STORM HAZARD AND RISK IN NEW SOUTH WALES

Supporting Document to the NSW State Storm Plan

APRIL 2018

PART 1 - TYPES OF SEVERE WEATHER AND THEIR IMPACTS IN NEW SOUTH WALES

1.1 GENERAL

1.1.1 Many different types of weather systems can produce storms which cause danger, damage and disruption in New South Wales (NSW). In terms of property damage, storms cause greater losses to the community than any other single hazard agent in NSW. The Australian Business Roundtable for Disaster Resilience and Safer Communities estimated that of the total average annual economic cost for natural disasters in NSW (being $3.2 billion), Storms made up 49%, Hail 17% and Cyclones 7% (Total 73%) of the total costs over the period from 2007 to 2016 (1). The most damaging storm in New South Wales history remains the April 1999 Sydney hailstorm (1).

1.1.2 Deaths occur as a result of storms. On average, about four people in the state die each year because of their direct effects (for example, lightning strikes and fallen trees, flash flooding) but there are additional deaths caused by indirect effects (for example, those relating to hazardous driving conditions on roads).

1.1.3 Different types of storm activity may occur in association with each other. The following paragraphs describe the different sorts of weather systems associated with severe and potentially damaging storms and briefly outlines the kinds of damage which tends to occur.

1.1.4 Climate change modelling suggests that there are likely to be little change in average rainfall across the state by 2030, with large seasonal differences.

1.1.5 The frequency of coastal flooding may increase as a consequence of sea level rise and the potential increased frequency of storm surge events, particularly as the events coincide.

1.1.6 Risks to population and infrastructure are likely to increase as a consequence of sea level rise and the increased severity and frequency of storms and coastal flooding.

1.2 THUNDERSTORMS

1.2.1 Severe thunderstorms are the most common and most damaging storm agents in New South Wales, accounting for the great bulk of the total cost of damage. They are relatively small-scale systems, with damage often only affecting areas a few kilometres across, and they have short life spans ranging from tens of minutes up to several hours. One class of thunderstorms known as a ‘supercell’ is particularly severe with life spans up to six hours or so and extensive damage tracks. The severe thunderstorm of 21 January 1991, for example, had a hail and damage path around 10km wide and over 40 kilometres long.

1. Deloitte Access Economics. Building Resilience to Natural Disasters in our States and Territories: Australian Business Roundtable for Disaster Resilience and Safer Communities, November 2017.

1.2.2 Although severe thunderstorms can occur at any time, the distribution of events by season shows a definite pattern. There is a marked tendency for severe thunderstorms (indeed all thunderstorms) to occur during the months from October through to March. This period is normally referred to as the 'Severe Thunderstorm Season' in New South Wales. The increase in storm frequency during this period is primarily due to the increase in energy provided by the sun during the warmer spring and summer months, coupled with spring and summer weather patterns that are favourable for storm growth.

1.2.3 The products of severe thunderstorms may be very strong winds (at least 90 km/h and sometimes greater than 200 km/h), tornadoes (see separate heading), large hail (at least 2cm in diameter and sometimes exceeding the size of cricket balls) and very heavy rain (leading to flash flooding, especially in urban areas when artificial drainage systems surcharge). Of these products, hail has been most damaging to property whilst strong winds, flash flooding and tornadoes pose the greatest threat to life.

1.2.4 Severe thunderstorms can cause severe damage to buildings, especially to roofs and windows, and may demolish whole buildings as a result of trees being blown over or having their trunks snapped. Damage also is caused to cars parked on streets and in commercial car yards, especially as a result of hail, and downed power and telephone lines are common. In some cases, people have been without electricity and telephone services for several days.

1.3 TORNADOES

1.3.1 Tornadoes are extremely damaging weather phenomena that occur in conjunction with some severe thunderstorms. A tornado itself is an intense, localised, funnel-shaped vortex that extends from the thunderstorm cloud base to the ground. Tornadoes range in size from a few tens of metres across up to around one kilometre in diameter. Because of their relatively small size, damage is normally restricted to a small area but it can be very intense and may include the complete destruction of buildings.

1.3.2 Most tornadoes in New South Wales occur in late spring and summer but they have been known to occur at all times of the year. They are most likely to be associated with supercell severe thunderstorms or with thunderstorms embedded within regions of strong wind shear in East Coast Low storms or tropical cyclones.

1.3.3 Tornadoes have been reported across NSW including Sydney, Bulahdelah, Port Macquarie, Cobar, Gilgandra, Dubbo, Moree, Tumbarumba, Merimbula, Pambula, Tucabia, Kiama and Mulwala. In some of these events, buildings have been demolished by the extreme winds which can range from 120 km/h to above 400 km/h in very rare cases.

1.4 TROPICAL CYCLONES AND EX-TROPICAL CYCLONES

1.4.1 Tropical Cyclones develop over very warm tropical waters from pre-existing tropical weather disturbances. They have relatively long life cycles, of the order of up to about two weeks. Tropical Cyclones and ex-tropical cyclones produce very strong winds, embedded tornadoes, flooding rains, very high seas and storm surges. High seas and storm surges may cause erosion of sand dunes and in severe cases may expose landward areas to sea water inundation.

1.4.2 Tropical cyclones have affected New South Wales in various ways over the past century with five making direct landfall and many others impacting the State as ex-tropical cyclones after moving overland through Queensland.

1.4.3 The northern parts of the state, especially the coastal areas, are the most affected, but the impacts of these systems can extend as far south as Sydney. Examples of land falling cyclones include Tropical Cyclones Nancy (February 1990) and Beatrice (January 1959), which both crossed the New South Wales coast at Byron Bay as category 2 systems. Examples of ex-Tropical cyclone impacts include Debbie in 2017 which tracked into NSW from Queensland causing widespread rainfalls and flooding in Northern NSW, Zoe which crossed at Coolangatta/Tweed Heads in March 1974, Violet which caused very high seas between Coffs Harbour and Ballina in March 1996 and flash flooding in coastal areas and Oswald (January 2013) which produced significant flooding and spawned several tornadoes as it moved through Queensland into northern NSW. Tropical Cyclone No.137 made landfall on the Gold Coast in February 1954 before moving southwards into New South Wales causing disastrous floods and claiming 30 lives.

1.4.4 Within the Australian Government Bureau of Meteorology, the Brisbane Tropical Cyclone Warning Centre maintains a cyclone warning service for New South Wales down to Taree (32o south) but may extend warnings further south in some situations. Cyclone warning services are also provided for Lord Howe Island.

1.5 MID-LATITUDE LOW-PRESSURE SYSTEMS (INCLUDING EAST COAST LOWS)

1.5.1 More frequent visitors to coastal New South Wales are intense low-pressure systems known as East Coast Low-Pressure Systems. As a rule, these storms generally have much shorter lifetimes than Tropical Cyclones, usually of the order of only a day or two. They generally develop over the Tasman Sea close to the coast and often intensify dramatically overnight. They have a compact size and deep low-pressure centre, and like Tropical Cyclones can produce gale to storm-force winds, heavy rainfall and in some cases very high seas and storm surges. Erosion of sand dunes and the inundation of land by sea water may occur.

1.5.2 Examples of East Coast Low storms include:

a. the April 2015 storms which comprised two successive East Coast Lows within a 3 week period. This was the most severe East Coast Low setup since 2007. The first low caused widespread rainfall, priming catchments in south eastern NSW. The second of the lows formed off the Hunter coast, staying near stationary and causing severe weather across the Sydney and

Hunter regions. High localised rainfall up to 436 mm two day totals at Maitland and prolonged severe winds caused very widespread damage to power distribution and in turn telecommunications networks as well as fatal and damaging flash flooding in Maitland, Dungog, Greta and Stroud.

b. the “Queens Birthday Storm” of June 2007 that saw torrential rain, 9 deaths and the grounding of the bulk carrier “Pasha Bulker” at Newcastle; and

c. the August 1986 storm which brought Sydney’s highest ever 24-hour rainfall of 327.6mm

d. the “Sygna Storm” of May 1974 that produced a 165 km/h wind gust at Nobby’s Head and beached a 30,000 tonne coal carrier on Stockton Beach;

1.5.3 Due to their relative fast development and short life cycle, warnings issued for East Coast Lows will usually have less lead time than their tropical counterparts. Typically, a land gale warning will provide 6-24 hours lead time of winds expected to average at least 65 km/h over land or gust over 90km/h. Routine forecasts issued by the Australian Government Bureau of Meteorology may also mention locally heavy rainfall and strong winds and dangerous surf in the lead-up to a significant event.

1.5.4 More distant low pressure systems can create hazardous conditions along foreshores as large swells can extend many thousands of kilometres from their generation zone.

1.6 LOW PRESSURE TROUGHS

1.6.1 Regions of low pressure that do not possess a closed circulation are known as low-pressure troughs. Although they lack the strong winds typical of cyclones and east coast lows, these systems are often the focus for thunderstorms and rain.

1.6.2 Troughs on or near the east coast, combined with very strong onshore winds, have been responsible for very severe flash flooding events such as at Coffs Harbour in November 1996 and Wollongong in August 1998.

1.7 COLD FRONTS AND SOUTHERLY BUSTERS

1.7.1 Frontal activity can produce strong winds that generally shift from the west or northwest around to the southwest as they pass a location. They are often the focus of thunderstorms. On hot, dry and windy days, fronts can pose serious problems in the control of bush fires as they sweep narrow fire flanks into raging fire fronts. Frontal passages are a feature of all months but are more prevalent during Winter and Spring.

1.7.2 Southerly Busters are quite common during the warmer months. They produce shallower wind changes that mostly affect coastal locations in the South Coast, Illawarra, Metropolitan and Hunter districts. Winds following a southerly buster can be strong and gusty for several hours with peak wind gusts of around 90-100 km/h. The strongest on record is 113 km/h in December 1948. In January 2001 a strong southerly buster with a maximum gust of 100 km/h caused blackouts, property damage and uprooted trees over a large part of Sydney, resulting in one death and over 2000 NSW SES requests for assistance.

1.8 COLD OUTBREAKS

1.8.1 At times from late autumn through to early spring, significant outbreaks of cold air advance northwards over New South Wales resulting in unseasonably cold temperatures and snowfalls on the ranges, sometimes as far north as the Queensland border. These conditions produce snow and ice-related problems on roads over the ranges although they seldom result in deep snow conditions. Vehicles can be stranded on roads which are impassable and communities can be isolated for hours or days.

1.8.2 Widespread snowfalls and blizzard conditions are most commonly associated with persistent north westerly winds over the New South Wales Alps. These result in heavy accumulations of snow rather than mere showery falls that occur during a true cold outbreak. Areas in the Alps can be cut off for several days by heavy snowfalls. Examples of such events are July 1965 and August 2005.

PART 2 - COASTAL EROSION

2.1 GENERAL

2.1.1 Adverse weather systems can produce storms that generate strong winds, large waves and elevated ocean water levels along the NSW coastline. These conditions are generally short-lived but can result in extensive erosion along sandy beaches and seawater inundation where wave run-up overtops coastal dunes or sea defence barriers.

2.1.2 Large waves coinciding with elevated ocean water levels commonly results in conditions likely to result in erosion of beaches and inundation by the ocean. During storms, ocean water levels can be significantly elevated above the predicted astronomical tide, particularly due to the combined influences of strong winds (wind setup) and lowering of barometric pressure (barometric setup). The combination of wind setup and barometric setup is more commonly referred to as "storm surge". In NSW, storm surges exceeding 50cm have been measured during extreme storm conditions.

2.1.3 Storm surge in NSW occurs as a result of intense low pressure systems offshore of the NSW coast. These low pressure systems include tropical cyclones, ex-tropical cyclones and east coast lows.

2.2 COASTAL EROSION

2.2.1 Erosion is part of the natural response of a beach to changing wave and water level conditions. Storm wave attack can move significant quantities of sand offshore. The volume of unconsolidated (or sandy) material removed from a beach during an erosion event is commonly termed a "storm bite" or "storm demand".

2.2.2 The extent of beach erosion during a particular storm event depends upon a variety of factors that include (but are not limited to):

a. The wave conditions and elevated water levels generated by the storm;

b. The presence of rip cells;

c. The condition of the beach;

d. The condition of dune vegetation which can influence the volume of sand in the dunes which help to buffer the effects of storm erosion; and

e. The presence and influence of adjacent headlands and coastal and offshore structures, which can modify local wave conditions and the supply of sediment.

2.2.3 Storm waves undercut the beach berm and frontal dune to form a pronounced erosion escarpment. Fore dunes along the open coast of NSW have been measured to retreat by up to 20m after a single extreme ocean storm event or series of closely spaced storms. The pronounced lowering of the beach berm during beach erosion events can expose rock outcrops and historical protection works which are normally buried and result in a high, near vertical erosion escarpment formed at the back of the beach.

2.2.4 Over time, near vertical erosion escarpments will slump typically to an angle of repose of between 30 and 35 degrees. Instability of the escarpment may pose a hazard to beach users following storms with recorded instances of children and beach users buried by the collapsing sand face.

2.2.5 Buildings and facilities located within the "active" beach system, or area subject to erosion, could be undermined, and if not designed for this hazard, may collapse. In addition to the primary threat posed by erosion of the frontal dune, the remaining dune system immediately landward of an erosion escarpment will be subjected to a zone of reduced foundation capacity, the extent of which will generally be dependent on the height of the dune and the physical properties of the underlying soil mass.

2.2.6 After storms pass, the sand that has been eroded and transported offshore is generally not lost from the overall beach system. The sand is gradually returned back onshore following the storm by lower swell waves. On beaches which are in 'long term equilibrium', the amount of sand which returns to the beach is equal to the amount eroded during the storm. However, for a beach which is experiencing long term recession, the sand may not all be returned with an erosion scarp typically moving landward over time in response to storm activity.