ASSESSMENT OF THE CAPABILITY OF LOCAL GOVERNMENT FOR THE VISUALISATION OF COMMUNITY VULNERABILITY

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Abstract
Information available to officers of Local Government and regional authorities on community risk associated with hazards such as landslide at a particular location is typically limited to an assessment of the risk of the hazard eventuating. However, community vulnerability to these hazards is related to many aspects of a specific location. Factors include the proximity to the source of the hazard, proximity to the propagation path of the hazard, demographics (population density, age, income, ethnicity, education etc), value of land and improvements, and post-incident availability of essential services and support (a destroyed bridge may isolate an otherwise unaffected community from essential services) and continuity of utilities such as gas, electricity water etc. Information on these further variables is often available to Council, but not in an integrated form immediately useful for community education and hazard mitigation. The Thredbo Landslide (New South Wales, 1997. 18 people dead) has prompted many responsible authorities in Australia to commission geotechnical landslide risk assessments, typically resulting in classification maps (eg. high, medium & low risk). While these classifications provide a useful planning tool, they do not necessarily represent the true community risk. For example, a high value, high density residential development located on stable ground (low risk) downhill from a high-risk area may represent a far greater overall community risk. This project develops a framework to validate geotechnical risk assessments using Geographic Information System (GIS) and visualisation technology to integrate existing landslide probability assessments with social, infrastructure and economic measures to provide a visualisation of community vulnerability to landslide. The resultant information tool will then be evaluated for practicality and usefulness in community education, mitigation of landslip and other hazards.

Introduction
Landslides in Australia are attributable for at least 83 deaths and property damage involving over 200 buildings in the order of $30 million (AUS) present day dollars since 1842. Major incidents to receive international media and community attention occurred at a ski resort in 1997 at Thredbo, New South Wales, involving the displacement of 2,000 cubic metres of liquefied soil resulting in 18 deaths and a cliff collapse in 1996 at Gracetown, Western Australia, resulting in nine deaths. (Emergency Management Australia Reducing the Community Impact of Landslides 2001**)**

The Shire of Yarra Ranges is a municipality located on the eastern metropolitan fringe of the Capital City of Melbourne in Victoria, Australia. With an area of almost 2,500 square kilometres

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the Shire is the largest of any metropolitan or fringe Council in the State. The Shire has a population currently estimated to be 141,170 people.

In terms of population it is the seventh largest municipality in the metropolitan area and the eighth largest in the State of Victoria in terms of population.

The Shire has an extensive history of landslides. The types of landslides that occur in the Shire include falling boulders, debris flows, slow long-term earth movements, small landslides up to the size of a residential block and large landslides involving entire hillsides. Some landslides move relatively frequently whereas others have not moved for hundreds, perhaps thousands of years. Landslides can be caused by both natural and artificial causes. Heavy rainfall has triggered many landslides in the Shire, such as those that occurred in 1863, 1891, 1928,1934, 1958, 1992, 1994 and 1996. Many landslides often occur then re-occur in the same location, therefore sites where landslides have previously occurred have a higher risk of future landslide.

The largest recorded landslip occurred at Montrose (at the base of the Dandenong Ranges) in July, 1891, and involved the displacement of approximately 30,000 cubic metres of earth and rock causing damage over 1.4 kilometres and was estimated to have travelled at a speed up to 40 kilometres an hour. Two horses were killed, a house destroyed and a lady was trapped but quickly pulled from the debris with minor injuries. In 1992 a significant shift at an active landslip in Blackwood Avenue, Warburton, resulted in permanent closure of the road, evacuation of a number of houses and ultimately the demolition of some houses in that area. (Coffey Partners International Pty Ltd Emergency Response Procedures for Landslides within the Shire of Yarra Ranges M2964/2-AG dated 19 June 2000)

It has been estimated that as a direct result of heavy rainfall in August, 1996, four significant landslips resulted in disaster funding claims to the order of $500,000. In 1998/99 the Shire obtained the services of engineers to conduct a geotechnical survey of the municipality with a view to devising an Erosion Management Overlay for inclusion into the new Planning Scheme and the Shire's Geographic Information System.

The following table describes the risk categories and criteria designated under the Erosion Management Overlay:

Ex	Exempt	Flat land, unlikely to be any instability, no impacts
L	Low	Landslip unlikely even though the land is gently sloping
MO	Medium Risk	Construction requires compliance with guidelines
M1	Medium Risk	Construction requires compliance with guidelines
M2	Medium Risk	Slopes>20% require a mandatory planning permit and site specific geo-technical assessment
H	High Risk	At risk of landslip without any development. A planning permit can only be issued where a geo-technical investigation shows risk is acceptable. There may be circumstances where a planning permit cannot be issued.

There are approximately 55,000 rateable properties within the Shire of Yarra Ranges.
The survey identified 434 properties in the High Risk category and 5,556 properties in the M2 Medium Risk category. This translates to approximately 11% of total properties.

Given the large percentage of properties affected within the municipality, considerable resources were directed at ensuring extensive community consultation was undertaken. Other than an initial influx of general inquiries from property owners requesting access to static mapping information in their particular areas, there has been little response to the information program. Council Officers are now questioning whether there might be a general lack of appreciation of community vulnerability arising from the use of static risk maps.

The information on community risk associated with hazards such as landslide and fire at a particular location, which is available to officers of Local Government and regional authorities, is typically limited to an assessment of the risk of the hazard eventuating. However, community vulnerability to these hazards is a function of many aspects of the location. These include proximity to the source of the hazard, proximity to the propagation path of the hazard, demographics, engineering and other lifelines and the environment.

From an emergency planning perspective the information gained by this survey for the Erosion Management Overlay was limited in that it focussed on the risk of landslip for a given geographic location but it did not provide information indicating the direction of a landslip or debris flow. Emergency planning for landslip would be greatly enhanced if the current information could be modelled to provide an insight as to the impact of an event. Such a tool would be useful in determining the vulnerability of the community by identifying the number of properties affected, the disruption caused by loss of infrastructure such as roads, gas, water, sewerage, electricity, etc. It would also assist in the identification of risk to specific buildings deemed through the nature of their occupancy to be more vulnerable, for example kindergartens, schools, aged person accommodation, hospitals etc.

The Shire's Geographic Information System (GIS) currently captures information relating to rateable properties, topography, satellite imagery and various planning overlays however current resources were insufficient to undertake this project. The Shire also lacked specialist geotechnical knowledge regarding landslip.

In acknowledging the need for expertise and in keeping with its collaborative approach to emergency management, the Shire commenced dialogue with the Royal Melbourne Institute of Technology (RMIT) and the Australian Geological Survey Organisation (AGSO). A joint application was then made to the federal government body, Emergency Management Australia (EMA), to assist in joint funding to assess of the capability of local government for the visualisation of community vulnerability.

The project has been managed by a panel consisting of the research supervisor, Mr Norm Free, Executive Officer Emergency and Safety Planning, Shire of Yarra Ranges, and Matt Hayne, Geoscience Australia. A researcher, David Fraser, a Senior Lecturer, has been appointed and is directly supervised by Dr Ron Grenfell of the Department of Geospatial Science, RMIT University. The researcher has consulted with members of the panel on a formal and informal basis and other members of their organisations on an as-needs basis.

Role of Local Government in Emergency Management

Local government has a moral and legal responsibility of duty of care to its citizens. Legislative controls are put in place to ensure that local government meets its obligations in this area. In Victoria, Australia, the Emergency Management Act 1986 requires that each municipal council forms a Municipal Emergency Management Planning Committee (MEMPC) for the purpose of formulating, monitoring and reviewing a Municipal Emergency Management Plan (MEMP) in relation to the prevention of, response to and recovery from emergencies within the municipality.

The Shire of Yarra Ranges Community Risk Based Emergency Management Plan has been modelled against the Australian and New Zealand Standards for Risk Management AS/NZS 4360:1999 and the Victoria State Emergency Service Community Emergency Risk Management Model (Risk Management and Municipal Emergency Management Planning 1998 p.vi), creating a transparent process and auditable trail in recording the identification, analysis, evaluation and treatment and decision making. This process relies on community consultation and the Shire has made the completed plan will be available to the community. With the integration of 'risk management' into Municipal Emergency Management Plans, (MEMP) the Shire of Yarra Ranges fulfils the recently revised funding requirement under the Commonwealth/State Natural Disaster Relief Arrangements.

Under the Australian and New Zealand Standards for Risk Management AS/NZS 4360:1999, risks are analysed through qualitative measures of likelihood and consequence and then prioritised according to a risk analysis matrix. In many cases it is possible to reduce the likelihood or impact of a risk by adopting various strategies ranging from physical engineering mitigation works to community awareness campaigns. The aim of any mitigation strategy is ultimately to reduce or eliminate the likelihood of an event occurring. If it is not possible to eliminate the possibility of an event occurring then efforts need to be directed at reducing the impact of an event. This structured and rigorous risk management process rated landslip as a high priority.

Topography and history of landslip in the Shire of Yarra Ranges

The Shire of Yarra Ranges can be divided into three zones, the undulating country to the west with suburban development, the forested hills to the east and the valley of the Yarra River, which runs east to west and is surrounded by farmlands. There are four major water reserves in the mountainous areas which supply drinking water for the Shire and metropolitan Melbourne: the Silvan Reservoir in the Dandenong Ranges, Maroondah Reservoir above Healesville, the smaller O'Shannassy Reservoir north-east of Warburton and the Upper Yarra Reservoir further east again. The majority of the suburban areas are found in the western part of the Shire around Mooroolbark, Montrose and Lilydale. The Dandenong Ranges are moderately populated, especially, the Belgrave-Upwey area. Even though much of these hills are heavily wooded approximately one third of the Dandenong Ranges is given over to forest parks, the remainder being zoned for residential or agricultural purposes. Forested mountainous areas also stretch from the surrounds of Healesville in the north-central part of the Shire across almost the entire eastern section. This forms part of the Great Dividing Range. The highest point is Snowy Hill at 1380m above sea level and is located at the northern most point of the Shire. The other major geographical feature of the Shire is the Yarra River, which flows along the eastern part of the Shire and runs through the Melbourne CBD into Port Phillip Bay.

There are 1116 kilometres of sealed roads and 838 kilometres of unsealed roads crossing the Shire. Approximately 60 road bridges providing major links to townships throughout the Shire. Many of the bridges carry essential services such as water and communication cables. Electricity is supplied to all residences with natural gas covering the majority of residences. Council has recognised that the physical diversity of the Shire, in particular the mountainous terrain and large floodplains, also creates challenges in developing and maintaining the infrastructure and in servicing the residents to the desired levels.

Origin of the Project and the Partnership Approach

The value of networking amongst emergency management and associated professionals cannot be underestimated. The annual conferences of the International Emergency Management Society (TIEMS) are based on the strengths and advantages of providing an opportunity for professionals to gather and debate theories and provide insights as to practical application of emergency management.

The concept for this project was born from informal networking of professionals following the Australian Disaster Information Network (AusDIN) workshop conducted at the Australian Emergency Management Institute at Mt. Macedon Victoria, in 2000. The Institute is the education and training centre managed by Emergency Management Australia a Commonwealth (National) body established in 1974 as the Natural Disasters Organisation (NDO) to absorb the functions of the existing Directorate of Civil Defence, coordinate Commonwealth physical assistance to States and Territories in the event of disaster, and assist them to improve disaster management capabilities. Since then the organisation has provided assistance in numerous major counter-disaster operations such as the Cyclone Tracy (which decimated the Northern Territory Capital City of Darwin) in December 1974, the 1983 "Ash Wednesday" Bushfires in Victoria and South Australia, 1986, Cyclone Winifred in Northern Queensland, the 1990 "Great Floods" in central NSW and southern Queensland, the 1993 north-eastern Victorian floods and the 1994 NSW bushfires. In 1993 NDO changed its name to Emergency Management Australia (EMA) and currently performs emergency management functions in relation to natural, human-caused and technological hazards. (Emergency Management Australia website www.ema.gov.au)

Geoscience Australia was first established in 1946 as the Bureau of Mineral Resources, Geology and Geophysics (BMR) with its main aim to perform the systematic geological and geophysical mapping of Australia. It then shifted focus in 1978 to develop a geological understanding of the Australian continent and its offshore areas and subsequently moved towards strategic research. During the 1980s BMR gained expertise in remote sensing and groundwater investigations and commenced nuclear monitoring and geohazard assessment, by building on its activities in earthquake monitoring.

BMR became the Australian Geological Survey Organisation (Geoscience Australia) in 1992 and provided much of the geoscience information that underpinned exploration and development work for petroleum and minerals in Australia. A review carried out in Geoscience Australia's infancy concluded that geoscience was relevant to society by providing information essential for economic prosperity and for the proper use of resources to protect the local and global economy. The change of name to AGSO – Geoscience Australia in August 2001, and to Geoscience Australia in November 2001, is recognition that the agency's work is vital in a wide range of contexts. (Geoscience Australia website www.agso.gov.au)

RMIT is a university with a global focus in Melbourne, Victoria, with three main campuses and offers many qualifications in collaboration with more than 190 partner institutions around the world including a student exchange program with the University of Waterloo. It is a member of the Australian Technology Network (ATN), a coalition of five leading Australian universities across the country and part of the Global University Alliance (GUA), a partnership of ten international universities, dedicated to providing students across the globe with accessible education using the latest interactive web and data-based technologies.

The RMIT University Geospatial Science Initiative (RMIT GSI) - an initiative of RMIT University's Department of Land Information - aims to create business and strategic partnerships, ensure the commercial application of the university's best R&D in the geospatial sciences , and

grow the geospatial science industry in Victoria and nationally. RMIT University's Department of Land Information is recognised nationally for supporting leading edge R&D in specialist areas including technology convergence, remote sensing and geographic information systems, information modelling, satellite positioning, measurement and mapping sciences , multimedia, visualisation, the World Wide Web applications and sustainable development. (RMIT University website www.rmit.vic.gov.au)

Project Aim

The primary aim of this project is to assess the capability of local government to produce an effective visualisation of community vulnerability from currently available data, modelling techniques and technology, suitable for community education and hazard mitigation. The project will develop a methodology for integrating currently available data, models and techniques for this purpose and will then assess the effectiveness and limitations of the resultant visualisation. Geographic Information System (GIS) and visualisation technology will be utilised to integrate existing landslide probability assessments with social, infrastructure and economic measures to provide a visualisation of community vulnerability to landslide. The resultant information tool will then be evaluated for practicality and usefulness in community education and hazard mitigation.

Project Objectives

The project's objectives are deliver the following:

- A methodology for Local Government to integrate currently available data, models and techniques for community vulnerability visualisation
- An assessment of the adequacy of currently available data, models and techniques for visualisation of community vulnerability, together with an assessment of the likely improvements from wider knowledge and information sharing
- Identification of hazards originating from land owned by other agencies, eg Department of Natural Resources and Environment, other municipalities, that impact on vulnerable elements of the Shire of Yarra Ranges thus requiring a collaborative approach to mitigation
- Increased awareness of community vulnerability to landslide by the Yarra Ranges community
- Incorporation of the information into all facets of emergency Management within the Shire of Yarra Ranges including planning, preparation, response and recovery
- A case study in the Shire of Yarra Ranges as an example of the degree to which an authority with significant need for such an information product is able to do so with generally available resources and organisational arrangements. The case study will be packaged in a form suitable for dissemination through the World Wide Web.

Project Methodology

Review literature on community vulnerability landslide modelling, and visualisation. Considerable research has been conducted utilising resources of the University, EMA (which is reputed as having the most extensive emergency management library in the Southern Hemisphere) and Geoscience Australia.

Review suitability and availability of existing data, models and technology identified as relevant following the literature review. The Shire currently possess a mature Geographic Information System (GIS) to support Council's mapping and information needs. An initial review

of the data suggests that there is a clear deficiency in information relating to the specific location of utility infrastructure relating to electrical and gas utilities. The AGSO Cities Project which assesses the effects on urban communities of a range of natural hazards incorporates examples of some of the models currently being reviewed.

Consult with Council and AGSO officers to develop a model of community vulnerability to landslide. The model will be a function of proximity to the source of the hazard, proximity to the propagation path of the hazard, demographics (population density, age, income, ethnicity, education etc), value of land and improvements, post-incident availability of essential services and support, and other variables identified in previous steps. Two levels of vulnerability were established. Primarily the community, infrastructure and environment directly in the path or immediately adjacent to the debris flow and secondly to those elements not directly impacted upon but vulnerable as a result of the damage and disruption caused by the landslide which would include people isolated by the damage to roads or from the loss of engineering and other lifelines.

Knowledge of the level of vulnerability to an event becomes a crucial element in reducing its impact. If one considers vulnerability as the relationship between susceptibility and resilience then by reducing susceptibility (such as ensuring physical distance of community to a risk) and increasing resilience (by educating a community on the existence of a risk and how to respond appropriately) one can effectively decrease the level of vulnerability to which that community is exposed.

Select an appropriate case study site with guidance from Yarra Ranges Shire Officers.

The choice of the case study site was based on needs of both the Shire Officers and the researcher and included the need to select a relatively small geographical area with preferably a well known active landslide that had been studied by a geotechnical engineer to provide expert advice as to the anticipated debris flow in the event of a catastrophic failure. The project model could then be tested to ascertain whether it provided information consistent with that predicted by the geotechnical engineer. Other factors were also considered relating to the location and proximity of a variety of vulnerable elements to the site.

In October 1992 an active landslip in Blackwood Avenue, Warburton (located in the eastern region of the Shire), moved significantly resulting in the evacuation of houses in the immediate area and the permanent closing of the road. Historical information indicates that this landslip has been in existence for, perhaps, thousands of years and was almost certainly well established prior to European settlement in the Warburton area. The earliest recorded movement of the landslip occurred in the early 1950's. The landslip has moved every decade since then and is expected to continue moving. It is believed that total movements in the order of 20 to 30 metres have occurred since the landslip formed (based on the present slope profile and the assumed pre-landslip profile).

The Blackwood Avenue landslip lies on the north bank of the Yarra River at Warburton. The toe of the landslip is at the edge of the river. Cumulative movements up to about 1.5 metres have been measured on the Blackwood Avenue landslip in the last seven years. Concern has been expressed that this landslip may fail catastrophically, blocking the river, and this could lead to flooding of the Warburton area. The landslip covers approximately 6 hectares. It is irregular in shape and has a maximum length of about 320 metres and a maximum width of about 230 metres. Currently there are no occupied buildings on the landslip. Four houses were on the site until the early 1990's. They have since been demolished or permanently vacated. Four houses lie in close proximity to the edges of the landslip.

No evidence has been found to suggest the landslip may have blocked the Yarra River in the geological past, let alone in more recent times. The available evidence indicates the landslip is "slowly shuffling" along, most likely in response to heavy rainfall and that substantial movements

causing the river to totally block are unlikely to occur. Irrespective, given the narrowness of the river and the uncertainties regarding the behaviour of any landslip and the events that could take place in a major storm/flood event, the consequences of the landslip blocking the river need to be considered.

In the opinion of the geotechnical engineers engaged to assess the landslip, in the very unlikely event of a total blockage of the river, the resulting landslip dam is likely to be made up of loose debris, which would erode quickly, particularly if over topped by the river. If the unexpected happens and the dam is not rapidly eroded, flooding will occur. This will, in turn, primarily effect infrastructure, such as the bridge spanning the Yarra River (shown above), which carries the main Highway through the township. This will result in the isolation of services such as the hospital and the volunteer fire brigade and loss of engineering and other support lifelines. (Coffey Partners International Pty Ltd Emergency Response Procedures for Landslides within the Shire of Yarra Ranges M2964/2-AG dated 19 June 2000)

Obtain and integrate relevant models and data in a GIS environment, developing general integration methodology. A number of relevant models are still being explored including those incorporated by AGSO in its Cities Project which assesses the effects on urban communities of a range of natural hazards.

Four broad data sets are currently being collated and/or considered for inclusion in this project . Each set has been categorised into a general and more specific groupings.

SET 1 - Hazard identification: Awareness Level 1 – general includes land cover, streams, flood plain, slope gradient. Level 2 – specific includes geology, mantel of soil and rock fragments, bare soil, erosion gullies, forest cover and groundwater regime.

SET 2 - Areas prone to instability in the Shire: Awareness Level 1 – general includes broad geographic areas such as the rolling slopes of Mooroolbark, Silvan, Wandin Yallock, Forest Hill and Wandin East; Kalorama and the western and north-western slopes of Mt. Dandenong. Level 2 – specific includes land fill, soil creep, batter slopes, seepage.
SET 3 - Critical facilities analysis Level 1 – general includes **e**xisting development, key economic centres. Level 2 – specific includes hospitals, emergency services, retirement villages, government offices. Level 3 – detailed includes roads, gas lines, electricity lines, water mains, telecommunications, public transport. This data set will also be considered to include an inventory incorporating details such as facility name, type, street address, town, owner, contact name and title, contact telephone number and emergency service district.

SET 4 - Environmental analysis Level 1 – general including **e**nvironmentally sensitive locations, areas subject to primary environmental impact, areas subject to secondary environmental impact. Level 2 – specific includes structural vulnerability, operational vulnerability, societal vulnerability. Level 3 – detailed includes critical facilities hazard risk areas, natural hazards risk areas, population (*housing*) density, location of hazardous or toxic sites, cleared sites, natural drainage interference, assembly areas for population.

Create alternative visualisations of community vulnerability

To date the following visualisations have been created:

- Warburton satellite image
- Blackwood Avenue landslide
- Topographic map of the Blackwood Avenue Case study Area
- The Yarra River and Bridge at the Blackwood Avenue study site
- Digital Elevation Model of Blackwood Avenue Environment
- Site of the Blackwood Avenue landslide

- Possible flooding extent after the landslide shown with public buildings (buffered)
- Buildings on low lying land
- Steep slopes in relation to buildings
- Steep Slopes on terrain model
- Steep slopes in relation to road locations

Evaluate information products through focus groups consisting of community members and council officers.

Stakeholders, including the community, other land owners and other stakeholders, who have been identified as vulnerable to the impact of a landslide in the selected site such as a local school and an aged care facility, are currently being canvassed as to their needs with a view to conducting a public meeting. This forum will provide and opportunity to demonstrate the various visualisation models and obtain feedback as to the relevance and effectiveness of the visualisations. The forum will also provide an opportunity to gauge support for community involvement in a system to monitor the landslip.

Evaluation of the project

The project will be evaluated in achieving its objectives and its effectiveness by:

- surveying the community and stakeholders regarding the visualisation in meeting their needs.
- survey of Shire of Yarra Ranges Officers from the Emergency and Safety Planning, Planning, Building Surveyor and GIS areas as to the suitability of the model to meet individual needs.
- survey of other municipalities regarding the model.
- survey of RMIT and AGSO stakeholders.
- Overall assessment for broader application by Emergency Management Australia.

Conclusion

Although this project is still in progress a number of significant factors are worthy of note:

- The opportunities derived from informal networking at emergency management forums to initiate collaborative inter-agency projects
- The appreciation for community involvement in emergency management projects
- The acknowledgment of State and Federal Agencies of the need for tools to assist emergency management practitioners and the community in reducing vulnerability
- An acknowledgment of the advantages to be gained through the application of computer technology to aid emergency practitioners
- The opportunity for effective practical advances in emergency management through the collaborative efforts of practitioners and academics.

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