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FLOOD RISK IN SOUTH EAST QUEENSLAND, AUSTRALIA

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Abstract

Geographical information systems (GIS) have been used to model building flood damage in South East Queensland. The research shows that if a flood with a 1% annual exceedence probability (AEP) occurred simultaneously in all rivers in the region, 47,000 properties would be inundated, with about half of the properties likely to experience overfloor flooding. Ninety percent of affected properties are located in the Brisbane-Bremer River system and the Gold Coast catchment. Eighty-nine percent of properties affected by flooding are residential. Nearly 60% of the residential flood damage is located in the Brisbane-Bremer River system, with damage estimated to be highest in those areas which historically have suffered high flood losses. Equivalent average damage per residential building is highest in the Gold Coast catchment. If the cost of the actual damages were to be spread among all residential buildings in South East Queensland, than the equivalent flood damage would be 1.09% damage from a flood with a 1% AEP.

Key Words: Flood, risk, building damage, geographical information systems

Introduction

The direct average annual cost of floods in Australia between 1967 and 1999 is estimated to be in the order of $315 million, with 99 deaths and 1019 serious injuries (BTE 2001). Economic loss from flooding varies greatly from year to year and is dependent on a number of factors, for example flood magnitude and location.

The South East Queensland region, which is the focus of this study, is one of Australia's fastest growing urban regions, and is one of the most flood prone regions in Australia. Smith (1998) estimated the direct annual average urban flood damage in Queensland alone at approximately $100 million, with many of the buildings at risk of flooding in the South East Queensland region. The 1974 floods in South East Queensland were one of the most severe examples of urban flooding in Australia, with flood damage in Brisbane alone costing approximately $700 million at 1998 values (ARMCANZ, 2000).

The large numbers of buildings at risk of flooding in South East Queensland is exacerbated by the absence of state-wide floodplain management regulations. These might typically aim to prevent residential development in areas subject to flooding up to the 1% AEP (100 year average recurrence interval - ARI) level. In Queensland such regulations are left to individual Local Government Authorities to establish. A number of local governments have developed stringent development guidelines, in an attempt to minimise flood risk. However, flooding remains a large problem for many areas across the region.

Population growth and development in the region have increased urban flood risk by increasing the elements at risk. Low awareness of flood hazard (partly as there have been no major flood events in the region in recent years), has also increased flood risk to the community.

This paper describes the use of GIS based modelling to identify areas with the greatest flood risk in the South East Queensland region during a 1% AEP flood. It also discusses the potential effect on critical facilities and services in the region. This work is part of a much larger study which assessed the risks posed by natural hazards to South East Queensland (Granger and Hayne eds. 2001). This study could be used to improve emergency management response, flood mitigation and public awareness of flood hazard.

The Study Area

The South East Queensland study area is located on Australia's east coast (Figure 1). The major urban centres are Caboolture, Redcliffe, Pine Rivers, Brisbane, Ipswich, Redland, Logan and the Gold Coast. The area covers approximately 5230 square kilometres, has close to 700,000 developed properties and is home to almost two million people. The northern coastal region is drained by the Caboolture River, Burpengary Creek, North and South Pine Rivers and the northern streams of the Brisbane River which

flows into Moreton Bay. The Brisbane-Bremer River system is the major catchment in the region and includes a number of urban creeks including Oxley and Bulimba Creeks on the southern side and Moggill and Enoggera Creeks to the north. The southern coastal region is traversed by the Logan River and its major tributary, the Albert River, which empties into the southern extent of Moreton Bay. The Pimpama, Coomera and Nerang River systems (hereafter simply referred to as the Gold Coast River system), empties into The Broadwater south of Brisbane.

Figure 1: Location of South East Queensland study area.

Modelling

Areas most at risk of riverine flooding in the urban centres of the South East Queensland region were identified using GIS, hydrological and hydraulic modelling and historical data. The study used pre-existing flood hazard mapping provided by the Councils of Caboolture, Pine Rivers, Brisbane, Ipswich, Logan and the Gold Coast and value added it. Councils currently use the flood mapping for floodplain management in their respective local government areas. Modelling of the more extreme events (<1% AEP) was unavailable except for Ipswich.

Hazard models

Analysis was undertaken by catchment, therefore flood modelling from Brisbane and Ipswich, and Beenleigh and Logan were combined in GIS, to form the Brisbane-Bremer and Logan-Albert catchments respectively. Only historical flood information was available for the Brisbane River (> 1% AEP level), though 1% AEP flood lines were available for the major Brisbane creeks and the Bremer River at Ipswich. For Logan the flood mapping ranged between 50 and 125 year ARI flood levels depending on the location.

Digital elevation model and floor height

A ten metre digital elevation model (DEM) was used to interpolate ground height for each property. Floor height for each building was estimated from building age rather than field survey. Water depth was modelled using the DEM and assigned to each building point in the GIS.

Flood loss curve

Residential building flood damage was estimated as a percent of insured loss by incorporating the depth of water overfloor with a flood loss curve (Blong 2001). The curve used was developed for single storey residential buildings but used in this study for all residential buildings. The flood loss curve combined structure and contents loss, with contents valued at 30% of the value of the structure (Figure 2).

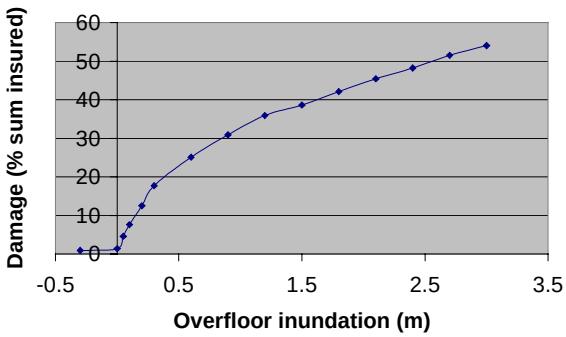

Figure 2: Combined structure and contents flood loss curve at a ratio of 0.3 (Blong 2001).

Modelling of flood damage was done on a building by building basis, but is presented as an average loss per building across the entire region or at the census collectors district (CCD) level, which comprises, on average, 200 dwellings.

Flood risk

Flood risk to developed properties is presented by catchment in the appendix as Table A1 and as equivalent damage (% sum insured) for residential buildings in Table A2. Building damage for each catchment is aggregated to give building damage for the region, assuming that each river in the region reached the 1% AEP flood level. The probability of all the rivers in the region flooding to the 1% AEP level from the one rain event, however, is much less than 1% in any one year. One rain event, such as that which caused the devastating floods in South East Queensland in January 1974, could, however, cause all the rivers in the region to flood. The impact from a 1% AEP flood in the Brisbane-Bremer River system alone though, would be devastating.

Developed properties

Across the region more than 47,400 developed properties are affected by flooding at the 1% AEP flood level, of which more than half are affected by overfloor inundation. Ninety percent of the properties at risk are in the Brisbane-Bremer and Gold Coast River systems, which have approximately 70% of the population of South East Queensland.

Flood damage is greatest in the Brisbane-Bremer catchment; both in total numbers of developed properties inundated and in the percent of properties with overfloor flooding. Approximately 14,000 properties are likely to have overfloor flooding during a flood with a 1% AEP in the Brisbane-Bremer catchment alone.

In the Brisbane-Bremer River system, 84% of the flood damage is in Brisbane and 16% in Ipswich, which is roughly proportional to the total number of buildings in each city. Though the Gold Coast catchment has a similar number of properties flooded (approximately 21,000), only 40% of those properties flooded would have water overfloor compared with 65% in the Brisbane-Bremer River system. The percentage of building stock with water on the property in the Gold Coast catchment (20%), however, is more than three times the percentage of building stock affected in the Brisbane-Bremer catchment (6%).

The majority of developed properties affected by flooding are residential (89%), though only 7% of residential properties in the region are affected at the 1% AEP flood level. In the Gold Coast, the percentage of residential properties affected is much higher than the average at 20%.

Though commercial and industrial buildings form only a small percent of flooded properties, the economic cost resulting from flooding of these facilities may be significant, particularly through loss of business and damage to expensive items such as plant equipment.

The risk posed by extreme flood events could not be modelled across the region due to insufficient data. Modelling available for Ipswich for the 1%, 0.5% and 0.2% AEPs and the probable maximum flood (PMF), however, indicates a five-fold increase in the number of developed properties vulnerable to flooding between a 1% AEP flood and the PMF. A three fold increase in damage occurs between a flood with a 0.2% AEP and the PMF. Variations in parameters such topography, means that other catchments will behave differently. Therefore, the impact of extreme events on flood damage in other catchments should be established.

Equivalent damage (percent sum insured) for residential buildings

Damage (percent of sum insured) for residential buildings is shown as an equivalent average damage per building; i) by catchment and region in Table A2, and ii) spatially by CCD in Figure A1. Also shown in Table A2 is the contribution that each catchment makes to total flood damage for the region. The geographical size of the CCDs varies widely (ie. CCDs located in the inner city are much smaller than those in the outer suburbs), though the number of dwellings in each CCD is similar. As in Table A1, damage is shown as an aggregate across the region.

The total number of residential properties across the South East Queensland region (used to calculate equivalent damage per building in the region) includes the three urban centres of Redland, Redcliffe and Pine Rivers, although they have not contributed damage. Damage for Pine Rivers could not be calculated because of insufficient data to model flood depths, but damage is likely to be low because of the low population. No riverine flood damage will occur in Redland and Redcliffe because flood risk is limited to localised stormwater surcharge, the impact of which is not considered in this assessment.

If the cost of the actual damages were to be spread among all residential buildings in the South East Queensland study area, than there would be an equivalent flood damage of 1.09% (Table A2). The Gold Coast river system has the highest damage per residential building at 1.8% because it has the greatest percentage of its building stock with overfloor flooding during a flood with a 1% AEP. Damage per residential building in the Logan-Albert River system would be 1.4% and in

the Brisbane-Bremer River system 1.2%. However, the Brisbane-Bremer River system contributes nearly 60% of the total residential building flood damage in the region. The Gold Coast contributes 27% of the residential building flood damage, the Logan-Albert River system about 13% of the damage, and the Caboolture-Burpengary River system less than 2%. Though the Brisbane-Bremer River system contributes just over double the damage than the Gold Coast, the Brisbane-Bremer has more than three times the number of residential buildings than the Gold Coast.

The Brisbane-Bremer River system has the highest residential building damage by CCD. The areas with the highest damage (30-45%) are those CCDs falling in the suburbs of Fairfield, Rocklea, Chelmer, Saint Lucia, Toowong and Graceville, all of which suffered devastation during the January 1974 floods. In the Logan-Albert, the CCD with the highest damage (24%) falls in the suburb of Waterford West, an area which was also considerably affected by the 1974 flooding. In the Gold Coast, the highest residential building damage for a CCD is 23%, followed by the Caboolture-Burpengary River system at 10%.

These results demonstrate that South East Queensland has significant potential for dramatic economic loss resulting from a 1% AEP flood. However, the reliability of this result is limited by the quality of the flood models and vulnerability curve employed. Inclusions of the uncertainty, however, are likely to increase the total estimated risk or damage, because the models/curve are more likely to be underestimates of the hazard and damage than overestimates. Future research into improving flood models and vulnerability curves is recommended.

Sensitive facilities and transport routes

Across the region approximately fifty sensitive facilities (e.g. buildings associated with public safety and utilities) are likely to be inundated, though more may be isolated by flooded access roads. Seventy-five percent of sensitive facilities flooded are located in Brisbane and the Gold Coast. Included among these is the emergency services operations centre, located in Beenleigh, covering the state emergency services units in Ipswich, Logan and the Gold Coast.

Historically, floods smaller than the 1% AEP flood have washed away sections of road and destroyed or damaged bridges in the region. This significantly hinders the movement of people, goods and supplies. Disruption of fuel supplies, for example, could result from a flood severing access routes to the fuel refineries, which are located at the mouth of the Brisbane River. In the event of flooding lasting more than a few days, the impact on the South East Queensland region could be considerable, given their reliance on road transport and fuel supplies.

Conclusion

This research shows that if a series of 1% AEP flood events occurred in all the rivers across the South East Queensland region more than 47,000 developed properties will be flooded. About half of these properties are likely to experience overfloor flooding. Ninety percent of the developed properties at risk from flooding are located in the Brisbane-Bremer (46%) and the Gold Coast (44%) River systems.

Across the South East Queensland region, the equivalent average damage per residential building is expected to be 1.09% from a 1% AEP flood event. The Brisbane-Bremer River system contributes nearly 60% of the residential flood damage to the region, more than double the damage from the Gold Coast, because of the greater number of buildings in the Brisbane-Bremer with significant overfloor inundation. Damage per residential building is higher in the Gold Coast because of the greater percent of buildings affected.

As population growth and development increases rapidly in the region, urban flood risk will increase unless measures are taken to mitigate flood risk. Lack of awareness of flood hazard, resulting in part from the lack of major flooding in recent years has also increased the vulnerability of the community to flooding. This study will be useful in reducing flood risk through increasing community awareness of flood hazard, and as a tool for emergency managers and those involved in flood mitigation.

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Appendix

Table A1: Flood risk to developed properties at the 1% AEP flood level

River system	Developed properties	Percent flooded	Properties flooded	Overfloor inundation
Caboolture	37,254	2%	824	428
Pine Rivers	38,390	0.5%	203	No data
Brisbane–Bremer	366,625	5.9%	21,777	14,070
Logan–Albert	68,881	6.7%	3738	2796
Gold Coast	106,881	19.6%	20,945	8365
Total	**618,031**	**7.7%**	**47,487**	**25,659**

Table A2: Equivalent damage (% sum insured) per residential building, 1% AEP flood

River/creek system	Residential properties	Equivalent % damage	% damage of region
Caboolture R. – Burpengary Ck.	36,128	0.34	1.8
Brisbane-Bremer R.	345,648	1.18	58.3
Logan-Albert R.	65,578	1.43	13.4
Gold Coast	100,637	1.84	26.6
South East Queensland	**644,686**	**1.09**	**100**

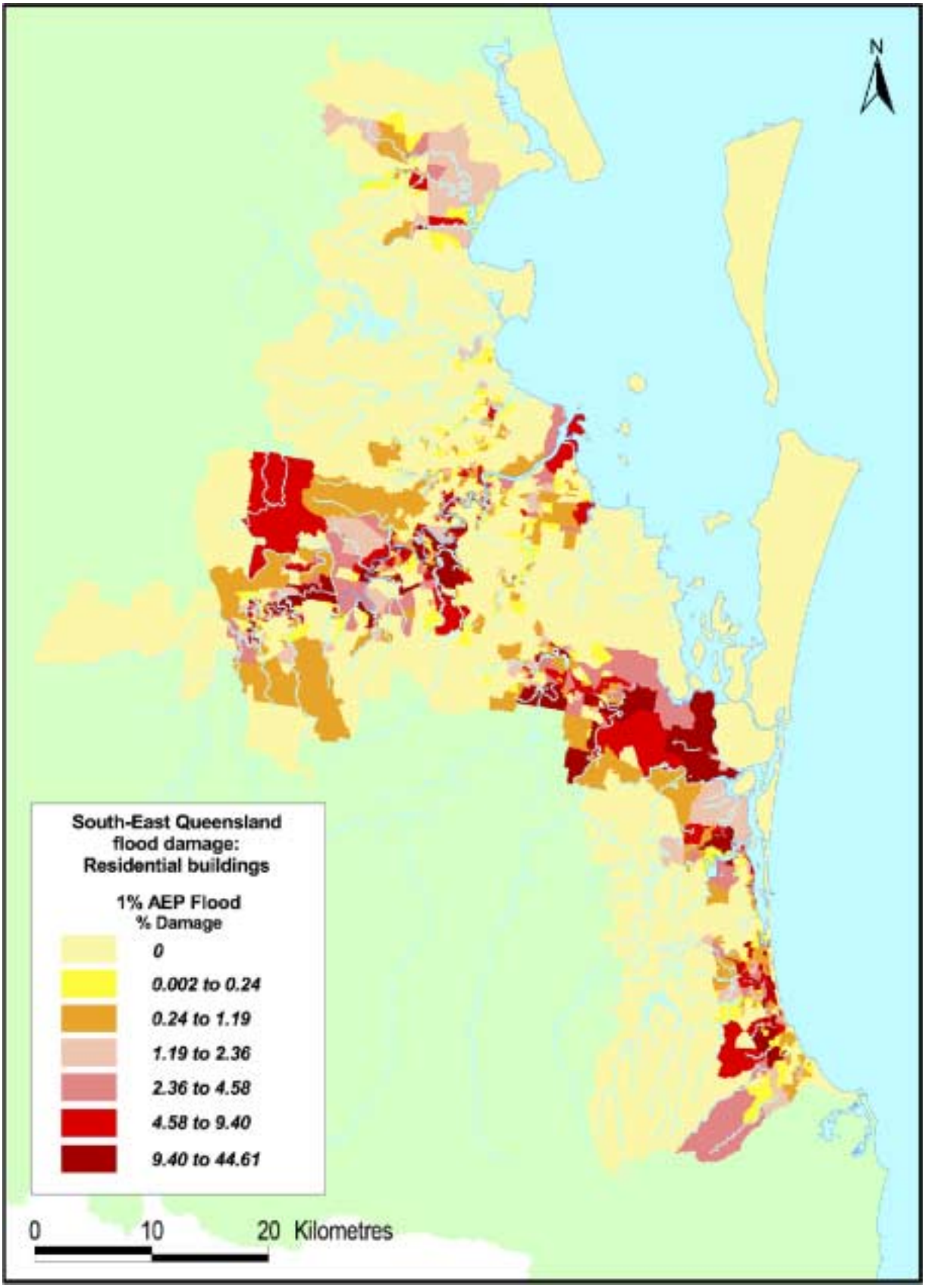

Figure A1: Equivalent flood damage (% sum insured) by CCD for residential buildings, 1% AEP, South East Queensland region

Author Biography

Miriam Middelmann has been an environmental scientist with Geoscience Australia for the past three years. She works in the Urban Geoscience Division as part of a multi-disciplinary team assessing the risk of natural hazards to urban communities. Geoscience Australia is located in Canberra. She holds professional qualifications in Science (Honours) from the Australian National University and Arts from the University of Sydney.

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