequency and severity of those hazards that have a climatic association were considered.

Tropical Cyclones, East Coast Lows and Severe Thunderstorms

The phenomena of tropical cyclones, east coast lows and severe thunderstorms each bring with them potentially destructive winds and intense rainfall. Thunderstorms also bring the potential for damaging hail and lightning strike. Each one of these forms of severe weather has had damaging impacts within Logan City.

Logan City has a long history of destructive impacts of tropical cyclones, east coast lows and severe thunderstorms. The destructive winds associated with these hazards probably represent the most significant and widespread threat to the Logan community's property.

Tropical Cyclone Recurrence

The national cyclone database shows that 71 cyclones have come to within 400 km of Logan[1] in the period from 1906 to 2006. Of these, 26 came to within 200 km and four to within 50 km. This gives a crude average recurrence interval of 0.7 cyclones a year coming within 400 km and 0.26 a year within 200 km.

There is considerable year-to-year variation in the occurrence of cyclones in SEQ.

East Coast Low Recurrence

The incidence of east coast lows is significantly greater than that of tropical cyclones in SEQ.

The incidence of these types of storms fluctuates quite widely from one year to the next, with none in some years and the highest incidence being twelve events in 1978/79. The long-term average annual recurrence is about 2.5 storms per year but since 1960 the average has increased to 3.7.

While the frequency of occurrence prior to 1960 will be affected to some extent by the lack of routine satellite coverage, the approximate doubling of frequency of storms over the past 30 years appears highly significant (Hopkins & Holland, 1997) and appears linked to broader climatic indices such as the SOI.

Severe Thunderstorm Recurrence

Analysis of storms within 150 km of Brisbane between 1967 and 1997 indicated an average annual occurrence of around 20 storms a year, and showed the following characteristics:

- on each of these days there are often up to 5 individual storm systems involved
- the thunderstorm 'season' is mainly October through April
- predominant approach direction is from the south-west

[1] A radius of 400 km is close enough for most cyclones to have a potentially damaging impact on the area.

- the typical forward speed of storms is 40 km/h
- approximately 30% of severe storm days involve severe hail; and
- tornadoes occur on average about 1 day per year in the region.

Floods

Put simply, floods are *water where and when it is not wanted*. Floods account for the largest amount of loss caused by natural hazards in Australia.

Logan City has a significant exposure to flood hazards, in both main stream rivers such as the Logan River and Albert River, and from flash flood in the smaller catchments, especially Scrubby Creek, Slacks Creek and Oxley Creek. Mainstream flooding from the various major creeks is less frequent than flash flooding and storm water surcharge.

Flash Floods

While main stream flooding is the most commonly analysed form of flood hazard, in Logan City, it is the flash flooding and storm water surcharge in smaller streams and sub-catchments that has been demonstrated to be the most frequent problem.

The Catchments

The major catchments of Logan City are the Logan and Albert Rivers, which flow to Moreton Bay, and Oxley Creek, which flows to the Brisbane River. The Logan River rises in the Macpherson Range and flows through Scenic Rim Region before entering Logan City at its junction with Teviot Brook. Scrubby Creek is a significant tributary of the Logan River in its northern reaches.

Records of large floods in the Logan and Albert Rivers extend back as far as 1855. Since then there have been several major flood events; however, the record before 1974 is rather fragmentary. Most of these events are reported from the areas now located within Logan City. The incidence of flood in the Logan catchment recorded at Waterford is illustrated in Figure 3 and the extent of the modelled 100 year ARI flood across all catchments is shown in Figure 4.

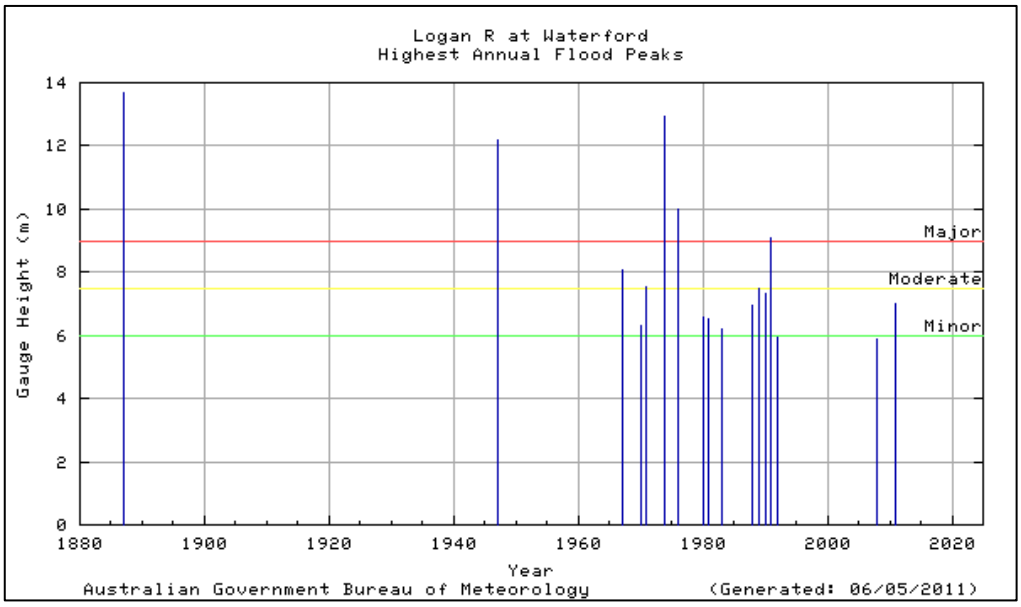

Figure 3: Historic flood peaks in the Logan River at Waterford (BoM data)

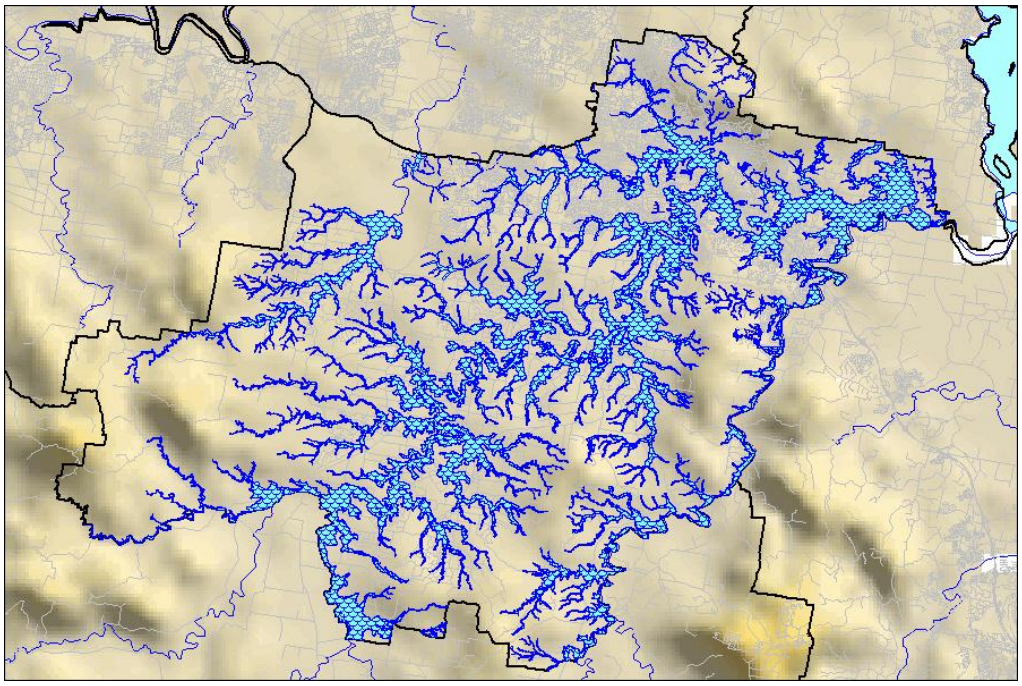

Figure 4: Extent of the modelled 100 year ARI flood (LCC data)

Landslides

Logan has a limited landslide hazard that is confined to well-identified zones of steeper slopes and slip-prone soils.

Factors in Landslide Hazard

The landslide process is complex and involves a range of factors including the underlying geology and soils, slope, geomorphology, drainage and vegetation status (cleared or uncleared). *Any landslide risk assessment cannot be based on slope angle alone.*

Rainfall is clearly the most common trigger for landslides and the more widespread the rainfall - as with a tropical cyclone or east coast low - the more widespread will be the occurrence of landslides. Conversely, the more localised the rainfall, the more localised will be the landslide occurrence.

Developed slopes, such as road cuttings and benched house sites, tend to be more susceptible to landslide than natural slopes but hazards can generally be mitigated by carrying out the development with appropriate geotechnical advice.

Bushfire

Logan City has a significant potential bushfire hazard, primarily in its bush interface areas.

Bushfire Hazard Mapping

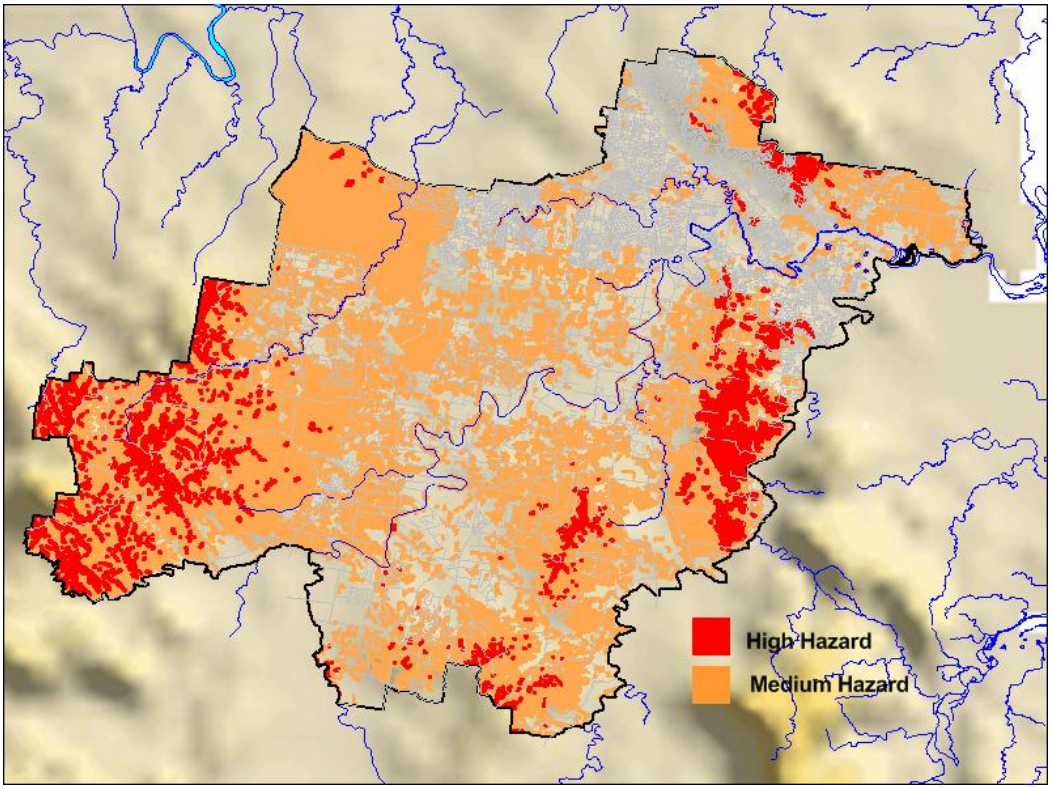

Figure 5: Logan City bushfire hazard (QFRA data)

Logan City Council has incorporated a 'bushfire-prone land' hazard layer into their planning scheme based on mapping produced by QFRA but which combines the high and medium hazard zones buffered according to SPP 1/03 into a single zone. The original QFRA mapping buffered to the SPP 1/03 requirement is shown in Figure 5. The QFRA mapping was undertaken at a resolution of 25 m.

Earthquake

Based on the historical record, Logan City has a low level of earthquake hazard.

Earthquake effects

Earthquake effects are 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 Logan City. Within a square, the boundaries of which are approximately 500 km from Logan Central, the *National Earthquake Database* contains records of almost 800 earthquakes, the earliest of which was on 27 January 1841, a M_L 4.9 event located in the New England area of NSW, whilst the largest on record was the M_L 6.0 event of 6 June 1918 located off Bundaberg.

Interestingly, there is only one epicentre in this database that is actually located within Logan City itself – a barely noticeable M_L 0.7 event on 6 August 1992, located close to the Logan River in Loganholme.

Effects on Buildings

Earthquake engineers tend to argue that earthquakes do not kill people – poorly designed and constructed buildings kill people. In extreme cases total collapse can occur, injuring or killing the occupants. People can also be killed or injured by falling debris as they run outside during an earthquake. Building damage can also occur where buildings are sited on soft sandy soils that are prone to liquefaction, thus damaging building foundations.

Damage to in-ground infrastructure such as water pipe networks can also occur as the result of both ground movement, particularly if the pipeline crosses the fault that moved, and liquefaction. Earthquakes can also generate secondary hazards such as fires and damage to hazardous materials storage facilities.

Tsunami

In historic times no large tsunami has been recorded within Moreton Bay and the coastline adjacent to Logan City. In the unlikely event of a significant tsunami impact along the SEQ coastline, the only area of the City that may have some exposure would be in the lower reaches of the Logan River and here the effects would be very small.

Heatwave

Heatwave is usually seen as a public health issue. Nevertheless, heatwave is clearly the most lethal of all natural hazards in Australia, probably killing more people than all other natural hazards combined (Coates, 1996). No point within Logan City is immune from heatwave conditions.

Heatwave in SEQ

The historic records of fatalities caused directly or indirectly by heatwave have been reported in the SEQ region since at least 1857 (Granger, 2005). Perhaps the most severe heatwave, in terms of fatalities, occurred between 25 and 30 January 1940, when at least 52 people died across the SEQ region.

Most recently, between 19 and 21 January 2000, heatwave conditions contributed to the death of 22 people in the SEQ region and hospitalised a further 595 over three days, and in a six-day episode during February 2004, heat contributed to the death of at least 12 people and hospitalised 221 (QH, 2004). The victims of these recent episodes died of heat-associated stress, with most of the victims being elderly residents of the region's urban centres, many of whom lived alone.

The period from November to March carries the greatest likelihood of potential heatwave conditions, with the period December to March carrying the greatest level of hazard. However, dangerously high temperatures have been experienced in the region as early as September and as late as April. No point within Logan City is immune from heatwave conditions.

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.

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.

LOGAN CITY EXPOSURE AND VULNERABILITY

The next step in the process of assessing the risks posed by natural hazards to Logan City is 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.

Six elements of exposure and vulnerability are discussed here:

- developed properties
- populations
- critical infrastructure
- the economy
- the environment; and
- institutional arrangements.

Developed Properties

Detailed mapping of the developed properties (i.e. properties on which houses, businesses, schools, etc. have been constructed) was undertaken to facilitate the measurement of exposure to the different hazards. There were 98,540 residential properties, 3348 commercial properties, 1205 sensitive properties and 258 critical properties included.

On this analysis, residential properties represent by far the greatest proportion (95.3%) of the number of developed properties in the City.

Building Age

As a general rule the older the building the more susceptible it is likely to be to severe wind or earthquake impact. This is in part because of the steady upgrading of standards designed to make buildings more resilient to these hazards; and in part because of changes in the style and materials used in construction.

No detailed data are available to identify building age across the City. Field observation suggests that perhaps more than three-quarters of residential buildings were constructed since 1979.

Population

At the 2011 census, the population of Logan City was 278,106. This population was concentrated within the City's suburban areas. The smaller rural centres such as Jimboomba. and their surrounding rural and rural residential areas, make up only 18% of the total population.

Community Vulnerability Index

For whatever reason, there will always be people within the community that are more susceptible to the effects of a natural hazard than others. The very young and the elderly or the disabled, for example, are groups that are likely to be physically more susceptible to disaster impact than older children or more youthful adults. Others will be less able to cope economically, less able to self-evacuate, or have only limited awareness of the risks.

The study employed an indexation analytical model to assess community vulnerability, shown in Figure 6.

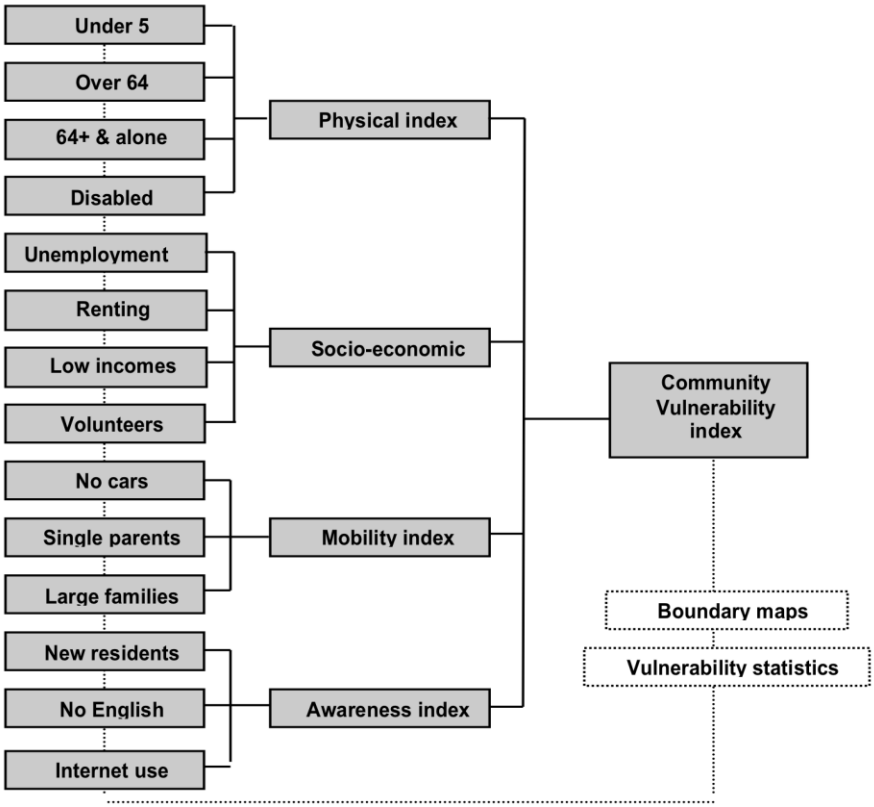

Figure 6: Community vulnerability analysis model.

The highest concentration of the more vulnerable communities are concentrated in the more densely urbanised areas around Logan Central, while the more resilient areas tend to be the rural communities.

Critical Infrastructure

The well-being and safety of the community is also dependant on a range of critical (or lifeline) infrastructure networks. For Logan City, these include the road network (2250km), the rail network (42.75km), power reticulation, water reticulation (2080 km of mains), sewerage reticulation (2008 km), telecommunications services; and logistic support facilities (e.g. fuel and food supply).

There is a significant degree of interdependence between the disaster hazard impacts on these critical infrastructures. For example, loss of power supply will have a significant impact on water supply, communications, fuel supply and food availability.

Construction Standards and Age of Infrastructure

A wide range of engineering standards 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.

The Economy

The economy of the Logan City is based firmly on service industries with the largest employers being from the manufacturing, retail trade, construction, and health care sectors.

Natural disasters affect economies in two ways. They destroy capital stock (homes, roads, factories, pipelines), not all of which is covered by insurance, and they disrupt the ordinary flow of production and consumption. A key determinant in the magnitude of economic loss is the length of time it takes to recover from the loss and/or to return to production.

When disasters strike there are short, medium and long term consequences to any community, especially those that rely on single industries like agriculture and tourism.

The Environment

The lengthy period of European occupation of the region has seen around 40% of the native vegetation removed or greatly modified. Significant areas of largely undisturbed vegetation are preserved in the City's National Parks and Conservation Parks as well as the large area occupied by the Greenbank Military Camp.

The City retains a wide range of terrestrial and aquatic fauna. They range from the larger mammals such as kangaroo; to medium mammals such as koala and possum; and small mammals such as gliders, bandicoots and bats. There are perhaps 400 species of birds recorded as being found in the City, many of them migratory.

Disasters that result in loss of habitat, either by too-frequent fire, or by the exclusion of fire, may have a longer-term impact, and species can/will be lost to the area.

Institutional Arrangements

Throughout the study a number of indicators of institutional vulnerability were identified. Of these, the lack of a well-integrated information infrastructure suitable to support emergency risk analysis has been most notable.

Information Culture

So-called 'silos' of information exist in various agencies and sections of agencies such as the City Council. The degree to which those silos can be quickly connected appears to be around the local government average. This was evident to some degree with spatial information used in this study's GIS analysis.

ANALYSIS OF THE RISKS

Table 1 shows the top 11 ranked disaster hazards. The top four places in rank order alternate between bushfire, flood and heatwave. It is clear however that severe heatwave is a much more frequently occurring hazard than severe flood. The (full) comparison of all hazards considered is contained in the full ERSA assessment.

Table 1. Logan City top 11 disaster risk comparison (subset of the full comparison)

HAZARD	FREQUENCY	SERIOUSNESS	MANAGEABILITY	AWARENESS	URGENCY	GROWTH	OUTRAGE	SCORE
Extreme fire danger	3	5	5	3	3	3	5	**27**
500 year ARI flood	2	4	4	4	4	3	5	**26**
6-day heatwave	3	5	4	4	3	3	4	**26**
4-day heatwave	4	4	3	4	3	3	3	**24**
100 year ARI flood	3	3	3	3	4	3	4	**23**
2-day heatwave	4	4	3	3	2	2	3	**21**
Severe fire danger	4	2	3	3	2	2	2	**18**
Severe storm	2	4	3	2	2	3	2	**18**
Extended heavy rain landslide	4	2	3	3	2	2	2	**18**
Category 3 cyclone	2	4	3	2	2	3	2	**18**
Category 2 cyclone	3	3	2	2	2	3	2	**17**

Tropical Cyclones and Severe Thunderstorm Risks

The widest exposure to all of the hazards considered in this study, apart from heatwave, is to the severe winds brought by tropical cyclones, east coast lows and severe thunderstorms. Whilst no area of the region is immune from the impact of destructive winds, there are some areas that have an elevated level of exposure.

ERSA's modelling indicates that the risks posed by the destructive winds of severe storms on a City-wide basis is relatively low given the low frequency of severe cyclone impacts in the area. The risks posted by the much more localised impact of severe thunderstorm wind and hail is marginally higher because of the limited footprint of such events.

Flood Risks

Floods are potentially amongst the most damaging of the single-event hazards encountered in Logan City. Fortunately, the more frequently occurring levels of flood produce inconvenience rather than disaster.

Council's greatest exposure to most floods is with the storm water drainage network and roads for which it is responsible. These will inevitably suffer some damage, from the flood waters themselves. Roads will also be subject to damage from being used by heavy vehicles before they have adequately dried out.

Floods approaching the extremely rare 'probable maximum flood' levels would be devastating and potentially lead to significant loss of life and extensive property loss.

It is perhaps fortunate that much of the development within Logan City occurred after the major flooding of 1974 so that subsequent floodplain development has been limited. The risks posed by flood, on a City-wide basis, is moderate given the medium frequency of the more severe floods and the fact that most development has avoided the major floodplains. Nonetheless, it is clear, that the Logan River poses the greatest level of risk. Flash flooding in both Oxley Creek and Scrubby Creek remains a concern.

Landslide Risks

The hill-slope areas of the City have a history of minor landslides on cut slopes along the road network. Whilst a major rainfall event may give rise to multiple landslides, the vast majority occur in isolated and undeveloped areas. The risks to people, buildings and infrastructure are, consequently, relatively limited – though the direct impact of a landslide is invariably damaging and potentially lethal.

Bushfire Risks

The principal ingredients for bushfires are the availability of ample fuel and the incidence of 'fire weather'. The types of vegetation that can produce such fuels are found in broad areas of the City. Whilst fire is commonly used as a land management tool in rural areas, and communities in those areas are very familiar with the hazard and how to manage it, its management in more closely settled areas, however, is more problematical given a greater level of unfamiliarity with fuel management or fire control.

There is very little threat to suburban communities, but the risks posed by bushfire in rural residential areas can be considerable. Fire fighters are the most likely people to be injured or killed by bushfire.

The risks posed by large-scale bushfires are relatively high given that most such events are likely to occur in the areas dominated by rural residential development on the growth edges of the City. The risks posed by the much more localised impact of bushfires are marginally higher where they are located within the interface zone between the bush and urban development.

Earthquake Risks

The historical evidence suggests that whilst the impact of earthquakes may be experienced in all parts of the City, they pose a relatively low level of risk overall.

The risks posed by earthquakes are relatively low across the City but clearly highest in Logan East D6/10, particularly with the older masonry in Beenleigh.

Tsunami Risks

Given the rarity of significant tsunami and the minimal extent of exposure, tsunamis pose negligible risk to Logan City.

Heatwave Risks

Heatwaves are undoubtedly the most significant hazard in terms of its direct threat to life and health. The key factors that determine the magnitude of the risk are the senior citizens (i.e. especially those over 84 years of age) and the older buildings which have generally poor thermal properties. Agriculture and construction workers, which together make up 20% of the Logan City workforce, also carry a heightened risk due to the outside nature of their employment.

The risks posed by heatwaves across Logan City are generally much higher than generally recognised.

Risks Comparison

Much of the analysis of the risks posed by the six hazards described above is, fortunately, hypothetical or theoretical because the Logan City has had a rather benign history of major hazard impacts, the more recent exception being the devastating 2011 floods. Nonetheless, it is possible, using the knowledge of the various hazard phenomena and the experience of other communities in Australia and elsewhere, to make reasonable estimates of the 'what if' consequences of a wide range of event severities and recurrence intervals.

It is common to rate the severity of the risks posed by either the number of people killed or injured or the economic cost of the event. Both approaches are considered here.

Personal Risk

The hazard with the most significant risk of a death toll is heatwave. Rather than producing large numbers of fatalities in a single event, heatwave kills relatively small numbers of people in each event, but there are frequent events over time. It is conceivable that more than 5 fatalities and as many as 50 hospitalisations due primarily to heatwave conditions can occur in the Logan City in heatwaves of a severity that has an ARI of 10 years and a death toll of more than 10 people and 80 hospitalisations in events with an ARI of more than 25 years. The projected climate change effects are likely to reduce those recurrence intervals by as much as four times.

Severe storms, floods and bushfires appear to have roughly the same potential for producing fatalities with similar recurrence intervals. What makes them especially significant is that emergency workers (SES in the case of storms and floods and QFRS in the case of bushfires) are likely to be the most at risk. The average death toll over a decade would, however, be probably less than 5 for each hazard, though in extreme events (those with ARI of 100 years or greater) the death toll could be much greater.

Landslides probably pose a limited threat to people but their relative frequency of occurrence places them ahead of earthquakes based on the Australian record of natural hazard experience.

Economic Cost

Statistics compiled for the most recent report, by 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 in 1999 dollars) was flood ($111.7 million), followed by cyclones ($89.9 million) and severe storms ($37.3 million), with bush fires occupying a distant fourth place ($0.4 million). While reports

indicate that costs of recent events may be an order of magnitude higher that the study period, the comparison of relative cost between natural hazards is still considered reasonable.

TREATING THE RISKS

ERSA recommends 27 strategies that are considered likely to go a long way in eliminating the risks posed by all hazards throughout Logan City in all but the most extreme events. Put simply, the adoption of the identified strategies will contribute to making the Logan City a safer and more resilient community.

Priority for Adoption

ERSA has also identified priority for adoption of the 27 strategies as follows:

- high – should be commenced within 6 months
- medium – should be commenced within 12 months
- low – should be commenced within 18 to 24 months.

The High Priority Strategies

The following list summarises the 14 High Priority Strategies that ERSA recommends should be commenced within six months:

- Generic strategy 5: The LDMG consider activating the local EOC in response to the more frequently occurring lower-level emergency situations to expand the experience of members and their agencies of providing a 'significant and coordinated multi-agency response'.
- Generic strategy 7: Before the onset of the annual storm season the LDMG 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. As part of that update, the LDMG should seek engineering advice as to the suitability of buildings designated as evacuation centres under all potential circumstances.
- Generic strategy 8: Logan City DMU and LCC welfare staff liaise with the retirement villages with regard to their emergency planning and evacuation arrangements.
- Storm strategy 1: Council conduct its annual community cleanup campaign and free dumping strategies immediately ahead of the storm season.
- Storm strategy 3: Council, in consultation with the asbestos disposal industry, maintain a plan for the management of broken fibro and other asbestos-based products following storm damage and identify appropriate disposal sites.
- Storm strategy 4: Council ensure that power supply in all new subdivisions is placed underground.
- Flood strategy 1: 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.
- Flood strategy 2: Council record 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.

- Fire strategy 1: Council, with the assistance of QFRS, conduct an annual audit of fuel conditions on Council-controlled land.
- Fire strategy 2: Based on the results of that audit, Council allocate adequate human and equipment resources 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.
- Fire strategy 4: The LDMG consider formation of the Logan City Fire Management Committee with representation from QPWS, Defence, Powerlink and Energex as a sub-committee of the LDMG.
- Fire strategy 5: Council encourage QFRS to install and maintain prominent 'fire danger' signage in urban interface areas to improve community awareness in periods of elevated fire danger.
- Heatwave strategy 1: The LDMG develop a heatwave risk response sub-plan under the LDMP and ensure that all LDMG member agencies are alerted when a heat weather warning is issued by BoM.
- Heatwave strategy 2: The LDMG Welfare Committee maintain contact with other welfare sector agencies such as Meals on Wheels with knowledge of elderly or disabled residents who are living alone and who are particularly vulnerable to the impact of heatwave conditions.

Conclusions

The overall risks posed to the population of Logan City are relatively small and infrequent. Heatwave and bushfires pose the greatest threat to life, with floods and storms representing the most significant threats to property.

By adopting the strategies outlined above, the Logan City Council will go a long way to eliminating the risks posed by all hazards throughout the City in all but the most extreme events. Their adoption will also make Logan City a safer and more resilient community.